Residential Internship

Johnson Space Center

Project M: Scale Model of Lunar Landing Site of Apollo 17

Vanik, Christopher

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Reviewed by:

Dr. Timothy P. Crain | Mr. Richard Mrozinski

GN&C Autonomous Flight Systems Branch EG6

# Project M: Scale Mockup of the Apollo 17 Lunar Site: Focus on Lighting Conditions and Analysis

Christopher S. Vanik[1] and Dr. Timothy P. Crain[2]
*National Aeronautics and Space Administration, Lyndon B. Johnson Space Center, Houston, Texas, 77058*

**This document captures the research and development of a scale model representation of the Apollo 17 landing site on the moon as part of the NASA INSPIRE program. Several key elements in this model were surface slope characteristics, crater sizes and locations, prominent rocks, and lighting conditions. This model supports development of *Autonomous Landing and Hazard Avoidance Technology (ALHAT)* and Project M for the GN&C Autonomous Flight Systems Branch. It will help project engineers visualize the landing site, and is housed in the building 16 Navigation Systems Technology Lab. The lead mentor was Dr. Timothy P. Crain. The purpose of this project was to develop an accurate scale representation of the Apollo 17 landing site on the moon. This was done on an 8'2.5"X10'1.375" reduced friction granite table, which can be restored to its previous condition if needed. The first step in this project was to research the best way to model and recreate the Apollo 17 landing site for the mockup. The project required a thorough plan, budget, and schedule, which was presented to the EG6 Branch for build approval. The final phase was to build the model. The project also required thorough research on the Apollo 17 landing site and the topography of the moon. This research was done on the internet and in person with Dean Eppler, a space scientist, from JSC KX. This data was used to analyze and calculate the scale of the mockup and the ratio of the sizes of the craters, ridges, etc. The final goal was to effectively communicate project status and demonstrate the multiple advantages of using our model. The conclusion of this project was that the mockup was completed as accurately as possible, and it successfully enables the Project M specialists to visualize and plan their goal on an accurate three dimensional surface representation.**

## Nomenclature

*ALHAT* = Autonomous Landing and Hazard Avoidance Technology

[1] INSPIRE Intern, EG6, NASA Johnson Space Center, Montezuma-Cortez High School
[2] Project M Flight Dynamics Lead and mentor, EG6, NASA Johnson Space Center

| | | |
|---|---|---|
| M | = | the Roman numeral for 1000 |
| GN&C | = | Guidance, Navigation, and Control |
| FCD | = | Foot Candles |
| EG6 | = | GN&C Autonomous Flight Systems Branch of the Aeroscience and Flight Mechanics Division |
| NSTL | = | Navigation Systems and Technology Lab |
| TLI | = | Trans- Lunar Injection |
| LRO | = | Lunar Reconnaissance Orbiter |
| LOX | = | Liquid Oxygen |
| STEM | = | Science, Technology, Engineering, and Mathematics |
| JSC | = | Johnson Space Center |

## I. Introduction

This document is a step by step guide to the research and work performed by Hollie O'Brien and Christopher Vanik during the INSPIRE program Summer STEM Experience of 2010 at the Lyndon B. Johnson Space Center.

The lunar surface still has many mysteries surrounding it. Geology is a major part of the mysteries. How did the moon form? When did it form? Geologists cannot go to the moon to study the crust themselves, but a revolutionary new concept, Project M, may open the door to exploration of the moon once again.

The student summer project was to develop a detailed model representation of the Apollo 17 landing site at the moon, which will include several key elements such as surface slope characteristics, crater sizes and locations, prominent rocks, and specific lighting conditions. The purpose of this project was to develop a scale, accurate representation of the Apollo 17 landing site on the moon. This was completed on an 8'2.5"X10'1.375" reduced friction granite table in the Navigation Systems and Technology Laboratory at Johnson Space Center.

## II. Research

Several areas had to be researched before and during the construction of the scale model, including maps, lighting conditions, and availability of materials. The following information details the research, procedures, construction, and significance of the research to the project overall.

## A. Project M

Project M is a proof of concept idea that is based around the goal of sending an operational humanoid robot, Robonaut 2, to the moon in 1000 days. Project M has three primary goals: successfully demonstrate new, advanced technologies; inspire students in STEM related careers; and demonstrate the ability to work quickly in the agency. Robonaut is scheduled to arrive on the moon in a small lander, which in and of itself will provide valuable information for future technologies. The lunar lander that carries Robonaut will have a revolutionary propulsion system composed of primarily methane and liquid oxygen (CH4/LOX). This system for propulsion was chosen because the fuel burns more cleanly, and it is easier to test and store. Autonomous Landing and Hazard Avoidance Technology, or ALHAT, will be installed on the lander, providing precision landing and hazard avoidance systems. The ALHAT systems use a series of lasers to scan the ground and ensure the selected area is safe on which to land. If ALHAT recognizes a potential hazard, it will redirect the lander to a safer alternative. After successfully landing on the moon, Robonaut will be deployed. Robonaut is the most dexterous robot in the world, and is suited for many tasks without the assistance of adapted tools. Robonaut will be able to work remotely, away from the lander to run specific tests on the geology of the moon, and one day it might assist the astronauts with tasks deemed too hazardous to be completed by a human.

**Figure 1.1, RR2 free flight test**

**Figure 1.2, Logo**

## B. Topographical data and maps

Research also needed to be conducted on the moon's topography. The moon is a satellite of Earth, and is the fifth largest body in the solar system and is approximately 384,403 kilometers away from Earth. With many unique characteristics that make it interesting to scientists, astronomers, and geologists, the moon includes many deep craters, prominent rocks, steep slopes, and cliffs, which can create a problem while attempting to land.

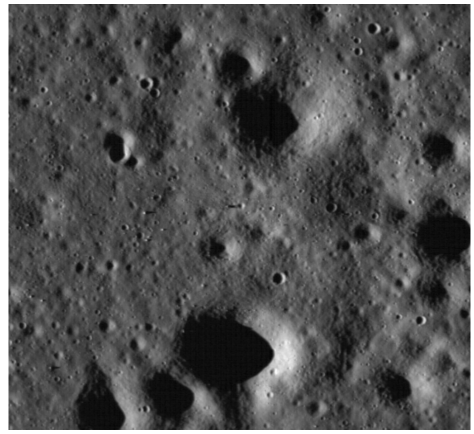


Figure 2, Image around which the model was based.

To complete the project assignment accurately, it was necessary to find as much information about the Taurus- Littrow Valley Region as possible. The process began by searching the internet. After extracting information, such as panoramas, elevation maps, and journals, more data was needed. The project engineers continued their research by meeting with space scientists to discuss Lunar Reconnaissance Orbiter images and surface journals. One key image, Figure 2, is based on a scale of 1 kilometer. The collected information allowed the project to choose a scale on which to base the model. The project mockup is based upon Figure 2 because of the 1 kilometer scale, as it was the most detailed and builder friendly. The picture was split into sixty-four equal squares, which gave the map a grid to compare the physical mockup to. Each square on the map was equal to one 1' x 1' section, making the mockup approximately equal to eight by eight feet. The three major craters served as reference points while creating the mockup.

## C. Materials and Budgeting

During the course of this project, materials and budgets were constantly evaluated for the lowest possible weight and the least cost. It was decided that the following major materials would fit the above criteria the best: charcoal powder, Portland cement, talcum powder, plywood, foam board, aluminum screening, and wood glue. After brainstorming, and revising the project structure, a computer generated cross section (Figure 3) was created to demonstrate the types of materials needed and how they were significant in the project assignment.

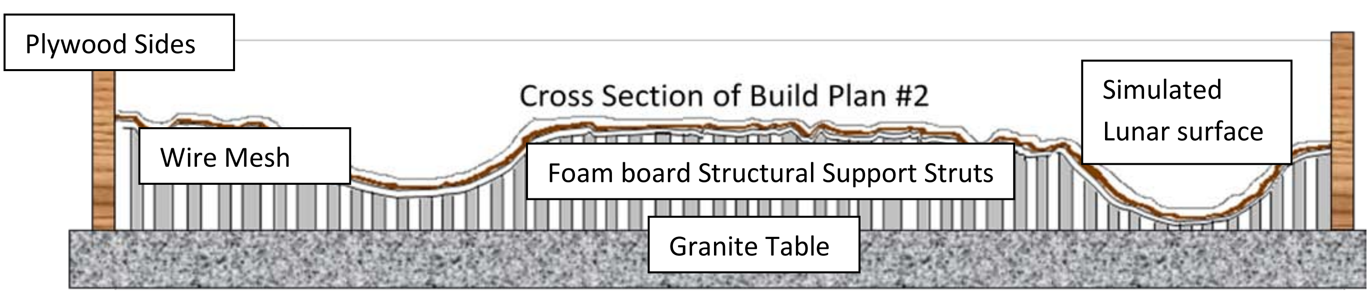



Figure 3, Model Cross section designed by Hollie O'Brien

A budget was needed with specifications and quantities of each item. These items were purchased from retail stores in the general vicinity of Johnson Space Center. Budgets needed to be completed for the rapid prototype and final mockup, and then were combined into a total budget.

