
# Progress Report Electronics

## Work done from 25 October 2021 to 31 November 2022

This report covers the design, components used and architecture of the main components used in the rover. This includes the detailed analysis of power system, drive system, video system, main control, navigation system, communication system and wiring in the bot.

### Video Sub-System

For the navigation of rover and complete various missions we will use high definition cameras which will also assist the bot in autonomous traversing missions during the competition. We did a detailed literature review for LIDAR v/s vSLAM architecture, the number of cameras to be used, their positioning in the bot, resolution of the cameras and the FOV for the required tasks.
Detailed view of cameras which we will use are discussed below.

**Main Camera**
First we will compare the cameras available in our budget range and then finalize them.
**Intel Realsense D400**
The maximum operating temperature of the camera is 35ºC. The camera is not meant to be used in extreme environments outside of the operating temperatures specified in the datasheet. In order to use the camera in extreme conditions, an enclosure must be designed for it that will protect the camera. This goes for all real sense cameras.
**Intel Reaslsense T265**
Intel RealSense T265 is not a depth camera. It features two fish-eye lenses for feature detection but does not compute dense depth. It is possible to use the image feed from the cameras to compute dense depth, though the results will be poor compared to other Intel RealSense depth cameras as lenses are

optimized for wide tracking field of view rather than depth precision, and there is no texture projected onto the environment to aid with depth fill.

**SLAM solutions**

All SLAM solutions and there are many good ones, are limited by the information they receive. It is possible to run host-based SLAM using our D400 series depth cameras – ideally the D435i, however, these cameras are optimized for depth accuracy at the expense of field of view – D400 cannot see as much of the world as T265.

Tracking with T265 is platform-independent, has a low integration cost, and can run on very low compute devices. For some use cases, SLAM on the D435i will be ideal, but for the highest quality tracking, choose the T265. For both quality depth and tracking, use the D415 and the T265 in parallel.

**Depth Camera Finalized**

T265 is redundant because of no depth but has a large FOV; Ideal for tracking
d455 has a wider FOV but a 1MP RGB sensor as compared to d435i which has 2 MP RGB sensor.\\
Status: d435i vs d455 Both are good. Will decide after testing and further discussion.
From the extensive research, it is clear that d455 outperforms d435i for both depth sense and FOV.
Finalized Depth Camera is Intel Realsense d455.

**Additional Cameras**

**IP Cameras**

**Benefits of IP cameras:**

- Two-way audio: A camera owner can listen and speak to a subject via a speaker on the camera.
- Remote access: Authorized users can view live video footage from any smartphone, tablet, or computer
- Better resolution: IP cameras have up to 4x the resolution of analog cameras.
- Fewer cables and wires: Power over Ethernet supplies power through the Ethernet cable, allowing the camera to operate without a dedicated power supply.

**Types of IP cameras(on the basis of focal length flexibility)**

1. **Fixed focus cameras:**
   These use a lens set to a single focal length and hence the field of view is fixed. This keeps the cost down but makes the camera selection (or in some cases, the lens to be installed) even more critical.
2. **Manual variable focus cameras:**
   These cameras have a range of focal lens, such as 2.8mm to 12mm. You can change these at any time by adjusting the lens in the camera. Of course the flexibility means you pay more.
3. **Motorized cameras, Pan-Tilt-Zoom (PTZ)**:
   These cameras are motorized in all the axes of motion. You may also find Pan-Tilt (PT) cameras which have a fixed focus. Typically, these are the most expensive cameras that the DIY security enthusiast can purchase.

**Required features**

- IP protocols support: Make sure the camera supports the ONVIF and RTSP protocols. This will ensure compatibility with NVRs and other home automation equipment in the future.
- Power-over-Ethernet: Instead of running a separate power cable and ethernet cable to each camera, the Power-over-Ethernet feature allows you to transmit power over the data cable itself. This is hugely convenient as you can use ethernet cable runs of up to 100 feet. Reference for PoE is given in below sections.
- Make sure it supports the 802.3af Power-over-Ethernet standard and the 802.3at standard for PTZ cameras. The 802.3at standard supports higher power ratings that are needed for motorized cameras.
- Weatherproofing: Make sure outdoor cameras are at least IP66 compatible. It may also be worth adding an extra layer of sealant around the camera to provide extra protection.
- Resolution: With analogs cameras, you would judge resolution by the 'number of TV lines (TVL) or 'lines of resolution'. With digital IP cameras, the resolution is specified by the number of pixels. Currently, we recommend a minimum of 2 MegaPixels. 3MP is the standard but 4MP cameras are quickly becoming mainstream.
- Infrared: Most IP cameras have built-in Infra-Red(IR) illumination. The most common ring-type LEDs tend to fade after a year or so and are found in entry-level models. EXIR LEDs are stronger and more long-lasting. In any case, you will need external IR illumination because the IR produced by cameras generally tends to behave a flashlight effect and are effective only in enclosed spaces. Another issue with built-in IR is that flies and spiders are attracted to the IR hence blocking the camera's view or frequently setting off motion detection alerts.

**Discussion and Challenges**

IP cameras are quite cheap. So a number of them can be used on Rover depending upon the requirements. A little costly(Around 5K) version can be used for night vision; will give a better edge to the rover. All cameras chosen should have ethernet support. These camera feeds will be connected to a LAN network through which data will be transferred to the Jetson Nano. In case of when the camera is required on-board only USB connectivity can be checked. However we have to handle multiple feeds on the same network along with control data flow and other communications, for which we need to do find a solution.

Two cameras from which we can choose are:

1. Hikvision 4 MP IP network dome CCTV camera.
2. If bullet camera is viable: IMOU bullet 2C security camera.

**Robotic arm cameras**

Two cameras to be used most probably: One for surveillance while controlling the arm through the joystick and one on tip of the robotic arm for other important robotic arm missions.
Surveillance Camera: For Surveillance, we will be using a simple IP camera or some cheap cameras with low features.

