NDSG AFFILIATES MEETING 2017

Testing Apollo Lunar Tool Modifications in a Regolith Bin

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APRIL 8, 2017

Outline

- Introduction
- Background
- Statement of Problem
- Data
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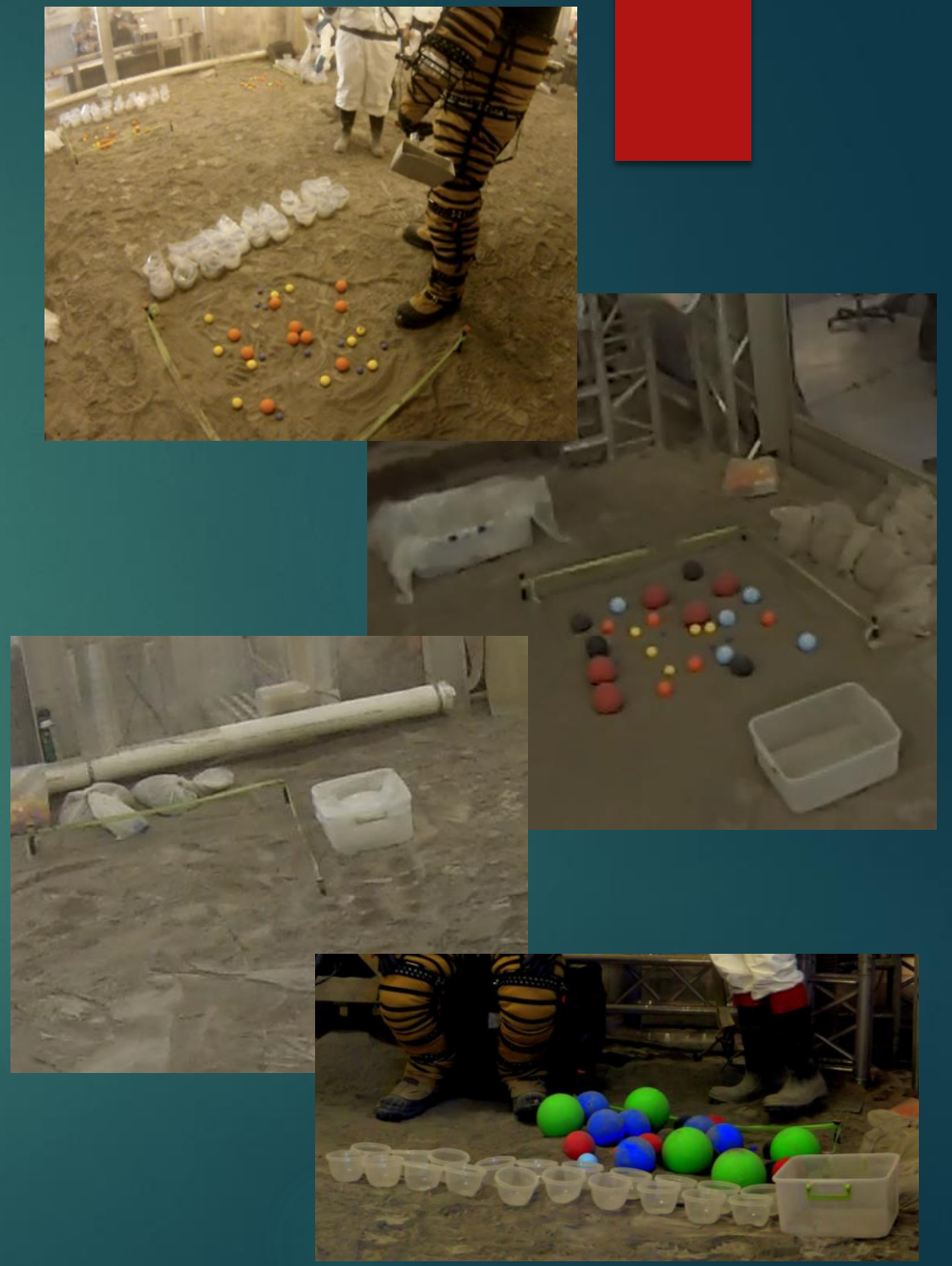
- Future Research Directions
- Questions

