

2026 NASA LUNABOTICS UNIVERSITY COMPETITION: SITE PREPARATION WITH BULK REGOLITH

**XXVI Space Resources Roundtable
Colorado School of Mines
June 3, 2026**

Rob Mueller

Senior Technologist - Swamp Works

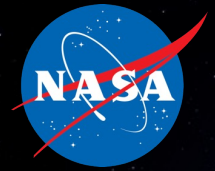
**Laboratories, Development & Testing Division (NE-L)
Granular Mechanics & Regolith Operations (GMRO) Lab**

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Kennedy Space Center, Florida, USA

Co-Authors

National Aeronautics and
Space Administration



Cislune inc.

Erik Franks - Cislune

Emily Stephens – University of Central Florida

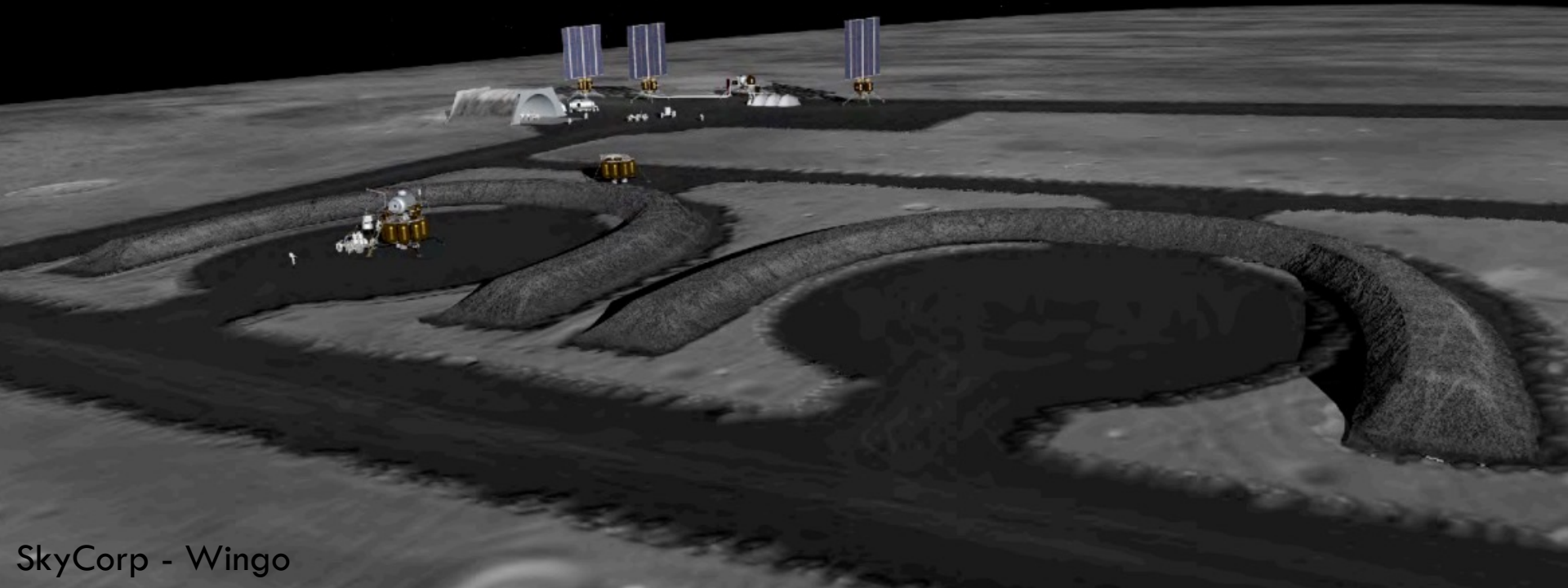
Hale Reynolds - All-Star Agency



NASA
Artemis 2 Lunar Flyby
April 6, 2026

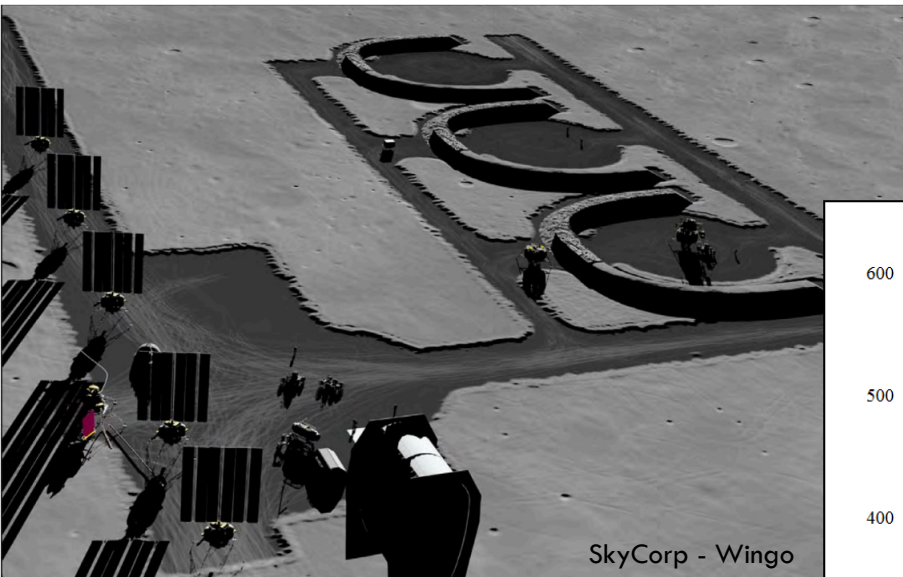
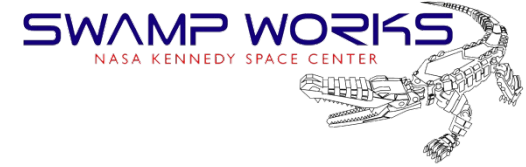


