CSCE 4561 Capstone I

Fall 2020

Project Proposal:

NASA/Robotic Mining Competition Rover

Group Members:

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Jett McCullough, Carson Molder

December 6th, 2020

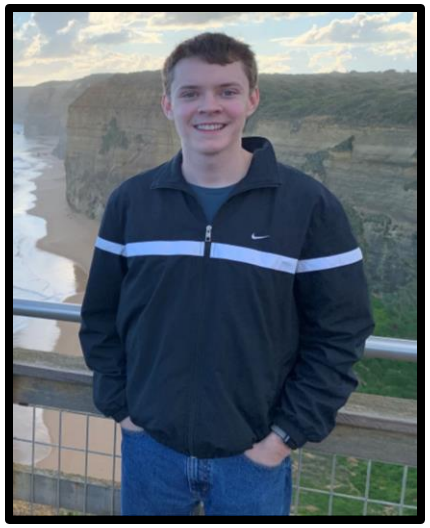
About us

Andrew Burroughs
Comp. Sci.
Senior

Calvin Franz
Comp. Sci.
Senior

Z. Gunner Lawless
Comp. Sci./Eng.
Senior

Jett McCullough
Comp. Sci.
Senior



Carson Molder
Comp. Eng.
Senior

Problem

It costs about $1.2 Million/kg to send materials to the moon (2019 est.)[1]

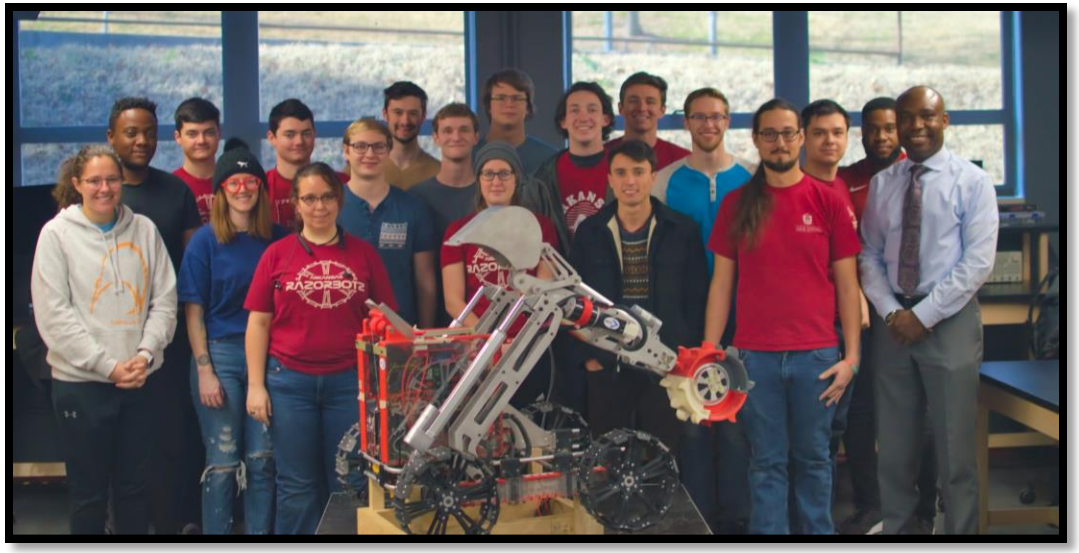
- NASA's Artemis program:
  - 2024 — Return to Moon
  - 2030s — Visit Mars
- Extended missions are too expensive
- Need to gather and process materials while in space

Image Source: nasa.gov [1]

Objective

Our goal is to develop the software for a robot that can autonomously mine rocks on the moon.

- NASA Artemis Student Challenge
  - Held at Kennedy Space Center
  - Competition between universities for the best mining robot
- Razorbotz
  - Team of UARK students competing in RMC
  - Led by our project champion, Professor Uche Wejinya
- We want to win first place!



