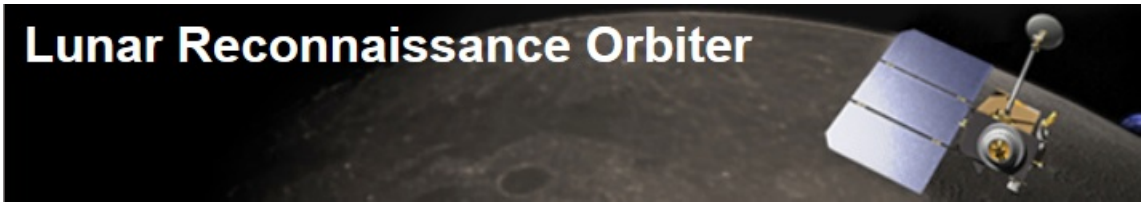


Lunar LRO Data to 3D Printer
For the Big Moon Dig

Tom Riley Draft
February 26, 2015
File: BMD3DPrintmmdddyy.docx

1. Purpose

The task is to convert scientific data from the LRO lunar mission, into a solid object you can hold in your hand through 3D Printing.

A detailed process to obtain the data and process it to the point that it can be 3D printed is provided at:

Big Moon Dig / Lunar Surfaces
http://bigmoondig.com/Games/BMDSurface.html

And as a .pdf file at:

"Lunar LRO Data to SketchUp Landscape"
http://bigmoondig.com/Games/BMDLROData.pdf

This process is used to insure that the lunar landscapes used on the Big Moon Dig games and stories are as authentic as possible and is based on the latest scientific data.

2. Printer Used

The 3D printer used for the test was a MakerBot Replicator 1. It has a maximum size of 285mm x 153mm x 155mm (11" x 6" x 6"). This work was done at the Node Baltimore, a maker group.

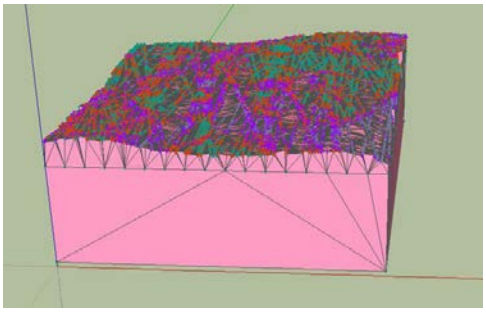
Scott A, Site 3D Printer Block

3. Full 3D Printer Process

The lunar surface can be printed out with a 3D printer as a block with a data derived top surface. This process requires a number of steps:

3.1. In Excel:

1. Run the SketchUp VGA module, *LROMakeBot* (2 minutes). "Yes" to scaling. Enter the limits of longitudes and latitudes that you used to get the data and that show on your layout sketch. This VGA module scales the points from thousands of meters to meters for the first step.
2. Save the main file.
3. SaveAs Sheet6 as a CVS file.
4. Block out Sheet1 D1:P7. Print Selection. This information may be needed for the 3D printer.



SketchUp Block for 3D printing

3.2. In SketchUp:

5. Open SketchUp with plug-ins -- *Total Station Point Importer*, *Triangulate Points*. The latest version of SketchUp may not run these plug-ins. I keep an unupdated Version 13 with these plug-ins. For later versions check to see if updated version of anything that will read a CVS file as points and will triangulate a surface is available.
6. Run *Total Station Point Importer* on the CVS file -- Commas, Meters, ENZ/XYZ, Yes; get the CVS file; No, No, No, Yes.
7. Use *Camera/Standard View/Top* to make the points visible -- You should get a rectangle of colored points most of which are in lines across the terrain. Rotate to front view. The axis origin should be at the reference point.

8. Select the group the *Edit Group*.
9. Now select only the actual points and the lines of defining points just below them. Do **not** select the bottom four defining points.
10. Run *Triangulation points* -- Yes, Triangles. This takes about 45 minutes on a moderate sized file. The bottom line counts up to the number of points, then doubles the number and counts up again. If you have trouble with bombing try turning off the Internet and all other interrupts you can.
11. Save file.
12. *Close* SketchUp 13 -- *Open* latest SketchUp version latest -- *Open* the file with your latest SketchUp version and *SaveAs* with a version indication.
13. Some manual work is now required. Draw lines between points to fill out the surfaces along the edge of your block. Be very careful to only end you lines on *endpoint*. Draw in the sides as large triangles. Do not accept rectangles or anything with more than three points. If a square fills in automatically, go ahead and add the remaining lines anyway. Be sure to do this to the bottom.
14. Clean Up the edges – You can clean up the edges by erasing the extra lines that run down the sides and drawing in lines on the top surface between all the points to make triangles. This can take an hour.
15. Inspection -- Inspect to see that there are **no** see-through holes left. Rotate the shape around and watch for see-throughs. If you find any it usually means you missed a line end point (green circle). Simply erase any suspect lines and draw them in again.
16. Make the edges nice. You can now erase lines that cause rough edges and then draw in new lines with a smoother top. This can take some time.
17. Save file
18. Scale the group -- Deselect the group and then select it again. Open the *Scale* icon. Move the far yellow block diagonally a little. Enter the scale factor, .005 for single blocks or .0025 assemblies of blocks, in the lower right hand corner and *Return.* The whole group will get a lot smaller.
19. *Move* the entire group back to the *Origin*.
20. Save the file.
21. Use the Measuring tape to insure that you have the dimensions you need for your printer. The scaling has been done in two steps, one in Excel and one in SketchUp, to make this process less likely to hang up. The total scaling is 1:200000 or 1:400000.
22. *File/Export STL*. This plug-in is available from the extension warehouse. Use Millimeters, ASCII. You can also choose meters, centimeters, or millimeters if this works better for your printer. It helps if you shorten the file name.