Concept for a Future SpacePort on the Moon



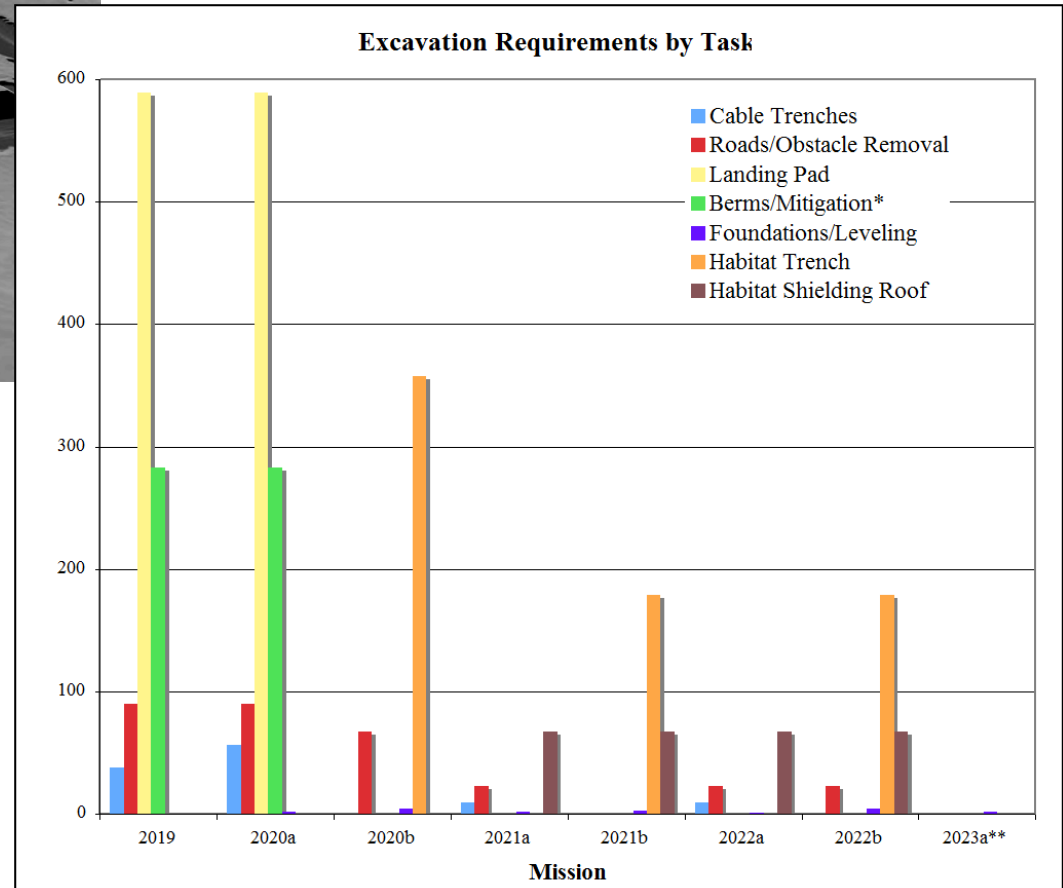


Lunar Surface Construction Tasks



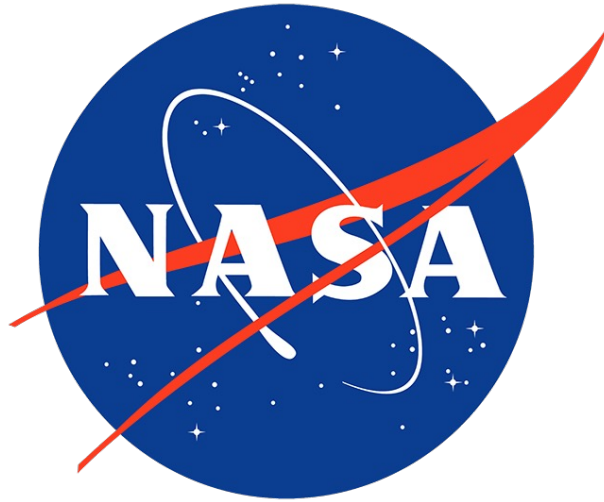
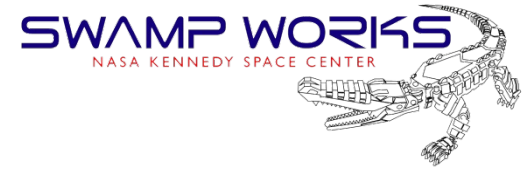
Criteria for Lunar Outpost Excavation
 R. P. Mueller and R. H. King
 Space Resources Roundtable –SRR IX
 October 26, 2007
 Golden, Colorado

SUMMARY	
Task	%
Trenching	4
Clearing and Compacting	48
Building Berms	18
Habitat Shielding	31
	100
Ice Mining	17
Regolith Mining	83
Construction	84
Mining	16





NASA Regolith Excavation Challenge: 2007-2009

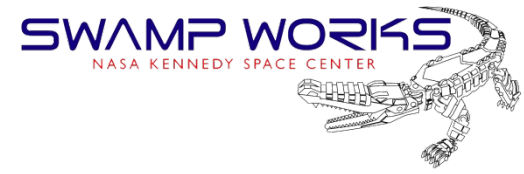


CENTENNIAL CHALLENGES

- In 2005 the United States of America congress funded a program of contests to stimulate innovation and competition in technical areas of interest to NASA.
- The Regolith Excavation Centennial Challenge was won in 2009 by Paul's Robotics, Worcester Polytechnic Institute, MA. - \$500,000 prize



2010 - 2026



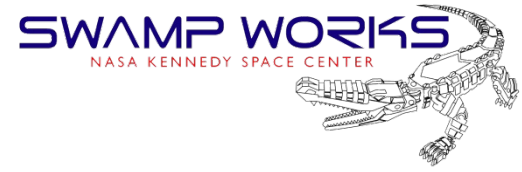
17th Anniversary of Lunabotics!

<https://www.nasa.gov/learning-resources/lunabotics-challenge/>





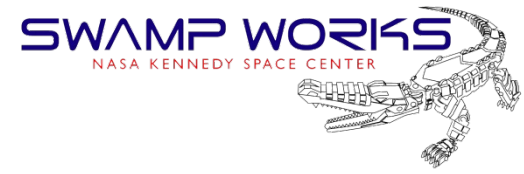
Lunabot Specifications



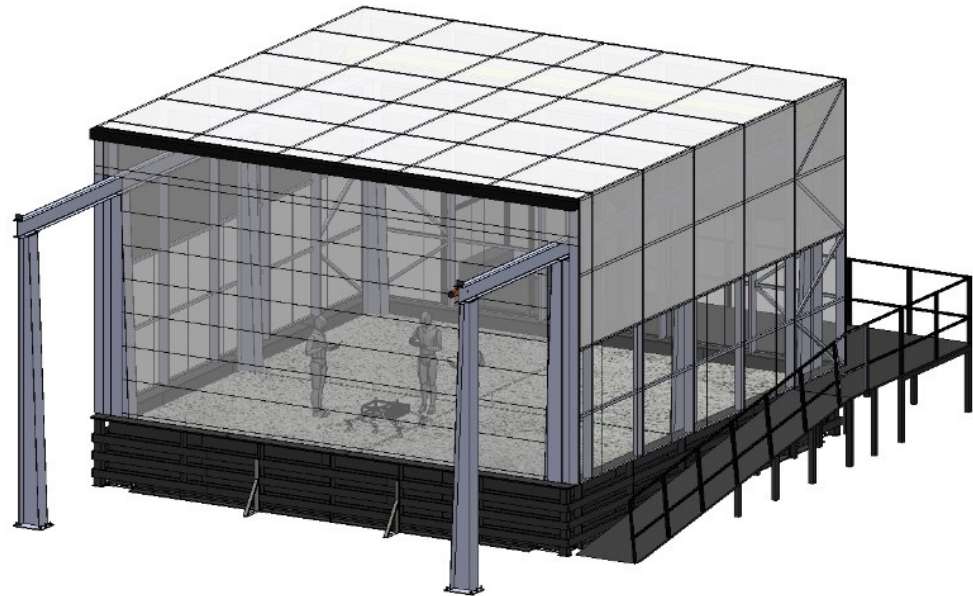
- ✓ **Robot Controlled Remotely or Autonomously**
- ✓ **Visual and Auditory Isolation from Operator**
- ✓ **Excavates Exolith Lunar Highlands Simulant (LHS) & Black Point 1 (BP-1) Simulant**
- ✓ **Builds a berm structure with excavated regolith**
- ✓ **Mass Limit - 80 kg**
- ✓ **Lunabot Dimension Limits - 1.5m x 0.75m x 0.75m**
- ✓ **Designed, Built, Tested and Operated by University Student Teams**
- ✓ **Must use NASA Systems Engineering methods**