**Cameras for end effector of the robotic arm:** For this we have some cameras reviewed but the finalization is remaining.

## Life Sciences and Sensors

**LiDAR review and Discussion**

The LiDAR unit was an off-the-shelf product chosen as a second vision system for its ten meter range, greater than 1KHz sample rate, and seventy percent reflectivity coefficient, making it ideal for operating in bright conditions. Additional sheathing was also added in the mount to further protect against bright sunlight. A 1D unit pointed at an angle towards the ground was used in favor of something with more dimensions because the LiDAR was designed to be a last resort due to the unreliability of data from these point clouds in bright light- if Tricam could not identify a hazard like a cliff or a steep hill, the data from the LiDAR unit was to be used to stop the rover and give the SOM time to generate a new point cloud from Tricam in order to create a new best course of action for the rover.

Discussed and concluded that LiDAR is to be involved only if there is a dire requirement due to the failure of vSLAM during missions.

**IMU sensor**

Due to its up to the mark properties listed below, we chose BNO055 IMU sensor for our rover.\\
-Absolute Orientation (Euler Vector, 100Hz) Three axis orientation data based on a 360 degree sphere.
-Absolute Orientation (Quaterion, 100Hz) Four point quaternion output for more accurate data manipulation
-Angular Velocity Vector (100Hz) Three axis of 'rotation speed' in rad/s.
-Acceleration Vector (100Hz) Three axis of acceleration (gravity + linear motion) in metre per second square.
-Magnetic Field Strength Vector (20Hz) Three axis of magnetic field sensing in micro Tesla (uT).
-Linear Acceleration Vector (100Hz) Three axis of linear acceleration data (acceleration minus gravity) in metre per second square.
-Gravity Vector (100Hz) Three axis of gravitational acceleration (minus any movement) in metre per second square.
-Temperature (1Hz) Ambient temperature in degrees celsius.

**GPS module**

After doing an extensive literature review on the available GPS modules we have finalized u-blox ZED-F9P GNSS module.
Some features are listed below:

- Concurrent reception of GPS, GLONASS, Galileo, and BeiDou.
- Multi-band RTK with fast convergence times and reliable performance.
- High update rate for highly dynamic applications.
- Centimeter accuracy in a small and energy-efficient module.
- ZED-F9P High Precision GNSS receiver EVAL module USB, I2C, UART, SPI with SMA antenna connectors.

Specifications of the module are:

- 0.5V to 3.6V power supply voltage range.
- 100mA output current.
- 10dBm input powe
- 40°C to 85°C operating and storage temperature range.

**Micro-controllers**
For the main control we are going to use NVIDIA Jetson Nano and for controlling other sub-systems we chose Raspberry-pi and STM32 controllers.
The working basics of R-pi, NVIDIA Jetson Nano and STM-32 are studied using some online resources and data sheets.

## Inter Component Communication

**CAN Study**
First we will see some of the advantages and disadvantages of the CAN.
**Advantages**
Low Cost, Built-in Error Detection, Robustness, good speed and flexibility.
**Disadvantages**

- It is likely to have undesirable interactions between nodes.
- It incurs more expenditure for software development and maintenance.
- CAN driver must produce atleast 1.5V across typical 60 Ohm.
- Network should be wired in topology which limits stubs as much as possible.
- In order to reduce signal integrity issues such as reflections CAN bus should be properly terminated at both the ends with resistors.
- Node removal requires use of termination resistors of 120 Ohm value at appropriate places on the CAN bus.

**Further Discussion**

- CAN are usually used in vehicles and are the most potential candidate for central inter module communication.
- We need some module for connecting each node to the CAN network. On a Raspberry Pi this can be achieved by using PiCAN2 module.
- Same thing can be achieved using Robocraze MCP2515 Can Bus Module Board TJA1050 Receiver SPI for 51 MCU Arm Controller.
- The module is low cost (Around 200 rs only). This module can be used with Arduino, STM32 and Raspberry Pi. However, Since Raspberry Pi is 3v3 device and the MCP2515 is a 5V device, We will

have to use a voltage shifter or voltage converter.

- The only downside of the CAN is that none of the devices that we might be using in the project is compatible with CAN protocol. For each node on the CAN bus, we need a separate CAN controller and CAN trans-receiver. The both come packed in a module which will cost around 200 Rs per node on the network.
- Also any device with SPI compatibility can be used for CAN bus.

**I2C Study**

Disadvantages of using I2C-

- Conflicts: Due to chip addressing, there’s always a possibility of an address conflict.
- Slower speeds: I2C protocol uses pull-up resistors rather than the push-pull ones used by its peers. Due to the open-drain design, the speed is limited.
- Requires more space: It isn’t such a positive attribute that the I2C protocol requires so much space for its pull-up resistors.

**Discussion**

The CAN bus is very superior to I2C bus in terms of many parameters. The only downside of the CAN is that none of the devices that we might be using in the project is compatible with CAN protocol. For each node on the CAN bus, we need a separate CAN controller and CAN trans-receiver. The both come packed in a module which will cost around 200 Rs per node on the network.

I2C can be used in places where a local communication is to be done between the micro-controller and sensors such as in Life Science module. Else where for important communication such as inter module communication CAN should be preferred. However I2C to Ethernet converters are easily available.

Challenges being faced in Inter Component Communication

- How to transfer data from a CAN bus to a LAN bus bidirectional.
- Integrating Various components over LAN bus.
  We will do literature review and solve the challenges shortly.

## Communication subsystem

To establish the communication system between the rover and the base station, we will be using the standard bands and number of channels according to the requirements. There will be one omni-directional antenna mounted on the rover and one directional antenna at the base station. The number of antennas can vary according to the consumption of the allowed band. For example, the control signal and other data can be communicated using different bands and so, using separate antennas. The signal received by the camera will be first digitized (if not done by the camera already), then the digital signal will be encoded and modulated into an appropriate modulating scheme. This signal will then be transmitted by the transmitter embedded on the rover. The control signal will also be transmitted in a similar manner. For the purpose of implementation of this system, an appropriate USRP will be used and it will be configured according to our requirements using LabView. Also, since the distance between the rover and the base station will be large, the power amplifier circuit has to be implemented for a longer range.