Last Year's Team and Rover

Background: Key Concepts

- Refactor existing code
- Automation with computer vision
  - Identify objective locations and key targets
  - Path generation/discovery
  - Tools: ZED SDK, PyTorch, Git
- Robot Operating System 2 (ROS2) to program robot
  - Multi-language support (Python, C, etc.)
- Overhaul interface for manual control of the robot

PyTorch

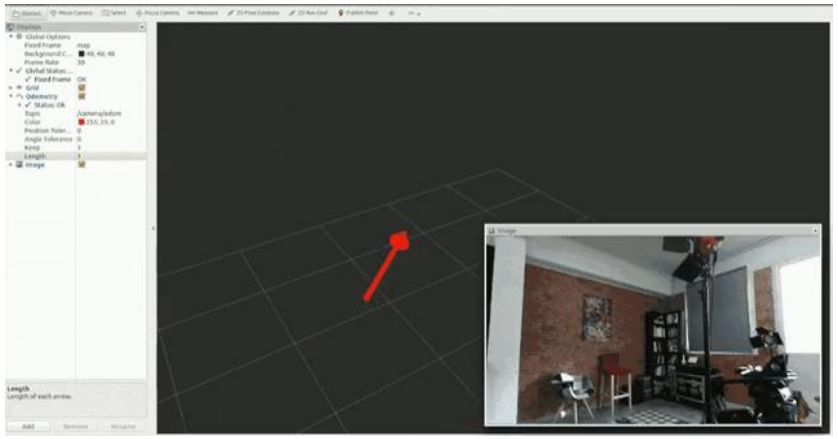


Image Sources: ZED Docs [2], Pytorch.org [3]

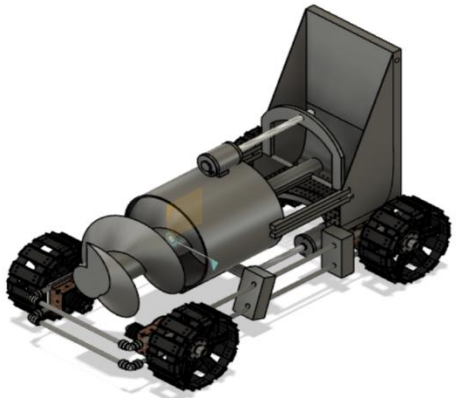
Background: Related Work

- Existing code from previous years
  - Developed largely by mechanical engineers
  - Codebase needs overhaul
    - Documentation
    - Git
    - Unit Testing
    - Version upgrades
- Robot automation
  - New emphasis on autonomy in competition
  - Increased automation with computer vision
- Improvements
  - Programming standards
  - Software stability
  - Usability
  - Autonomy

Deliverables

- Design document
- ROS2 nodes
  - Port ROS 1 code to ROS2
  - Nodes are small, independent “building blocks” of ROS that send and receive data
  - Autonomy, excavation, navigation, movement nodes
- Documentation
- Robot testing data
  - Evaluate in test lab
- Final report
- Project website
- Competition prize!

Image Source: ros.org



Tasks

Refactor and Upgrade Old Code

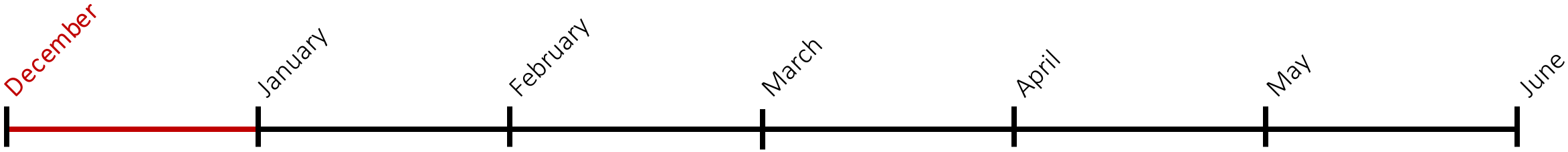
- ROS1 to ROS2
- Update Modules
- Documentation

Improve Manual Control and UI

Implement Full Autonomy

- Excavation, Dump, Travel
- Machine Learning

Timeline

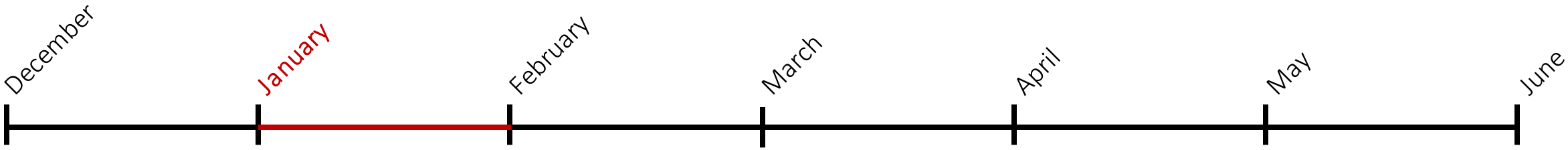


December

- Finish conversion from ROS to ROS2
- Finish Manual Controls

Image Source: github.com/ros2 [4]