## Total Materials Budget

| | | | |
|---|---|---|---|
| **White Foam board** | **4X8** | **25** | **~$380** |
| **Portland Cement** | **47lb. Bag Type 1 Gray CEMEX** | **2** | **~$95** |
| **Black Charcoal** | **25lb.** | **1** | **~$80** |
| **Talcum Powder** | **22 oz.** | **4** | **~$10** |
| **Plywood** | **32ft by 1ft** | **2 -4X ½ X8** | **~$75** |
| **Wire Mesh** | **64 square feet** | **$3.76/Sq Ft** | **~$40** |
| **Plaster Cloth** | **36”X6 yards** | **9** | **~$100** |
| **Supporting Materials** | **Tape, nails, brushes, lights, Plastic sheet, Wire Cutters, Exact-o Knife** | **1 of each** | **~$200 Total:$1,263- including the prototype materials** |

Table 1

The allowable budget (Table 1) for the mockup project was between two and five thousand dollars. The final estimated cost for the entire project was $1,300, and the total spent was $1,260.

### D. Albedo and lighting calculations

In order to ensure the model was as accurate as possible, the lighting conditions on the moon needed to be replicated. Albedo, light source, distance, angles, azimuths, and illuminance all had to be incorporated to create an accurate portrayal. The project needed to take into account the three times the Project M members needed to visualize: the beginning, middle, and end of mission. They also needed to analyze the three possible times of the year the lander might need to land: July, August, and September of 2013. After first researching on the

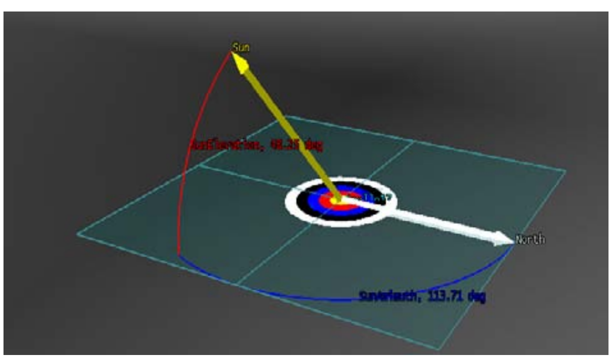
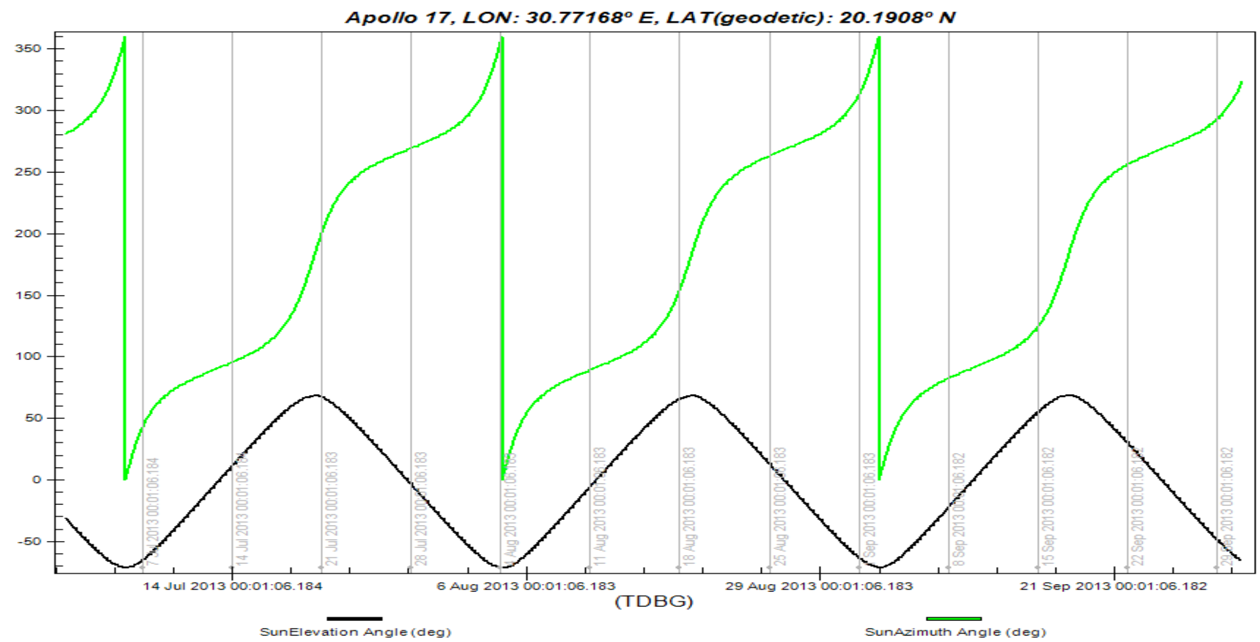



Figure 4, Example of a sub solar point

internet, it was found that an azimuth is the angle from true north at which the sun is located. The elevation notes how high the sun is in the lunar sky. The combination of these two angles produces a sub solar coordinate, generally a specific point of interest. This sub solar coordinate would set a standard point by which to measure the albedo, and base the lighting distances off of later. The times that were wanted, July 2013- September 2013, and the sub solar point that were needed was entered into a data sheet, which was previously created to generate a list of sun azimuths and elevations for each minute of each day, of each month. This data is depicted in Graph 1 below.




**Graph 1, Collected Lighting Data**

This graph represents all 132,486 data points collected. The data matches expected trends as the moon revolves around the Earth in the same circular path every month, thus the trigonometric functions of sine and tangent will be present. It was then necessary to complete the following procedure to filter, sort, and utilize the collected data:

1. Filter out all elevations <0. Take elements with elevation >= 0 and copy to new workbook.
2. Sort by date. Separate into 3 groups (3 lunar days).
3. Do a count of the number of points (minutes). Divide by 12, which should give the number of minutes "x" in a lunar hour (assuming a 12 hour day). This gives row 1 = 6 a.m., row x = 7 a.m., row 2x = 8 a.m.
4. Record azimuth/elevation corresponding to 8, 9, 10 a.m. These are the solar vectors for that lunar day.

5. Repeat for other 2 lunar days. Total: 9 solar vectors.
6. Place model on table. Determine "North" vector. Use Azimuth and a protractor to get 9 lines for the sun. Mark off these lines with tape on the floor.
7. Pick a distance from the center of the model. Use tangent of elevation angle to figure out height of light.

After the angle, elevation, and position were found, the simulated albedo needed to be determined. Albedo is the reflectivity of the simulated lunar regolith, a layer of loose, heterogeneous material. The albedo of the simulated lunar regolith was found by doing the following:

1. Place luminance meter (measured in candela meters squared, Figures 5, 7) on tripod and measure multiple points on the lunar surface, at respective angles of 45 degrees and 90 degrees. Average the luminance readings from a given point.
2. Average these readings as the average reflectance of the surface.
3. Measure illuminance with meter (measured in foot candles, Figure 6) of multiple same points.
4. Measure illuminance of light source- 67.6 fcd, 60 watt incandescent light bulb (Figure 6).

