Computer Engineering/Engineering Design Project 2

EEE dept., Imperial College London

I. Aim

The aim of this project is to design and build an autonomous rover system that could be used in a remote location without direct supervision. The rover will have a processing unit that is capable to receive movement commands and send status data. In doing this it needs to detect and avoid obstacles in its working area. Over time the rover should be able to build a map of its local working area (including those obstacles) on an offsite data store. A charging station will be also designed and implemented to charge the batteries used to power up the rover. A 3D model of the Mars rover is shown in Figure 1.

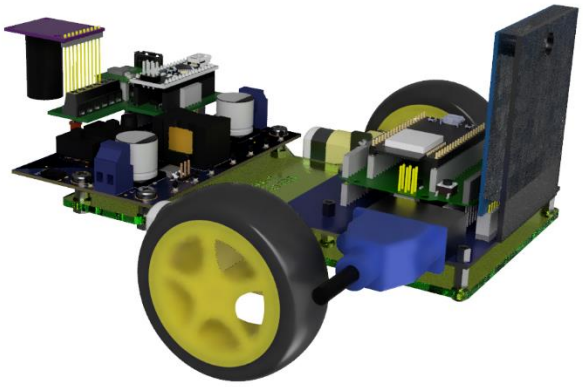

Figure 1 A 3D model of the Mars Rover.

II. The rover Subsystems

The rover is composed of six subsystems: energy, drive, vision, control, command, and integration. Figure 2 represents a block diagram and all the main components of each subsystem.

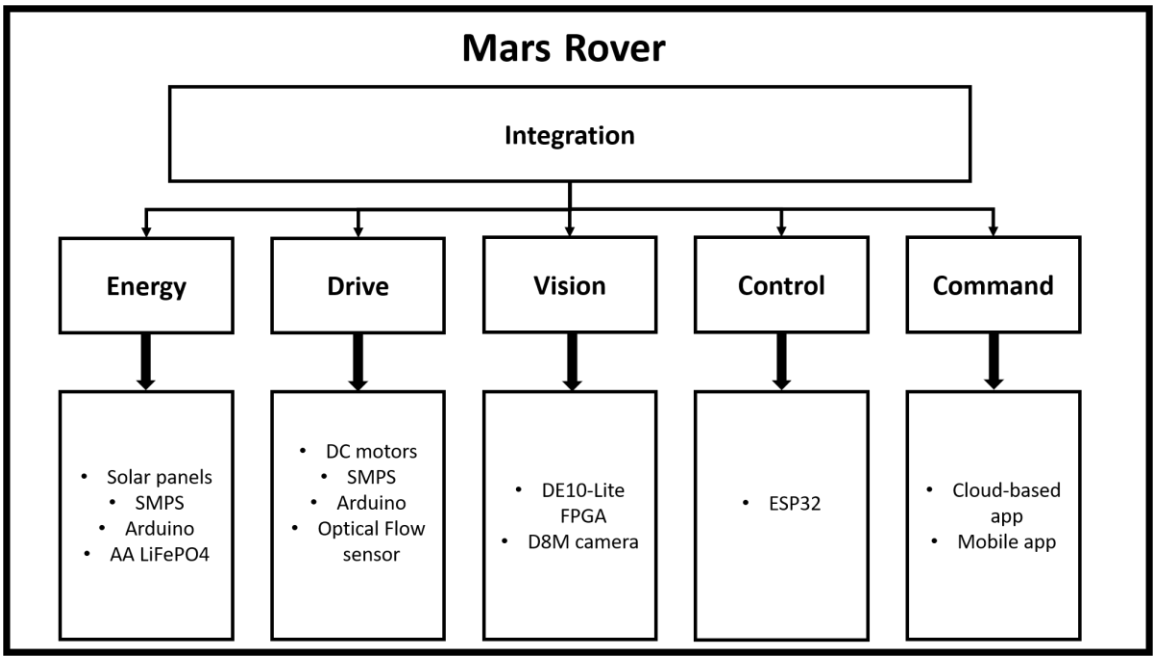

Figure 2 A block diagram of the Mars Rover project.