The challenges that have to be considered are configuring every component of the communication system according to our frequency band requirements, the interference of other nearby signals, the long distance between the rover and the base station and the non line of sight communication. These challenges will be addressed after implementation of the modules mentioned above.

## Battery

Recommended specifications of the battery according to the Mechanical and Electronics team are as follows:

- Voltage: 24V.
- Max current: 20A.
- Power: 20-30 Ah.

**24V and 30 AH (LiFePo4) Battery pack**
Its High power, high Back Up facility. You can use this battery in your 250 watts motor, 350 watts motor easily. This battery is protected with BMS connection. Means battery is with over charge protection. Low discharge protection. This battery weight is very low than your normal lead acid battery. And can provide appropriate Power to your Motor. This Battery provides a lifespan of max 8 years and has a mileage capacity of max 80 km approx.

**24V and 24 AH (LiFePo4) Battery pack**
Its High power, high Back Up facility. You can use this battery in your 250 watts motor, 350 watts motor easily. This battery is protected with BMS connection. Means battery is with over charge protection. Low discharge protection. This battery weight is very low than your normal lead acid battery. And can provide appropriate Power to your Motor. This Battery provides a lifespan of max 8 years and has a mileage capacity of max 65km approx.

Of the two batteries above, former has a longer life and less weight(2.5Kg) span due to which we will use the same.

## Power System

In a vehicle built to encounter harsh terrain, the components of a rover must be both durable and well secured. Special consideration must be given to the power distribution system - it must be able to protect itself amid a mechanical failure. Should electrical components loosen, there is a possibility that they could short or spark and harm connected devices or other sub-systems. On the other hand, the power distribution system must also remain both easily serviceable and accessible. To function safely and properly, individual units of the power distribution system should continuously relay data about their present operating conditions. The team can then monitor these conditions in real-time, and adjust them as necessary while the rover is in operation.

There are five major sub-systems. These include the following: Drive-train, Communication, Manipulators, Rover core, and Science Module.

The entire work can be divided into two sub-units :

1. Power distribution.
2. Power Management system(PMS).

**Finalized Battery**
The team carefully analyzed our power requirements along with any modules that might be added later and decided on the following specifications for the battery. Voltage 24V; Max current 20A Power: 20-30 Ah. Based upon these specifications, we decided on E-Bike LifePO4 Lithium Iron Phosphate Battery.

**Power Management System**
Need for a Power Management system
The primary purpose of the PMS is to monitor and manage the condition of the battery pack. As LiPo batteries that operate below or beyond their rated voltage can ignite or explode, it is imperative that the team is able to continually assess their condition while operating the rover.\\

Requirements of PMS

1. Continuously measure and record the temperature, voltage, and current draw of the battery pack.
2. As data is collected, the micro-controller communicates this information to team operators and, if necessary, protects the pack from danger. All readings should be transmitted to the team's base station.
3. As per the requirements of the URC, It should have a kill switch to stop all the functions of the rover in case there is some emergency.
4. An LCD screen can be used to indicate the current status of the power systems. (Optional)

To build PMS, the team has decided to use a custom board. The device encompasses a custom printed circuit board coupled with an STM32 microcontroller, various MOSFETs, and an array of individual sensors. As data is collected, the microcontroller communicates this information to team operators and, if necessary, protects the pack from danger. Furthermore, the PMS protects the entire power distribution system against overcurrent by automatically shutting down the rover should it detect current levels greater than the allotted output of the batteries. Coupled with a manual emergency stop button that disconnects the rover's batteries from the power board completely, these two emergency stop functions ensure the safety of team operators should any type of problem arise concerning the rover's sub-systems

**Extra additions to the PMS**:

1. As per monitoring of the systems, cooling fans can be controlled via feedback from sensors.
2. The entire power report can be further sent to the Base station for further analysis.

**Power Distribution**
Need for Power distribution board

The power board is responsible for regulating and distributing the power received from the battery box to the rest of the systems on-board the rover.

**Design of Battery distribution board**

Power can be allocated from the batteries to the other sub-systems through a collection of different buses. The four buses - communications, logic, actuation, and extra - power devices across the rest of the rover's sub-systems. There are devices that use 24,12,7,5,3.3 V as operating voltages. The 24V needs to be stepped down and regulated. As these four buses must receive power at a constant rate of 12V, pack voltage and the current first pass through one of three different 12V buck converters to accommodate this restraint. The buck converters will be custom designed.

The communications bus powers all of the communication devices on-board, while the logic bus powers all of its other integrated circuits and micro-controllers. The actuation bus powers the higher current devices, such as the cameras on-board the rover. Each of the buses has its own independent current sensors, switching MOSFETS, and fusing. The current sensors report data about each bus to the micro-controller which has software-defined current limits. Should the current draw for any bus rise above the set limit, the micro-controller will automatically disable that bus. The fuse for each bus is installed in series to provide a hardware backup should the micro-controller fail. The motor buses connect directly to their specified motor controller/driver by means of connectors on the power board.

**Final Discussion**

We are yet to work upon the exact specifications and components finalized for these two systems because that will require a lot of testing and improvising that can be done only when the teams will meet offline.