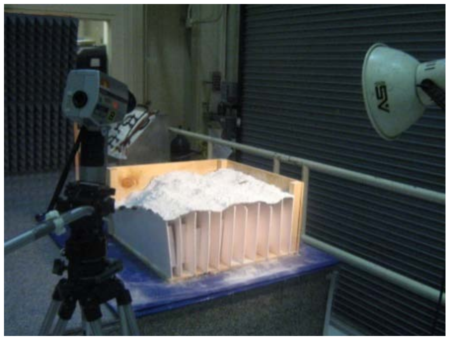


**Figure 5, Albedo measurement**

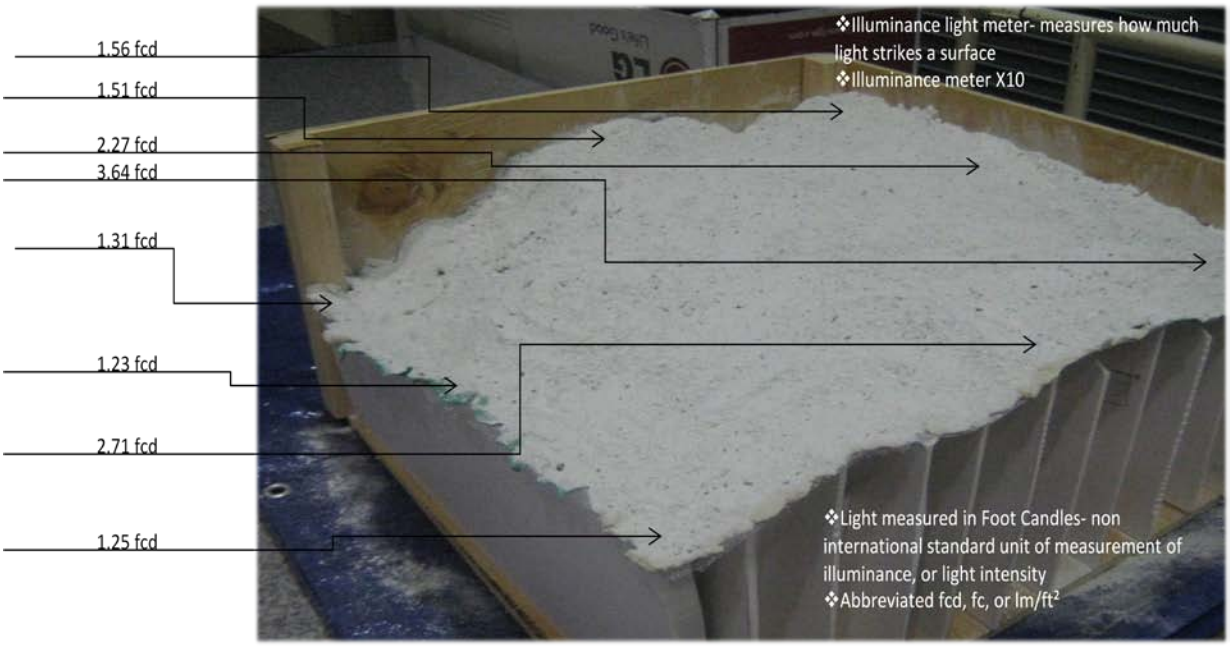



**Figure 6, Illumination of the surface**

5. Convert to lux –converted fcd to lux by multiplying by 10.764 lux/fcd
6. The measured reflectance divided by the measured illumination is an approximate estimate of the albedo.
7. The assumption made with this approach is that the lunar surface is uniformly diffuse. If a surface is uniformly reflecting in all directions, then lux = candela/m^2

**Figure 7, Illuminance Meter**

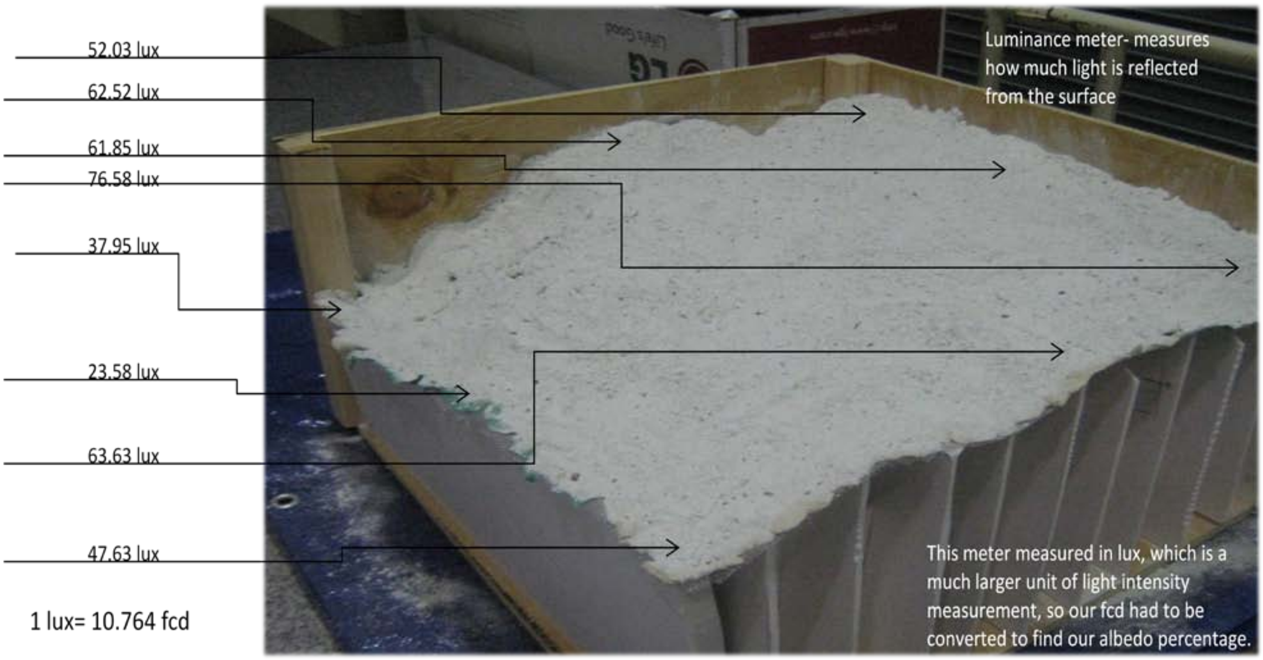



**Figure 8, luminance of the surface**

Using this method for finding the albedo, the prototype had a reflectivity of 37.15 %, which meant the charcoal powder needed to be increased in the regolith mixture, and the talcum powder could be decreased. One of the disadvantages to measuring the albedo using this method was the fact that the distance could not be easily scaled, and the intensity of the light's illuminance very likely interfered with the readings. By combining the azimuth angles, sun elevations, and albedo of the lunar soil, the project successfully replicated the shadows and lighting during the possible mission times, as well as the albedo percentage of 19%, similar to the Apollo 17 landing site during the possible times of landing.

## III. Procedures

After the research portion of the project was completed and all safety approvals were granted, the building of the prototype and model began. Through building the prototype, several changes in materials and build techniques were implemented because of the experience of building the prototype. After the materials were gathered, the foam board needed to be cut to size, those pieces contoured, and cut to the contours. The foam board struts provided support, and were glued on after the segments were completed (Figures 9, 10, 11).


Figure 9


Figure 10


Figure 11

While the foam board and struts were drying, construction began on the plywood box. The outside of the box was painted with black paint to make it more aesthetically pleasing and realistic of deep space (Figures 12, 13). Two handles were then installed on parallel sides of the box, (Figure 14). After the handles were installed, the contoured foam board was installed by means of wood glue and tape. The struts allowed the entire structure to be extraordinarily stable (Figure 15). The aluminum screening was then contoured to fit the craters and foam board, and nailed into place, to support the cloth and lunar regolith (Figures 16, 17).

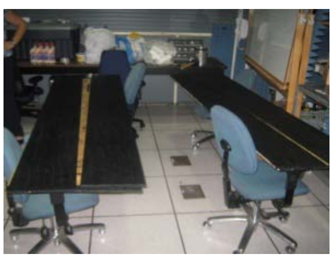


Figure 12


Figure 13


Figure 14

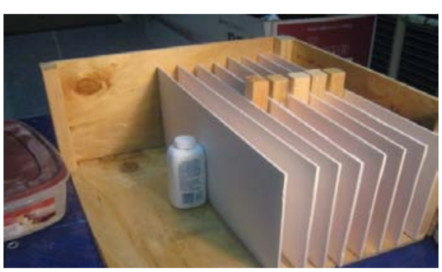


Figure 15


Figure 16


Figure 16

When building the prototype several types of clay were tested, and none worked the way that was needed. So, the modeling team resorted to using plaster cloth to cover the aluminum screening and making a base for the lunar regolith (Figures 18, 19). The simulated lunar regolith was added to the plaster cloth, and the mockup was then moved onto the granite table. Two cans of spray mount were then applied to keep the dust under control, and the soil in its place.

**Figure 18**

**Figure 19**

## IV. Conclusion

In conclusion, the project was completed accurately, with the necessary lighting conditions, contours, and structural support, providing a fully functioning three-dimensional model to aid in visualizing the approach and terminal descent phases of the Project M lander. Further tests and expansions suggested for this model include continuing to create a more realistic and accurate lighting environment, adding models on the simulated surface, and calculating trajectories from which the lander can approach.

## Acknowledgements

The author thanks the following persons for their valuable contributions to this project:

Dr. Timothy P. Crain, Mentor

Mr. Richard B. Mrozinski, Supervisor

Ms. Hollie O’Brien, INSPIRE Program Intern

Ms. Linda Smith, INSPIRE Program Coordinator

Ms. Alissa Keil, INSPIRE Program Coordinator

Ms. Jeanette Fanelli, Aeroscience and Flight Mechanics Division Executive Assistant

Mr. Mark Hammerschmidt, Deputy- Aeroscience and Flight Mechanics Division

Ms. Angie Zavala, Aeroscience and Flight Mechanics Division Administrative Officer

Mr. Chet Lund, Aeroscience and Flight Mechanics Division Safety Officer

Mr. Dean Eppler, Space Scientist

Mr. Jim Maida, assistance with lighting data

Mr. Jacob Sullivan, assistance with data analysis

## References

[1]Crain, Timothy., "Landing a Humanoid Robot on the Moon in a 1000 Days 'Project M'," Aeroscience and Flight Mechanics Division., NASA JSC, Houston, TX, 2009.

[2]Crain, interview by Christopher Vanik. *Project Leader* (June 14th-August 6th, 2010).

[3]Crain, Timothy P. "Project M." July 19, 2010. http://robonaut.jsc.nasa.gov/default.asp (accessed July 19, 2010).

[4]Eppler, Dean, interview by Christopher Vanik. *Space Scientist* (July 16, 2010).

[5]Sullivan, Jacob, interview by Christopher Vanik. *Aerospace Engineer* (July 29, 2010).

