Lunabotics 2020 Executive Summary

University of Massachusetts, Amherst Robotics Team[1,✉]

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Executive Summary

As NASA prepares for the return of astronauts to the lunar surface, it crowdsources unique and critical engineering challenges to universities across the country. In preparation for the inaugural season of the organization's Artemis program, the University of Massachusetts Amherst has provided resources for students and faculty to develop a robot capable of autonomous navigation and decision making. This collective effort is in hopes of creating a machine capable of mining ice regolith from the lunar surface without the need for human intervention. The excavation of this regolith will be paramount in fueling the next generation of space travel, experimentation, and exploration for the expansion of humanity's knowledge of deep space and the unknown.

1.0 Primary Objective.

Mentioned earlier, UMass Robotics is committed towards designing a cost-effective autonomous system capable of extracting icy-regolith from the lunar surface with minimal or no human intervention. In order to develop a robot capable of such feats, the Software Team has prioritized computational power, machine learning, and sensor analysis. The Mechanical Team has focused on passive filtration, load intake, and modularity. Section 1.1 and 1.2 go into these aspects in greater detail.

1.1 Primary Software Goals.

The Software and Hardware teams fixated on achieving maximum robotic autonomy possible using a combination of sensor data to perform object avoidance and detection in combination with a deep learning model. The purpose of this design over a traditional finite state machine was to enable greater decision making in the unpredictable environment of the lunar surface. Successful implementation of the design could result in smaller human intervention to improve cost efficiency and productivity on the moon.

To execute this plan the team has invested a great deal of time into researching object detection and navigational path planning, in order to create a system capable of exploring the terrain independently. Additionally, the team has learned ROS (Robot Operating System) and has stimulated the robot in a virtual environment called Gazebo. In this environment, we can simulate a lunar experience and train the model using virtual hardware and sensor data. This also allows us to collect vast amounts of virtual data to train the robot without running constant wear and tear on the physical system.

1.2 Primary Mechanical Goals.

The members of the Mechanical Team have focused on mining and delivering the most regolith while staying vigilant to the time and sizing constraints, modularity of the components, material selection, and budget. Conducting several design review meetings every week, members would discuss ways to better meet these goals, and modifications were constantly made to the overall assembly.

The team also worked to review current designs to improve the ability to easily repair the robot, should specific components fail on the moon. Another design point is creating a storage system that is capable of storing at least half of the robot's weight worth of regolith while also passively filtering unwanted debris while the robot excavates material. Collectively working on the designs, the team was able to incorporate all facets of these ideas while ensuring optimal sensor layout and hardware space for the autonomy module of the robot.

2.0 Conclusion.

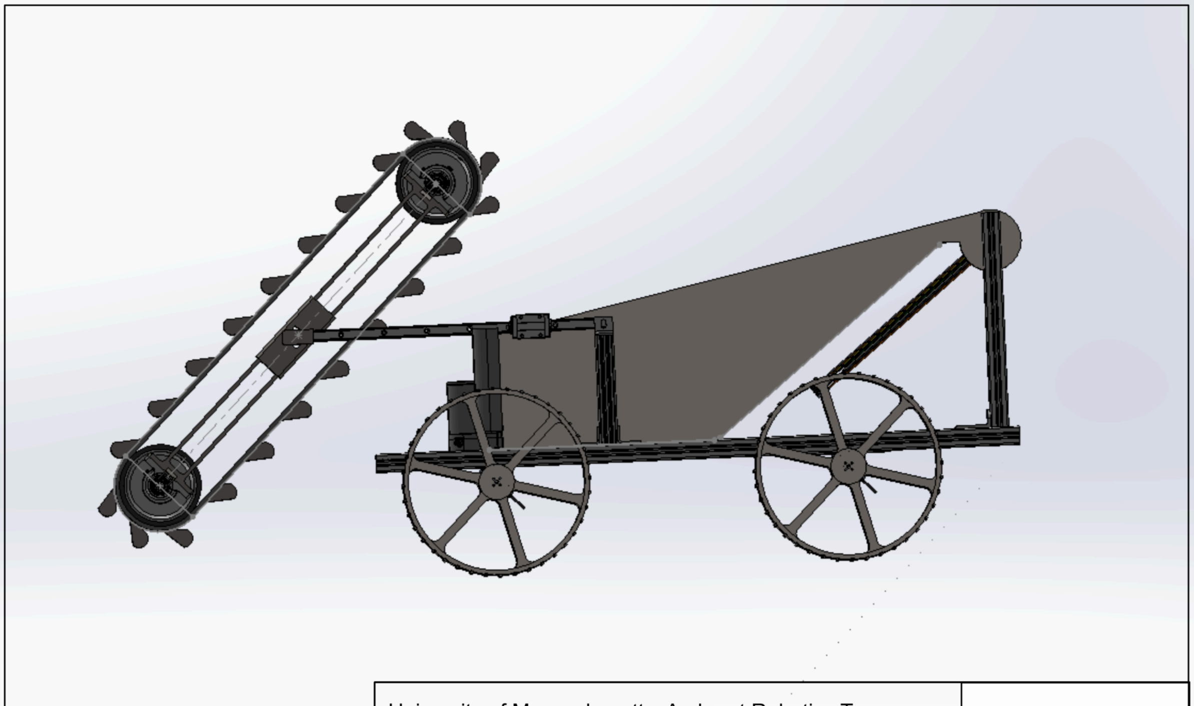
This robot will provide researchers with the answers they need to learn more about our moon, contributing to the final goal of the Artemis mission. The University of Massachusetts Amherst plays a crucial role in developing a system capable of collecting this material without any intervention from the operator. This frees up astronauts and ground crew alike to carry out the other integral aspects of the Artemis mission.

