RoveCrest at UC Davis: University Rover Challenge Preliminary Design Report

Team and Leadership Structure: The strength of RoveCrest is currently 65, with 13 board members and 52 general members. The board consists of the President (executive head), Treasurer, and Sub-Team leads, with decisions being made through collective consensus. While most of our members are from the College of Engineering, we have a diverse team with Mechanical, Aerospace, Bio-medical, Electrical, Chemical Computer Science, Math, Geology, Managerial Economics, and Communications being just some of the majors on the team.

Recruitment and Educational Outreach: Being our first year, we recruited team members through just the application form, but going forward we plan to conduct interviews. Even though everyone on the team comes with a vast skill set we understand that being students it is vital to develop our skills, so we have held both closed and open workshops conducted by either Professors or board members.

Advising & Laboratory: Our team is advised by Prof. Dawn Sumner who is from the Department of Earth and Planetary Sciences and has worked on the Curiosity rover, and Prof. Chen-Nee Chuah who is from the Department of Electrical & Computer Engineering and teaches the self-driving car class at UC Davis. We frequently talk to Professors and graduate students from all fields to help make better design decisions. Our team is currently housed in the Startup Center, ESDC, and the Engineering Design Lab, but we are in discussion with multiple departments to secure an independent lab for manufacturing.

Funding: While our expected budget along with 10% overhead is only $5,665, we do hope to raise the full $18,000 to implement additional features on the Rover if required, and to account for unforeseen circumstances due to which we might have to rebuild a substantial portion of the Rover. Our business team along with the board drive the finance for our team. We have currently raised $1,500 from the Department of Engineering and have also secured donations worth $600 from Prof. Chen-Nee-Chuah for the AI team, and donations from Empire Magnetics for most parts needed for the robotic arm ($550 initial evaluation). To secure the remaining funding we are in discussions with the Department of Computer Science, Department of Electrical Engineering, Department of Biomedical Engineering, Department of Earth and Planetary Sciences, College of Biological Sciences and College of Agriculture at UC Davis. We have also reached out to and have had some preliminary discussions with NVIDIA, Bishop Wisecarver, Nippon Pulse, and Automation Direct. We are also exploring UC Davis crowdfunding, grants, and UC Davis alumni donations as further sources of funding. Our goal is to be fully funded ($18,000) by 7th of January and have our budget $5,665 secured by the 14th of December.

Project Management Plan: Keeping in mind the diverse set of tasks the Rover must complete we have split the team into 8 sub-team. Three CSE Sub-teams; Communications, Robotics, and Ai/Navigation; three Mech Sub-teams; Structures, Suspension, and Drive Control; and a Science and Business sub-team. Sub-system members also work across sub-teams based on required skill set (Suspension members helped build CAD for the robotic arm). Our general timeline is to complete the detailed CAD's, circuit designs, and algorithm structures by the end of 2019, and start production in the first week of January 2020. Each sub-system is expected to be manufactured by January 21st and test independently by February 7th. Communications and Structures members have been attending and will continue to attend all other sub-team meetings to ensure proper knowledge while assembling the entire Rover. These teams will be at the forefront of integrating all sub-systems together by February 14th and then testing the Rover to meet pre-defined expectations by February 21st. From February 21st to February 28th our goal will be to produce a refined system acceptance review video and report.

Preliminary Technical Design

Robotics: Our robotic arm is made of Aluminum 6061 beams and has a reach of 1.5m with 5 axes of movement, which include a rotating base, 3 main joints (shoulder, elbow, wrist), and a rotating joint perpendicular to the main joints at the wrist. Each joint is made of a stepper-motor-planetary-gearbox combo (2Nm – 70Nm Torque) along with a taper roller bearing in TDO configuration, and an optical encoder for feedback control. ROS running on a Raspberry Pi will interface controls with the stepper motors.

Science & Exploration: Our science plan includes four tests on the rover which indicate conditions conducive to life:

1. Use colored filters to detect wavelengths of light reflected by minerals.
2. A microscope camera will observe any light produced by organic matter on exposure to UV light.
3. We detect carbonates by adding a few drops of HCL to the sample and observing for effervescence.
4. Nitrogen is observed if the detecting powder turns pink on insertion into 7 funnels of extract solution.

Robotics, Comms. And S&E: A vacuum chamber will extract soil from the site, and the robotic arm will extract rocks with a specialized gripper. These extracts will then be inserted into an independent chamber to conduct the carbonate and nitrogen tests. The full spectrum, and microscope camera will be mounted at the front.