---

# Work done from 1 December 2021 to 5 January 2022

Finalized almost all sensors and actuators to be used.

| Name | Quantity | Requirements | Purpose |
|---|---|---|---|
| Jetson nano | 1 | Module Power: 5 – 10W \| Power Input: 5.0V Current 2.5 A | As the main computer of the rover; Performs GPU extensive task |
| Raspberry Pi | 3 | 5V at 3A. | For controlling and communicating with various devices within a module |
| 24 V Motor 100 W Stepper | 6 | Phase current: 5Amp Resistance/phase: 0.76ohm Inductance/Phase : 8.5mH | Used as the main drive. Chosen because of flexibility b/w RPM and Torque |
| Robotic arm steppers | 5 | Current: 1.2 A/Phase Holding Torque: 4.2 kg-cm Detent torque: 2.2 N.cm (Maximum) Lead Wires: 4 | Used for actuating robotic arm. |

| Name | Quantity | Requirements | Purpose |
|---|---|---|---|
| Absolute Encoders | 6 | | to operate at high speed and with high accuracy |
| USRP | 1 | 6 V 3 A | For communication between Rover and Base via RF |
| Depth camera | 1 | 380mA / 5V USB Powered | Used as a mainstream camera with Depth support to implement vSLAM |
| IP Cameras | 2 | 2 VDC, 0.34 A, max. 4 W; PoE (802.3af, 36 V to 57 V), 0.2 A to 0.1 A, max. 5 W | Cameras for extra FOV and tasks assigned |
| Bullet IP camera at the end effector | 1 | 5 V 0.5 A | Getting a feed of tip of the robotic arm |
| Anemometer | 1 | 4 to 20mA DC 12-24V. Power consumption: MAX≤0.3W. | To measure wind velocity |
| UV detector | 1 | Supply voltage: 3 V to 5 V DC | To detect UV radiations present in the atmosphere |
| pH sensor | 1 | 5V | For measuring pH in soil |
| Temperature Sensor | 1 | Operating Voltage(V) 3- 5 Operating Current(mA) 2 | For measuring temperature |
| IR camera | 1 | 3.3-5 V | Used for thermal imaging |
| GPS module | 1 | 3.3 V | For getting GPS coordinates of the rover |
| IMU module | 1 | 3.3 V | For getting orientation readings |
| STM8S105K4T6 Minimum System Board Microcomputer STM8 ARM Core Board | 10 | 5V power 2.5 A | To be used as microcontrollers for drivers, BMS, Thermals, etc |
| Thermal Fans | 2 | 5VDC 0.200A | To maintain the temperature of the Electronics bay |

## Drive Systems:

**NEMA34 STEPPER MOTOR 85KGCM TORQUE-Drive motor**

**Features:**

- Step Angle: 1.8 Degree
- Configuration: 4 wire bipolar stepper motor
- Holding Torque: 85kgcm bipolar mode
- Phase current: 5Amp
- Resistance/phase: 0.76ohm
- Inductance/Phase: 8.5mH
- Rotor inertia: 2700 gcm2
- Length (L): 118mm
- Shaft Dia: 12.7mm
- Shaft Length: 32mm
- Weight: 3800 grams

Alternatively, DC geared motors can also be used but steppers are to be preferred.

| Characteristics | Brushed DC Motors | StepperMotors |
|---|---|---|
| **Control characteristics** | Simple; no extras needed | Simple; microcontroller needed |
| **Speed Range** | Moderate (depends on type) | Low (200-2000 RPMs) |
| **Reliability** | Moderate | High |
| **Efficiency** | Average | Low |
| **Torque/speed characteristics** | High torque at low speeds | Maximum torque at low speeds |
| **Cost** | Low | Low |

In case we decide to use geared DC motors due to budget constraints, We finalized a DC geared motor too.

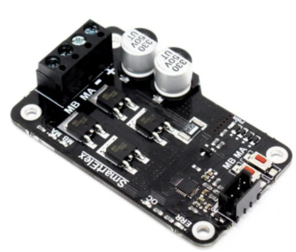
**We will be using Planetary DC Geared Motor 148 RPM 183N-CM 24V IG45-33K**

Brand: Cytron Rated Voltage: 24VDC Rated Torque: 18 kg-cm Rated Speed: 148 RPM Rated Current: 3500mA Rated Power output: 49.5W Gear ratio: 33:1

For **Motor drivers** either we are going to make **6 channel** 24V 30A circuit boards or we will use 6 separate **SmartElex 15S DC Motor Driver 15A**

**Specification**

1. Supply Voltage: 6.8-30 VDC.
2. Continuous Current: 15 Amp.
3. PWM Frequency: 20 kHz.
4. Max Peak Current: 30 Amp(For 10 Seconds).
5. One brushed DC motor Bidirectional control.



This motor driver comes with PWM pins which can be controlled by the microcontroller.

## Encoders:

An encoder is a sensing device that provides feedback. Encoders convert the motion to an electrical signal that can be read by some type of control device in a motion control system. To get the exact position and speed of a moving part. Since the motors weren't final and could be finalized only after some hands-on experience in the lab, We found this link to get encoders as per our requirements.

We can order the exact size, precision, and type of encoder from the below link: https://www.encoderoutlet.com/

To finalize the exact features of the drive systems, we need to have access to DC motors and steppers. We hadn't worked with encoders before. Since few members of the team are on campus. They are tinkering with motors and actuators already available in order to conclude.

## Robotic arm motors:

After brainstorming with the mechanical team, We found out that even after getting the specifications of stepper motors, the motors might need revision. Since some of the team members have already reached the campus, we decided to tinker with steppers available in the Robotronics Club room. Some of the Steppers that we tinkered with are :

**NEMA17 4.2 kg-cm Stepper Motor:**

Step Angle: 1.8 ° Current: 1.2 A/Phase Holding Torque: 4.2 kg-cm Detent torque: 2.2 N.cm (Maximum) Lead Wires: 4 Shaft diameter: 5 mm

**STEPPER MOTOR NEMA23 10KGCM TORQUE - ECONOMY:**

**Features:**

• Step Angle: 1.8 Degree
• Configuration: 4 wire bipolar stepper motor
• Holding Torque: 10.2kgcm bipolar mode
• Rated voltage: 3.3VDC
• Phase current: 2.8Amp
• Resistance/phase: 0.83E
• Inductance/Phase : 2.2mH
• Rotor inertia: 275 gcm2
• Length (L): 51mm
• Weight: 650 grams

