Project Management Plan

Team Name: SWARM

Team Members

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Problem Statement

Professor Xie would like a team of undergraduate students to conduct research and implement on how to develop multiple Unmanned Ground Vehicles (UGVs) to complete **time extensive computational** tasks. Large matrix computing tasks such as image processing, communication networks, and sending and receiving data are common problems when dealing with more than one UGV.

Need

In order to decrease the time it takes to perform a large computational task, the Swarm team will design and implement Swarm-AI topology by using a master rover to break up tasks between multiple slave rovers. The master rover must then be able to communicate these tasks to the slave rovers and get the individual results back in return. There is a great need for autonomous UGV swarms in situations such as security and surveillance, search and rescue, environmental mapping, disaster management, or military applications.

Statement of Work

Our Senior Design Project is to create an autonomous mobile distributed computing network. The team of engineers is responsible for communications, controls, autonomous movement, circuitry and PCB design for Unmanned Ground Vehicles (UGV). Our design will be built upon the current Senior Design B team, Smile Cloud 9, that is currently working with Professor Xie.

Advisor

We have already confirmed Dr. Xie as our team's advisor. Dr. Xie conducts research in computing networks at the SysteMe and InteLligEnce (SMILE) lab at SDSU. Dr. Xie currently has a senior design team working on a project for her that she would like us to take over for the next semester.

Validation Plan

Validation is key to this project because it ensures that all problems will be identified for each prototype iteration thereby preventing the efficient resolution of design issues. The plan for validation is shown in Table 1. It is expected that this list will grow as we learn from testing and debugging along the way.

Test	Description	Success Criteria

DC Bias	Test all power supply voltages and DC bias levels in the circuit	Bias levels match theoretical predictions with respect to the specified battery
DC-DC Converter	Test all in body converters	Step-down DC power to desired specifications of 5 or 3.3 V
Motors are driven	Test to see if axle movement occurs	Motors will move when specified voltage is supplied
Functional switching diodes	Test proves that switching diodes prevent the motors from inductive kickback	Motors are not pulling more current than necessary and diodes prevent inductive kickback
Ferrite Beads	Provides as a staple to suppress high frequency noise that could be projected onto components and external hardware	Modules and microcontrollers do not pick up error signals and components/external hardware aren't affected by noise
Rover Communication	3 way handshake between the two nodes for verification.	Write a script to verify that a packet is either sent or received from node to node.
Object Detection	Test a rover's ability to detect a specified object	Place specified objects in the rover's path and see if the rover signals that the object is there
Object Avoidance	Test a rover's ability to move around an obstacle in its path	Place specified objects in the rover's path, and see If the rover re-routes path to avoid running into the object.
Autonomous Movement	Test a rover's... (i) ability to specify coordinates, (ii) ability to accurately process coordinates, (iii) translate commands to move to specified location	Give the rover a specific coordinate and see if it verifies the three parts listed in test description
Localization	Test a rover's ability to determine its current location	Ask rover to give its current location and verify its accuracy using RVIZ
Arduino Nano Input Voltage	Test voltage input of Arduino	Use a DMM to verify that the

		input voltage is between 7 and 12 Volts

Table 1 - Validation Plan

Budget

The anticipated costs are estimated in Table 2 below and are estimated to be $380, however this does not allow for contingencies. Based on discussions between the group and with our advisor, the items shown in Table 3 were drafted. Based on the anticipated budget and contingencies, our group has agreed to a total of around $500 on this project.

Item	Cost
Jetson Nano Developer Kit	$100
Ground Rover Chassis	$60 ($30 for master rover & $30 for slave rover)
PCB Design	$60 ($30 each iteration)
Xbee3	$32
Arduino Nano	$42 ($21 each)
Motor	$8 ($4 each)
Raspberry Pi Camera	~$8
Passive Electrical Components	$56
Total	~$358

Table 2 - Anticipated Costs

Cost Contingency	Project Cost Impact
Motors are damaged from electrical design flaw	$8
PCB Design error (Scrapped electrical components)	$30
PCB is damaged beyond use/repair	$30
Chassis damaged beyond repair (respect to environmental aspects)	$30