1) Energy Subsystem

The energy subsystem will provide the rover with charged batteries using solar panels.

The main tasks in this subsystem are:

- Charge batteries.
- Battery charge profile design.
- Battery charge status estimation.
- Battery balancing algorithm.
- PV MMPT algorithm.
- System Integration and Test.
- Rover range estimation
- Prevent explosion/melt.

2) Drive Subsystem

The drive subsystem allows the movement of the rover. It contains the rover frame, the motors and the optical flow sensor.

The main tasks in the drive subsystem are:

- Speed control.
- Direction control.
- Turning method.
- Distance measurement.

3) Vision Subsystem

The vision subsystem allows the rover to detect and avoid obstacles to achieve its target destination.

The main tasks of the vision subsystem are:

- Use on-board vision to identify obstructions and objects of interest.
    - Move the robot around the terrain according to instructions from the remote commander, including:
    - ✓ Avoiding obstructions
    - ✓ Closed loop monitoring of position.
    - ✓ Sending commands to the motor control.

4) Control Subsystem

In this subsystem ESP32 microcontroller will be used to communicate with all the subsystems via different communication protocols. The ESP32 will have a unique IP address and will be used as an access point.

The main tasks of the control subsystem are:

- Communicate in both directions with the motors.
- Communicate with the FPGA.
- Receive commands from the command subsystem.
- Send rover status to the command subsystem.
- Receive Energy status from the charging station.

5) Command Subsystem

This subsystem allows the remote control of the rover by connecting to the control subsystem, which is accessible via a web browser/mobile app.

The main task of this subsystem is:

- Create a web or mobile dashboard to control the rover remotely and receive information from the different subsystems.

6) Integration Subsystem

The integration task brings the whole rover together in one place and requires the connection and integration of all the other modules. The integration student will have access to a second set of other hardware kits to allow the design work to be replicated without shipping equipment between students to make a complete functional rover.

The main objectives are:

- Developing the central processor of the rover ensuring correct functionality of all the systems together
- Managing communications between the onboard rover systems and the cloud command processes
- Build, maintain and assist in debugging the other modules.
- Testing and proving of the full rover system with the aid of the other students remotely.

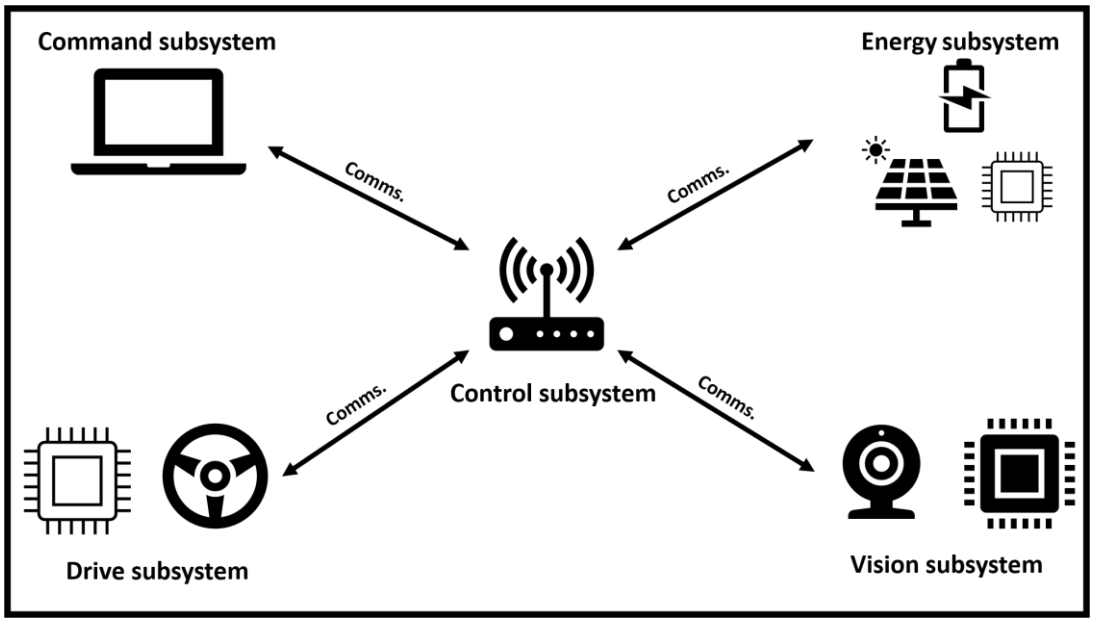

Figure 3 A schematic with all the rover subsystems showing the communication links.