**28BYJ-48 Stepper Motor:**

Rated voltage: 5V DC Reduction Ratio: 64:1 Step Angle: 5.625° /64 Frequency: 100Hz

Self-positioning Torque: >34.3mN.m Friction torque: 600-1200 gf.cm Pull in torque: 300 gf.cm

## Inter-component communication

**Implementing I2C bus**

We tried to make an I2C communication bus on Raspberry Pi. Read about how the I2C bus works at All from Texas instruments guide. On a single i2C bus all the sensors /motors(nodes) need to have different i2C addresses. This isn't a problem when all nodes connected to the bus are different or they have features to alter their addresses. An address is of format **0x**10 (Hex values).To use the I2C bus on Raspberry Pi, We must first enable the I2C interface from the Rpi configuration. To list all the devices that are present on bus type Sudo i2cdetect -y 1When there is the same type of devices on the same bus and their addresses cannot be altered at their end, we face great problems. . We can create our own I2C bus by making two GPIO pins as SDA and SCL. Thus multiple sensors can be handled in this way.

Sensors used on the I2C bus:

**DHT11-** [https://www.freva.com/dht11-temperature-and-humidity-sensor-on-raspberry-pi/#:~:text=The DHT11 is a low,pin of the Raspberry Pi](https://www.freva.com/dht11-temperature-and-humidity-sensor-on-raspberry-pi/#:~:text=The%20DHT11%20is%20a%20low,pin%20of%20the%20Raspberry%20Pi).

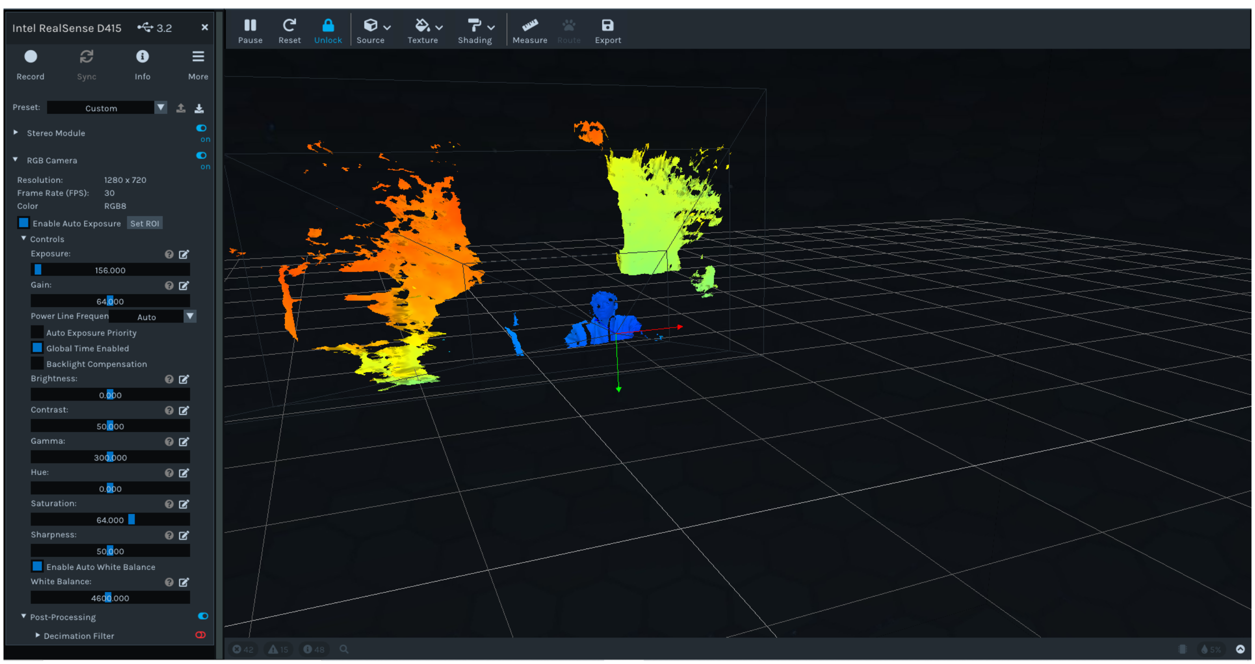
**MPU6050-** https://www.electronicwings.com/raspberry-pi/mpu6050-accelerometergyroscope-interfacing-with-raspberry-pi

## Camera and Vision systems

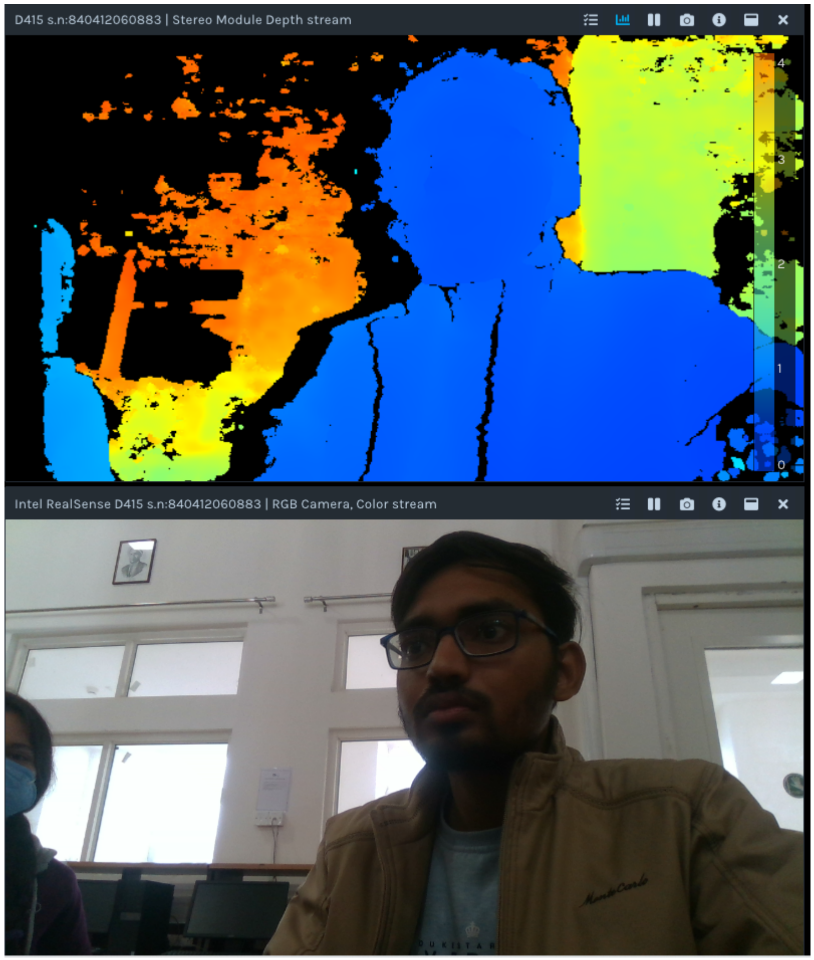
The team has already finalized depth cameras in the previous report. On reaching the campus, we went to the communication lab and came across two commonly used depth cameras. We tested and benchmarked the cameras.