http://www.apolloarchive.com/apollo_gallery.html {Credit: NASA}

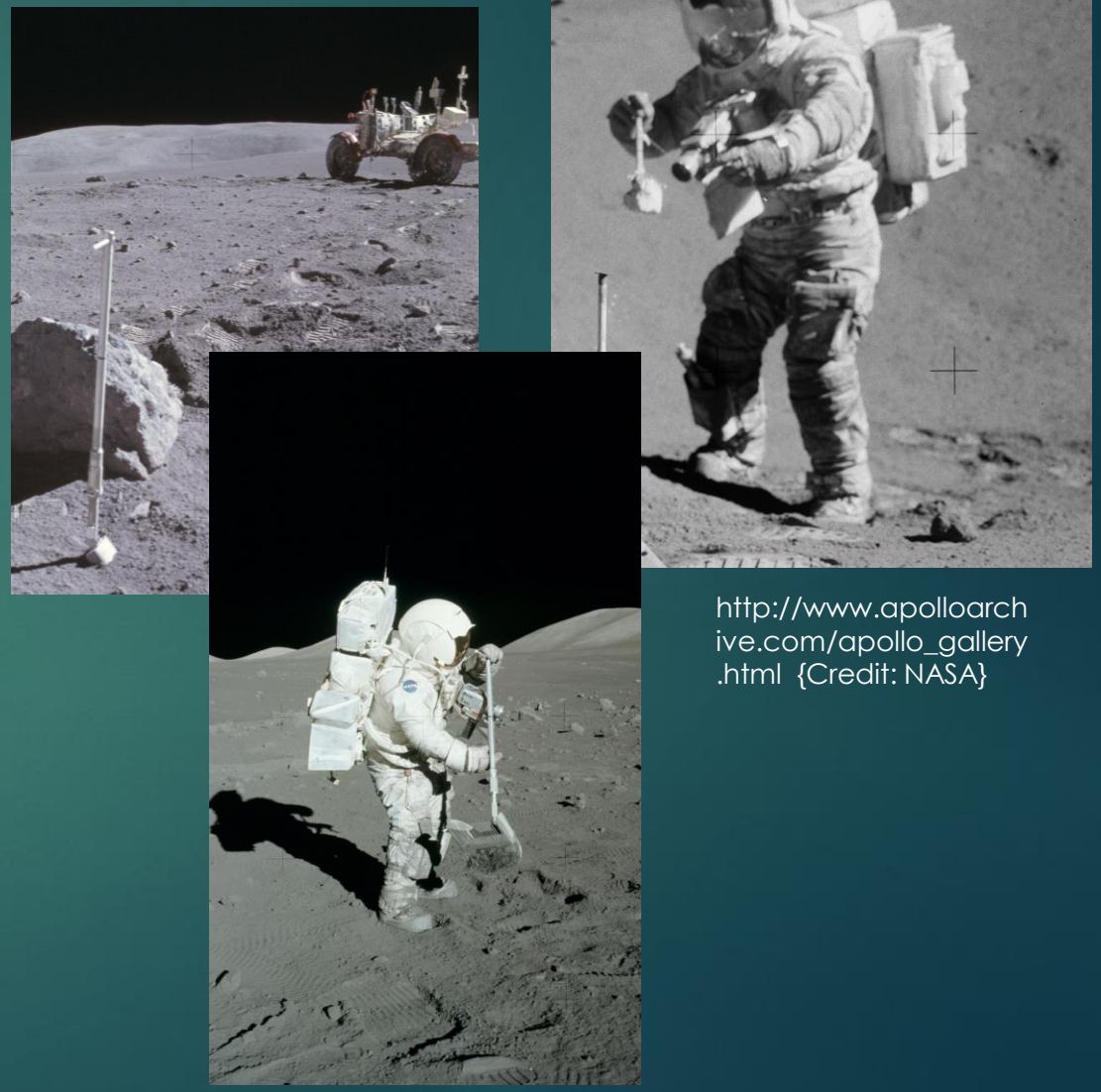
Introduction

- 2016 Graduate of UND's Space Studies Department
- Received funding through ND Space Grant Consortium's Fellowship program in Spring 2016 semester
- Thesis titled: A comparative analysis of the geology tools used during the Apollo Lunar Program and their suitability for future missions to the Moon



