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1st Annual NASA Jet Propulsion Laboratory Team Space Design Competition at UIUC

Autonomous Algorithm for Determining a Safe Landing Site on a Planetary Surface

Competition Introduction

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Entry, descent, and landing is a critical part of a mission. Among the many challenges during this phase, choosing a safe landing site is a difficult one. The landing site can be selected ahead of time based on available data, but ideally the final landing site would be chosen by an autonomous algorithm by analyzing real-time data.

CHALLENGE: Develop an autonomous algorithm to identify safe and hazardous regions on given data sets. Results will be judged by JPL engineers who are experts in entry, descent, and landing.

1st place: \$2,500
2nd place: \$1,500
3rd place: \$1,000

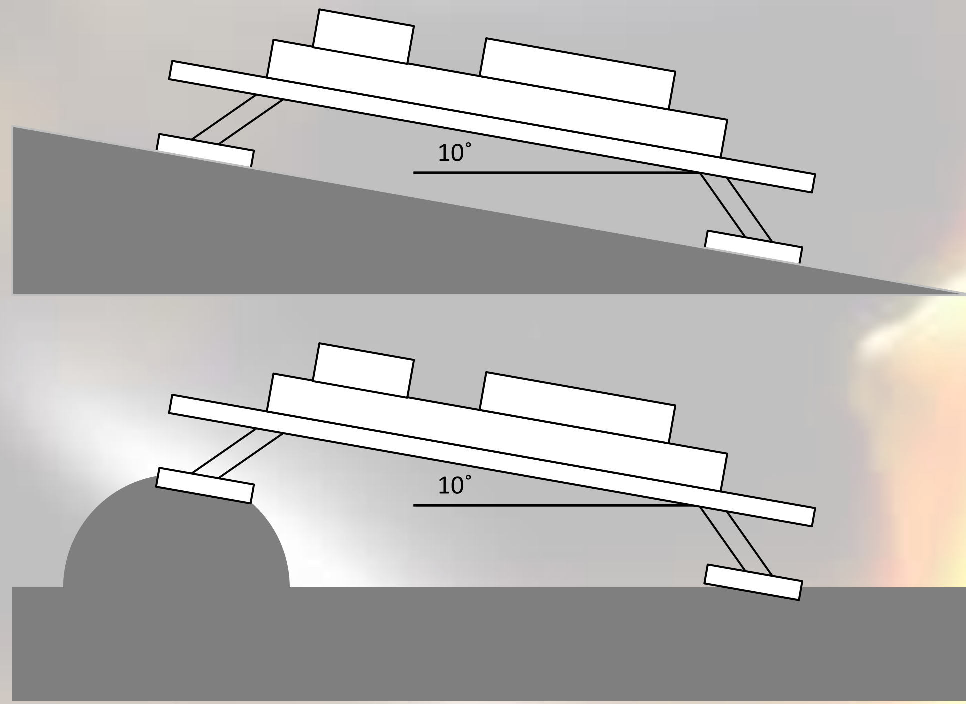
What is a Safe Landing Site?

A safe landing site is one that is free from hazards. There are many objects or circumstances that could be considered hazardous. If the rover lands at too much of an angle, it could slide, tip, or roll. If it lands on top of a large rock, that rock could pierce the underside of the vehicle.

For this competition, the definitions of hazards are given on the following pages.