UCF Qualification Event

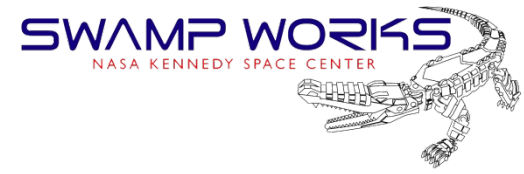


- A qualification event was held for 47 teams at the University of Central Florida (UCF) Exolith Lab in Orlando, Florida
 - 10m x 10m x 1 m deep
 - Exolith Lunar Highlands Regolith Simulant (LHS)

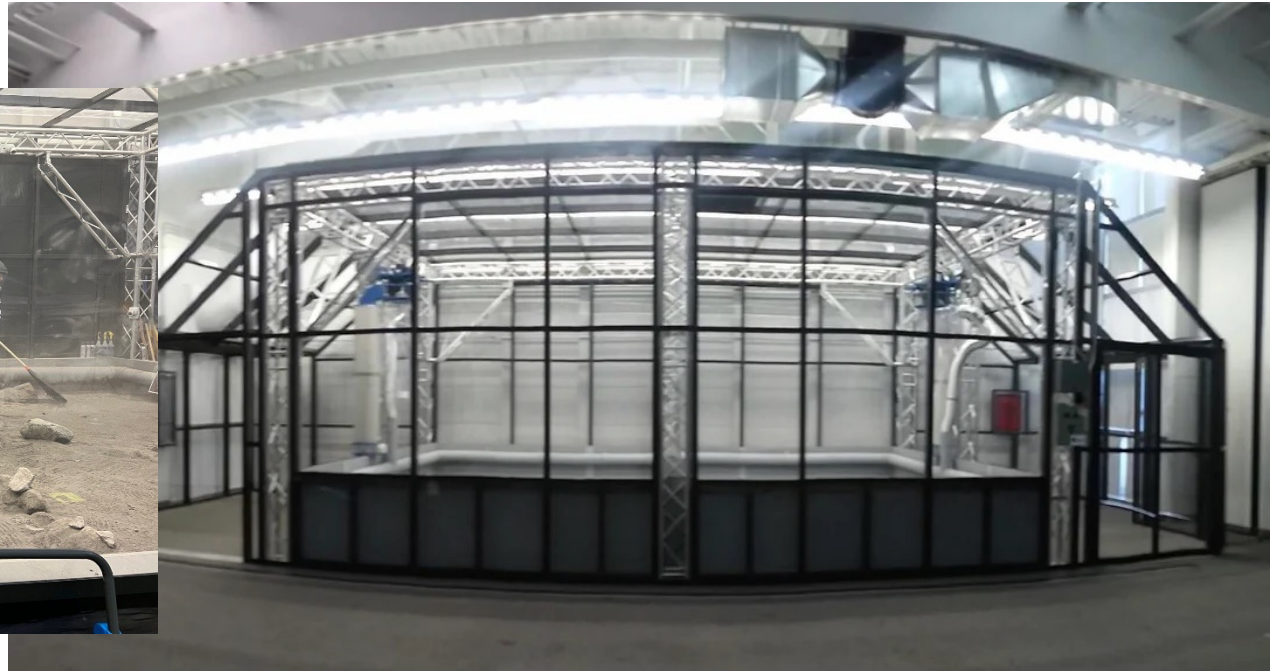




KSC Final Competition

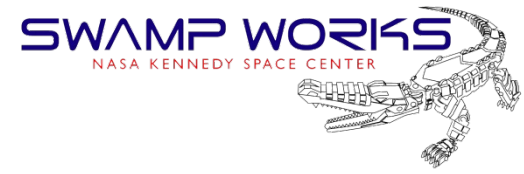


- The top 10 teams advanced to the Lunabotics Challenge final event held at the NASA Kennedy Space Center (KSC) Center for Space Education
 - 6.9 m x 5 m x ~ 0.6 m deep
 - Black Point (BP) 1 regolith simulant