Total	$98

Table 3 - Budget Contingencies

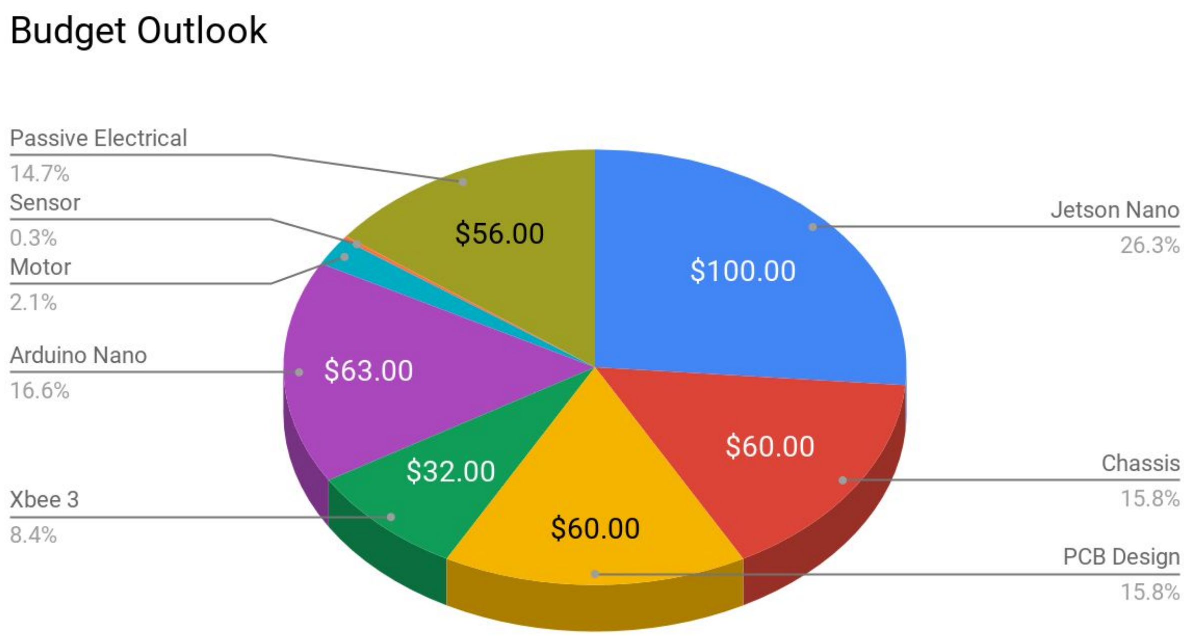

Figure 1 - Costs Breakdown

Task Breakdown

Tasks for the project are shown in Table 4 below. These tasks comprise 542 hours and will cover 32 calendar weeks requiring approximately 4 hours per person per week. These tasks feed Key Milestones as described in Table 5. After the first prototype has been evaluated, the team will identify and schedule tasks comprising "Design Iteration."

Task Name	Description	Estimated Hours	Feeds Key Milestone
Developing Autonomous Capabilities	i) Developing techniques and algorithms to program the UGV to be autonomous ii) PCB design for movement	80 Hours	Movement (Rover)
Localization	Implementing GPS	20 Hours	Movement (Rover

	and/or cameras in order to localize rover's current position		
Simulate UGV movement through ROS	Testing our rover's movement using through ROS simulation before programming out physical UGV	50 Hours	Movement (Rover)
Testing UGV's component movement	Testing our rover's movement physically	50 Hours	Movement (Rover)
Complete Block Diagram	A breakdown of the controls hardware, communication, and tasks of the UGV	2 Hours	Documentation
PDD and Revision	Project Description Document	8 hours	Documentation
PMP and Revision	Project Management Plan	8 hours	Documentation
Presentation	Creating our project presentation slides and presenting our project	3 Hours	Documentation
Identification of key components	To identify cost, size, and performance	5 Hours	PCB design
Design PCB draft through KiCad	Design PCB which implements the electrical design and meets all engineering specifications	15 Hours	PCB design
PCB Fabrication	Ordering PCB and soldering on all necessary components	2 hours	PCB design, Design Iteration
PCB Debugging	Test all connections	1 hours	PCB Design, Design