### Some Real-time snips from Intel Realsense D415:

3D point cloud:




2D depth map:



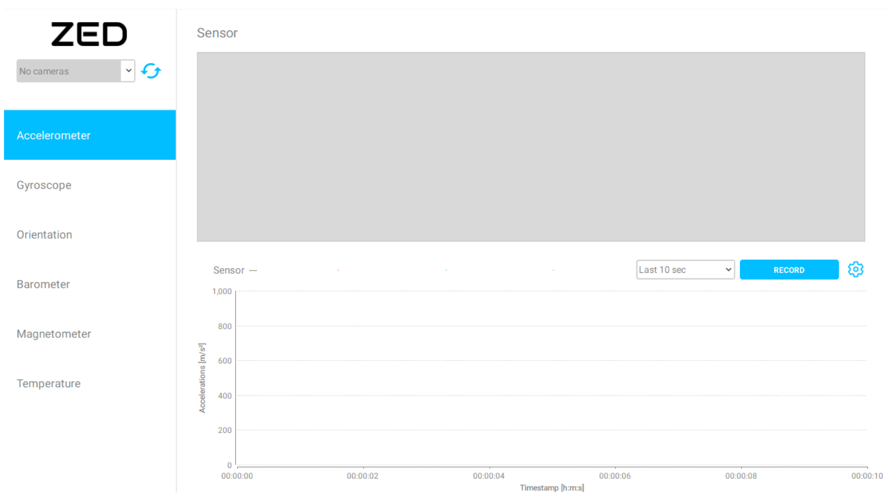

USB type A to type C interface, to be attached to Jetson nano. The above snaps are from the laptop

## Stereolabs ZED:

There are two independent feeds as shown in the snip above.

**Depth map of ZED:**


There are also many sensors available in ZED cameras. We can utilize them to make a stabilization platform.




## Power Electronics:

For power management, we can use either a DC/DC Converter, a linear regulator, or a combination of the two.

DC/DC Converter
A DC/DC Converter changes DC voltage levels. Three common types are:
**Buck Converter:** Takes a higher input voltage to a lower output voltage
**Boost Converter:** Takes a lower input voltage to a higher output voltage
**Cuk Converter:** A combination of a boost and buck converter that can take an input voltage and either boost or drop it.
**Linear Regulator**

A linear regulator also takes a higher input voltage and provides a lower output voltage. Typically, the output voltage is "cleaner" with less noise than a DC/DC converter and we will find regulators used to power embedded computers and microcontrollers.

**System Recommendations**

We can use a Cuk Converter between your battery and the 12V motors. we can also use a 5V regulator to get the necessary power to your Raspberry Pi. Instead of using the power distribution panel, you can try everything on a breadboard and then move to a perf board. Many of these parts should be available on Digikey, Adafruit, or the electronics vendor of your choice.

We came across a **PSIM simulator** for the simulation of power electronics and control design. PSIM’s power electronics simulator delivers unbeatable simulation speed while producing high-quality system-level results. Even with no prior experience, PSIM’s friendly user interface means easy implementation and seamless adoption in any environment. The team has finished the preliminary design of the power distribution board and battery monitoring systems. We have also finalized the battery to be used. What we aim next is designing circuit, generating gerber files, fabricating PCB, and manufacturing full-fledged Power systems for our rover.

## Communication Systems:

Following components are available in Communication lab:

| Sr. No. | Item Name | Quantity |
|---|---|---|
| 1 | NI USRP 2920 | 8 |
| 2 | NI USRP 2921 | 10 |
| 3 | NI USRP 2954 | 2 |
| 4 | Libelium Make Waspmote | 1 |
| 5 | NVIDIA JETSON TK1 development kit | 1 |
| 6 | NVIDIA JETSON TX2 SOM | 1 |
| 7 | Spartan 6 | 1 |
| 8 | EIC-Q20-210 (e-infochips) Developmen | 1 |
| 9 | ZED Stereo Camera | 1 |
| 10 | Intel Real Sense Depth Camera | 2 |
| 11 | Geophone Sensor | 2 |
| 12 | Mems Microphone | 10 |
| 13 | Condnesor Microphone | 5 |
| 14 | Logitech C170 HD Webcamera | 4 |
| 15 | Logitech Z120 Speaker | 1 |
| 16 | Logitech H1 Wired Headphone | 3 |
| 17 | EEG Spake Electrode Kit | 1 |
| 18 | Texas LaunchXL CC2650 Board | 6 |
| 19 | STM Discovery Board | 6 |
| 20 | 4G GSM Module | 2 |
| 21 | 2G GSM Module | 2 |
| 22 | Digital Multimeter | 2 |
| 23 | Beagal Board | 3 |
| 24 | Power Bank | 2 |
| 25 | Wi-Pi Module | 4 |
| 26 | Raspberry Pi | 50 |
| 27 | Raspberry Pi Camera | 12 |
| 28 | Raspberry Pi Sense Hat | 5 |
| 29 | VGA to HDMI Cable for Raspberry Pi | 35 |
| 30 | HDMI to HDMI Cable for Raspberry Pi | 35 |
| 31 | Power Adapter for Raspberry pi | 50 |
| 32 | Ethernet Cable for raspberry Pi | 35 |
| 33 | Arduino UNO | 32 |
| 34 | USB A to B for Arduino | 32 |
| 35 | Node MCU 8266 Module | 35 |
| 36 | ESP32 Module | 10 |
| 37 | Micro USB for Node MCU | 30 |
| 38 | FTDI Module | 4 |
| 39 | ZIG UsBee with breakout Board | 15 |
| 40 | 8 bit Voltage Shifter | 10 |
| 41 | 16*2 LCD | 5 |
| 42 | 4 Digit 7 Segment Display | 10 |
| 43 | LORA Module | 4 |
| 44 | Soil Sensor | 4 |
| 45 | Solenoid Valve | 1 |
| 46 | Microcontroller Programmer | 1 |
| 47 | Temperature Node Sensor DS18B20 | 10 |
| 48 | Humidity Sensor | 10 |
| 49 | GAS Sensor | 4 |
| 50 | Ultrasonic Sensor HC-SR04 | 20 |
| 51 | Thermistor Sensor D2018 | 10 |
| 52 | Motion Sensor | 10 |
| 53 | Breadboard | 15 |
| 54 | LM 35 Temperature Sensor | 20 |
| 55 | Push Buttons | 20 |

Video data from camera -> compression/source encoding -> channel encoding -> modulation -> transmission (reverse at the receiver side)

**Components needed as of now -** USRP (for transmission) (available in communication lab)

**Software -** LabView / GNU Radio (for signal processing before transmission) (available in communication lab)

**Antennas** - omnidirectional at rover and directional at the base station (available in lab)

https://academic.csuohio.edu/yuc/mobile/mcproj/z_Shashanka_Asha.pdf

Video compression technique, source coding, and channel coding techniques, channel utilization - needs to be decided

Range and gain of the antenna, etc specs can be tried and tested at the campus

**Transreceiver (receiver - superheterodyne):**

https://www.bhphotovideo.com/c/product/504839-REG/RF_Video_PX_916_PX_916_2_Channel_900_MHz.html/overview

https://www.microhardcorp.com/brochures/pDDL2450.Brochure.Rev.1.4.1.pdf

https://www.electronicscomp.com/ts835-fpv-5.8g-600mw-48ch-2-6s-wireless-av-transmitter?gclid=Cj0KCQiA_c-OBhDFARIsAIFg3eytVFXLLTaWn93T56wLNSrj44G9uqcasuty9g3L4TO1ELfpzKKqV1AaAiVCEALw_wcB

1. Camera -(video)-> jetson nano -(processed video data)-> transmitter
2. Licensing
3. Source coding and error coding
4. Video compression

**Future Plans -**

1. How does the RF module interact with the processor
2. Modulation in software or hardware
3. 5 cameras - how to send the data
4. Rpi of a robotic arm - connected to jetson nano
5. Rpi - drive system - connected to jetson nano
6. Rpi - life science - “
7. UART

We will configure the USRP with some of the tutorials given below

https://www.ni.com/pdf/manuals/376326a.pdf

https://www.researchgate.net/figure/Right-Functional-block-diagram-of-a-USRP-2920-radio-showing-a-complete-RF-chain-and_fig4_276852772

**Questions we are trying to answer for our system:**

Q1. how will we encode data into binary form?

Q2. video data compression

Q3. creating packets for data stream (this is after modulation or before??)

Q4. data rate?? modulation scheme??

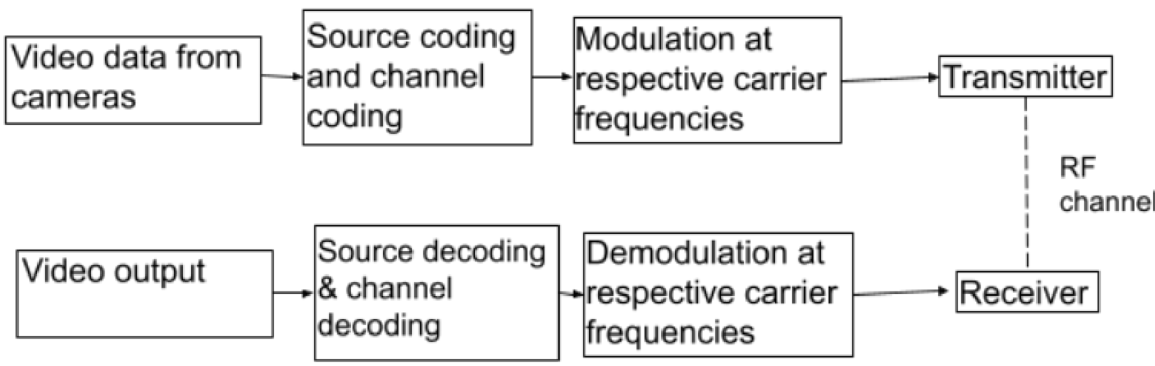
Q5. how to parallelly transmit all the 5 camera data => modulating at diff. Freq. and demodulating at respective freq.

Q6. uart between microcontroller and usrp??

Q7. how to configure usrp acc to our requirement

Q8. can we compress data in LabVIEW? Or Matlab file will be sufficient? How will we integrate things?

Q9. how will usrp transmit? Using wifi, ethernet, or something? It should be generating carrier signals itself!




