Lunar Librarian Newsletter
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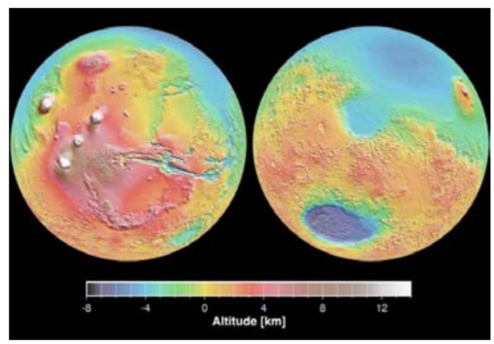
LRO News

MOLA, MLA, and LOLA: Three Generations of Laser Altimeters

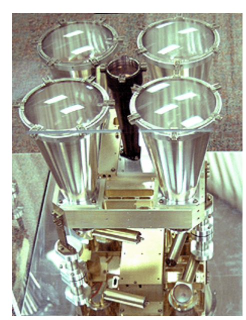
Whether it is looking at the Earth or at another planetary body, the topography tells a lot about a surface. Topographical maps can help explain the geological history of a planet by showing mountains, valleys, plains, and faults. A laser altimeter, located on an airplane or orbiter, works by emitting a laser pulse, striking a surface, such as the Earth or another planetary body, and then reflecting back. By using the measurement of the pulse's round trip time and the known orbital path, scientists can determine the topography of the planetary object.



Topographical view of Mars.

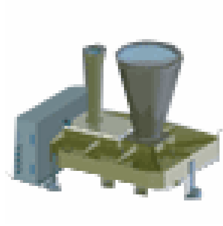
MOLA, MLA, and LOLA are three generations of laser altimeters. This family legacy began with the Mars Orbiter Laser Altimeter (MOLA). MOLA was one of five science instruments aboard the Mars Global Surveyor (MGS), launched on November 7, 1996. Scientist used the data from MOLA to create topographical maps of Mars, such as the one to the right. With the MOLA instrument, scientists are able to distinguish object, such as rocks and craters, that are at least 160 meters wide. From the MOLA data, it was possible to determine some of the geological history, ex. past water flow, of Mars. One of the initial findings observed about Mars is the South Pole is approximately 6 kilometers higher in elevation than the North Pole.

The laser portion of MOLA stopped working in June of 2001, but the sensors still continue to detect changes in the surface brightness. These changes in brightness are evidence of cloud coverage and atmospheric variations.

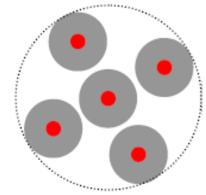


MLA

Launched on August 3, 2004, Mercury Laser Altimeter (MLA) is one of eight scientific instruments on MESSENGER (MErcury Surface, Space ENvironment, GEochemistry and Ranging). MLA is the "daughter" of MOLA and GLAS (Geoscience Laser Altimeter System). MLA receiver (image to the right) consists of four 11 centimeter diameter reflective telescope. Due to the limited fuel capacity, MESSENGER will be in a highly elliptical orbit around Mercury. This will result in the topographical mapping of the northern hemisphere of Mercury. .



LOLA – artist rendering



LOLA receiver configuration

To follow in the footsteps of the preceding laser altimeters, the Lunar Orbiter Laser Altimeter (LOLA) will be making its debut on Lunar Reconnaissance Orbiter (LRO), schedule for launch in October 2008. Unlike MLA, LOLA has a laser beam which is split into five separate beams when it passes through a lens. The five laser beams are mapped to five independent receivers, producing over 4 billion measurements over the course of the mission. This allows for an increase of mapping coverage for each orbit around the Moon. Due to the configuration of the receivers, see image above, the return data will provide more detail about the surface including the slope and roughness. This information will help in determining potential landing sites and possible water ice in permanently shadowed regions. It will also be able distinguish object that are at least 50meters width and 1 meter in height.

Although LOLA is the 'daughter' of MLA, MLA will not be taking measurements until three years after LOLA reaches her destination.

