CprE 288 Final Project Description

2017 Fall Lab Project

This document describes the requirements of the lab project.

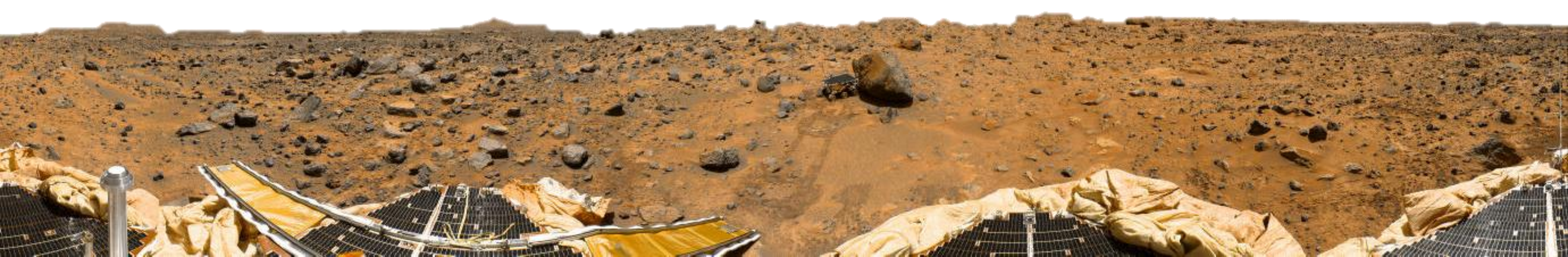
View the **"Supplemental Specifications"** document for details of the demo procedure and grading rubric. This project is worth **15% of your grade**, so start early!

Demos:

- Teams are required to demo their project during **Dead Week** in their lab session .
- You are encouraged to demo before Dead week. If you demo before dead week, then
  - **5 extra credit points** will be given for demos before Dead week. Note, you will not be given these 5 points if you also demo during Dead Week.
  - Your Demo time limit is extended to up to 30 minutes (as opposed to the 20 minute time limit). However, TAs have full discretion to stop your demo at any time.

Parts of the Project:

- Part I – Basic communication and control
- Part II – Navigating the robot to the retrieval zone
- Part III – Positioning the robot in the retrieval zone
- Part IV – Code and Documentation



Story

Briefing: VORTEX, the code name for your development platform, includes the iRobot Create, the Cerebot II board, and attachments such as the servo, SONAR, IR sensor, and LCD.

Your team has been asked to develop an interplanetary rover using the VORTEX platform. Both NASA and the European Space Agency have heard about your work with this platform and have assigned your team the job of designing the rover. Delegating this task will allow these agencies to focus on developing a launch vehicle. The primary task of the rover is retrieval; other international teams are busy working on a package that will collect rock samples and perform analysis. The VORTEX platform will be landing in Martian terrain that is unknown to you. The only knowledge of the terrain you will have is that which the VORTEX transmits to you.

At this early phase of the project, the **only objective** for you to complete is for the VORTEX platform to traverse the hazardous terrain for retrieval at a predetermined rendezvous site.

The terrain is hazardous, so the VORTEX must be capable of navigating the hazards of the terrain. The retrieval zone will be marked, so you will be able to recognize it from the information the VORTEX sends you. After the VORTEX enters the retrieval zone, it should send signals to mission control indicating the rover is ready for retrieval.

Project Description

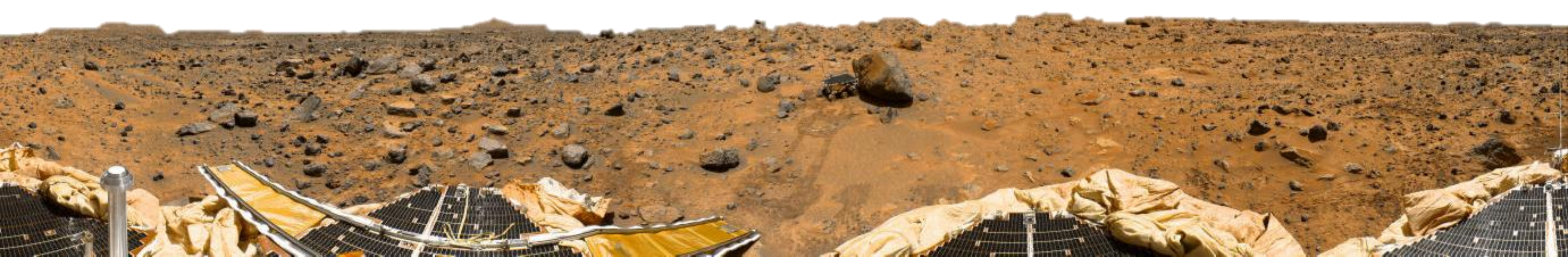
The VORTEX platform will be **placed at a random position** in the test field. The rover should traverse through several **hazards** to position itself within the **retrieval zone**. This project is composed of **three sub goals** defined in the following sections.