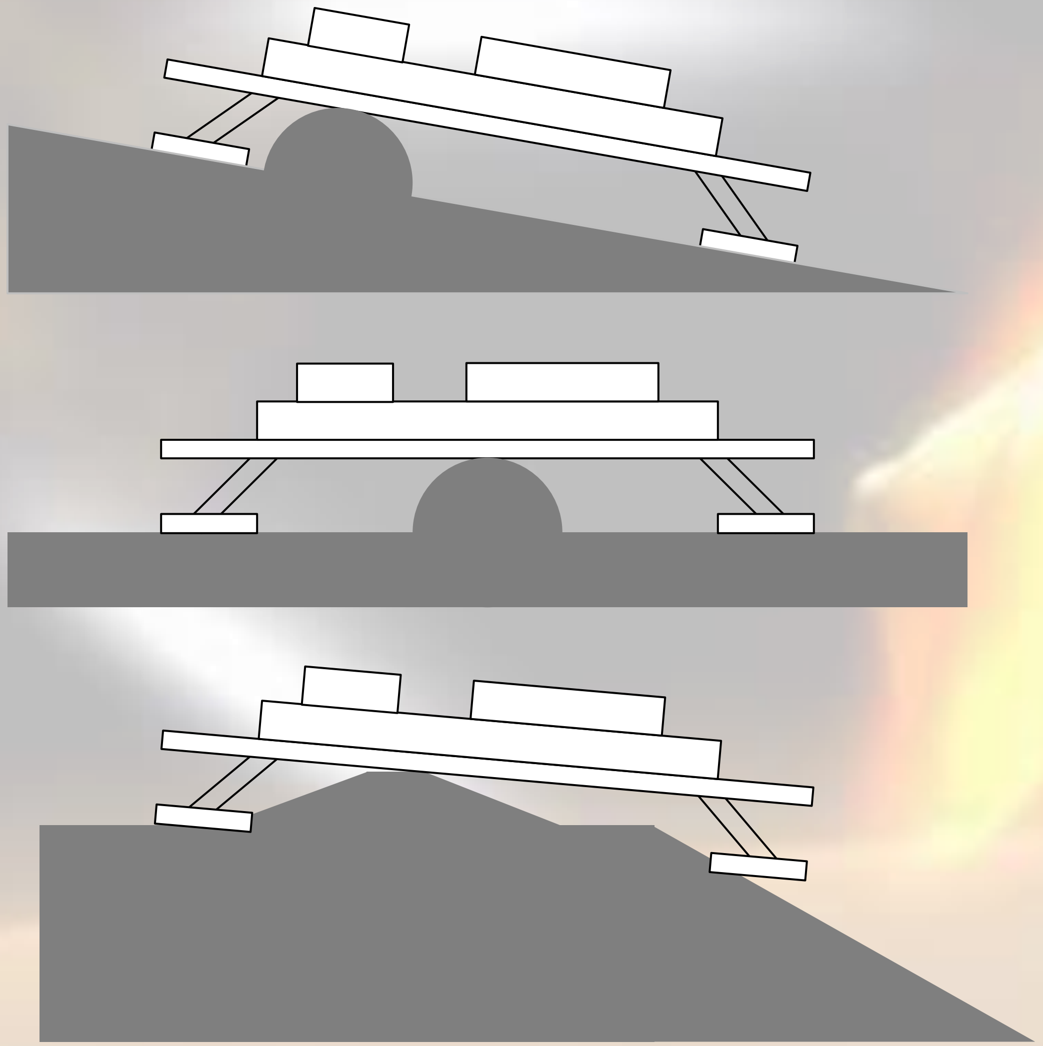
Slope Hazards

- Anything that makes the lander belly slope greater than 10˚ is a slope hazard.



Roughness Hazards

- Anything that touches the lander belly is a roughness hazard.



Lander Model

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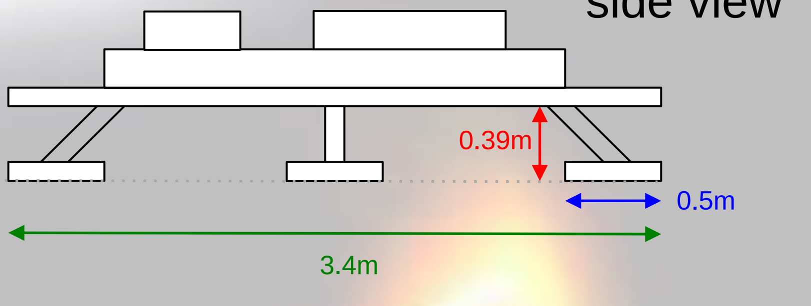
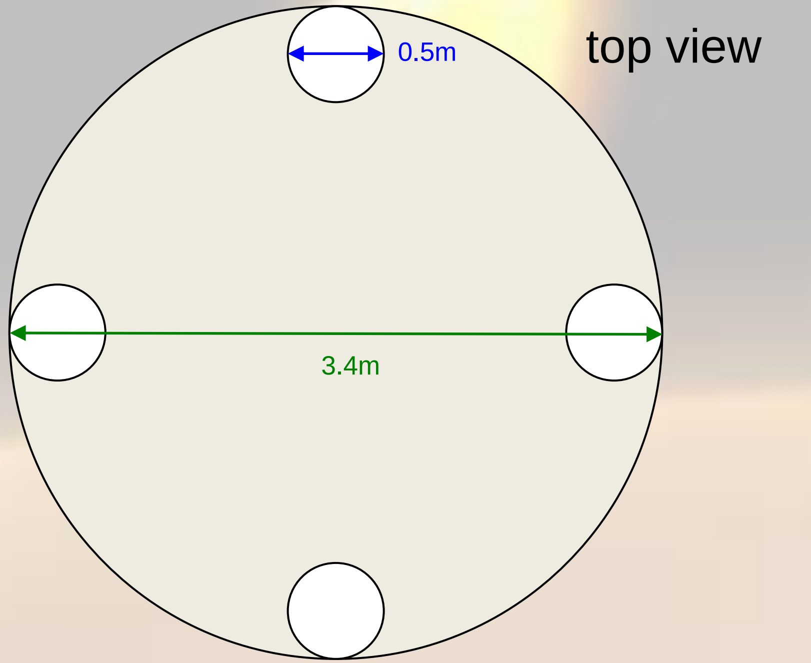
- Lander is 3.4m in diameter
- Lander foot pads are 0.5m in diameter
- The lander belly is 0.39m from the bottom of the foot pads