For more information:

MGS
http://mars.jpl.nasa.gov/mgs/index.html
http://nssdc.gsfc.nasa.gov/database/MasterCatalog?sc=1996-062A

MOLA
http://mars.jpl.nasa.gov/mgs/sci/mola/mola.html
http://nssdc.gsfc.nasa.gov/database/MasterCatalog?sc=1996-062A&ex=3

MESSENGER:
http://messenger.jhuapl.edu
http://nssdc.gsfc.nasa.gov/database/MasterCatalog?sc=2004-030A

MLA:
http://nssdc.gsfc.nasa.gov/database/MasterCatalog?sc=2004-030A&ex=5
http://ltpwww.gsfc.nasa.gov/ltp/mla.html
http://btc.montana.edu/messenger/instruments/mla.htm

LRO
http://nssdc.gsfc.nasa.gov/database/MasterCatalog?sc=LUNARRO
http://lunar.gsfc.nasa.gov

LOLA
http://nssdc.gsfc.nasa.gov/database/MasterCatalog?sc=LUNARRO&ex=4
http://lunar.gsfc.nasa.gov/missions/lola.html

NASA News

Discovery and New Frontiers Programs.

NASA has developed two programs to give scientists an opportunity to explore our Solar System. Discovery and New Frontier Programs

Discovery Program.

Started in the 1990's, the Discovery Mission was developed to complement many of NASA's larger planetary science explorations. Unlike the larger missions, these smaller missions had a small window for development. This means from the start of the mission to the launch could be no longer than 36 months. As a result, a new mission could be launched every 12 to 24 months.

Another limitation on the missions that would be part of the Discovery Program was the overall cost. The entire mission, including: design, development, launch vehicle, instruments, spacecraft, launch, mission operations, and data analysis, had to cost less than $425 million. The Discovery program supports the testing and use of new technologies and applications. "Each mission works with industry to transfer technologies used in the mission, especially those that enhances science acquisition and reduce cost." (http://discovery.nasa.gov/program.html)

Despite the limitations placed on Discovery Program missions, there were several initiatives made to enhance the understanding of the Solar System. They include:

- Broaden university and industry participation
- Increase public awareness of solar system exploration
- Requiring a plan for education and public outreach.

The Discovery Program made it possible to explore planets, asteroids, and the matter of space. A listing of the ten Discovery Missions is available at: http://discovery.nasa.gov/missions.html. One of the Discovery missions is MESSENGER.

New Frontiers Program

The New Frontier Program was developed in 2002. The missions in this program will have specific goals when it comes to Solar System exploration, as outlined in *New Frontiers in the Solar System: An Integrated Exploration Strategy*. NASA felt explorations of Venus, Jupiter, the south polar region of the Earth's Moon including the Aitken Basin, Pluto and other Kuiper Belt objects, and comets were of high scientific priority.

Typically, each of the New Frontiers missions has a principal investigator (PI) who is either affiliated with a university or research institution. In order to keep mission costs down, less than $700 million dollars, PIs will make "use of validated new technologies, efficient management, and control of design". For more information on the program is available at: http://newfrontiers.nasa.gov/. The New Horizons Mission is part of the New Frontiers Program.

Science News

NASA Science News has published several articles last month. Please follow the links to read the full stories.

Wide Awake in the Sea of Tranquillity

The fourth installment of Science@NASA's Apollo Chronicles explains why Neil Armstrong and Buzz Aldrin couldn't fall asleep 37 years ago in the Sea of Tranquility. http://science.nasa.gov/headlines/y2006/19jul_seaoftranquillity.htm?list907815

Birthplace of Hurricanes

Where do hurricanes come from? Researchers are flying across the Atlantic to catch the mighty storms in the act of being born. The data they collect could lead to better forecasting and a deeper understanding of hurricanes. http://science.nasa.gov/headlines/y2006/26jul_namma.htm?list907815

Crash Landing on the Moon

At the dawn on the Space Age, the first spaceship to reach the Moon crashed. Forty-seven years later, NASA plans to do it again. A ship named LCROSS is going to hit the Moon, not once but twice, in a daring search for lunar water. http://science.nasa.gov/headlines/y2006/28jul_crashlanding.htm?list907815

Lunar X Games

The X Games are underway in Los Angeles. One day--who knows?--they might be held on the Moon. This story takes a whimsical look at the physics and gear of Lunar X Games. http://science.nasa.gov/headlines/y2006/04aug_xmoon.htm?list907815

Perseid Earthgrazers

When the Perseid meteor shower peaks on August 12th, the nearly-full Moon is probably going to spoil the show. But there might be something to see before the Moon rises: a side-show of Perseid Earthgrazers. http://science.nasa.gov/headlines/y2006/07aug_perseids.htm?list907815

Backward Sunspot

A strange little sunspot noticed by astronomers on July 31st may herald the coming of an unusually stormy solar cycle. http://science.nasa.gov/headlines/y2006/15aug_backwards.htm?list907815

Meteor Mystery, Solved?