# Exit Presentation

Presenter: Christopher Vanik

Mentor: Dr. Timothy P. Crain

NASA JSC INSPIRE Tier 2B Intern

Photo Credit: Dr. Steven Lee, Curator of Planetary Science, Denver Museum of Nature and Science

# Agenda



- NASA INSPIRE SSE 2010 Program Overview
- About Me
- Project Assignment
- Project Research
- Project Documentation
- Other Connections, Opportunities, and Activities

- What I've Learned this Summer
- Future Plans
- Questions and Discussion

# NASA INSPIRE

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- ❖ Interdisciplinary National Science Project Incorporating Research and Education Experience- INSPIRE
- ❖ Online Learning Community (OLC)
- ❖ Tier 2B, Summer 2010 Summer STEM  Experience, Johnson Space Center (SSE, JSC)

- ❖ 8 Week Internship

# NASA INSPIRE Residential Interns

Christopher Vanik Exit Presentation

# About Me



- Born in Lancaster, Pennsylvania
- Live in Dolores, Colorado
- Montezuma- Cortez High School Senior
- Interests
  - Skiing, Bowling
  - Civil Air Patrol
  - Technology
  - Model Rocketry
  - Pilot's License

# About Me

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- Space Camp 2006
- Frontiers of Science Institute 2009
- NASA INSPIRE SSE Tier 2B 2010
- NASA INSPIRE SSE 2010
- NASA INSPIRE Pre college 2011
- Co- op Program 2012- 2016

- Guidance, Navigation, and Control (GN&C)
- Autonomous Flight Systems Branch – EG6
- Algorithm design
- Development of navigation systems
- Autonomous and intelligent GN&C systems
- Examples
    - ALHAT
    - Project M

# Project M



- Moon in 1000 Days
- Robonaut 2
- Propulsion method: methane and liquid oxygen
- Operated remotely by scientists on earth
- Primary purpose is to demonstrate innovation, better methods for engineering, and inspire students to pursue STEM related career
- Lander outfitted with ALHAT technology

# Project Overview and Objectives

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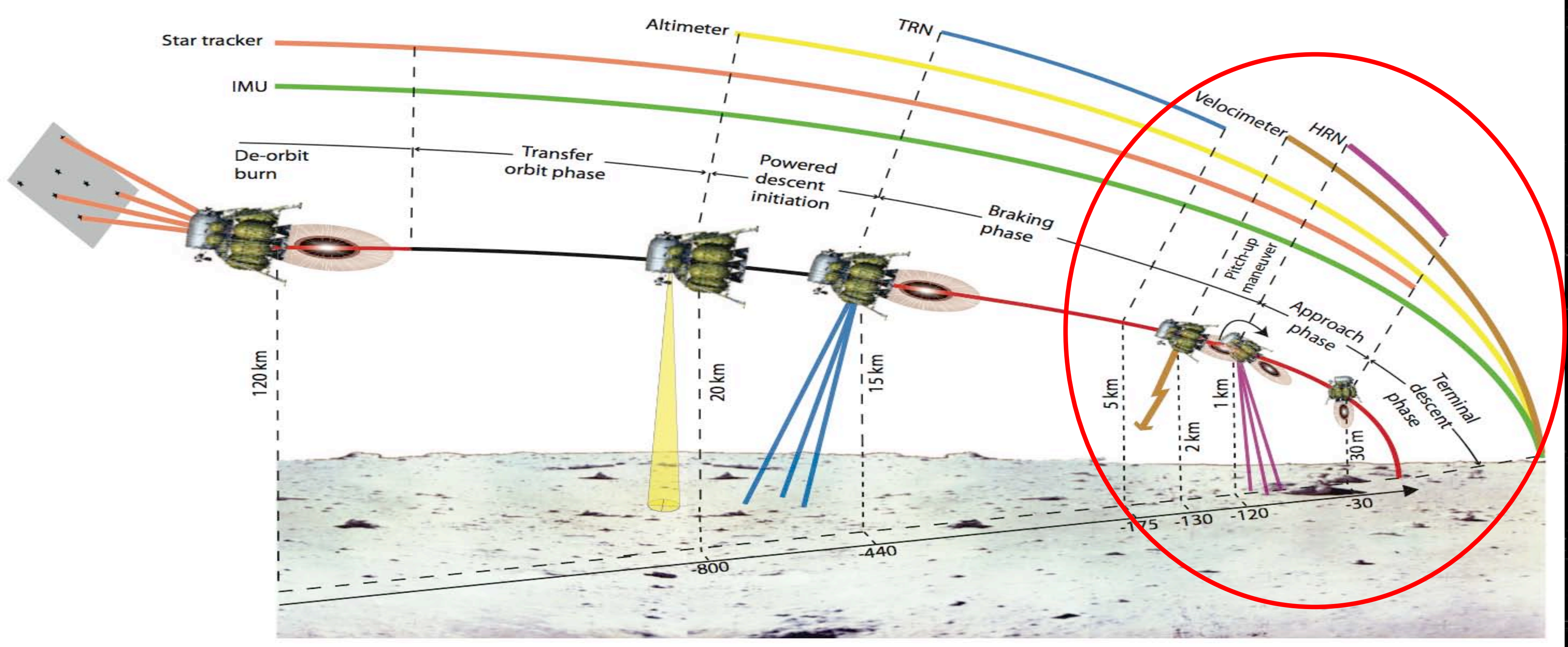

# ALHAT



- Autonomous Landing and Hazard Avoidance Technology
- Hazards- cliffs, steep slopes, tall rocks
- Could damage or tip Lander, harm payload
- Recognize these hazards and respond by selecting a new, safe landing site

# Project Overview and Objectives

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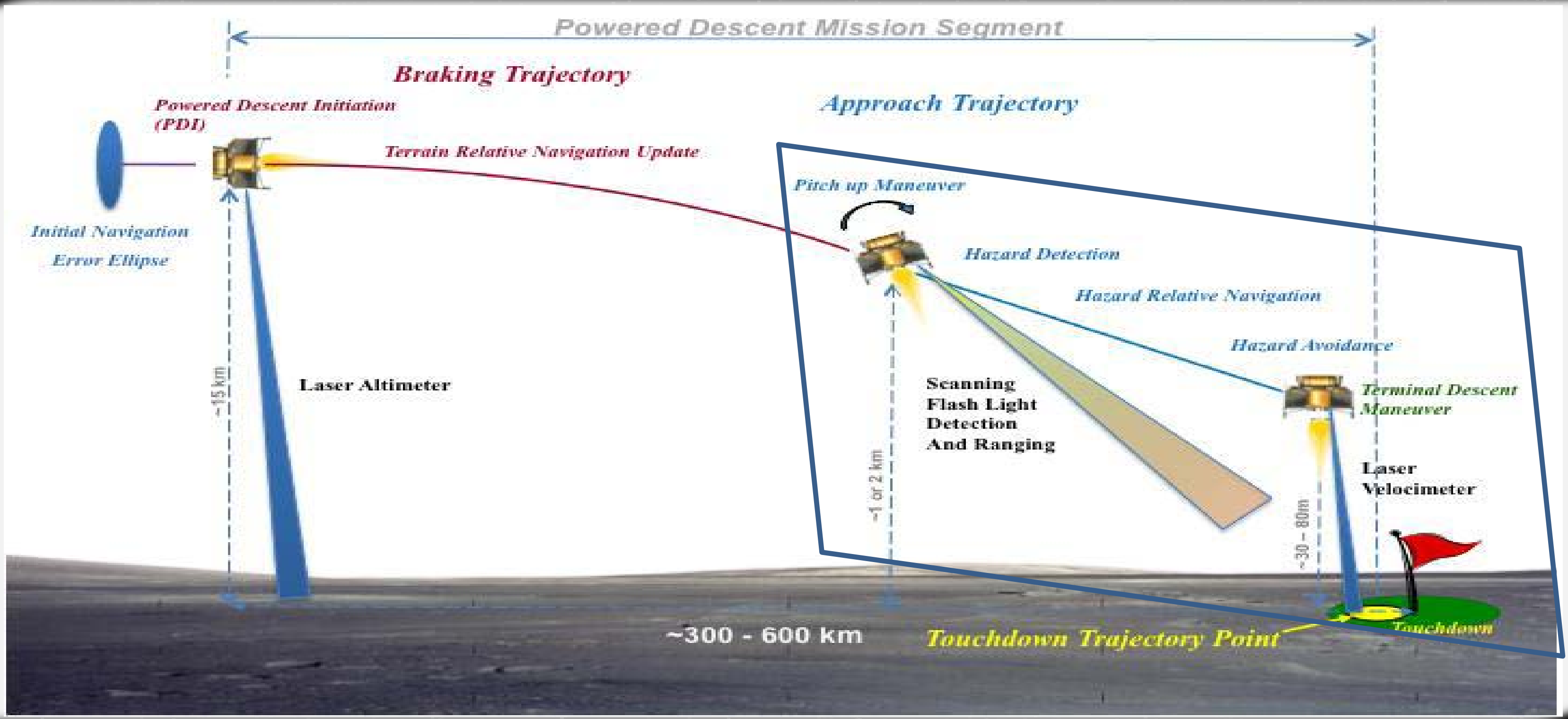