Because of differences in the atmosphere where the VORTEX will be used, there are areas where solar radiation could damage the VORTEX. In the test course these areas are marked off by **white tape**. Your rover should not to cross white tape. For the purpose of this test you can assume that the test course will be completely surrounded by white tape. The iRobot Create platform has a sensor that can sense when it crosses into the irradiated areas (see the oi_t struct related to the cliff sensor). Your team will lose points for each complete crossing. If the VORTEX platform completely leaves the test course, it will be physically placed back into the field perpendicular it where it went out.

Mission control needs to be able to process the information that the VORTEX platform sends to it. You should format the information appropriately so that it can be understood by the operator. It is up to you to decide what information the VORTEX platform will send you. Whatever information you choose to send it should be enough to navigate the test course. All information should be transmitted to the Mission Control via Bluetooth.

The Mission Control also needs to be capable of controlling the robot remotely. The amount of control that you give to the Mission Control is up to you. At minimum, the Mission Control should be able to:

- Send a signal to initiate the VORTEX at the start of the test.
- Send a signal to put the VORTEX in standby when it has reached the retrieval zone.



- Send a signal to identify that the retrieval zone has been found and ready the robot for positioning in the zone.
- Control the basic movement of the robot.
- Control the sensors of the robot.

Any command sent from the Mission Control will be considered a high priority command. This means that it will be fully executed before the VORTEX continues any of its normal routines.
However, you should assume that some sensors take higher priority. The priority of commands will be detailed later.

Beyond Mission Control being able to control the VORTEX, you may also want to consider giving the vortex some decision making capability. All commands will be sent to the VORTEX via Bluetooth.

It is strongly recommended that each team look carefully at the evaluation form and the supplementary specifications as they strategize and plan. Once the maximum point reduction has been reached for a penalty category, no further point reduction will occur for that penalty category.

Goal

To receive any points on the project, your team must submit your source code on BlackBoard Learn. Coding quality (absence of warnings, good indentation, proper comments) is also worth points.

To receive all points on your demo, you must remotely control your robot into the retrieval zone within a **set amount of time, without bumping into tall objects, without falling into holes in the floor, without leaving the course bounded by white tape, and without having to visually confirm where your robot is on the obstacle course.**

Team Policy and Project Progress

Teams of 4 to 5 students should be formed or will be assigned by Lab TA. Once formed, these teams will remain intact and work together until the end of the semester. The team's roster should be recorded during the first lab session of the project. Teams spread across multiple lab sections must work out a plan to complete the project on time.

All Students must attend the lab as usual until their project is demoed and submitted. Missing a lab without permission can result in a zero grade on the lab project and other actions as per course policy. The team should record the initial division of responsibilities and weekly progress in the attached **“project schedule”** document. This is **Mandatory** and weekly progress must be turned in to the lab TA at the end of the project.

Part I. Communication with the VORTEX

Since the key task of this project is information collection, you will be required to implement some form of user interface (UI) that can be used to retrieve information from the VORTEX and also to control the VORTEX.

One example of a simple UI would be a terminal interface where mission control would send single characters as commands to the robot. Such a terminal interface would be a text only interface. The design of the user interface is up to you, however, it must provide for the following functionality:

Your interface should be able to show the current state of the following sensors:

- iRobot Bump Sensor (left, right)
- iRobot Cliff Sensors (left, front left, front right, right)
- iRobot Cliff Sensor Signals (left, front left, front right, right)

List of functions which you will need to be able to control remotely:

- Moving the robot
- Taking a sweep of distance measurements (should transmit to the user interface either raw data, or information about the objects detected).

