ELEC50008 - Engineering Design Project 2

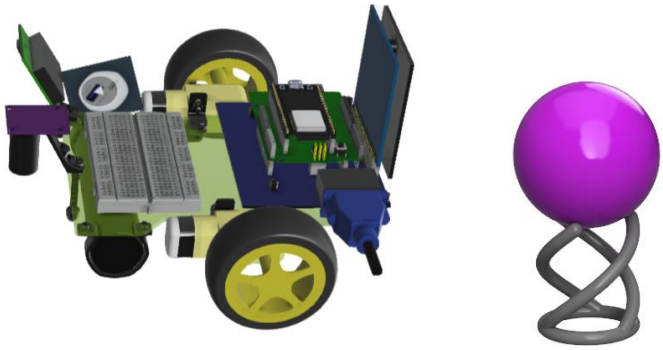
EEE dept., Imperial College London

Project description

23/05/2022

I. Objective

The aim of this project is to design and build an autonomous rover system (Figure 1 a) for exploring an alien colony (Figure 1 b) on Mars. The system must navigate a test arena, building a map showing the locations of aliens and their underground power infrastructure. It must do this without direct, real-time control from the user and without colliding with aliens or their structures. There must also be a system for powering the rover from solar energy.



(a) (b)

Figure 1 a) A3D model of the assembled rover starter kit and b) An example of an alien

II. Starter kit contents

Each group has a kit to get you started with the project. It contains:

Table 1 List of components in the Mars Rover kit.

Item	Quantity
Optical flow sensor with bracket, wires, and LED	2
H-Bridge motor driver module	2
Breadboard	2

Motors and wheels	4
EEE2 Rover Chassis and fasteners	2
Terasic D8M-GPIO camera module	2
ESP32 module with Arduino adapter and USB cable	2
VGA to USB converter	2
Aliens	4
Battery and mounting brackets	2
USB A to B 0.3m for battery to FPGA	1
HB100 Doppler radar module with bracket	1
Spinning Radar Reflector Assembly	1
Obstacle sample card	1
Terrain sample card	1
Solar Panels, sticky pads and stand	4
SMPS Adapter Board	1
2 Channel Relay Board	1
Power Lab (SMPS) Kit	2
USB Breakout Board	2
SD Card Reader, Card, and adapter	1
Tool Kit	1
Cutter/Strippers	2
Clamp Multimeter	2

III. The rover Subsystems

The rover is composed of seven subsystems: energy, drive, vision, control, command, radar, and integration. A block diagram where all the main components of each subsystem are listed is shown in Figure 2.

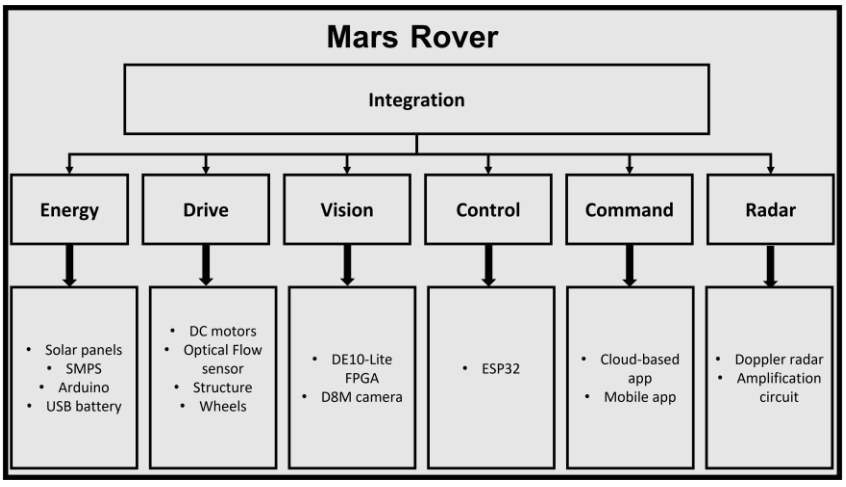


Figure 2 A block diagram of the Mars Rover project.

1) Energy Subsystem

The energy subsystem will provide the rover with charged power bank batteries using solar panels. There will be solar panels, an SMPS kit with an adapter board, and 2 channel relay board. Status of the battery when it is charging and when the rover is operational should be displayed. Rover range and capability estimation could also be tracked. A starter project will be provided with some instructions on how to use the kit.

2) Drive Subsystem

This module aims to control the movement of the Mars Rover and measure the distance travelled in x and y directions. This information can be transmitted to other modules to estimate the exact location of the Rover and to control its movement to achieve various objectives. This module consists of two main parts: 1) a motor drive PCB and 2) an optical sensor PCB. Sample codes to use the motor controller and the optical flow sensor will also be provided.