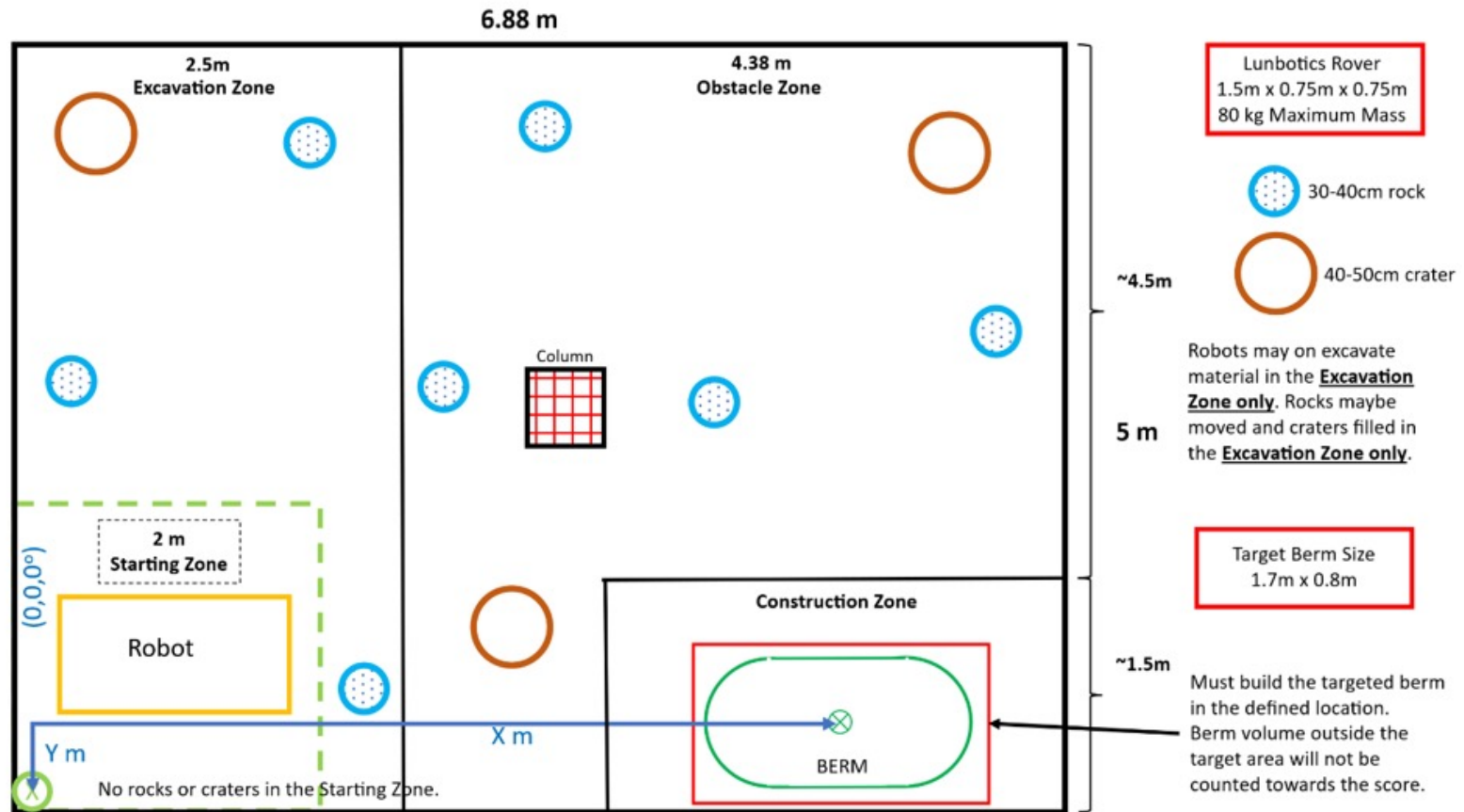
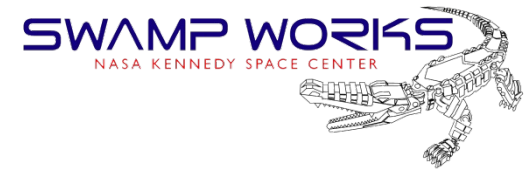


Lunar Like Regolith Simulant Behavior





Artemis Arena at KSC

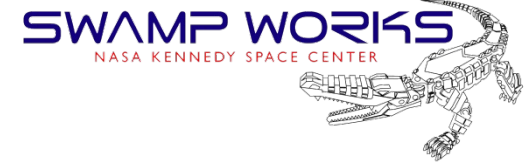


X: 5.38 m Y: 0.6 m

47 Universities from across the USA attended Lunabotics 2026



2025 LIDAR Scanning of Berm

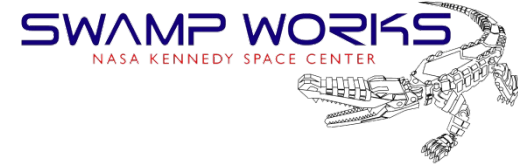


Goal was to build largest volume berm possible in 30 minutes

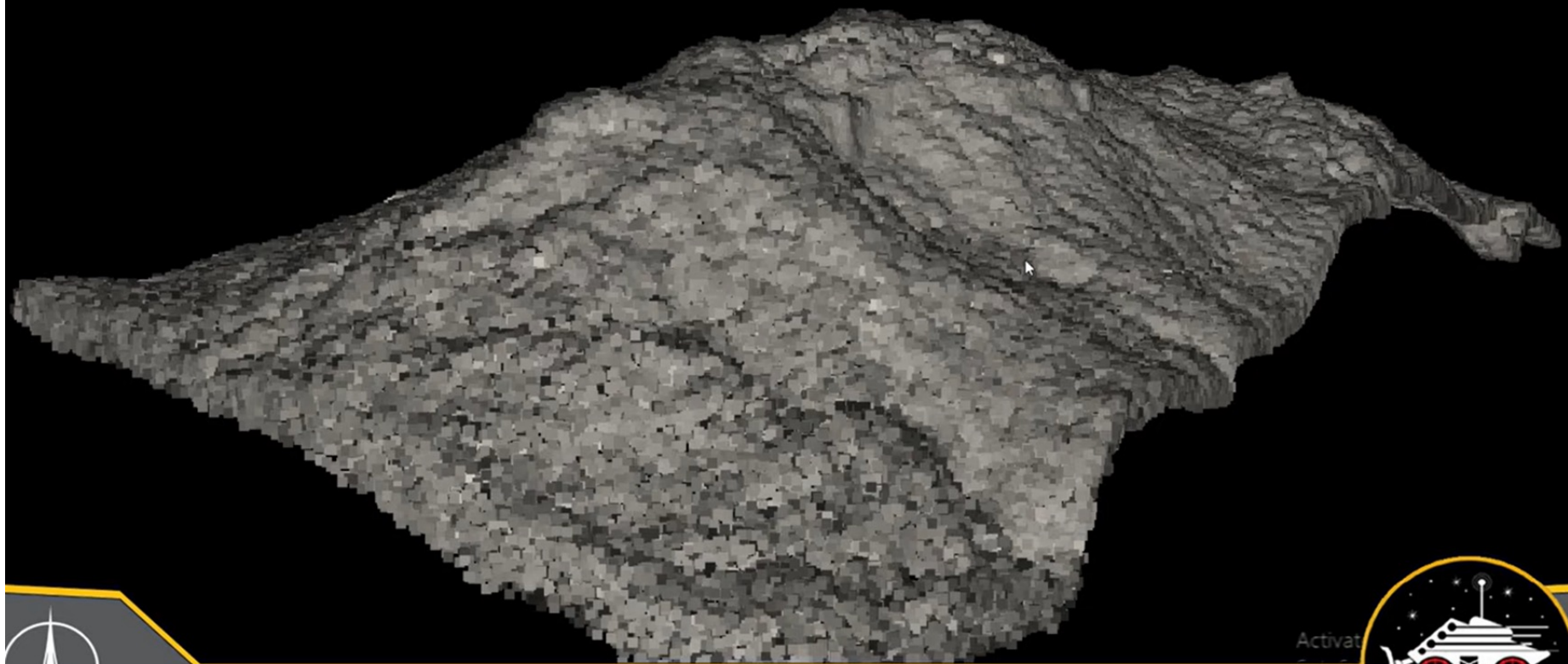




2026 LIDAR Scanning of Berm

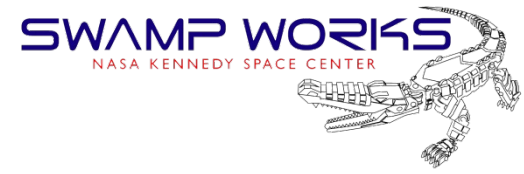


Time's up!
New Mexico Institute of Mining and Tech





Types of Lunabots



Regolith Excavation Mechanism	# of machines employing excavation mechanism
Bucket ladder (two chains)	29
Bucket belt	10
Bulldozer	10
Scraper	8
Auger plus conveyor belt / impeller	4
Backhoe	4
Bucket ladder (one chain)	4
Bucket wheel	4
Bucket drum	3
Claw / gripper scoop	2
Drums with metal plates (street sweeper)	2
Bucket ladder (four chains)	1
Magnetic wheels with scraper	1
Rotating tube entrance	1
Vertical auger	1