3.0 Additional Resources.

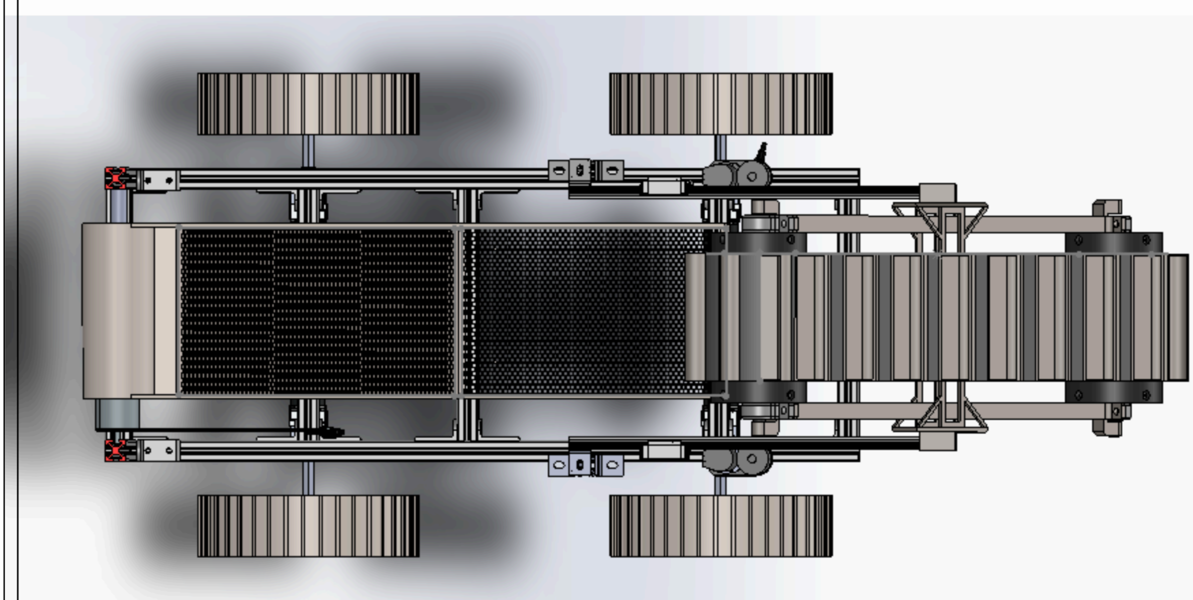
CAD Renderings and parts lists can be found in the articles below. While the design of the robot is finalized, some of the components and intricacies are subject to change. To view the CAD files as well as an animation of the robot in action, please visit the link below, thank you.
https://github.com/UMass-Amherst-Robotics
/Executive-Summary