Timeline

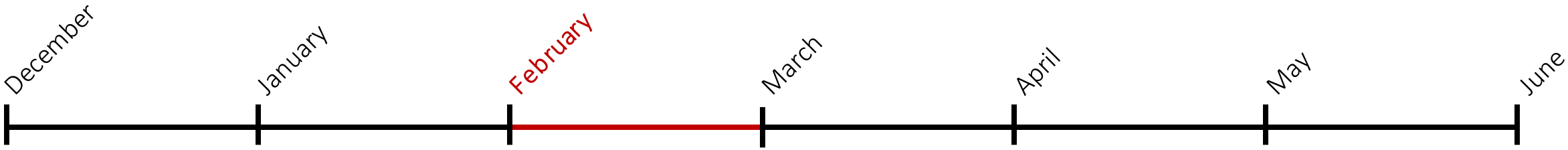


January

- Begin Excavation Macro
- Implement Sensors and Cameras

Image Source: stereolabs.com [5]

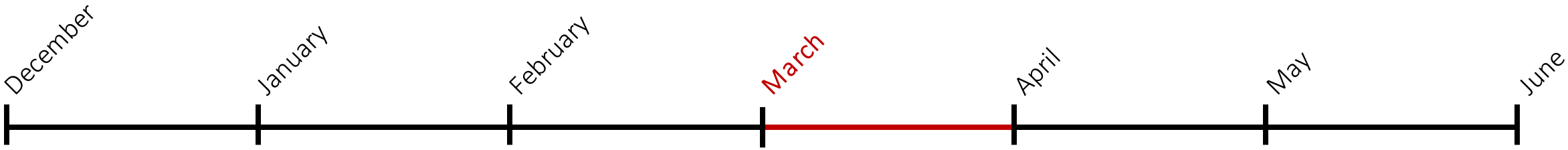
Timeline



February

- Begin Training AI to map excavation features

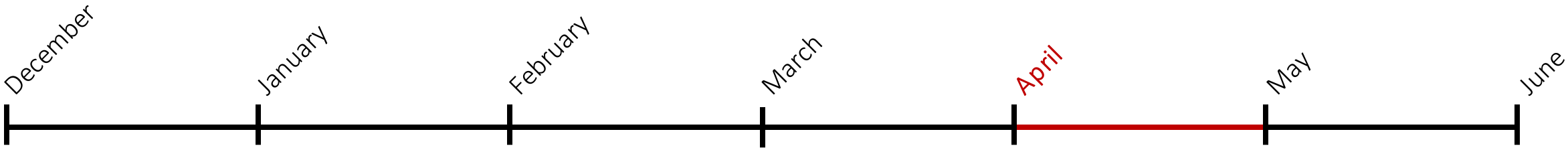
Timeline



March

- Complete Excavation Macro
- Finish Code

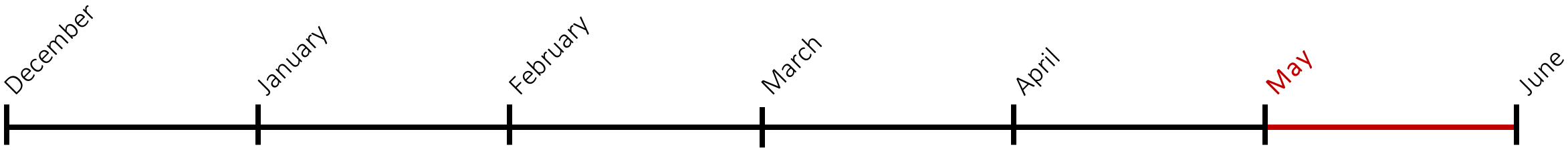
Timeline



April

- Finish Final Testing of Camera and Sensors

Timeline



May

- Graduate!
- Compete!
- Win!

Facilities and Equipment

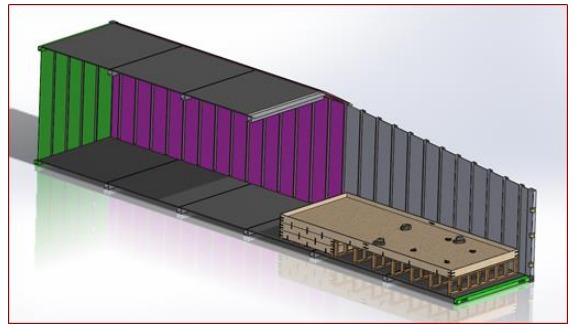
Mechanical Engineering Robotics Lab

Campus Test Pit

Autonomy / AI development

- Jetson Nano
  - Small computer that can run neural networks for the robot
- Nvidia RTX 2080 Ti
- Data Science Lab computers (potentially)