In Figure 3, the different communication channels between the subsystems are shown. All these links need to be checked during the integration phase.

III. Groups organization

The Mars rover is a multidisciplinary project and requires skills from EEE and EIE students. Each student will be responsible of a subsystem. The maximum number of students in each group is 6. 3 EEE students and 3 EIE students will be in the same group as shown in Figure 4.

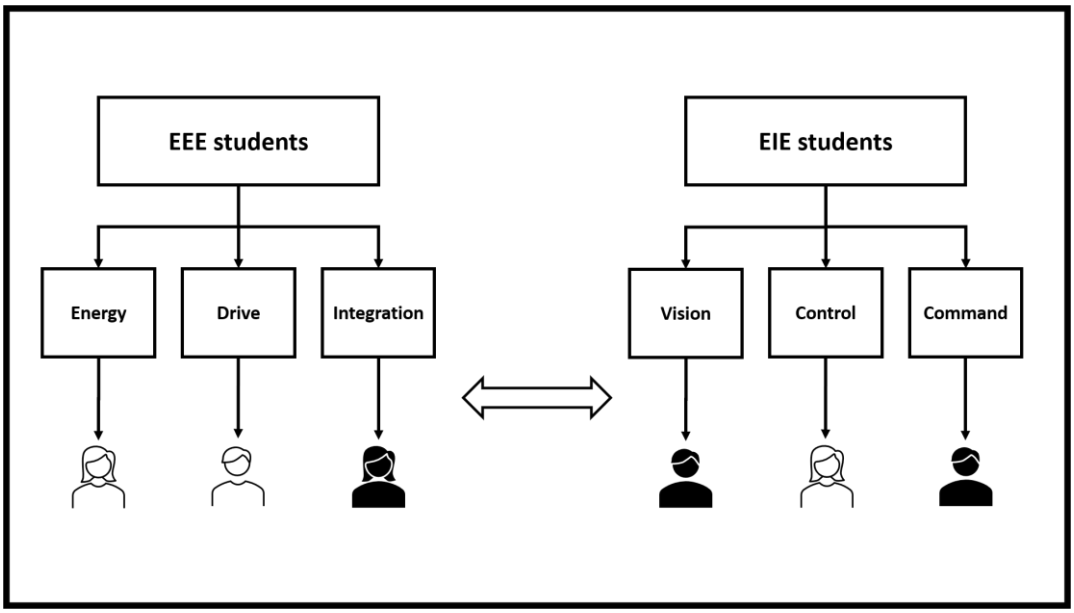

Figure 4 Group composition for EEE and EIE students and the correspondent subsystems.

Please fill in this form and choose your preferred subsystem by filling in this form. Different components need to be ordered by the subsystem's leaders. Before ordering the components for the selected subsystem make sure that you are in a group of 3 (EEE or EIE). To order the components please fill in this form.

IV. Timeline

The summer project will be from 11th of May 2021 to 25th of June 2021. Different sessions will be organized during the project to support you on how to design and manage your project. Technical support will be provided twice a week (Regular Office Hours every Tuesday and Thursday). The timeline for the summer project will be as follow

- **11/05**: Introductory session
- **12/05 to 26/05**: Engineering Design & Practice sessions.
- **14/06 to 25/06**: Assessment

V. Assessment

The assessment of the 2nd year project will have 3 components:

- A single report per group with all the technical details of the Mars Rover, the design process, and an assay about one of the lectures that will be held in the first 2 weeks of the project.
- A video demo of your operational rover.
- An oral exam.

VI. Contact person

For any enquiry, please contact Mr. Adam Bouchaala (a.bouchaala@imperial.ac.uk).