Item Description	Quantity	System
Conveyor Belt Roller	2	Excavator
Kevlar Belt	1	Excavator
Compact Flat Brushless DC Motors	2	Excavator
Mounted Roller Bearings	4	Excavator
Linear Actuator Rails	2	Excavator
High load Sliding Actuator	1	Excavator
Ball Bearing Rails	2	Excavator
High Load Sliding Mounts	2	Excavator
High Load 6-inch Retracted Shaft Linear Actuator	2	Excavator
(12x5x2) Blank of 6061 Al	3	Excavator
(2x2x5) Blank of 6061 Al	25	Excavator
Corner Machine Brackets	6	Excavator
Precision Wire Cloth	2	Transfer
304 Stainless Steel, 4 x 4 Mesh Size	2	Transfer
Multipurpose 6061 Aluminum Sheet, 0.19" Thick, 12" x 24"	3	Transfer
ElectroCraft's MPW52	1	Transfer
FC22 Compression Load Cell (0-100 lbs) - FC2231-0000-0100L	1	Transfer
Multipurpose 6061 Aluminum, 3" x 3", 1 Foot Long	1	Transfer
80/20 Beams, 15 series - 900 mm	2	Base
80/20 Beams, 15 series - 300 mm	6	Base
80/20 15 Series 2 hole corner brackets	18	Base
First Robotics BAG Motor	4	Base
First Robotics 100:1 Planetary Gearbox	4	Base
Multipurpose 6061 Aluminum, 3" x 3", 1 Foot Long	1	Base
Jetson Nano Developer Kit	1	Base
Raspberry Pi Model 4	1	Base
Jetson Xavier NX Developer Kit	1	Base
8192 CPR Encoder with Cable	6	Base + Transfer
ODrive Motor Controller v3.6	4	Base + Excavator + Transfer
Power Analyzer	1	Base
2 - Channel 24V Relay Switch	2	Base
4 - Channel 12V Relay Switch	1	Base
24V - 5V Step Down Converter PQDE6W-Q24-D5-T	1	Base
Emergency Stop Button	1	Base
24V - 12V Step Down Converter PQDE6W-Q24-D12-T	1	Base
Ethernet Router	1	Base
Slamtec RPI Lidar A1	1	Autonomy
VectorNav VN-300 SMD IMU	1	Autonomy
Ethernet Switch	1	Autonomy
2 mb USB video cameras	3	Autonomy

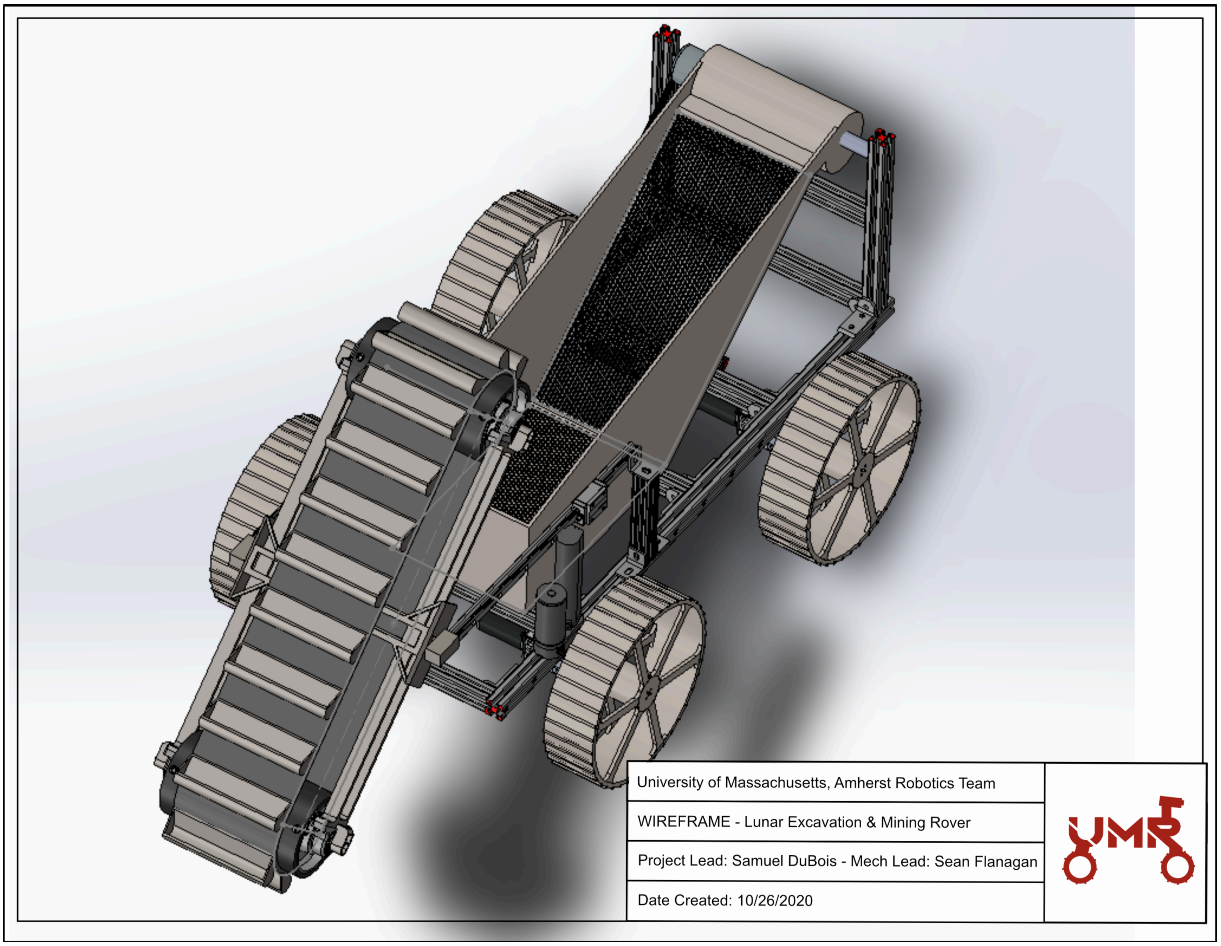
Table 1. Parts list of UMass Robotics 2020 Lunabot (Some components are subject to change over the course of the competition).