AI & Navigation: We will be using ROS on a Jetson AGX Xavier to process 3D visuals of terrain (obtain from ZED stereo camera), objects detected by LIDAR, and rover motion data from the IMU. Based on this data the optimal path will be determined and obstacle avoidance will be performed by a combination of vSLAM, Occupancy Grid, and GPS along with error correction through Kalman filters and PID controller. The PID controller will be generalized to enable interfacing with robotic arm if required.

Communications: Ubiquiti Rocket Modules will be used to generate a 900MHZ radio wave through which the high-gain Yagi antenna at base establishes communication to the horizontally rotating Omni antenna on the rover. Within the Rover, Arduinos connected to a fuse will communicate data from each sub-system to the Jetson which is the main control unit.

Drive Control: The drive control system consists of four 12 volts 65.25 amperes brushless dc motors controlled by two Arduino shields, and connected in parallel to give an output torque of 30 Nm each, which itself results in a speed of approximately 3.8 mph. The motors have a built-in brake setting to slow the rover down and for stationary braking we will be using a set current to hold the motors in place.

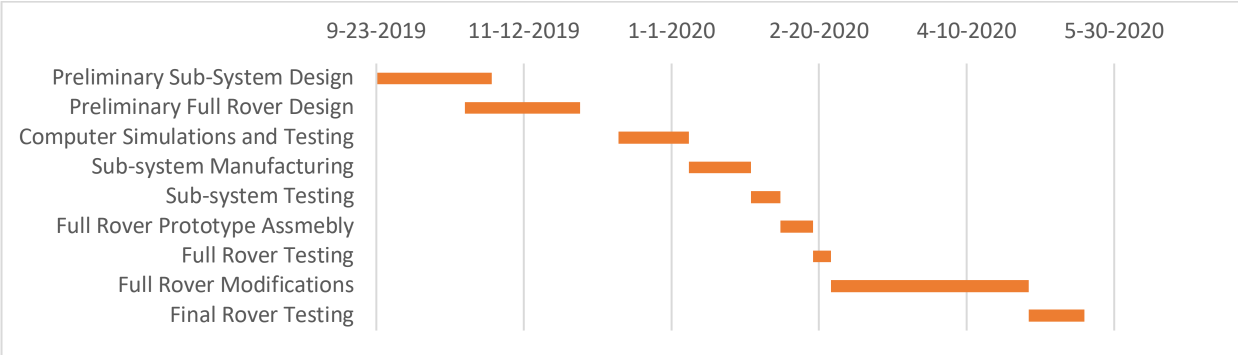
Power: A four LiPo cell battery pack, with two cells connected in series which together are connected in parallel to the other two in series, provides a voltage of 44V and ~480A. Along with this an inverter will be used to interface with the AC stepper motors of the robotic arm.

Suspension: We are using a modified version of the rocker-bogie suspension made out of hollow T6 6061 aluminum, with a differential gear mechanism. By not including stub axles or springs we enable the rover to climb twice the diameter of the wheels. The Tuff tire polyurethane foam wheels have extruded threading and can carry more than 100kgs.