Background - Methodology

- Selected three Apollo geology tools to test handle modification
  - Tools:
    - Scoop
    - Tongs
    - Rake
  - Modifications
    - Increased handle diameter
    - PVC handle covers



http://www.apolloarchive.com/apollo_gallery.html {Credit: NASA}

Background

Config. 1a/b	Config. 2	Config. 3	Config. 4

Config. 1a/b	Config. 2	Config. 3	Config. 4

Config. 1a/b	Config. 2

Background

- Secondary purpose
  - Develop methodology for tool testing
  - First pressurized-suited testing at NASA KSC's Swamp Work's regolith bin
  - Collaboration between UND, NASA KSC, and NASA JSC

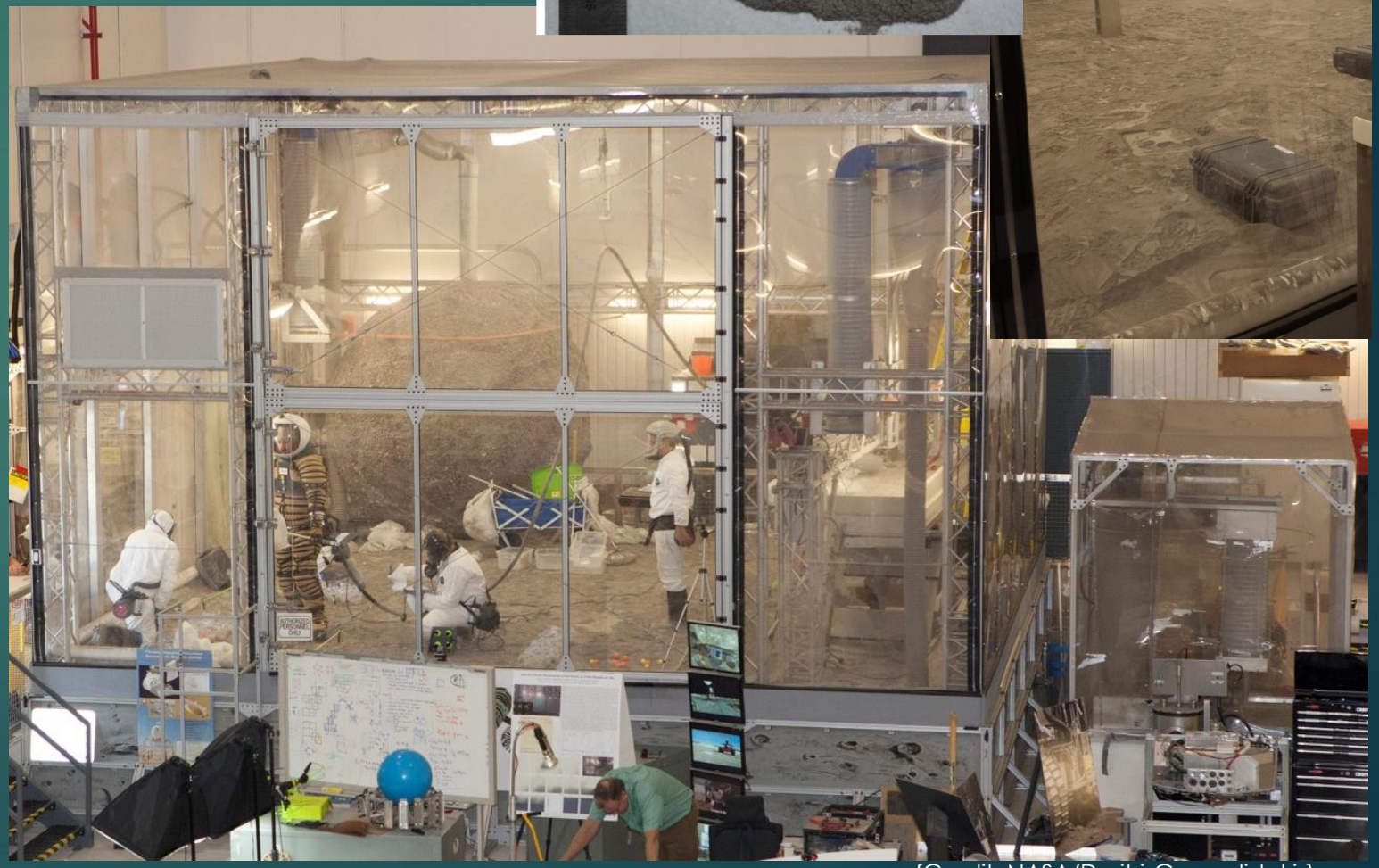
{Credit: UND Human Spaceflight Laboratory}