Provided Data

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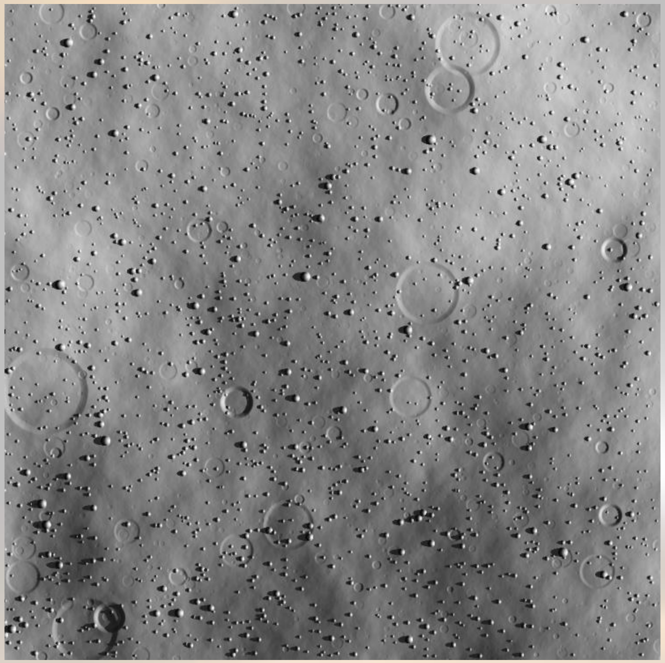
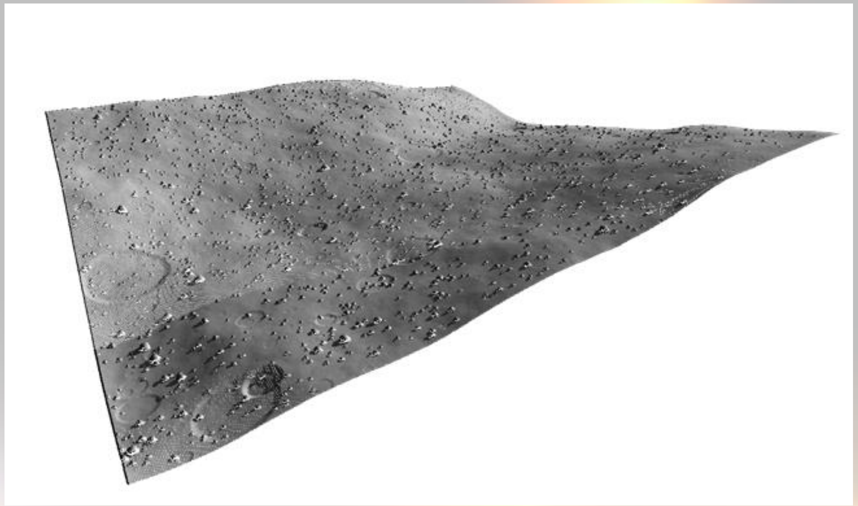
Each set of data is comprised of two parts – the most successful algorithms will probably use both sets of data.