3) FPGA and camera

The rover kit includes a Terasic D8M-GPIO camera to use with the DE10-lite FPGA board for mapping the environment. The aliens and their buildings have distinct visual characteristics that you can identify and locate in the field of view. A starter project is provided that sets up a video processing pipeline in Verilog with a live video output with an overlay for debugging. The system includes a NIOS II soft processor that can interface between your custom video processing logic and the ESP32 microcontroller for data uplink.

4) Control Subsystem

A powerful 32-bit microcontroller from Espressif is used to control the Mars Rover. The microcontroller should communicate with the FPGA, the motor drivers, and doppler sensors. The ESP32 has Wi-Fi and BLE capabilities that allow the rover to communicate with other devices to send the rover status and receive commands. The ESP32 is placed on a shield to allow direct connection with the DE10-lite FPGA. A list of instructions is provided to install the required tools and connect the microcontroller to a database.

5) Command Subsystem

The role of the command subsystem is to connect the Mars rover with a webserver to display its status and to control the rover remotely, if required, during the exploration phase. A web application is required to be developed to connect with the Mars rover. A local or cloud-based application could be selected for this project. Technical support will be provided to students to develop a web app using the NodeJS and ReactJS frameworks.

6) Radar Subsystem

The students will receive a small radar module that they can use to locate underground alien infrastructure. Our intelligence sources reveal that aliens use subsurface fans to pump air

underground. Your radar can detect moving objects, and you should use it to locate the blades of a rotating fan. The radar system description is provided. Students need to develop the post-processing (amplification and filtering) for the radar sensor.

7) Integration Subsystem

The integration subsystem allows the test of the rover's capabilities to move, avoid obstacles, and communicate with the command subsystem. Students should design their project in order to be able to run test routines, test the rover capabilities to reach a specific target and detect any operational issues. A systems engineering approach using block diagrams will be utilised.

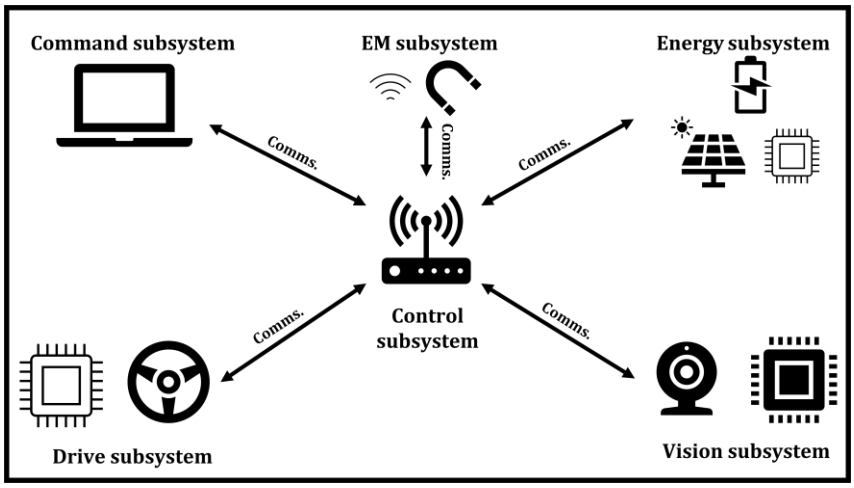


Figure 3 A schematic with all the rover subsystems showing the communication links.

In Figure 3, the different communication channels between the subsystems are shown. All these links need to be checked in the rover test subsystem.

IV. Group organisation

The Mars rover is a multidisciplinary and open-ended project that requires skills from EEE and EIE streams. Each group will be responsible for allocating tasks to all the members, independently of their stream. The maximum number of students in each group is 7, with a minimum of 2 EEE students and 2 EIE students.

V. Timeline

The summer project will run from 23rd of May 2022 to 25th of June 2022. Different sessions will be organized during the project to support you on how to design and manage your

project. Technical support will be also provided using a booking system (link). This year 1st year and 2nd year will be working in the L1 lab. To be able to use a bench you have to book from here.

The timeline for the summer project will be as follow

- **23/05**: Introductory session
- **23/05**: Technical support starts (booking system).
- **22/06**: Report submission deadline
- **28/06**: Demo Day

VI. Assessment

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

- A single report per group (15 pages) detailing the technical outcomes and the design process. (50%)
- A live demo of the Mars Rover. (25%)
- An interview during the demo day. (25%)

VII. Contact

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