{Credit: NASA-JSC: Larry K. Dungan}

Background

- Regolith bin
  - Surface area: 24 x 25 feet (7.3 x 7.6 m)
  - Height: 18 feet (5.5 m)
  - Regolith depth: 42 inches (1.1 m)
- Regolith simulant BP-1

(Suescun-Florez et al., 2015)



{Credit: NASA/Dmitri Gerondidakis}

Statement of Problem

This research is looking forward to answer some specific questions for the next steps in space exploration as outlined by the NASA Authorization Act of 2010 and NASA's declared plan for future manned planetary missions (NASA's Journey to Mars, 2015). EVA tool design is integral to human exploration of planetary bodies. A determination needs to be made whether hardware can be improved for different tasks so they may be performed efficiently and with the least physical strain and fatigue.

Data

- Objective data gathered in real time
- Subjective data gathered post-test
- Two subjects
- Various measures collected for each tool with all handle combinations

Results

- Significant differences for a modification in the combined subjects' data were supported in some instances by a single subject's data.
- No handle modifications were found to make a significant difference in a tool's performance from that of the baseline configuration in both Subject 1 and Subject 2's individual data.

- The subjective data submitted by both subjects favored the modifications over the original tools' configurations.
- This difference in perceived versus actual performance cannot be readily explained within the scope of this experiment.

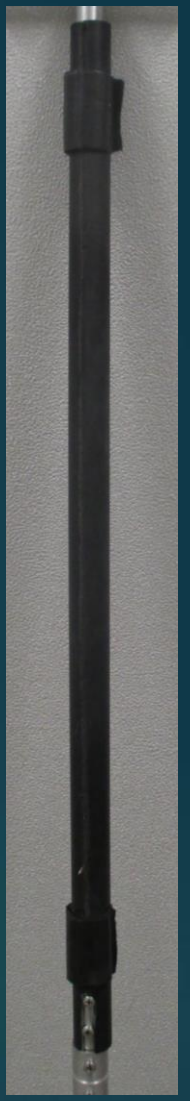
Future Research Directions - Testing

- Increased subject numbers
- Selecting subjects for specific personality traits or using select-out methods to avoid other traits
- Increased number of runs
- Different target sizes and shapes
- Scoop target test needs a new regolith collection system
- Motion Capture
- More emphasis on subjective data capture

{Credit: NASA-JSC: Larry K. Dungan},

Future Research Directions – Tool Modifications

- Handles were only tested at two different diameters
  - Unknown if a special case exists: maximum or minimum
- Testing a range of handle sizes, starting at the initial handle diameter and increasing through diameters that are large enough to show detriment to usability
- Permanent handle modifications
- Other tool modifications
  - Length
  - Rake: Subject 2 stated, "It clearly is the tool that needs [the most] redesign of all the tested ones."



Future Research Directions – Regolith Bin Testing

- Passing of the air or the air umbilical into the bin
  - Air umbilical was then suspended from a rope and pulley system above the regolith bin
  - Could be beneficial to have fittings placed at strategic points along the perimeter
  - Necessity to first connect the subject to the umbilical outside the bin before
- Wired communication system was used
  - Connections placed around the inside perimeter
  - Built in wireless system
- Camera system could be hardwired into the building

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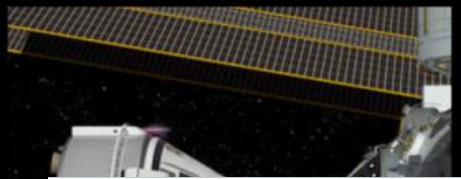

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@Astro_CabanaBob

Former astronaut and current Center Director of Kennedy Space Center.

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Testing Uof North Dakota's suit in regolith at Swamp Works. Cool stuff

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Spacesuit design tested at KSC's Swampworks facility to see how it might perform on another world. Learn more: go.nasa.gov/1UK3Vfz

View summary

Acknowledgements

- University of North Dakota's Space Studies Department
- Kennedy Space Center and Swamp Works – in particular Jack Fox, Doug Gruendel, and Joe Beardall
- Johnson Space Center
- The North Dakota Space Grant Consortium (NDSGC)

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Questions?