In 1967, NASA's Mariner 4 spacecraft was hit by a surprising flurry of meteoroids--a shower more intense than any Leonid meteor storm. Where did the meteoroids come from? It's been a mystery for

40 years. Now, astronomers may have found a solution: Mariner 4 had a close encounter with a "dark comet." http://science.nasa.gov/headlines/y2006/23aug_mariner4.htm?list907815

Martian Misinformation

Contrary to a wide-spread report, Mars will not look as big as the full Moon on August 27th. In fact, the red planet will be nearly invisible to the human eye. There is, however, something real to see on August 27th--a morning alignment of Venus and Saturn.
http://science.nasa.gov/headlines/y2006/25aug_marshoax.htm?list907815

SMART-1 to Crash the Moon

A European spaceship is about to crash into the Moon. Amateur astronomers may be able to observe the impact. http://science.nasa.gov/headlines/y2006/30aug_smart1.htm?list907815
SMART-1 crash landed on the Moon, on September 3, 2006.

Solar Sentinels

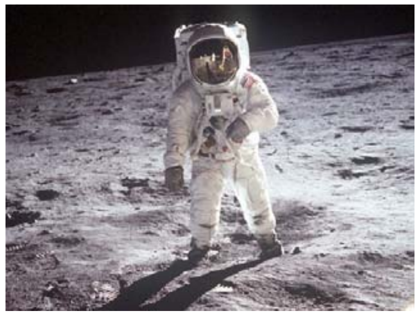
With astronauts returning to the Moon, reliable forecasts of space weather are more important than ever. A new proposed mission called "Solar Sentinels" would surround the sun with spacecraft to keep an eye on solar activity.
http://science.nasa.gov/headlines/y2006/01sep_sentinels.htm?list907815

Electric Ice

Imagine looking inside a million clouds. That's what NASA researchers have done using the TRMM satellite to explore the strange connection between lightning and ice.
http://science.nasa.gov/headlines/y2006/13sep_electricice.htm?list907815

Librarian News

To the Moon and Beyond . . .
Moon Camp at the Easttown Library & Information Center



At The Easttown Library & Information Center from July 31 through August 3, for one hour each day, our meeting room was transformed into a magical place in which this writer, two young adult volunteers, and 17 students ranging in age from the 4th to the 6th grade met together to learn about the LRO and the Moon. Hands on activities were many and included a memorable day of making impact craters followed by a major clean-up effort. During a debriefing of the activity, one student commented, "I enjoyed making a mess and not getting in trouble for it." Another student added, "And don't do this at home!"

Barbara Hartman, niece of astronaut Pete Conrad, visited the camp to tell stories about her uncle's walk on the Moon and to share memorabilia that included a flag that Pete Conrad had taken to the Moon. NASA sent Moon rocks and Tuesday night, parents Francis Murphy, Dave Walker and Steve Heron set up telescopes for Moon, planet and star-gazing at night. On the last day of Moon Camp, NASA scientists Brooke Carter and Heather Weir visited to talk about the LRO.

Many thanks to Brooke and Heather for coming to share the vision of space exploration!

Becky Sheridan
Easttown Library & Information Center

For information contact Becky Sheridan at bsheridan@ccls.org and for our web site, see www.easttownlibrary.org.

Here's what's going with some of the librarians who participated in the workshops

Pennsylvania:

Pittston Memorial Library will be holding a Scavenger Hunt

Easttown Library & Information Center will be holding a Moon Camp July 31- August 3, 2006. They are planning on having several hands on activities. On Tuesday night, they are hosting a family night of sky watching with an amateur with real telescopes. There will be 14-16 kids, 4th – 6th grades, enrolled in our Moon Camp and the time is 10:00 – 11:15 each day. Brooke and Heather attended on August 3.

Dillsburg Area Public Library held their first program June 15, 2006. It was attended by 26 children and 13 adults.

What's going on at your library??

Email Heather, heather_weir@ssaihq.com, with your library's space program activities by September 27, and it will be included in the next Lunar Librarian Newsletter. Feel free to send along pictures from your workshops.

Did you know?? Where can I find??

Need a NASA scientist or a speaker to come and talk at your library?

Please feel free to contact either Brooke Carter (brooke_carter@ssaihq.com 301-867-2112) or Heather Weir (heather_weir@ssaihq.com 301-867-2083) with details on what you are looking for and what you want to cover. Also, if you could provide a schedule of when you want to plan your event, this would be helpful.

Policy Change for Lunar Sample Disks

When making a request for lunar and meteorite sample disks please contact either Heather or Brooke, **NOT** Richard Blackmon. Please call us to inquire if your requested date is available. Once a date is confirmed, please send or fax us the required paperwork. We will pass this on to Richard. We will be contacting you when the samples have been sent to you. When you are in the process of returning the samples, please contact us to let us know that they are on their way.