1000 x 1000 2-D image of terrain



1 pixel = 0.1 meter

500 x 500 3-D model of the same region

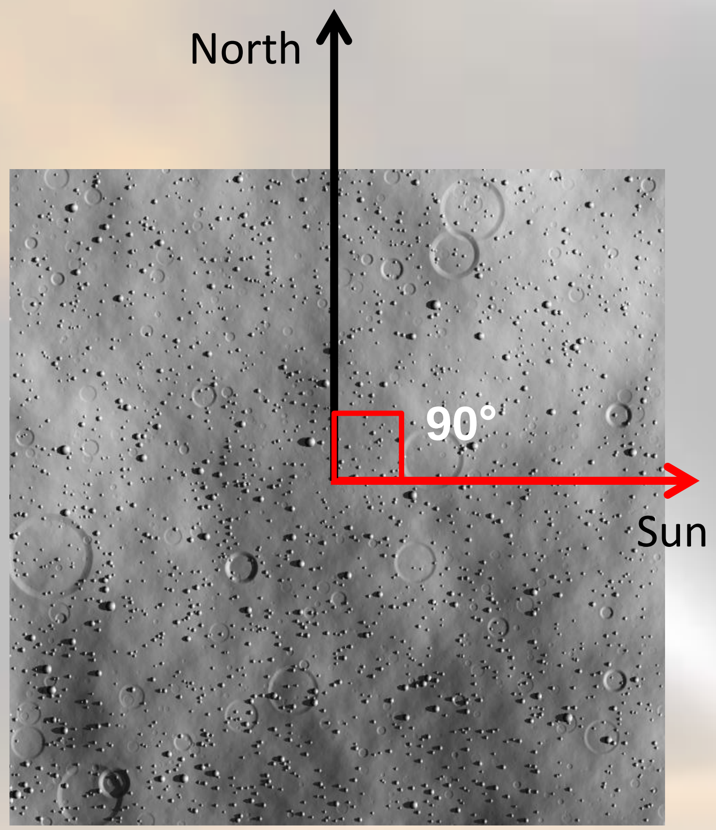


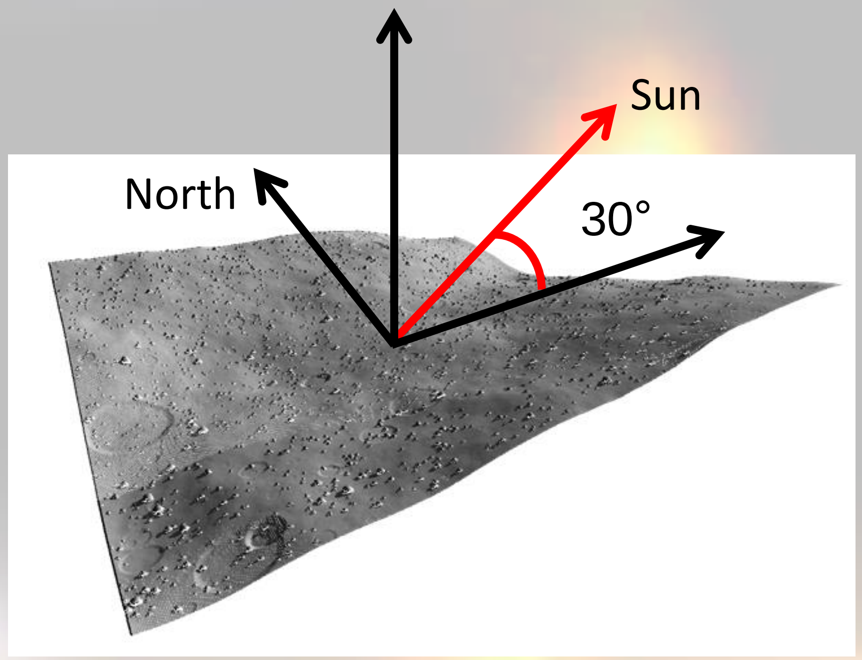
1 pixel = 0.2 meter

(constructed from the 1000 x 1000 model that produced the 2-D image)

Sun Position

- Sun elevation = 30°
- Sun azimuth angle = 90° (from north – “up” in given images)





Provided Data

There are four sets of training data available, in increasing levels of difficulty.