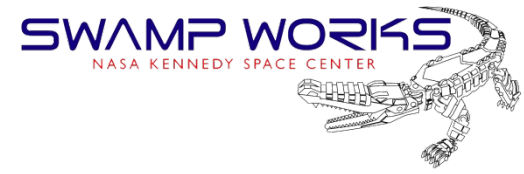


Mueller, R. P., van Susante, P., Reiners, E., & Metzger, P. T. (2021). NASA lunabotics robotic mining competition 10th anniversary (2010–2019): Taxonomy and technology review. *Earth and Space* 2021, 497-510.





Lunabotics: Failed Runs

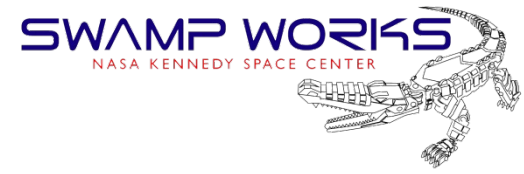


<https://www.youtube.com/watch?v=ugU5CbxO8og>





Extreme Success Videos



Event 2 - Univ Virginia -
Wheel Falls Off:

https://www.youtube.com/live/6TjQcgX_XBo?si=nR0C2JcnJJOBF4Ez&t=20118



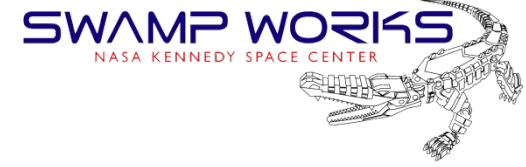
Event 6b - New
Mexico Tech - Robot
swims in hole it
made:

<https://www.youtube.com/live/yyLjc4Pallw?si=jNP2evcfpqpYXL8W&t=6224>



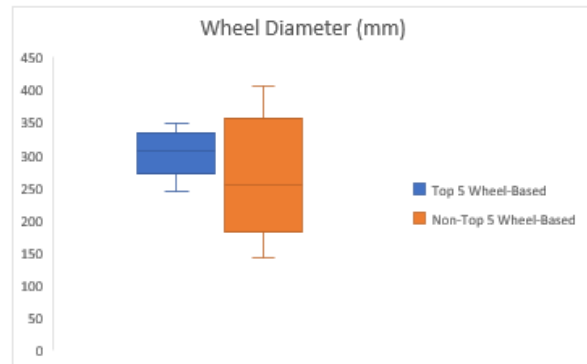


Useful Metrics for Reference

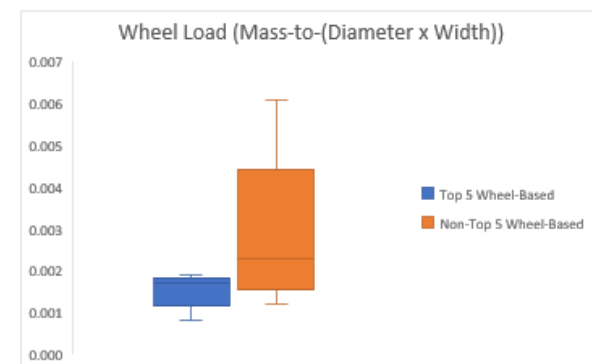
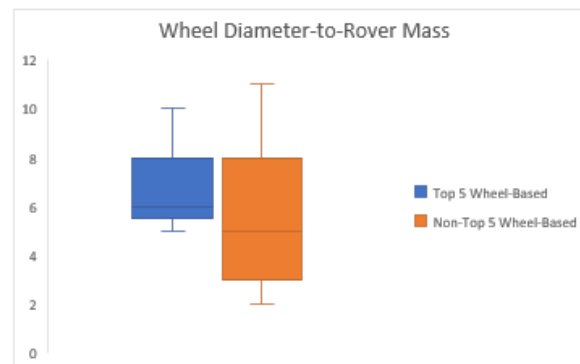
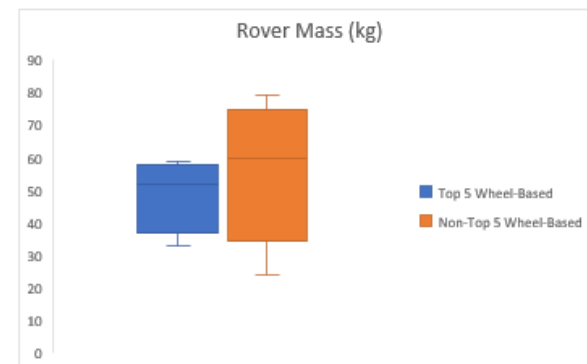
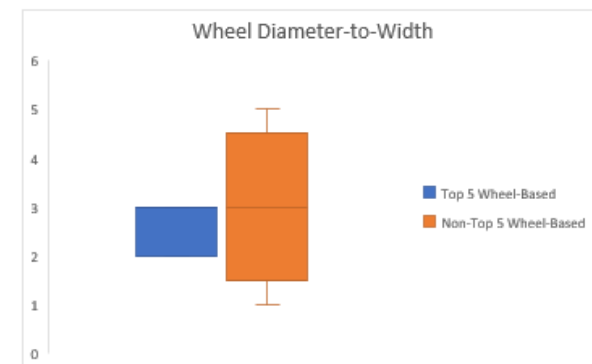
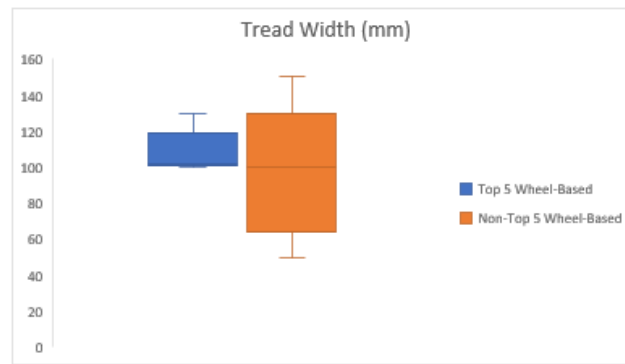


2025 Lunabotics Only:

Are larger wheels better?

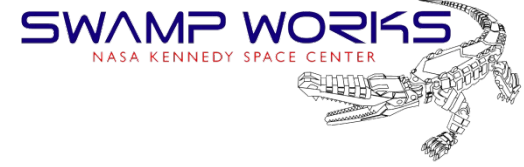


Are wider wheels better?