Resource Material

If you are looking to Moon books and resources, please take a look at the following two links.

"Back to the Moon" sets http://catalog.core.nasa.gov/core.nsf/item/300.0-74A

Back to the Moon Bulletin Board Set http://catalog.core.nasa.gov/core.nsf/item/300.1-55q

Ping-pong Altimetry Activity

From: http://education.gsfc.nasa.gov/experimental/all98invProject.Site/Pages/pingpong.html

Objective:

The learner will understand, through a hands-on experience, the basic concepts behind the use and working of a laser altimeter for the study of solar system topography.

Outcomes:

- Students will plot and graph data they have collected using a hands-on version of laser altimetry.
- Students will gain an understanding of the use of laser altimetry in the study of planetary topography.

Introduction:

January 10, 1999, the satellite NEAR begins an orbit of 433 Eros, which makes it the first spacecraft to orbit, and study, an asteroid. One of the instruments aboard the satellite is a laser altimeter. The laser will be used to take topographical measurements of the surface of 433 Eros. With this data, topographical maps and 3 dimensional models will be created. This activity will introduce you to the concept of laser altimetry and how the data is used in order to create maps and model solar system bodies.

Materials:

Ping-pong ball
wooden blocks of various sizes
masking tape - 2 pieces @ 10 cm each (optional)
meter stick
stop watch
graph paper (enough for 3 graphs per group)
pen/pencil

Procedure:

This activity requires at least two people per group. Three people per group would be the optimum. The jobs can be rotated if group members so desire. Read through the whole activity before beginning.

STEP ONE:

1. Choose a spot on a wall 2.2 m or higher from the floor, and place one 10 cm length of tape on the wall, at that height, parallel to the floor. (You may need a chair.)
2. Holding the ball next to the tape on the wall, between your first finger and thumb, drop it and watch to see how high it bounces back up. Mark that spot on the wall with your finger. It is best to do this step two or three times to determine the highest point of return. (Using

the mortar lines on cinder block walls will work well, too. Be sure to use the same two lines throughout this whole activity.)

3. Measure 45 cm toward the floor and mark this spot with the second piece of tape. This will be the constant for measuring the time for the ping-pong ball's period.
4. Measure the distance from the first piece of tape (or mortar line) to the floor and back up to the second tape line. Record this on your data sheet. This distance will be used to create a baseline for all other measurements, so be as precise as you can.
5. As in number two, one partner should hold the ping-pong ball next to the higher piece of tape, between the first finger and thumb, and approximately one inch from the wall.
6. One partner should have a stopwatch and have his/her eyes level with the second piece of tape. A third partner, if available should be recording the results of each ball drop using the attached data sheet or one that your group makes up for itself. * *Note: A spreadsheet would work well for recording and calculating this data.*
7. Drop the ball, and as you do say, "Go." The timer starts the stopwatch on "Go."
8. The timer will stop the watch when the ball rebounds and reaches the lower line. (His/her eyes should be level with the lower piece of tape. The time should be stopped as soon as any part of the ball touches any part of the line.) Record the time on the data sheet. Repeat this step four more times.
9. Calculate the velocities (V=D/T). After finding the velocity for each of the trials, find the average velocity of the ping-pong ball. This average will be used later in this lab. It will be your baseline for comparing data.

STEP TWO:

Now that you have found the velocity of the ping-pong ball, you will use this information to plot the topography along a line of latitude of an asteroid. You will be creating your own asteroid terrain on the floor against the wall where you just did Step One.

1. Create the topography model of *your* asteroid, along the wall where you did Step One. In order to do this you need to place the wooden blocks *against* the wall in a line about 6-8 feet long. Be sure that you build in some hills, mountains, valleys, etc. (See Figure A)
2. If you used tape in Step One instead of the mortar lines, you will probably want to add new lengths of tape to the originals that extend over the entire length of your topographical model. Be sure that the new lines remain parallel to the floor so that the heights don't change along the length of the model.
3. Starting at the beginning of the top piece of tape, place a mark every 20cm. The bottom piece does not need to be marked.
4. Again, starting at first interval mark you made at the beginning of the tape, you will drop the ping-pong ball as you did in Step One, and record the time in Data Table II. Drop the ball and record the results two more times. Be sure to be as accurate as you can with the timing.
5. Repeat number four for each of the interval marks you placed on the wall.
6. Find the average time for each of the intervals and record it on the data table.

STEP THREE: PLOTTING AND GRAPHING THE DATA:

You will now plot the data for the average times and create graphs of the altimetry readings for your topographic model. The graphs will use different intervals between readings, so that you can compare the preciseness of different levels of accuracy (called spatial resolution).

