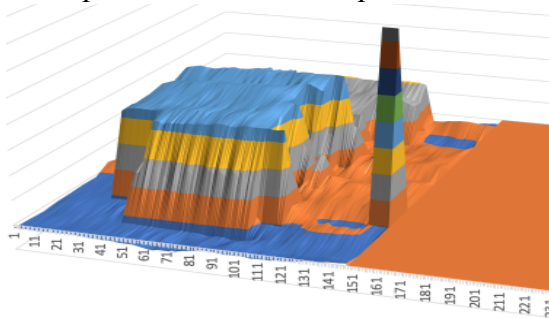


Remote Sensing – Mapping Terrain

Within the next decade, NASA and many other space agencies across the world are projected to launch dozens of missions aimed at exploring unknown worlds. Many of these new projects will be traveling to nearby planets and moons such as our own Moon, Mars, Venus, asteroids, Europa (Jupiter’s moon), Io (another of Jupiter’s moons), and more! With all of these exciting missions, there requires many years of extensive planning but also a detailed mapping of the planetary surface upon which a rover or probe will land.



Planetary scientists, astronomers, and engineers need to be able to decide where would be the safest location to land their million dollar (and more) scientific instruments to make the most of their chance for exploration.

In this design-based activity, you will get the chance to think like a scientist at NASA and map your own *planetary surface* and decide the most favorable landing locations to begin your mission!

Materials you will need: (working in teams of 3-4)

- Vernier GDX MD Motion Detector
- Meter stick
- Open hard surface floor space
- Masking Tape
- 1.5 m string with metal weight (fishing sinker, large washer or hex nut, etc.)
- 6-10 different size boxes
- Computer with:
 - Excel
 - Vernier Graphical Analysis

Scenario

Every mission to land a probe on another world requires years of planning, design, testing, modifications, and more testing. Your project team has been chosen to compete with other teams to be selected for their ability to design, describe, and carry out a method to accurately and efficiently locate significant features of an extraterrestrial terrain. The successful team will then

use their method in practice to map out areas of a yet unknown planetary surface in search for potentially suitable landing site.

To demonstrate your ability to successfully carry out such a mission, you will need to create a 3D representation of a *planetary surface* using a procedure of your own design. As professional planetary scientists, astronomers, and engineers, you are given little instruction, but instead must rely on your own creativity and ability to adapt, based on failure. You will be given any equipment that you need from the list of items above. The mission engineer will brief you on the use and specifications of some of the items in the materials list before you begin.

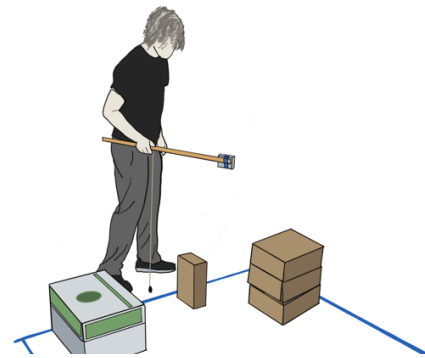
Once you have completed your data collection, you will be provided further instructions for how to create your 3D terrestrial representation. For now this is not important.

At the completion of your analysis of data, you will decide where you will want to land your group's own rover. Name your planet/moon. Name your mission and decide what you will want to study while you are there. At the end of the session, we will all join together as a class and discuss each group's surface and their own mission details.

Good luck!

Procedure

Your team will create your own extraterrestrial terrain – the surface features of an unknown planet, moon, asteroid, etc. Given the tools available, you face the challenge to carry out a procedure to accurately map the terrain and create a 3D model of the surface features. You may have to try different approaches until you get the results you are looking for. Consider yourself in research!