University of Massachusetts, Amherst Robotics Team	
SIDE VIEW - Lunar Excavation & Mining Rover	
Project Lead: Samuel DuBois - Mech Lead: Sean Flanagan	
Date Created: 10/26/2020	



University of Massachusetts, Amherst Robotics Team	
TOP VIEW - Lunar Excavation & Mining Rover	
Project Lead: Samuel DuBois - Mech Lead: Sean Flanagan	
Date Created: 10/26/2020	


University of Massachusetts, Amherst Robotics Team
WIREFRAME - Lunar Excavation & Mining Rover
Project Lead: Samuel DuBois - Mech Lead: Sean Flanagan
Date Created: 10/26/2020
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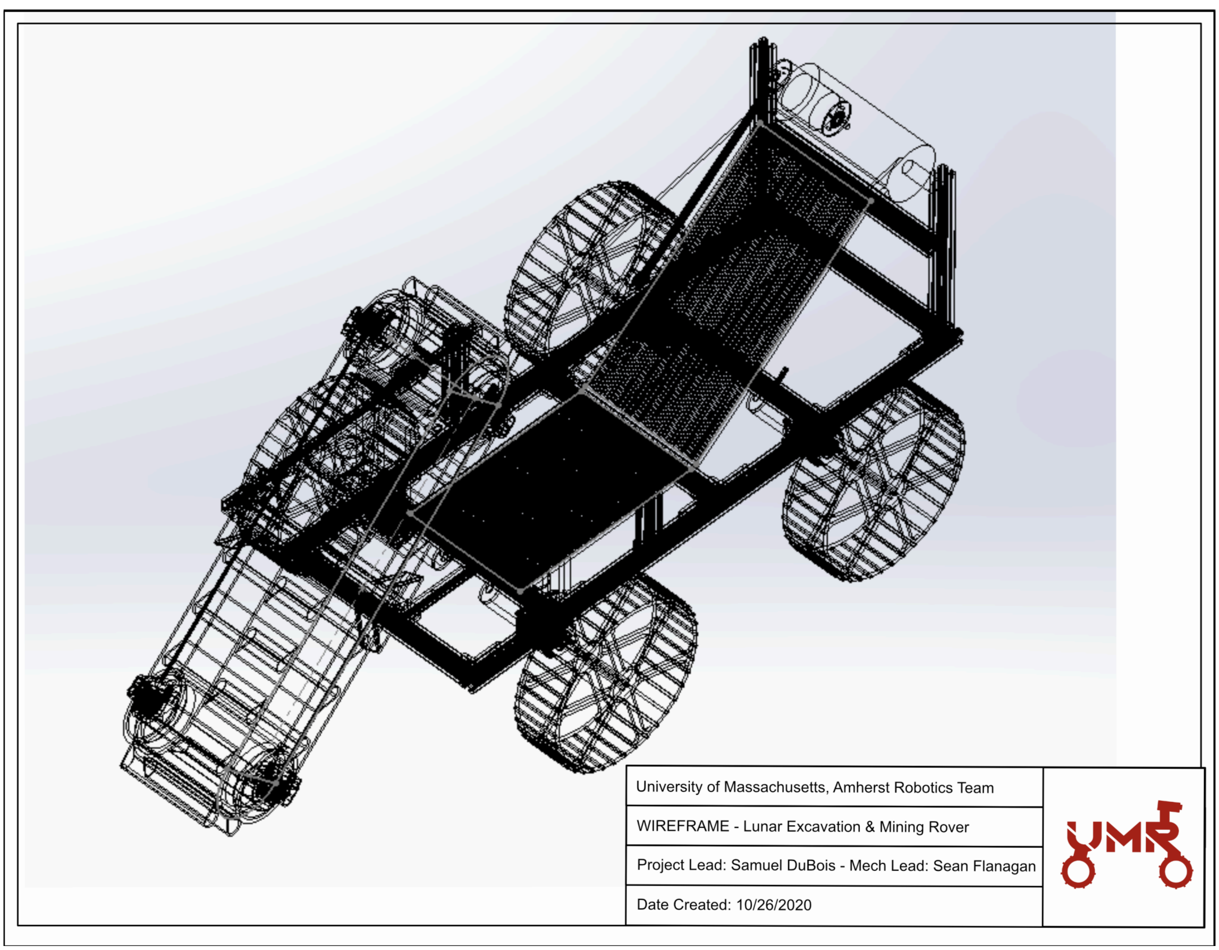
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