# Project Overview and Objectives

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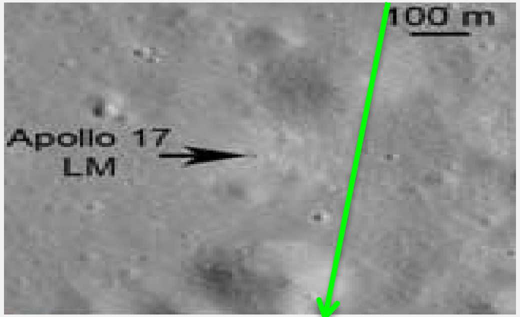
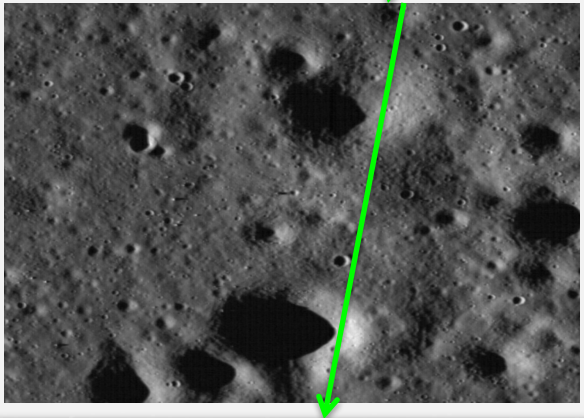
- ❖Scale Model of Apollo 17 Landing Site
- ❖Key Elements in this Model
    - ❖Surface Slope Characteristics
    - ❖Crater Sizes and Locations
    - ❖Prominent Rocks
    - ❖Lighting Conditions

- ❖Helps Project M Visualize the Landing Site
- ❖In collaboration with Ms. Hollie O'Brien



# Project Significance and Contributions

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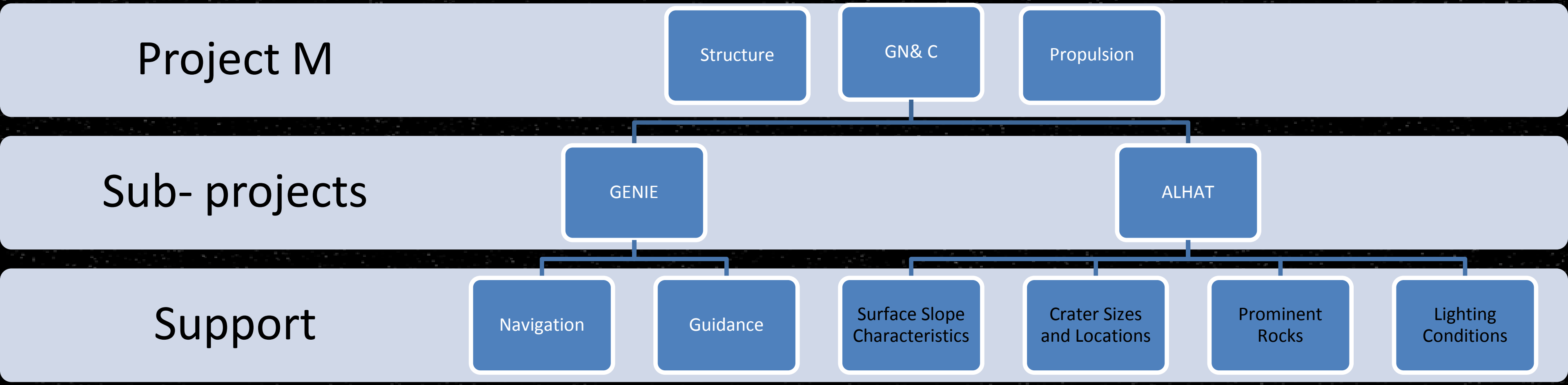

# Major Milestones

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- Milestone 1: Review research findings with mentor & EG staff
- Milestone 2: Review of construction plan for authority to proceed
- Milestone 3: Construct miniature model of lunar surface for scale use
- Milestone 4: Mid-term construction status report (verbal, walk-through)
- Milestone 5: Model demonstration and exit presentation

# Project Data and Documentation

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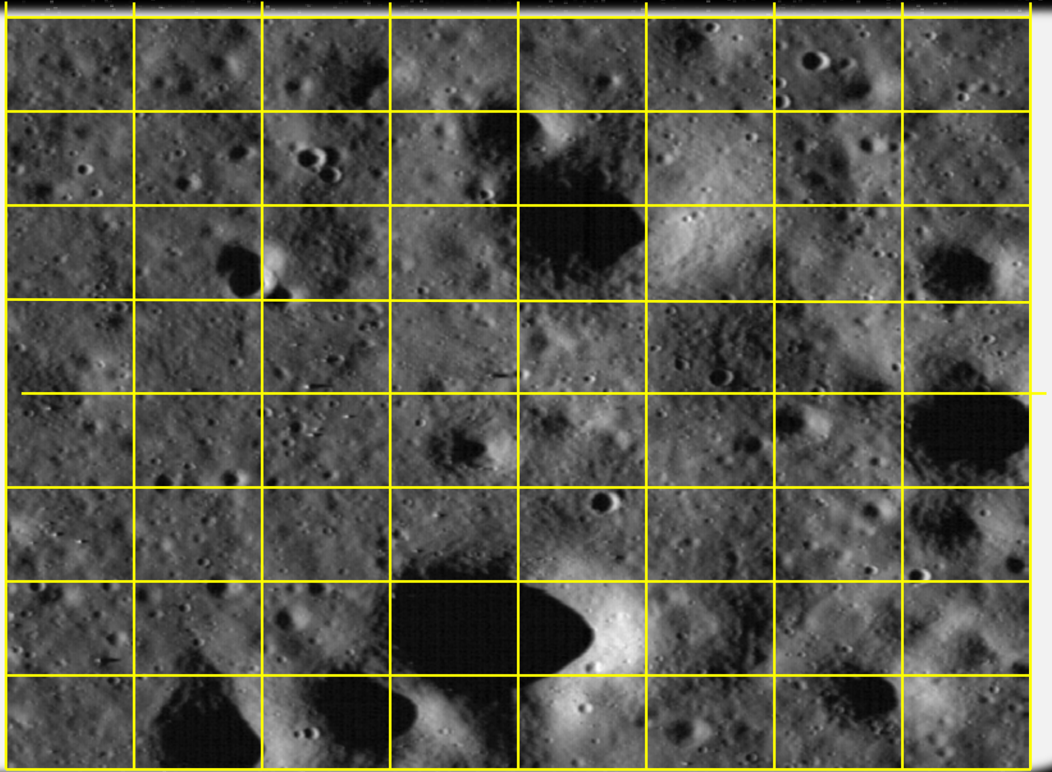
- Scale of 1 kilometer total
- Each square is approximately 1’ X 1’
- 1 inch= 10.42 meters



# Project Data and Documentation

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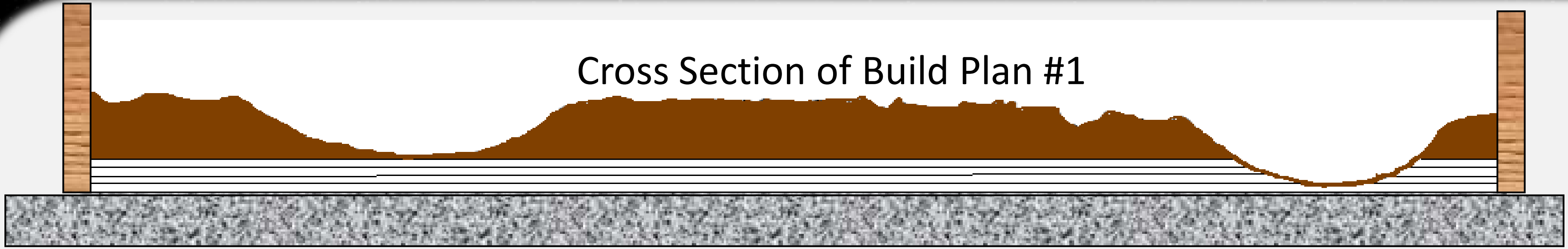