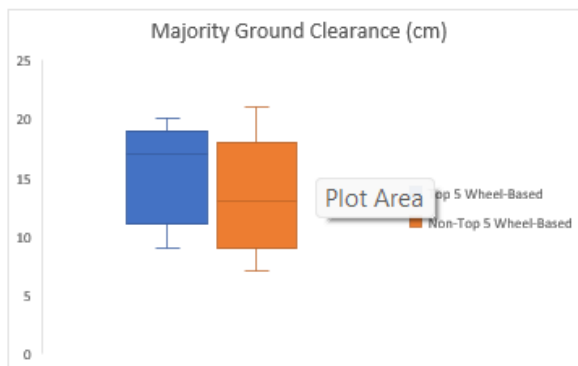
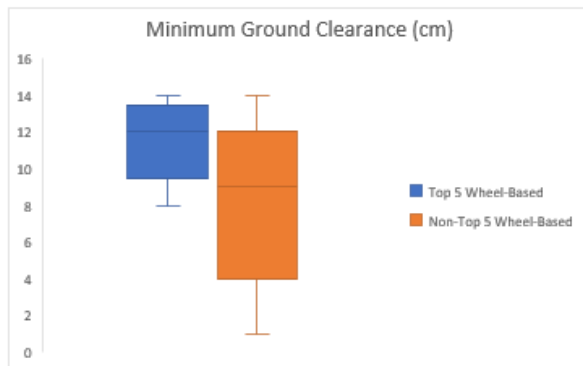
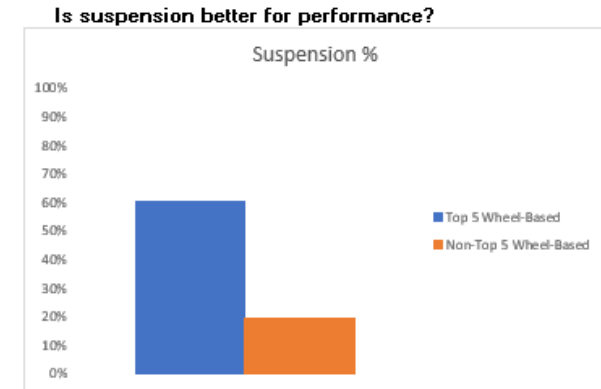
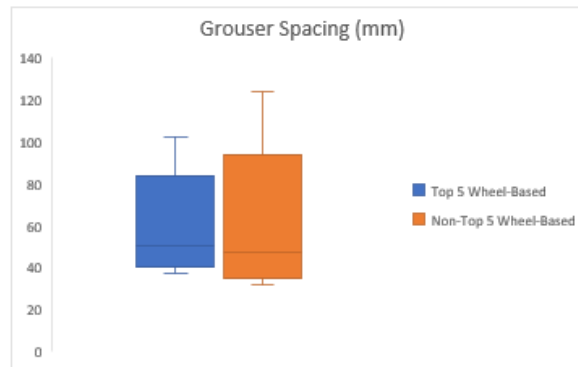
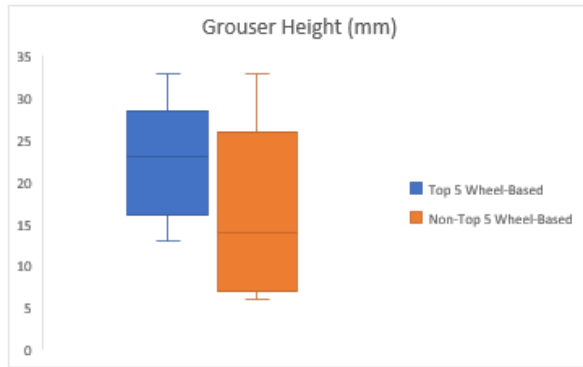




Useful Metrics for Reference

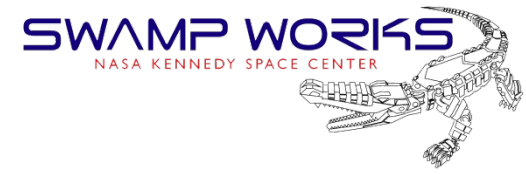


2025 Lunabotics Only:





2025 Benchmarks



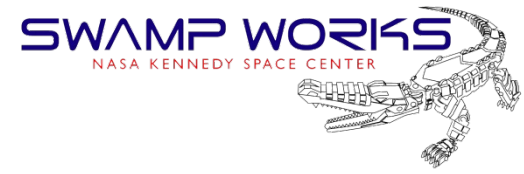
Consolidated Benchmarks

Based on the 2025 data, we advise teams to align their designs with the following directional benchmarks to maximize their probability of success:

Metric	Reliability Benchmark (Not Stuck)	Performance Benchmark (Top 5)
Min. Ground Clearance	~10 cm	~12 cm
Wheel Diameter	~250 mm	~300 mm
Grouser Height	~17 mm	~23 mm
Mass-to-Footprint Ratio	~0.002	~0.0017
Suspension	Optional	Integrated



Useful Metrics for Reference



2026 Lunabotics Top 10 Teams Only:

- Highest Excavation Rate: **742 kg/hour**
- Average Excavation Rate: 359 kg / hour

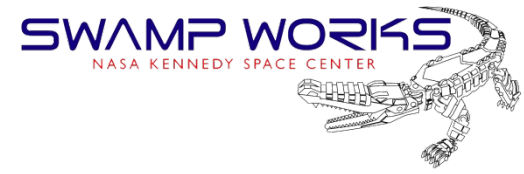
- Largest Berm Volume / hour: **0.437 m³/hour**
- Average Berm Volume / hour: 0.244 m³/hour

- Best Berm Construction Productivity (BCP): **122 cm³ berm /min /watthour**
- Average BCP Energy consumed: 62 cm³ berm /min /watthour

- Most common excavator designs:
 - **Bucket Scraper** **3** **Construction Prize Winner**
 - Front End Bucket Loader **3**
 - Bucket Ladder **3**
 - Double Bucket Drum **1**