Command Priority

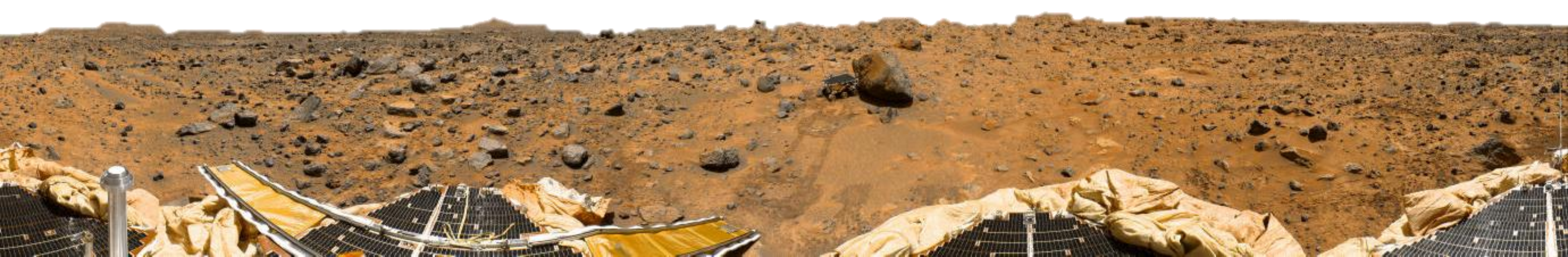
Along with being able to control the VORTEX, you need to be able to insure that a command you send to the VORTEX will not potentially damage the VORTEX (i.e. you should not be able to command the robot to drive forward off a cliff). For this reason, you should check the priority of any command before executing it. A list of command priorities has been supplied for you.

- (Highest Priority) Emergency Stop initiated by the sensors (bump, cliff sensors, or virtual wall)
- Mission Control commands.
- (Lowest Priority) Local VORTEX control (i.e. any automation you've programmed).

Completion Requirements

This part will be considered successfully completed when:

- The user interface for controlling the rover is implemented in a human readable form.
- The user interface contains the minimum required functionality.
- Commands to the VORTEX follow the proper priority.



Part II. Traversing Treacherous Terrain for Retrieval

Within the testing environment, there are hazards that will make traversing the environment challenging. There are boulders (i.e. weighted containers), craters (i.e. removed floor tiles), and stalagmites (i.e. pieces of PVC pipe). All hazards should be visible to at least one of the rover's sensors.

Some of the hazards are more dangerous to the rover then others. For example, falling in a crater could potentially cripple the rover, so points will be removed from the score of this project part if the rover falls in.

In the event the rover does fall into a crater it will be placed at the point it fell in facing perpendicular to the crater. The iRobot portion of the VORTEX has cliff sensors, which should be checked frequently.

Bumping into a boulder is acceptable in most cases and will not result in a loss of points. However, excessively bumping into a boulder are running into a stalagmite could become dangerous as bumping into the stalagmite may cause it to fall onto the rover.

The Rover needs to respond quickly to the bump and cliff sensors. Because of this, the VORTEX cannot wait for a response from the Mission Control on how to respond. Therefore, your program should have some preprogrammed response to the bump sensor. Not responding to a bump sensor being pressed will result in loss of points. The lack of response will be indicated by the VORTEX continuing to drive forward while still in contact with the object. Some latency is acceptable, but after about a second the energy loss resulting from this error could be detrimental to the mission, so points will be taken off from this project part for each incident.

WARNING: The response of the VORTEX to the sensors should be complete. For example, if the robot bumps into a boulder, it should not back up into a crater.

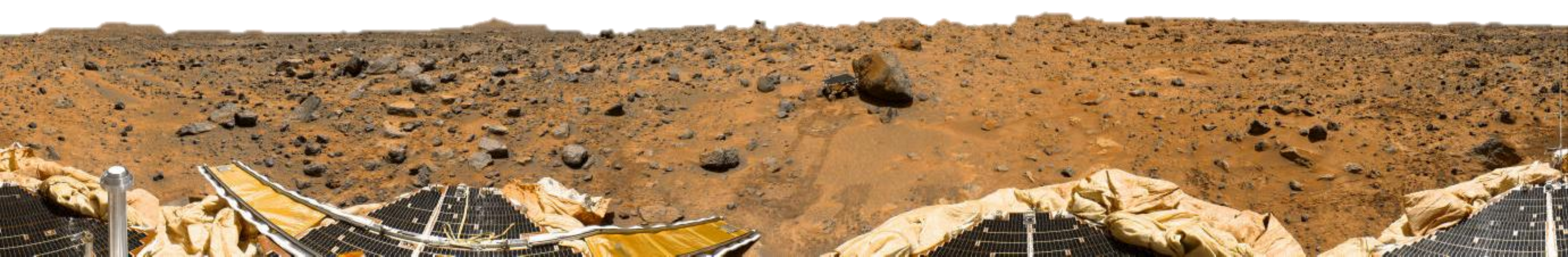
Sufficient clearance will be provided to ensure the VORTEX can traverse around obstacles.
Successful completion of this project part is determined by traversing the hazardous environment and identifying the retrieval zone. The retrieval zone is a clear area marked off by four pillars.