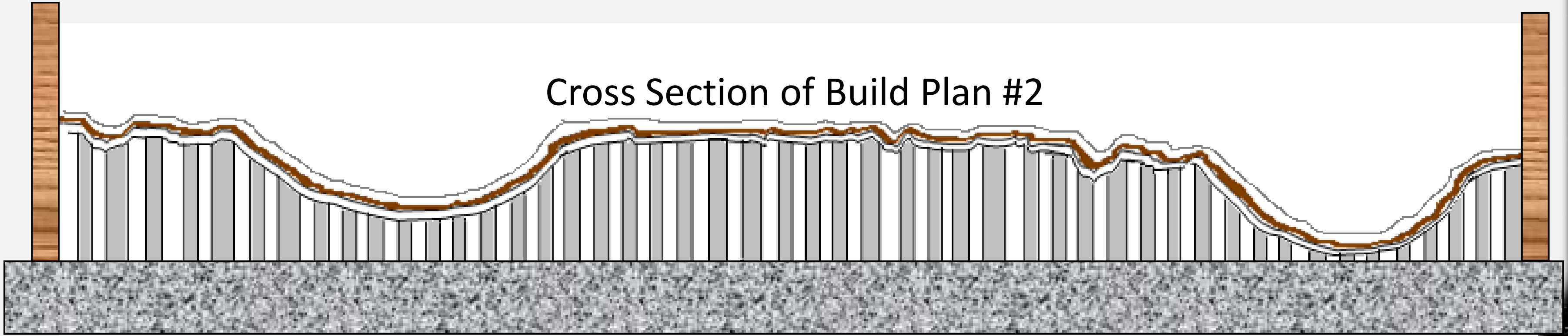

# Project Data and Documentation

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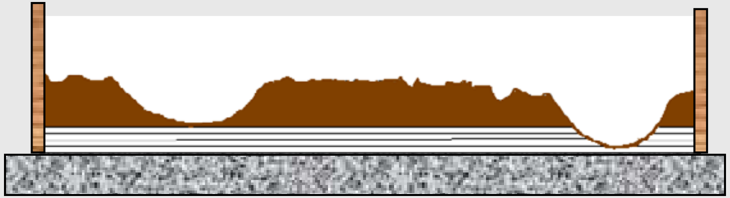
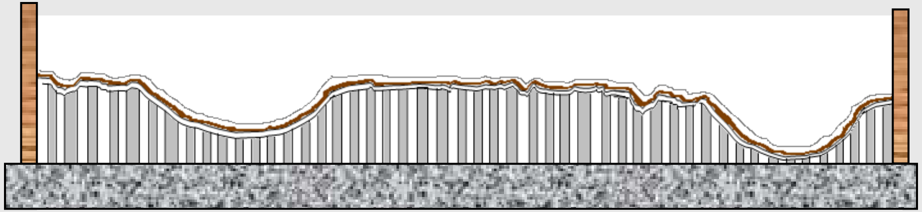
| | Plan 1: Original | Plan 2: Wire Mesh & Foam board |
|---|---|---|
| **Pros** | •Easier to reshape and reform in case of mistakes | ✓Light weight<br>✓Costs Less<br>✓Less Materials<br>✓Builders need to be less artistic<br>✓Easy to move and travel<br>✓Easy to clean up |
| |  |  |
| **Cons** | •Extremely Heavy<br>•Requires Art Skills<br>•More Material Intensive<br>•Costs More | •Contouring foam board is difficult<br>•Shaping Wire Mesh is very difficult |

# Project Safety Precautions



- Gained approval from Chet Lund
  - SPA (Safe Plan of Action)
    - Documented and Signed
  - MSDS (Material Safety Data Sheets)
    - Documented each chemical
  - Safe Techniques
    - Use safe lifting techniques
    - Protect sharp edges as necessary
    - Apply Personal Protection Equipment (PPE)

# Rapid Prototyping



- We Decided to do a Rapid Prototype- collaborated with Narchisha Norman
- Test Our Chosen Structure
- Revaluate Material Usage
- Evaluate building Techniques
- Evaluate ratio for lunar soil mixture for albedo testing
- 2’ X 2’ corner built to actual scale used in mockup

# Project Materials

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# Project Materials

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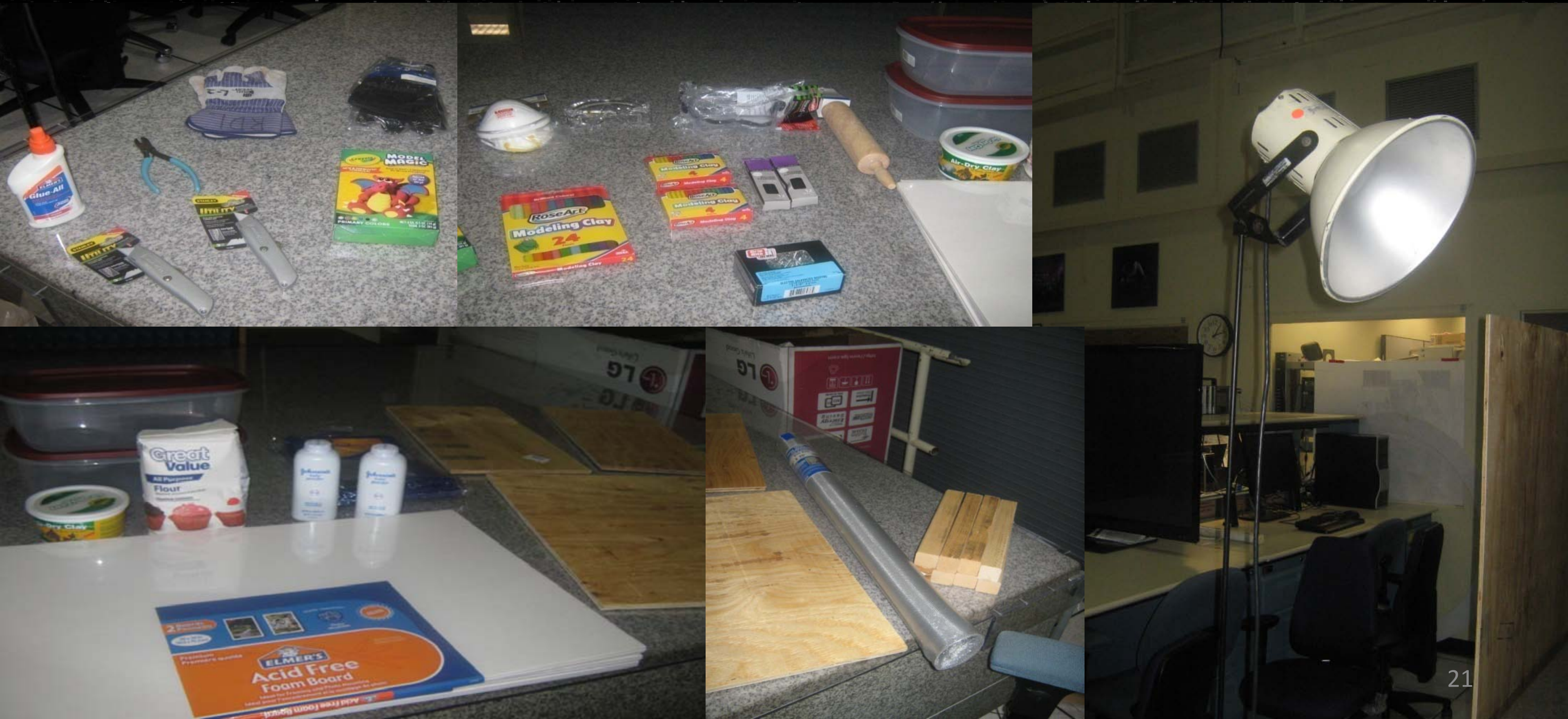

# Project Timeline

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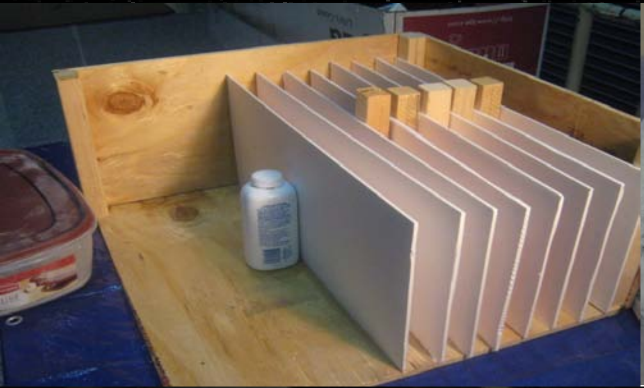