2026 Lunabotics Results



2026 Lunabotics Challenge Winners

Off World Grand Prize – Overall Excellence

University of Virginia in Charlottesville

Lunabotics Construction Award

1st place: College of DuPage in Glen Elyn, Illinois

2nd place: University of Virginia

3rd place: Michigan Technological University in Houghton, Michigan

Caterpillar Autonomy Award

1st place: The University of Alabama in Huntsville

2nd place: University of Virginia

3rd place: University of Utah in Salt Lake City

4th place: Purdue University in West Lafayette, Indiana

5th place: Iowa State University in Ames

6th place: College of DuPage

Lunabotics Efficient Use of Communications Power Award

Iowa State University

Systems Engineering Paper

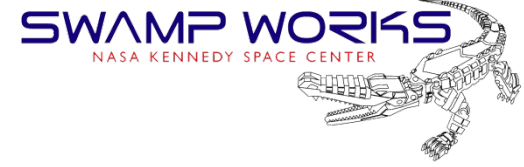
1st place: The University of Alabama

2nd place: University of Virginia

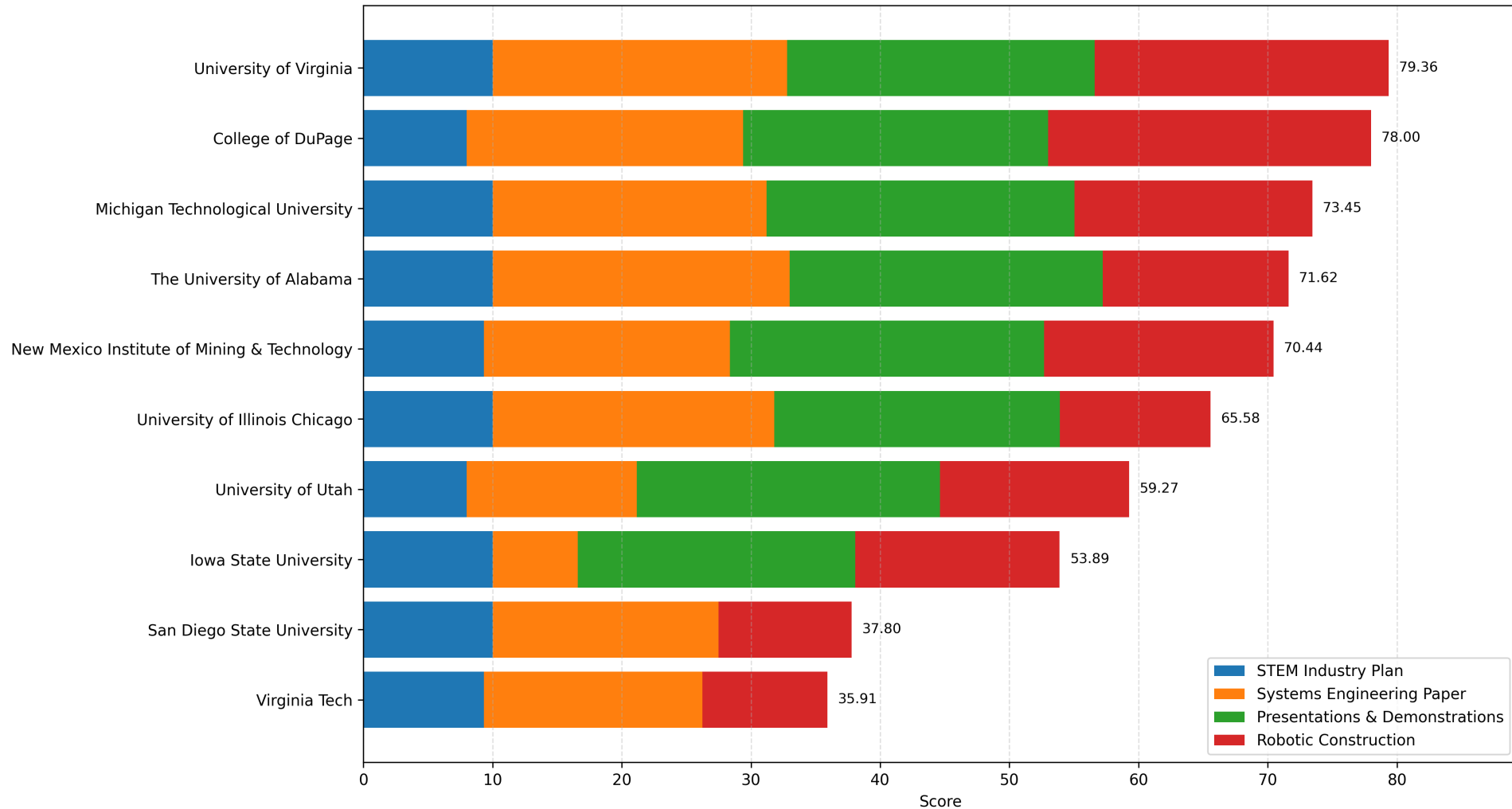
3rd place: University of Illinois in Chicago



2026 Grand Prize Analysis



2026 Final Scores by University and Score Category



Why the University of Virginia Won

The University of Virginia (UVA) achieved the **highest total score: 79.356**, outperforming all other teams. This outcome can be explained by strength across **every scoring category**, with **no weak areas** and **exceptional balance** in their performance.

1. Strong STEM Score

UVA earned **10 points**, tying for the **highest STEM score** in the field.

This indicates a strong foundational technical understanding—essential for all downstream categories.

2. Excellent Industry Plan (22.8 points)

UVA ranked among the top performers here.

A strong industry plan generally reflects:

- Clear understanding of real-world constraints
- Well-developed mission justification
- Feasible engineering and project management structures

This category is weighted heavily and contributed meaningfully to their win.

3. Consistently High Systems Engineering Score (23.8 points)

This is one of the **highest Systems Engineering scores in the competition**.

A strong SE score means UVA excelled at:

- Requirements decomposition
- Risk identification and mitigation
- Logical system architecture
- Verification and validation planning

Teams with strong systems engineering almost always finish near the top.

4. Solid Presentations & Demonstrations Score (22.756 points)

While not the top score in this individual category, UVA delivered:

- A clear, organized project narrative
- Successful demonstration of key concepts
- Strong communication of design choices

Importantly, UVA **did not suffer penalties** or zeros like several other teams.

5. No Critical Weaknesses

Many teams had at least one severely low category:

- San Diego State and Virginia Tech scored *zero* in Systems Engineering
- Iowa State had very low Industry score
- Utah had reduced Presentation performance

UVA avoided all such pitfalls.



Microsoft 365 Copilot




Overall reason Virginia won

Virginia's win came from **balance and consistency**.

College of DuPage had the best Robotic Construction score, but Virginia made up the difference by scoring higher in the other three categories:

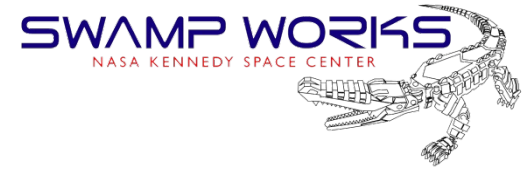
Category	Virginia	College of DuPage	Advantage
STEM Industry Plan	10.00	8.00	Virginia +2.00
Systems Engineering Paper	22.80	21.40	Virginia +1.40
Presentations & Demonstrations	23.80	23.60	Virginia +0.20
Robotic Construction	22.76	25.00	DuPage +2.24

Virginia gained **3.60 points** over DuPage in the first three categories, while DuPage only gained back about **2.24 points** in Robotic Construction. That left Virginia ahead overall by about **1.36 points**.

Bottom line: University of Virginia won because it combined a perfect STEM Industry Plan score with near-top scores in Systems Engineering, Presentations, and Robotic Construction. It was not necessarily the best in every single category, but it was the best all-around .