Graph 1

1. Plot the average time for every 60cm interval. (0cm, 60cm, 120cm, etc.)
2. Connect the points with a smooth line.
3. Label the graph appropriately.

Graph 2

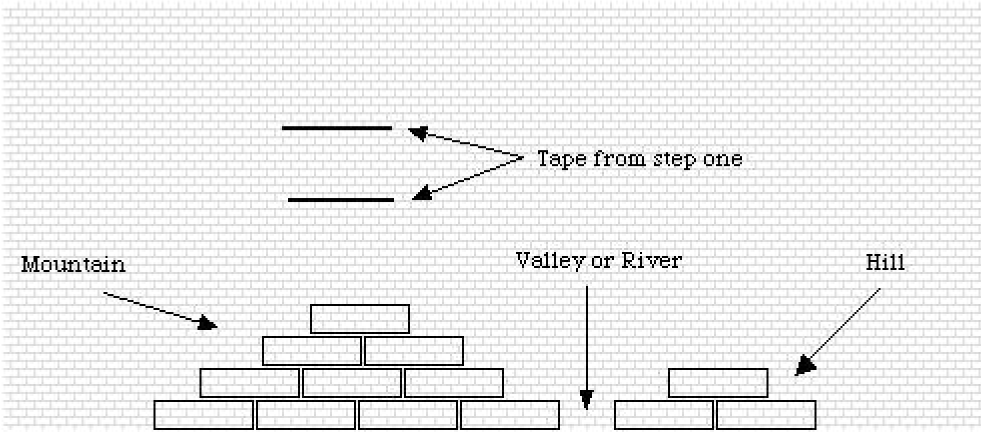
1. Plot the average time for every 40cm interval.
2. Connect the points with a smooth line.
3. Label the graph appropriately.

Graph 3

1. Plot the average time for every 20cm interval.
2. Connect the points with a smooth line.
3. Label the graph appropriately.

PING-PONG ALTIMETER
Data Table I

Drop	**Distance ball traveled**	**Time (seconds)**	**Velocity (distance/time)**
1			
2			
3			
4			
5			
		Average Velocity	________________



PING-PONG ALTIMETER
Data Table II

Interval	Trial 1	Trial 2	Trial 3	Average Time (sec)	Distance Ball Traveled (cm)
0cm					
20cm					
40cm					
60cm					
80cm					
100cm					
120cm					
140cm					
160cm					
180cm					
200cm					
220cm					
240cm					
260cm					
280cm					
300cm					

PING-PONG ALTIMETER
Data Table III

°R Interval	Original Distance Ball Traveled (From Data Table One) {D1}	Distance Ball Traveled (cm) {D2}	Altitude (cm) {D1-D2= Altitude}
0cm			
20cm			
40cm			
60cm			
80cm			
100cm			
120cm			
140cm			
160cm			
180cm			
200cm			
220cm			
240cm			
260cm			
280cm			
300cm			

Use your graphs and data to answer the remaining questions.

Why is it important to keep the distance between each altimeter measurement consistent?

How could we make the topographical profile more accurate?

What does the graph look like in comparison to your model (i.e.. the same, inverted, etc.)?

Which looks more like the model, the graph you generated from the shorter or longer distances between readings (intervals)?

What will you have to do to the data to make the graph look right-side up?

The Laser Rangefinder aboard NEAR sends out a laser beam and “catches” it as it returns from being reflected by the surface of 433 Eros. The instrument records how long it takes the beam to reach the surface and bounce back up. The scientists know how *fast* the beam is traveling; therefore, they can calculate how *far* it traveled. By measuring this time and multiplying by the velocity of the beam, they calculate how far the laser has traveled. They must then divide the distance the beam traveled in half.

Why did you not divide in half to find the distance to the object in *your* topography model?

Next, the scientist must compare this distance to a "baseline" distance we will call zero. On Earth, we might use sea level as the baseline. Another way to set the baselines is to start at the center of the planetary body being studied and draw a perfect circle as close to the surface of the body as possible. Using this baseline, the altitude compared to zero can be calculated and graphed. (Here, on Earth, we often say that some point is a certain number of feet above of below sea level.)

Why do we not use the term "Sea level" for Mars and other planets?

You will now calculate the altitude of the points along your model. To do this, subtract the distance the ball traveled, at each interval (from Data Table II) from the distance the ball traveled in Step One (column B, Data Table I). The number you come up with will be zero or greater. Use Data Table III to do your calculations. {The number in column B in this table should be the same for every interval. Remember, it was the baseline altitude and does not change.}