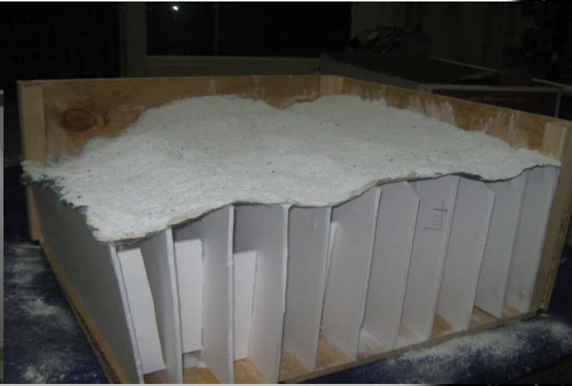

# Illumination Data Collected

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1.56 fcd

1.51 fcd

2.27 fcd

3.64 fcd

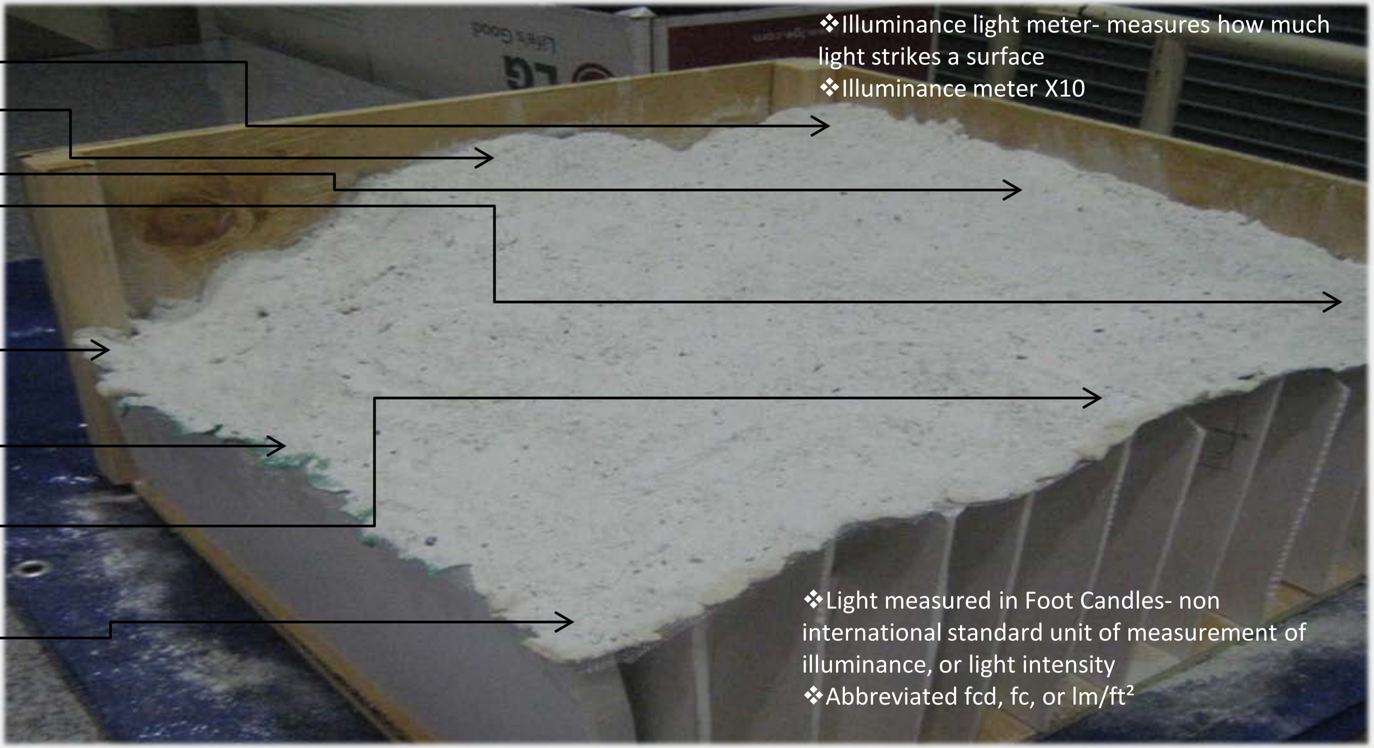
1.31 fcd

1.23 fcd

2.71 fcd

1.25 fcd

60 watt
incandescent light
bulb- 67.6 fcd



❖Illuminance light meter- measures how much light strikes a surface
❖Illuminance meter X10

❖Light measured in Foot Candles- non international standard unit of measurement of illuminance, or light intensity
❖Abbreviated fcd, fc, or $lm/ft^2$

# Lumination Data Collected

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52.03 lux

62.52 lux

61.85 lux

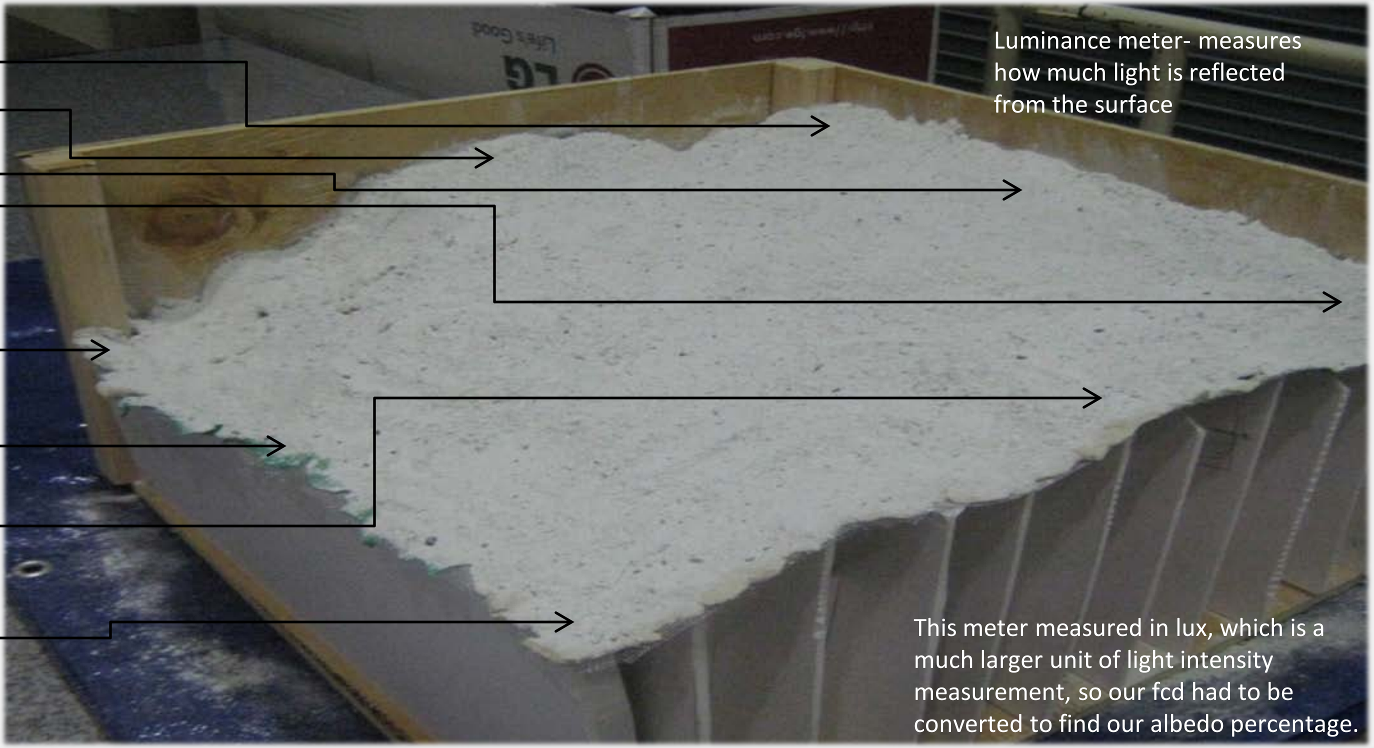
76.58 lux

37.95 lux

23.58 lux

63.63 lux

47.63 lux



Luminance meter- measures how much light is reflected from the surface

This meter measured in lux, which is a much larger unit of light intensity measurement, so our fcd had to be converted to find our albedo percentage.

1 lux= 10.764 fcd

# Project Albedo Calculations

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❖The measured reflectance divided by the measured illumination is an approximate estimate of the albedo.

❖ The assumption made with this approach is that the lunar surface is uniformly diffuse. If a surface is uniformly reflecting in all directions, then lux = candela/m^2

❖ Found out that the avg. albedo of the prototype was 37.15%, we needed 12%, so we needed to increase the charcoal and decrease the talcum powder usage

# Data and Lighting Conditions

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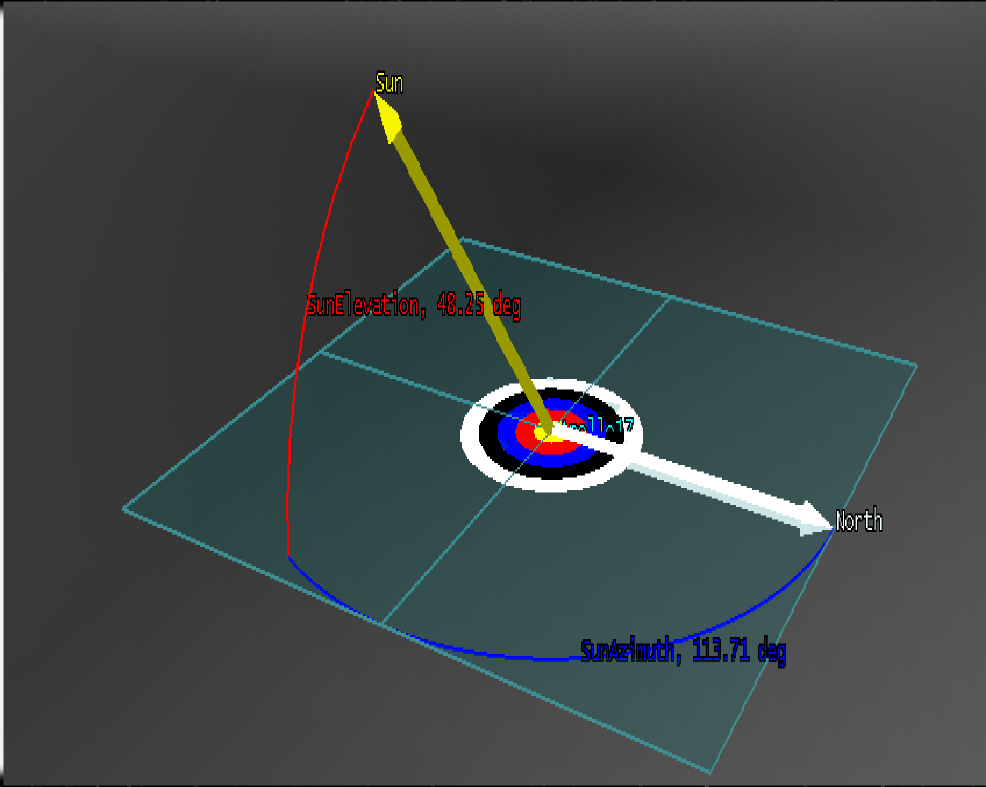
- ❖July, August, September 2013 were 3 possible times to land
- ❖Beginning, middle, end of mission lighting conditions to be replicated
- ❖Azimuth is angle sun is at from north
- ❖Elevation is how high it is in the lunar sky