Each of these pillars has distinct features that the VORTEX should be able to recognize using its sensors.

Completion Requirements

This part will be considered successfully completed when:

- Using the features from Part I, you are able to move the robot into the retrieval zone or within an adjacent tile of the retrieval zone. You will incur penalties for this section by: falling into a crater, mowing down stalagmites, excessively bumping into boulders, or robot leaving the testing area.



Part III. Positioning the Rover for Retrieval

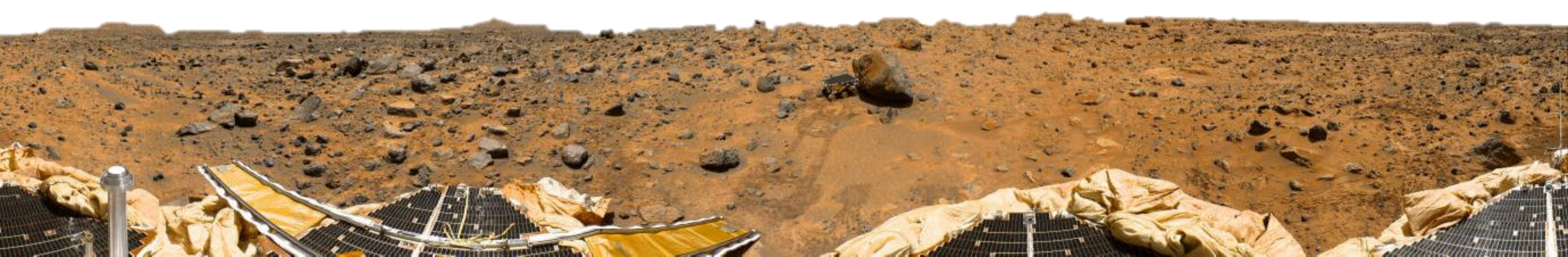
Once the retrieval zone has been identified, the people at Mission Control should be able to position the robot within the retrieval zone. The rover should be fully located within the retrieval zone. Failure to properly position the VORTEX could result in damage during retrieval. Points will be removed in the VORTEX is not properly positioned in the retrieval zone. The VORTEX should then signal the orbiter for retrieval.

Touching the pillars identifying the retrieval zone could be dangerous since the retrieval craft uses them to determine the position of the rover in the zone. The pillars are durable and heavy enough to be withstand minor contact, but if any are moved significantly during the process of positioning the rover in the zone, retrieval could fail. Penalties will be assessed in the event that any pillar is significantly moved. For point reduction specifics will be given in a Penalty Table in a following document.

Completion Requirements

This part will be considered successfully completed when:

- The robot is within retrieval zone and flashes its power LED light (four 3” PVC pipes will be placed in a square to indicate the retrieval zone. Partial credit may be awarded if the robot is partially in the retrieval zone.



Part IV. Code and Documentation

Once you have successfully demoed your project, NASA is expecting you to upload the source code and documentation for your project so that it can be compiled and loaded onto the real VORTEX rover. Any team that does not deliver their source code to NASA will not get paid, and receive zero points on the entire project.

Like any good government project, project documentation is required. Due to the Paperwork Reduction Act (44 U.S.C. 3501 et seq.) and your undergraduate status, NASA has relented and has only made one documentation requirement mandatory. You must use Doxygen to generate an on-line documentation browser of your source code.

Doxygen is a simple tool to use, and includes a wizard to aid you in generating documentation from your source code. If you comment all of your functions well, then this part of the project should be relatively straightforward.

Example of a well commented function:

```
/// Rotates the servo to a given angle.
/**
 * Adjusts the value of OCR3B so the servo faces the desired direction between 0 and 180 degrees.
 * @param degrees a double between 0.0 and 180.0 indicating the desired position of the servo
 */
void servo_rotate(double degrees) {
        …
}
```

Notice how a short description is given with a triple forward slash (///), and a long description is given in a comment block containing an extra * (/**). Relevant parameters are described using the @param key.

Other examples: http://www.stack.nl/~dimitri/doxygen/docblocks.html

Completion Requirements

This part will be considered successfully completed when:

- You submit a .zip file containing your project's code and documentation on BB Learn. Documentation should include the .html files generated using Doxygen.
- Your source code is properly formatted and compiles without warnings or errors
- Your source code is properly documented
- You successfully used Doxygen to generate your documentation