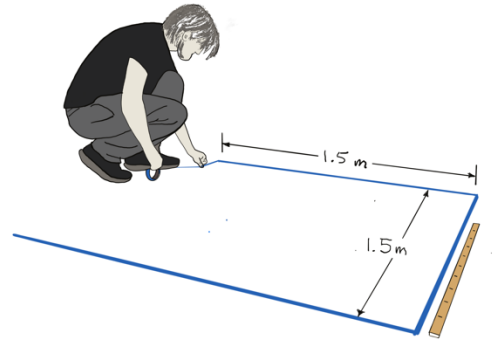


The Mission Engineer's Briefing

- Create a workspace somewhere between 1– 2 m, square or rectangle
- Allow at least 0.5 m surrounding your work space
- Specifications of the Vernier GDX MD; angle of view and operation
- What to consider; height, speed, signal noise
- Sensitivity to scale (size)
- Keep it steady
- Know where you are (how to keep track)
- Start small; trial and error
- More scans, more detail
- Distance versus height

Creating Your Terrain

1. Given the suggested area of your terrain, outline the perimeter on a smooth surface floor with painter's tape.
2. Within that area, arrange the materials available to create the features you would like to represent in your terrain.
3. Report back to the Mission Engineer or supervisor, the nature of the terrain you are attempting to create.



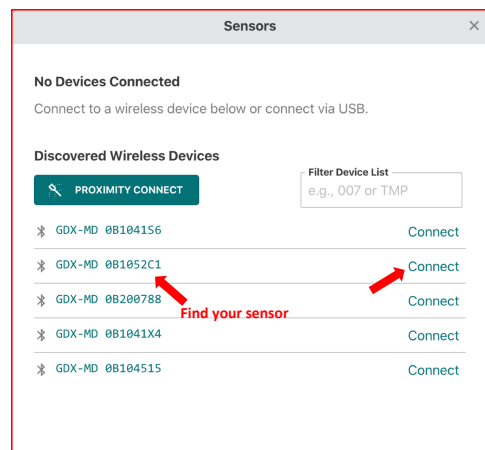
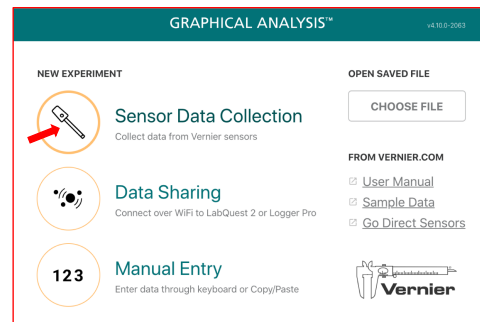
Scanning Your Terrain – Using the Motion Sensor

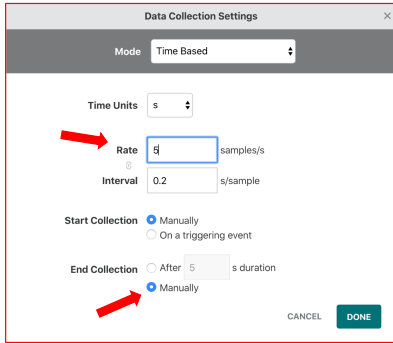
Before you are ready to begin scanning the terrain you have created, think about maintaining a fixed distance between the sensor and the floor during the process. How will you achieve doing that? Will your idea work anywhere within your workspace, or will you need to make modifications?

The motion sensor is based on the reflection of sound waves. It will send a Bluetooth signal to your computer program measuring the distance between the sensor and objects in encounters.

1. Open the Vernier **Graphical Analysis** computer program on your laptop or computer.
2. Turn on the Vernier GDX motion sensor (the Bluetooth indicator will start blinking red).
3. Select **Sensor Data Collection** from the pop-up menu (or Untitled/New Experiment list in the upper left corner).

Select the ID number (near the barcode) of the sensor you are using and **connect**. The Bluetooth light will change from red to green when it is connected to your computer. Done.

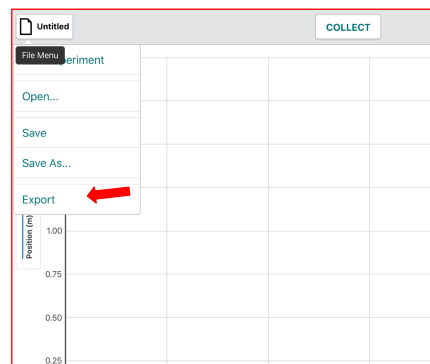




- Under Data Collection Settings, set to **Manually** start and end data collection.
- Try a rate of **10 - 20 samples per second** and select **Done**.

- Before clicking the **Collect** button to start and stop your data collection, think about how you can a **constant and equal speed** as you make scans across your terrain.