- Data Set 1: ONLY ROUGHNESS (No slopes and no craters)
- Data Set 2: SLOPE and ROUGHNESS (No craters)
- Data Set 3: SLOPE, ROUGHNESS, and CRATERS
- Data Set 4: INCREASED ROUGHNESS (More rocks)

On the day of the competition, the judges will provide four new sets of data to test your algorithm in real time. <u>All sets</u> will be considered in the judging process and contribute to the final score.

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Competition Details

Competition Rules and Prizes

Teams:

- Teams of 3-10 undergraduate or graduate students

Prizes:

- 1st place: $2,500
- 2nd place: $1,500
- 3rd place: $1,000

Deliverables:

- Letter of intent to compete
- A poster describing the team's approach to solving the problem. These will be presented during a poster session – 6 teams will present to the judges

Competition Judging

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Judging Criteria:

- 40%: Success shown on training sets images (provided for development)
- 40%: Practical application and feasibility on a new set of images (on the day of judging)
  - As compared to the true map provided by the judges
  - Computation time will be a secondary consideration
- 20%: Organization and Presentation

Judging Process:

- In the morning on the day of the competition (April 25th, 2015), each team will meet the judges and give a live demonstration of their algorithm on a new set of images (provided that day)
- Output of each algorithm must be in PGM format (see later slides) – this file will be compared with the judge's true solution map
- Judges will select the top 6 teams, each of which will each present their posters after lunch

Competition Timeline

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- Announcement – 13 Feb 2015
- Letter of Intent – 15 Mar 2015
- Receipt of Poster – 23 April 2015
- Competition – 25 April 2015
  - 9:00 a.m. – 12:00 p.m.: Live algorithm demonstration with unseen image data
  - 12:00 p.m. – 12:30 p.m.: Judges choose top 6 teams to present their algorithm
  - 12:30 p.m. – 1:30 p.m.: Lunch break
  - 1:30 p.m. – 4:00 p.m.: Top 6 teams present algorithm
  - 4:00 p.m. – 5:00 p.m.: Judges deliberate
  - 5:00 p.m. – 6:00 p.m.: JPL Judges Talk, announce winners
  - 6:00 p.m. – 7:00 p.m.: Reception

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Data

Data

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There are four sets of training data available, in increasing levels of difficulty. The folder names and descriptions are given below.

- Data Set 1 (“terrainS0C0R10_100”): ONLY ROUGHNESS (No slopes and no craters)
- Data Set 2 (“terrainS4C0R10_100”): SLOPE and ROUGHNESS (No craters)
- Data Set 3 (“terrainS4C4R10_100”): SLOPE, ROUGHNESS, and CRATERS
- Data Set 4 (“terrainS4C4R20_100”): INCREASED ROUGHNESS

In each training set folder, there are four files (see next slide for programs that can be used to view these files)

- *.pgm (PGM image of the terrain, 2D)
- *.invHazard.pgm (PGM image file containing the true solution, 2D)
- *.ply (3D data)
- *dem.raw (Raw image)

Viewing Data

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- PGM images can be viewed with many different free downloadable programs (i.e. ImageJ or InfranView)
  - Note that with these programs, you can save the image to other image formats, i.e. JPEG
- PLY files can be opened in MeshLab, available for free at (http://meshlab.sourceforge.net/)

Output Format

- The output of the algorithm must be in PGM format
- Final PGM:
  - 1000 x 1000 PGM file
  - “0” (a.k.a. black) represents hazardous regions
  - “255” (a.k.a. white) represents safe regions

PGM Reader

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- Also provided, to get you started, is a sample PGM Read/Write function, written in C
- To run, you will need Unix function “make” and GCC compiler:
  - Edit test_main.c with the PGM file that you want to read or the name of the desired output PGM file
  - Compile test_main.c by typing “make” at a Unix command prompt in the directory where the files are stored
    - Mac users use their command prompts
    - Windows users are recommended to download tools to run Unix functionality through Windows (i.e. the free software Cygwin, which will run Unix on a PC – see next slide on how to make sure to get the correct files)
  - Run the resulting executable file test_pgm
  - The output is a PGM file

WINDOWS – Downloading Cygwin

- https://www.cygwin.com/
- SPECIAL NOTE: In order to also get the “make” function and the GCC compiler, something must be specially selected
- When you get to this screen, click the word next to “Devel” so that it reads “Install” instead of “Default”