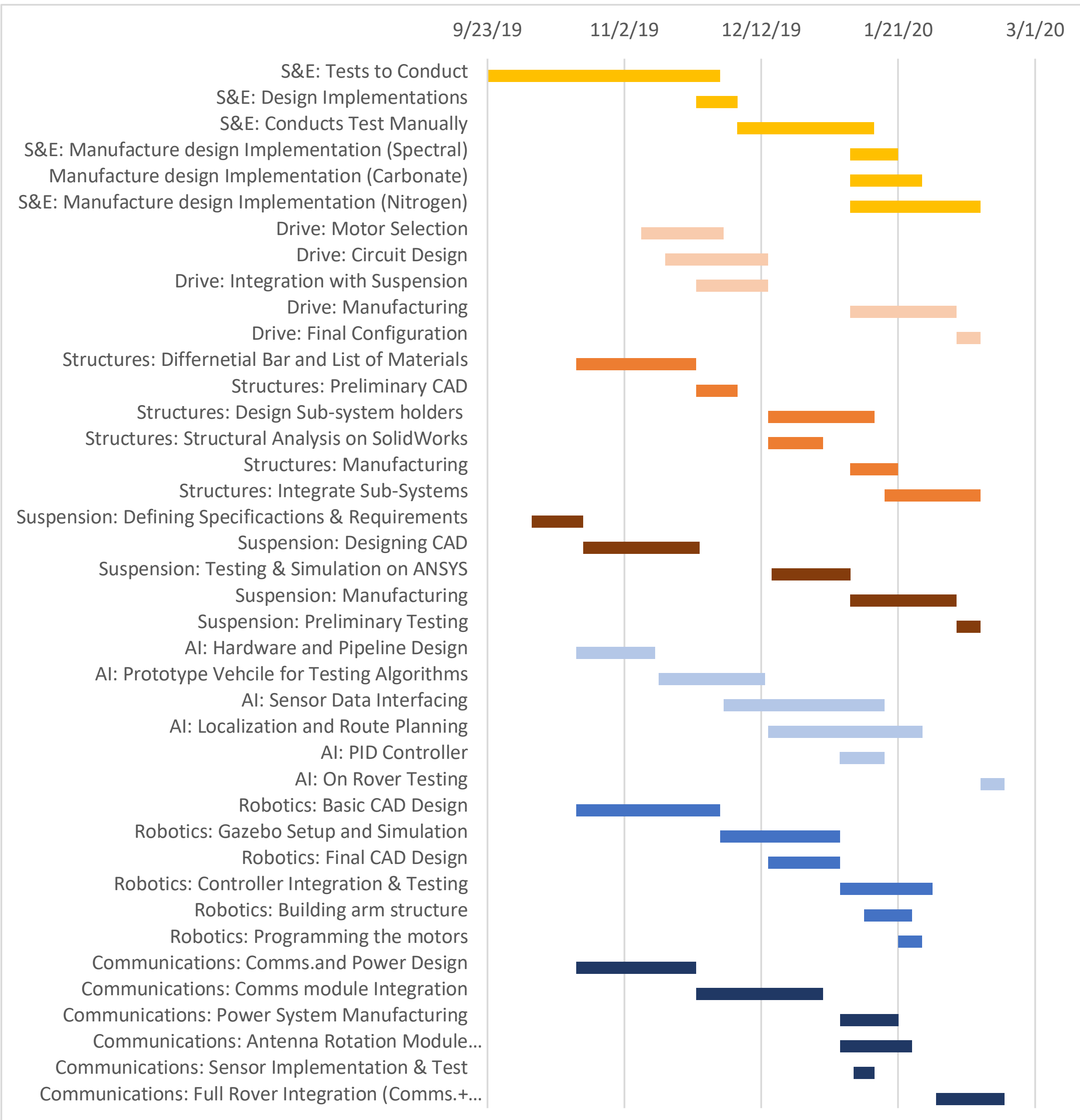
Structures: The structure is made of Aluminum 6061 and consists of the frame, hosing components which hold the differential bar, battery, and electrical circuitry, and the sub-system base. The structure will be modular, with the AI/Navigation, Robotic Arm, and Science and Exploration systems attached to the sub-system base depending on the mission.

Simulation & Testing: The mechanical robustness of the Rover will be tested through SolidWorks and ANSYS while the computing capabilities will be through a Gazebo environment.

Summarized Gant Chart:



Full Gant Chart:



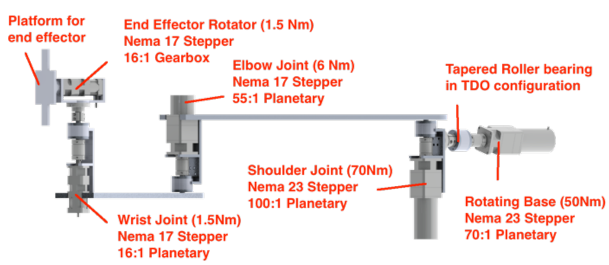
Budget:

Sub-System	Cost	10% Over.	Total
Robotics	$550	$55	$605
Comms.	$1,000	$100	$1,100
AI/Navigation	$1,200	$120	$1,320
Drive Control	$900	$90	$990
Suspension	$500	$50	$550
Structures	$300	$30	$330
Scien. & Explor.	$700	$70	$770
Total Cost:	$5,150	With Over.	$5,665

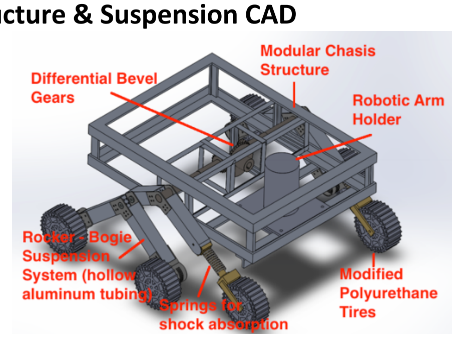
Funded:

Sub-System	Part	Amount
AI/Navigation	NVIDIA Jetson TX2	$600
AI/Navigation	Lidar & Camera	$600
Suspension	Frame	$300
Structures	Frame, Wheels & bearings	$500
Robotics	Stepper Motors, gearboxes & optical encoders	$550

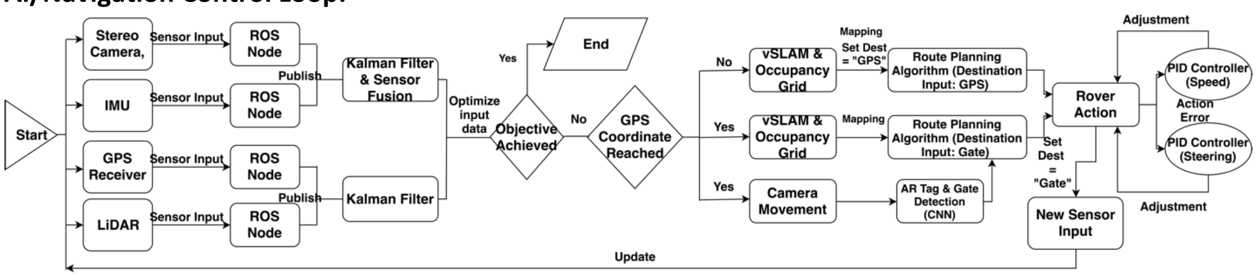
Robotic Arm CAD:



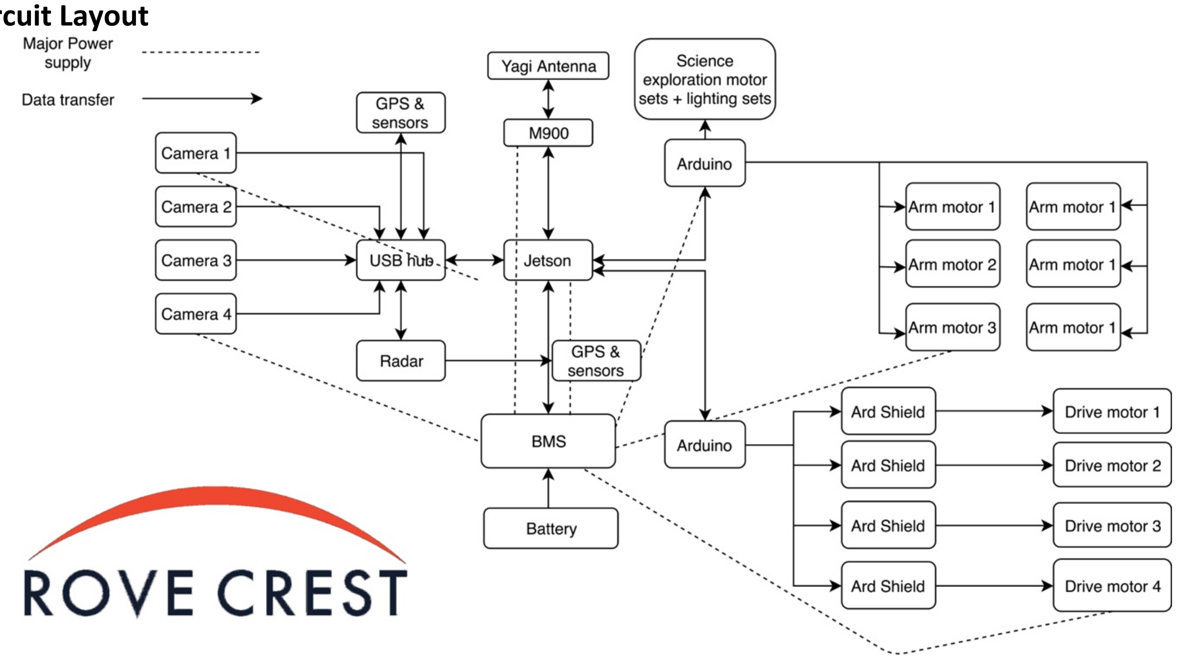
Structure & Suspension CAD



AI/Navigation Control Loop:



Circuit Layout



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