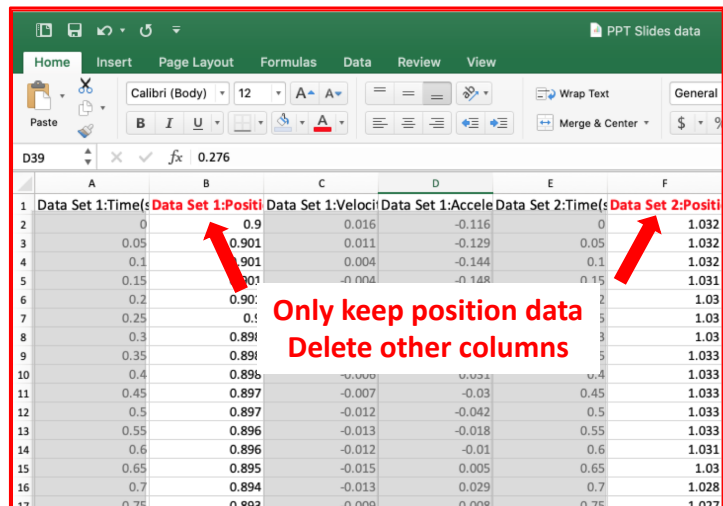
- Repeat as many scans as you think are necessary to completely describe the area of your terrain (perhaps as many as 20 scans).
- When you have finished scanning your terrain, choose the **Export** option to save your data as a **CSV** file. Select a location and remember where you saved your data.



3D Modeling of your data

Now it's time to see how well the data you collected can represent the actual planetary surface you created.

- Open and paste your CSV file into the spreadsheet. You should see columns labeled as Data Set 1, Data Set 2, etc. A Data Set is the result of a single scan across your terrain.
- You only need the **Position** column from each data set. **Delete** all other columns (Time, Velocity and Acceleration). Scroll through the columns to make sure you have the position column for all data sets.



3. **Position** is the distance between the sensor and the surface features. But to create your surface map, you want the **height** of the surface feature from the floor.

For that, you will need to **create a second data set**, subtracting Position from the distance between the sensor and the floor (the length of the string you used). The height data will be what you will use to create your surface map

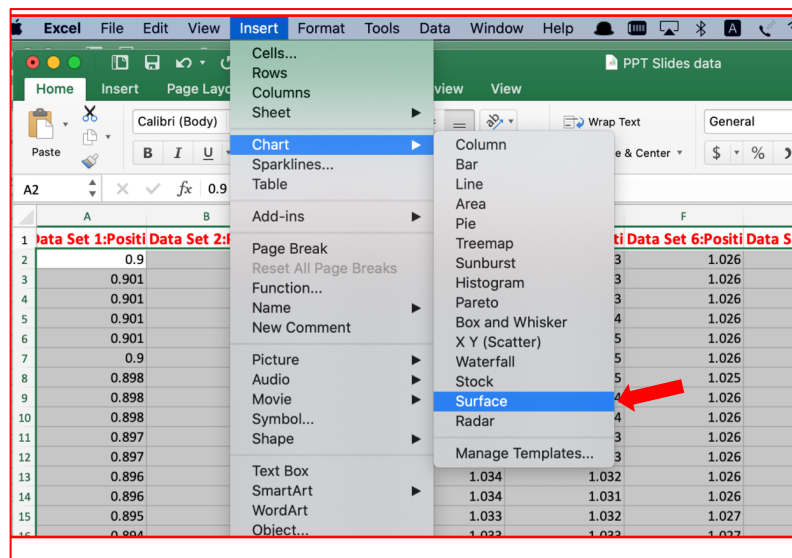
$$\text{Height of feature} = \text{string length} - \text{position}$$

5. Select your **time and height** data, click **Insert**, **Charts**, and **Surface**.

Right click on your graph, click **3-D rotation** and try to get the best view.

You can experiment with

- x rotation
- y rotation
- increase depth (go big, hundreds or thousands)



Questions for discussion and wrap-up

1. If you tried to model a particular surface feature what were you thinking of?
2. How closely does your surface map resemble the actual surface you scanned?
3. What ideas would you have that you think might improve the results you achieved, or the accuracy of your surface plot?
4. What were the greatest challenges for you in doing this activity?
5. We did not take time into consideration in anything we did. Can you think of a way in which using **time** might have been helpful?