# Excel Data Analysis

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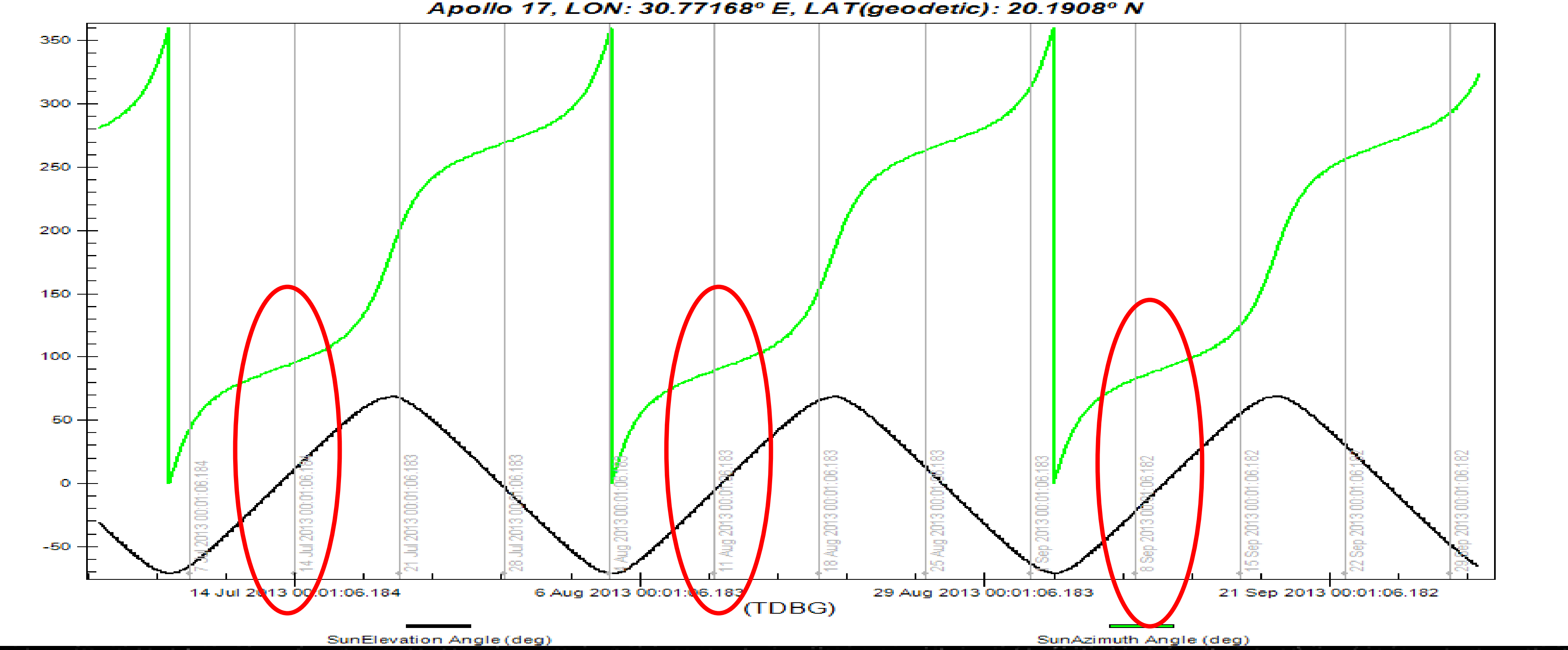

# Project Lighting Placement



| Time | Sun Azimuth | Sun Elevation | Lunar Time | Height of Simulated Sun | |
|---|---|---|---|---|---|
| 7/14/2013 18:21 | 99.018 | 19.305 | 8A.M | 1.0329m | |
| 7/15/2013 14:38 | 103.443 | 28.815 | 9A.M. | 1.649m | |
| 7/16/2013 10:55 | 108.806 | 38.126 | 10A.M. | 2.3523m | |
| 8/13/2013 5:22 | 99.096 | 19.305 | 8A.M. | 1.0329m | |
| 8/14/2013 1:34 | 103.489 | 28.708 | 9A.M. | 1.6424m | |
| 8/14/2013 21:47 | 108.814 | 37.986 | 10A.M. | 2.3438m | |
| 9/11/2013 17:15 | 98.839 | 19.478 | 8A.M. | 1.0623m | |
| 9/12/2013 13:44 | 103.273 | 29.08 | 9A.M. | 1.6629m | |
| 9/13/2013 10:13 | 108.659 | 38.484 | 10A.M. | 2.3863m | |

# Rapid Prototyping Summary

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We Found Out That:

- More charcoal powder- From lighting tests
- Less Portland Cement
- More nails
- Plywood base instead of plastic
- Less clay
- Need oil based clay, not air dry
- New Methods for contouring
- Cheaper wire mesh
- Stronger, more stable structure

# Project Budget

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| | | | |
|---|---|---|---|
| White Foam board | 4X8- Office Depot | 25 | ~$385 |
| Portland Cement | 47lb. Bag Type 1 Gray Cemex | 2 | ~$95 |
| Black Charcoal | 25lb. | 1 | ~$80 |
| Talcum Powder | 22 oz. - Walmart | 4 | ~$10 |
| Plywood | 32ft by 1ft- Home Depot | 2 -4X ½ X8 | ~$75 |
| Wire Mesh | 64 square feet- Walmart | $3.76/Sq Ft | ~$40 |
| Plaster Cloth | 36"X6 yards | 7 | ~$100 |
| Supporting Materials | Tape, nails, brushes, lights, Plastic sheet, Wire Cutters, Exact-o Knife- Walmart, Home Depot | 1 of each | ~$200<br><br>Total:$1,263- including the prototype materials |

# Final Build Pictures

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# Final Build Challenges

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- Materials delay
- Clay to plaster cloth
- Not enough charcoal to simulate lunar soil
- Technical paper
- Exit Presentation

# Project Results



- Mockup is completed
- Granite table still has original capacity
- Project M members are able to visualize
  - Approach phase
  - Terminal descent phase
  - Surface phase operations
- Accurate lighting conditions

- Albedo is 7-13%, which was our expected goal
- Remain in use for Project M for 3-5 years

# Feedback for NASA Associates



Positive Attributes:

- Open Door Policy

- Very Thorough in Explanation if I Needed Help
- Positive Attitude
- Support Structure

Possible Suggestions:

- More Frequent Sit Down Project Updates
- More Initial Project Details
- More Interactive Tours (eg. GENIE hardware)
- Warmer Work Area!

# Other Connections and Opportunities





- ❖ Mr. Gregory Reid Wiseman
- ❖ Neutral Buoyancy Lab
- ❖ Ellington Field
- ❖ Mission Control Center
- ❖ Lunar Samples Lab
- ❖ Mockup  Facility
- ❖ Galveston Beach Astronomy Viewing Night
- ❖ Gene Kranz Lecture
- ❖ Intern Professional Development Seminar

# Skills Learned/ Knowledge Acquired



- ❖ NASA Chain of Command and roles each serve
- ❖ Projects housed and centered at Johnson Space Center
- ❖ Lighting - subsolar point calculations, Trigonometry, placement, fcd, albedo, mixtures, ratios
- ❖ Russian- Я надеюсь, вы наслаждаетесь моего выступления!
- ❖ Communication via email and telephone
- ❖ Effective and professional meetings and presentations

- ❖ Professionalism
- ❖ Opportunities
    - ❖INSPIRE
    - ❖Co-op program

# Personal Challenges



- Waking up at 6:15 A.M. everyday
- Remaining professional
- Work-home balance- I always had something I wanted to do for work!

# Things I Will Miss



- IT Resources
- Security clearance
- Work environment
- My friends and colleagues
- My bed made when I return home

# Future Plans



- Embry – Riddle Aeronautical University -Prescott, AZ
  - Computer Engineering
  - Aerospace Engineering

- Employed in either an aeronautics or technology capacity by:
  - NASA
  - Lockheed Martin
  - Boeing
  - Microsoft

# Acknowledgments




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- Ms. Alissa Keil, INSPIRE program coordinator
- Ms. Jeanette Fanelli, EG1 Executive Assistant
- Mr. Mark Hammerschmidt, Deputy- Aeroscience and Flight Mechanics Division
- Ms. Angie Zavala, Administrative Officer
- Mr. Chet Lund, Safety Officer
- Ms. Narchisha Norman, Intellectual contributor, Ph. D. Candidate
- EG6 Personnel

# Thank You



Thank you for your support, help, and attendance.

# Questions and Answers



Are there any questions I can answer at the current time?