Campus Test Pit:



Jetson Nano:

Image Source: nvidia.com [6]

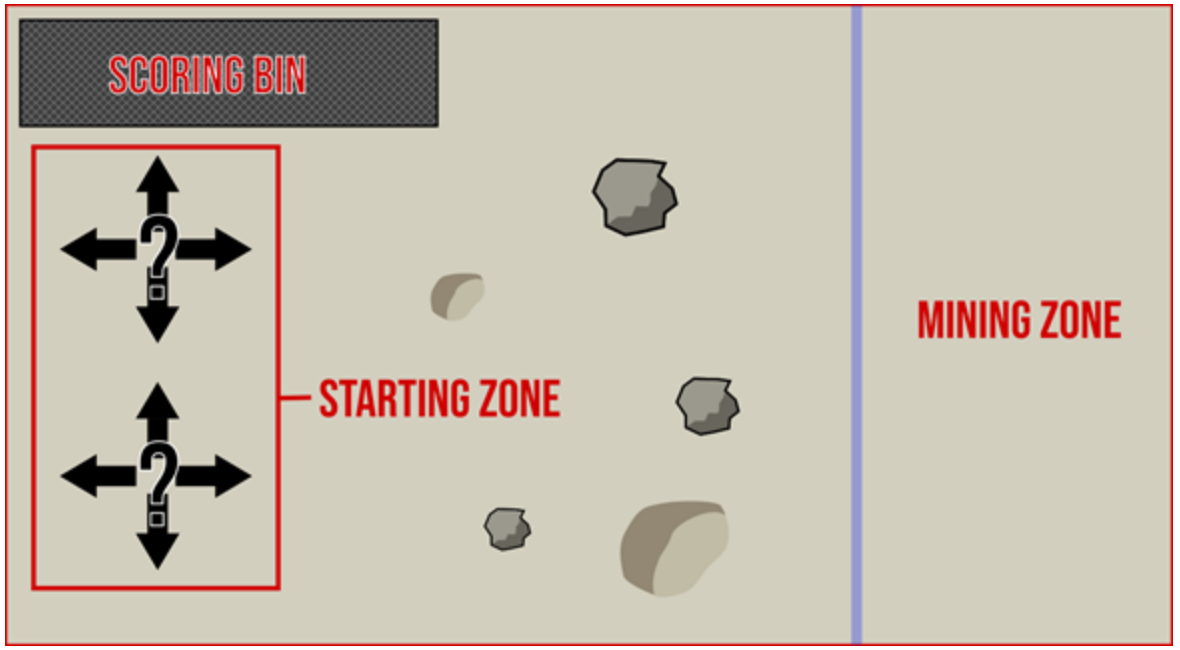
Requirements

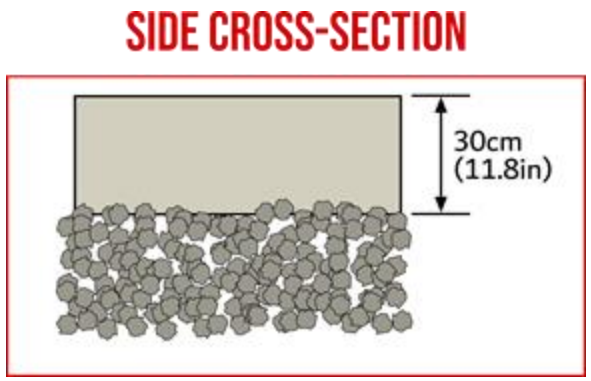
Autonomy

- Navigational Autonomy
- Excavation Autonomy
- Dump Autonomy
- Full Autonomy

Version Control

Unit Tests





References

[1] “NASA Robotic Mining Comptetiton (RMC) Lunabotics 2021, Registration, Rules and Rubrics,” NASA, 2020. url: https://www.nasa.gov/sites/default/files/atoms/files/000_rmc_lunabotics_rules_rubrics_2021.pdf

[2] “Getting Started with ROS and ZED,” Stereo Labs, 2020. url: https://www.stereolabs.com/docs/ros/

[3] PyTorch Homepage, Pytorch, 2020. url: https://pytorch.org

[4] "ROS2 Github Repository", Github, 2020. url: https://github.com/ros2

[5] "Sterolabs Homepage", Stereolabs, 2020. url: https://stereolabs.com

[6] “Jetson Nano Developer Kit,” Nvidia, n.d. url: https://developer.nvidia.com/embedded/jetson-nano-developer-kit