Summary



- 47 Universities from across the USA attended Lunabotics 2026
- The competition format focuses on berm building for lunar construction
- A qualification event was held from **May 12-17, 2026** at the University of Central Florida Exolith lab in a 10 m x 10 m x 1 m deep regolith simulant bin
- The finals were held from **May 19-21, 2026** at the NASA KSC Center for Space Education: the top 10 teams were invited from the UCF qualifier
- Excavation for construction requires more traction than ISRU mining surface excavation which will be challenging in 1/6th G on the Moon

Good systems engineering is consistently the differentiator between high scoring teams and lower scoring Lunabot designs

LUNABOTICS 2026 LINKS TO EVENTS

Day 1 – Tuesday - Entire Livestream:

https://www.youtube.com/live/6TjQcgX_XBo?si=075glAgBDiteA8Cc

Daily Intro:

https://www.youtube.com/live/6TjQcgX_XBo?si=2N1LdeFMFG8t3l0l&t=6110

Opening Ceremony:

https://www.youtube.com/live/6TjQcgX_XBo?si=5Xon_l2mOS0nGLmM&t=8049

Event 1 – College of DuPage - 1st Run:

https://www.youtube.com/live/6TjQcgX_XBo?si=3SNYVBeKE0uRzVsD&t=15029

Event 2 – Univ Virginia - 1st Run:

https://www.youtube.com/live/6TjQcgX_XBo?si=E02-czKcHJO_oShj&t=19393

Event 2 - Univ Virginia - Wheel Falls Off:

https://www.youtube.com/live/6TjQcgX_XBo?si=nR0C2JcnJJObF4Ez&t=20118

Lunch Award - Presentations & Demonstrations:

https://www.youtube.com/live/6TjQcgX_XBo?si=O-vEh2cPNHxCvhhbk&t=21285

Event 3 – Univ Utah - 1st Run:

https://www.youtube.com/live/6TjQcgX_XBo?si=qmB3ex_MLfo-391V&t=27796

Event 4 – Univ Illinois Chicago - 1st Run:

https://www.youtube.com/live/6TjQcgX_XBo?si=rxZb2a38ZKP5oQBJ&t=32268

Event 5 – Michigan Tech - 1st Run:

https://www.youtube.com/live/6TjQcgX_XBo?si=Li0LLGNxVlOzSga9&t=36404

Event 6 – New Mexico Tech - 1st Run:

https://www.youtube.com/live/6TjQcgX_XBo?si=u0TnDKfPCxRPdp1r&t=40401

Day 2 – Wednesday - Entire Livestream:

<https://www.youtube.com/live/wdADLct6T7c?si=J26e-NXflqMDh-n7>

Daily Intro:

<https://www.youtube.com/live/wdADLct6T7c?si=UHULOkGqouUfRmVV&t=1405>

Event 7 – Univ Alabama - 1st Run:

https://www.youtube.com/live/wdADLct6T7c?si=Rv_hwlakMXvcKhE&t=5148

Event 8 – San Diego State Univ - 1st Run:

<https://www.youtube.com/live/wdADLct6T7c?si=d9umbZ8vUEe0p3-M&t=9835>

Event 9 – Virginia Tech - 1st Run:

https://www.youtube.com/live/wdADLct6T7c?si=UmvYY_uY1wX5CQU4&t=14442

Lunch Awards - Systems Engineering:

https://www.youtube.com/live/wdADLct6T7c?si=0f_U7JWtoglRPESm&t=16775

Event 10 – Iowa State Univ - 1st Run:

<https://www.youtube.com/live/wdADLct6T7c?si=1P6qHclp51Xh0WYY&t=22580>

Event 1b - College of DuPage - 2nd Run:

<https://www.youtube.com/live/wdADLct6T7c?si=4dVlnYr3huFV1B-v&t=26155>

Event 2b - Univ Virginia - 2nd Run:

https://www.youtube.com/live/wdADLct6T7c?si=gTIQB0hAExs-5z7_&t=28965

Event 3b - Univ Utah - 2nd Run:

<https://www.youtube.com/live/wdADLct6T7c?si=tJ1XT75pCnZhUSU&t=31477y>

Event 4b - Univ Illinois Chicago - 2nd Run:

<https://www.youtube.com/live/wdADLct6T7c?si=YskXVv4g453pbXlh&t=34181>

Day 3 – Thursday - Entire Livestream:

<https://www.youtube.com/live/yyLjc4Pallw?si=N6GsS2yqkmNO-qtq>

Daily Intro:

https://www.youtube.com/live/yyLjc4Pallw?si=qGbe5U7GNnlylP_o&t=458

Event 5b - Michigan Tech - 2nd Run:

<https://www.youtube.com/live/yyLjc4Pallw?si=s5aTpRNX-E-gfoh1&t=2316>

Event 6b - New Mexico Tech - 2nd Run:

<https://www.youtube.com/live/yyLjc4Pallw?si=jwl-Y9Va39kP9jvY&t=5163>

Event 6b - New Mexico Tech - Robot swims in hole it made:

<https://www.youtube.com/live/yyLjc4Pallw?si=jNP2evcfppqYXL8W&t=6224>

Event 7b - Univ Alabama - 2nd Run:

<https://www.youtube.com/live/yyLjc4Pallw?si=1qTDKNVqxaxV2UIZ&t=8523>

Event 9b - Virginia Tech - 2nd Run:

<https://www.youtube.com/live/yyLjc4Pallw?si=et38txJUmb7wd7DU&t=11211>

Lunch Award - Robot Innovation:

https://www.youtube.com/live/yyLjc4Pallw?si=bg_gPxFAQdkm95mk7&t=15028

Event 8b - San Diego State Univ - 2nd Run:

https://www.youtube.com/live/yyLjc4Pallw?si=HyLpg_dXn7Kzgbet&t=19481

Event 10b - Iowa State Univ - 2nd Run:

<https://www.youtube.com/live/yyLjc4Pallw?si=hi5ISOQxjAUO9luN&t=22457>

Event 10b - Iowa State Univ - Robot Ingests Rock:

<https://www.youtube.com/live/yyLjc4Pallw?si=rSkV8ZCuoLa5dHxi&t=23198>

Event 10b - Iowa State Univ - Robot Tears Itself Apart:

https://www.youtube.com/live/yyLjc4Pallw?si=wQEA3aBQ_0-5ows5&t=23279

Kurt Crowd Work - Robot Jokes:

<https://www.youtube.com/live/yyLjc4Pallw?si=kAgp5rNkp5QzdJWn&t=29918>

Kurt Crowd Work - NASA & Space Trivia:

<https://www.youtube.com/live/yyLjc4Pallw?si=OPo0pCt-unte7SE2&t=30376>

Final Award Ceremony:

<https://www.youtube.com/live/yyLjc4Pallw?si=J0YecF9umUoCOwcY&t=31222nd>