Teacher Notes

A less structured open approach to this lesson can provide students the opportunity to think through what they need to know and how to plan their approach. Provide the scenario; mapping a terrain on an extraterrestrial surface. What do they need to consider, how could it be done, what approaches could students take, what pattern to use when making the scabs, what data would they need to know in order to create an accurate 3D representation.

One consideration before getting started is thinking about the primary goal; achieving a 3D model of the surface. What does that mean to the students? Ultimately on means we want to know the **height** and of the surface features. How can you know the height of a surface feature when you can only “see” (or measure) from the top down?

Check out the YouTube video describing this lesson; <https://bit.ly/SMAPMapTerrains>

Learning Goals

- Describe and demonstrate a method by which scientists can gain knowledge of a planetary surface from a remote location
- Describe and diagram the principles by which radar and sonar operate and what information they are able to provide.
- Apply knowledge of spreadsheet applications to create a surface graph.

Mission Engineer pep talk

You can create a scenario, a need know and reason to succeed, in which student teams are competing to earn the contract for the survey mission. In the lesson we provide a guide for the “Mission Engineer” to address the group a lay out the challenge. A guest visitor to the class can play this part well, particularly if they are actually well versed in the field – a real engineer.

The Mission Engineer can provide the specs for the sonar sensor, how it works, considerations of the angle of view and how that may or may not be important, along with the parameters and goals of the mission overall.

Set-Up

1. Students will need access to Vernier’s Graphical Analysis Program installed on their computer or laptop.
<https://www.vernier.com/downloads/graphical-analysis/>
2. Students will set up their workspace on the floor. You can let them decide the area within which they would like to create their model terrain, but 1-2 m on a side works well, square or rectangular in shape. They should maintain at least half a meter buffer on all sides to avoid reflections from extraneous objects (chair legs, file cabinets, etc.).

3. Place boxes (or other objects) within the workspace. Shoe box size, up to the size of a case of paper work well. Students can arrange them randomly, or try to create a particular shape (volcano, crater rim, dried river bed, etc.), or use myriad other items.
4. Students will tie the string to a meter stick or pole with a metal bob at the other end to establish the distance from the floor at which they will conduct their experiment. Encourage them to think about the entire scan process. Will the location of the string need to be adjusted at some point? A tied loop may work better than taping in place.
5. On one end of the meter stick, tape the Vernier Motion Detector (*Go Direct GDX-MD*) against the flat side. When you hold the stick out the detector surface should be facing the ground. Don't tape over the power button or the GDX identification number label.
6. Suggest to students to do some trial scans before they are ready to start to get a feel for maintaining a constant **speed** and **distance** between sensor and floor, creating a consistent **starting and stopping point** and consistently starting and stopping the software. They can see the graph generated in real time and evaluate their technique.
7. Students need to figure out a way to know how to space the distance between scans. Painters' tape spaced at intervals of maybe 10-12 inches (20 cm) will work well, located on opposite sides of the scanning area.
8. One person in a group can act as a "spotter" to try to make sure that the "scanner" doesn't wander one way or another during the scan, and that it remains a constant distance from level ground.
9. Undoubtedly, students will mess up and want to re-do a scan mid-way through their data collection – **don't!** The software will continue adding data sets to the experiment in progress and re-starting a scan will produce an extraneous data set that will confound results. The option would be to go to "New Experiment" and start over.
10. Some groups might try draping their surface with a sheet or drop cloth to more even sloped surfaces; encourage them to be creative in their approach with objects and shapes, keeping in mind that sloped or irregular shapes will require a finer resolution.
11. One final and important point. The angle of view of the sensor is about 15 degrees. For the size of the workspace, it may seem that maybe 5-6 scans would sufficiently cover the area. In practice, however, more scans are required in order to produce a surface graph with enough depth to accurately depict the area. 20-25 scans should work well.

Acknowledgement

This lesson is based on, *Earth Science with Vernier*, https://www.vernier.com/experiment/esv-19_mapping-the-ocean-floor/

Additional classroom lessons and experiments may be found in SMAP Selected Lessons, <https://bit.ly/SMAPSelectedLessons>

Watch the YouTube video of Mapping Terrains here, <https://bit.ly/SMAPMapTerrains>