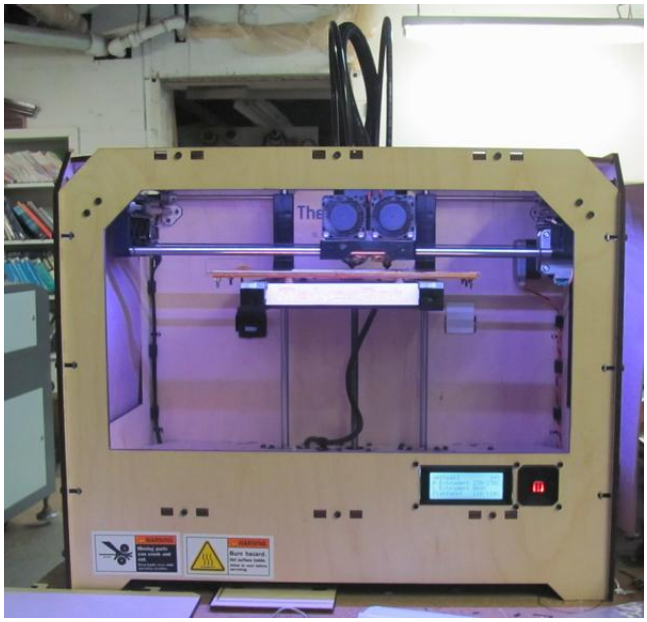
3.3. In 3D Printer software:

23. *Load* STL file.
24. Check scale against the information printed out from Excel. The finished size, after scaling in both Excel and SketchUp, was saved in millimeters and should now fit the printer stage. *Scale* with your printer software if necessary. The length and width should be precise but the height number is an approximation.

25. Arrange the model on the table. The longest dimension should be left to right. Center left to right. Set about 10 mm in from the front for best calibration.
26. Set file settings --
    a. The Raft should be "ON" – This strengthens the base and helps prevent loosing of the corners.
    b. The Supports should be "OFF" -- This feature can mess things up and is not needed since we made the edges very even.
    c. The internal fill should be at 10% -- This fills the inside of the block with small honey comb cells that support the small features, like craters, as the surface is being printed. If small carter bottoms go missing you may have to increase this number, try 12%. Trying to save time by reducing it does not work well.
27. Export the file and generate the G Code. This step converts the block to layers for printing and will take several minutes for the large files.

3.4. In 3D Printer:

28. Load filament color -- Dark gray is the best for this printout. Black, much more common, does not show shadows as well. The extruder will have to be heated before the filament can be swapped.
29. Calibrate printer -- This can be tricky and often requires printing out a test pattern. It is largely about getting the distance from extrude head to the table just right at all four corners. This may require adjustments of the four nuts under the printer table.
30. Protect from drafts – The table must be heated and the layers will not stick together well if they are cold. Block drafts from getting to the table.
31. Transfer file to printer. This can be done by cable or by loading on a SD card.
32. Print in 3D. The table and the extruder must first warm up. The printer should then lay out the base in several layers. It is OK if the corners curl up a little bit, but only slightly. Once the walls are started, only patience is needed. In a cool or drafty area, you many need to protect the printer from drafts. This step can take up to 5 hours for large locks.
33. Minor Fix ups -- Look over the finished print out and sand off extraneous bits, glue up any cracks, and fill in any minor holes. Super Glue works best for cracks; use with clamps. Thermal glue works best for small holes.



MakerBot Replicator 1

4. Conclusion

This is only a start. There are certainly better, less laborious, ways to get the LRO data available for use. Simpler processes are certainly possible.

We can now take real scientific data about the Moon and turn it into objects you can touch with your hands. Long live The Big Moon Dig.

We can do this.

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References:

1. The Big Moon Dig (internet) http://bigmoondig.com/BigMoonDig.html
2. MakerBot (Internet) http://www.makerbot.com/
3. The Big Moon Dig (internet) http://bigmoondig.com/BigMoonDig.html
4. The Big Moon Dig / Lunar Surfaces (Internet) http://bigmoondig.com/Games/BMDSurface.html
5. "Lunar LRO Data to SketchUp Landscape" (internet) http://bigmoondig.com/Games/BMDLROData.pdf
6. The Node, Baltimore (Internet) http://baltimorenode.org/