## Workflow:

The cameras will be connected to the microcontroller where the processing will take place as mentioned in the block diagram. The encoded data will be modulated at the selected frequencies and the modulated data will be transmitted by the NI USRP over the RF channel. The receiver will demodulate the received data by bandpass filtering the signal and will further decode the data the output video will be displayed at the base station. There will be one Omni-directional antenna mounted on the rover and one-directional antenna at the base station. The number of antennas can vary according to the consumption of the allowed band. For example, the control signal and other data can be communicated using different bands and so, using separate antennas. The USRP will be configured using LabView according to the requirements. The gain of the antennas will be decided according to the range of the communication. The microcontroller will communicate with the USRP through UART protocol.

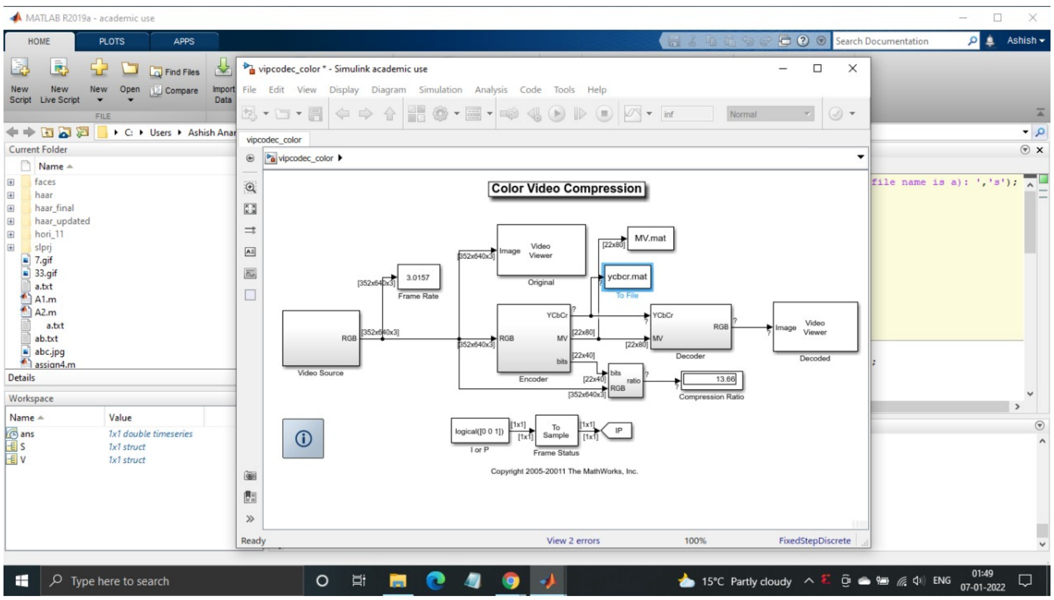
The source coding and channel coding techniques are yet to be determined. The testing of this system will be done on campus and the challenge of nonline of sight communication will be tackled at the same time.

USRP is chosen for transmission because of its longer frequency range (a few MHz to 2 or 5 GHz depending upon the model) and we can easily configure it according to our requirements.

## Video Compression Model:

We are using motion compensation and discrete cosine transform (DCT) techniques for video compression. Firstly motion vectors between successive frames are calculated and then they are used to reduce redundant information. Then each frame is divided into submatrices and the discrete cosine transform is applied to each submatrix. Finally, a quantization technique is used to achieve further compression. The Decoder subsystem performs the inverse process to recover the original video.

**Simulink model of video compression algorithm:**



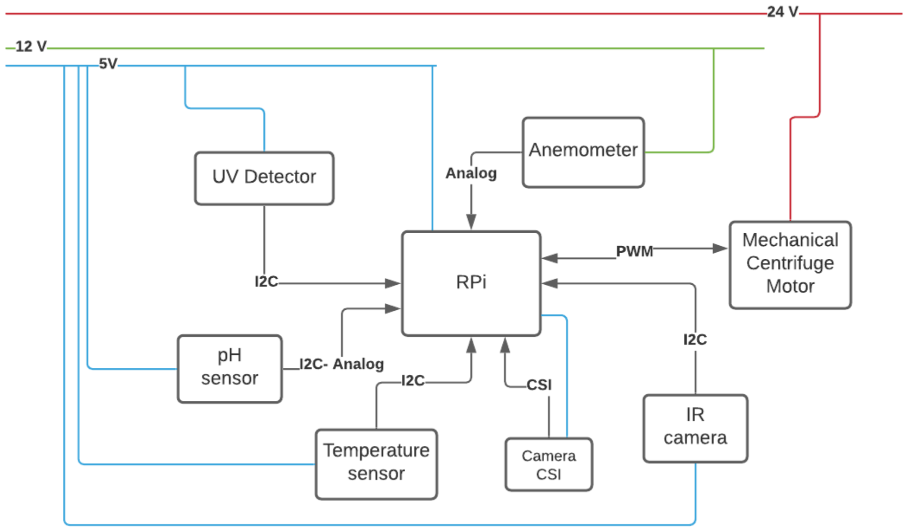

# Life Sciences

We worked in close coordination with Life Sciences Team to finalize the electrical components they are using.

We finalized the following components:

| | | |
|---|---|---|
| Anemometer | Rs 4,799 | Measures wind speed |
| UV detector | Rs 549 | Used to measure the speed of the wind |
| PH sensor | Rs 1999 | Detects Ph |
| Temperature Sensor | Rs 839 | Used to measure temperature from a distance |
| IR Camera | Rs 4956 | Used for thermal imaging |

We have finalized the preliminary design of our Life Science module.




The power supplies are indicated by colored wires. Each communication wire is labeled with its supported protocols. We can create our own I2C bus by making two GPIO pins as SDA and SCL. Thus multiple sensors can be handled in this way.

## Conclusion:

We have made a significant leap in power distribution module and communication. We are facing some difficulties in Drive Systems and actuation of robotic arm. We are trying to reduce the redundancies and contacting faculties in the domains we are struggling with. The major problem that the team faces is lack of instruments with team members and unavailability of members on campus.