	and components		Iteration
Hand calculations	Using circuit analysis to help with design of PCB	4 Hours	Circuit Design
Detailed Circuit Design	i) Implementation of hardware on breadboard using components and wires ii) Converting pre-circuity to physical PCB using KiCad	25 Hours	Circuit Design
Communications between rovers	Implement a software in order to enable Nanos to transmit and receive from a local host	30 Hours	Communications (Rover)
Send/Deliver a packet	Send a 127-bit packet between nodes and verify that the packets are identical	30 hours	Communications (Rover)
Software Debugging	Finding errors in our software code and figuring out how to fix the issue	20 Hours	Communications (Rover), Movement (Rover), Design Iteration
Technical Description	Create documents with all design information and know-how.	150 Hours	Technical Description
Live Rover Testing	Evaluating the rovers' physical movement and communication between each other physically in real time.	25 Hours	Evaluation, Movement (Rover), and Communications (Rover)
Demonstration of computational task	UGV SWARM Carries Out a Task	25 Hours	Evaluation

Table 4 - Task Breakdown

Key Milestones and Owners

The tasks in Table 4 feed the Key Milestones which are shown in Table 5 as well as in our schedule. Each Key Milestone has owners who are responsible for subdividing the tasks and tracking each team or sub-teams progress.

Task Name	Description	Responsibilities
Documentation	Create project description document and project management plan	Arrian, Dominic, Reginald, Cameron, Yenhung
Movement (Rover)	Obtaining movement from the rover with implemented hardware and software	Hardware: Arrian, Reginald Software Leads: Dominic, Reginald, Cameron
Communications (Rover)	Successful communications established between master node and slave nodes	Dominic, Reginald, Cameron
Evaluation	Prototype fully tested, deficiencies noted. Report created.	Arrian, Dominic, Reginald, Cameron, Yenhung
Design Iteration	Circuit design and PCB iterations between first prototype validation and final result.	Arrian, Dominic, Reginald, Cameron, Yenhung
Technical Description	Create documents with all design information and know-how.	Arrian, Dominic, Reginald, Cameron, Yenhung
Circuit design	Circuit design is complete, calculations, simulations archived, and CAD schematic done. All components selected.	Arrian & Michael
PCB design	Design PCB using KiCad.	Arrian & Michael

Table 5 - Key Milestones

Schedule

Key Milestones from the previous section are shown on the schedule in Table 6. This chart is continuously reviewed at each project meeting and revised if needed.

Task Name	Start Date	End Date
Robot Operating System - Simulating and Testing	April 1st 2020	May 2020
Circuit Design	June 1st 2020	June 22th 2020
PCB Design	June 22th 2020	July 6th 2020
Autonomous Development	May 4th 2020	August 28th 2020
Distributed Computing technique Development	May 18th 2020	August 7th 2020
Design Implementation - Putting the pieces together	August 24th 2020	October 2nd 2020
Technical Description / Documentation	March 2nd 2020	December 4th 2020
Design Iteration	October 2nd 2020	December 4th 2020

Table 6 - Schedule

Risks

This project requires two parts: simulation/research and implementation. To give background to the matter, the team will conduct multiple robotic and distributed computation simulations in order to solidify the teams' experience with robots. These simulations will include the needed techniques to achieve these computations through the use of specific software. After that, the team will then transition to the implementation part of the project where the software and hardware leads will collaborate in order to achieve a working robot. With this in mind, the team faces multiple risks that block the road to success if left unaddressed.

Our advisor made it clear that without the background knowledge of how a robot operates, the team is doomed to fail during the implementation phase. The team has to familiarize themselves with ROS, a powerful tool that was recommended by our advisor to help demonstrate robotic applications. This robotics middleware aids in the research and simulation aspects of our project. Once the team is accustomed to how a robot moves and communicates, we then move to the building side of the project.

There are many potential hazards when working with robots. Many hazards can be attributed to human errors which can occur at any point of our project such as programming, maintenance, or control failures. Capitalizing on controls, the brain of the robot, if left with faults, can lead to a dangerous workplace for the team. Other hazards could be attributed to different environmental settings, such as rain, due to the fact that our robot does not have any weatherproof capabilities planned yet.

Those are just a piece of the pie when regarding the risks our team has considered. Listed in Table 7 below depicts the many risks along with their consequences, likelihood of occuring, issues that arise, and mitigations to prevent such an event.

Risk #	Risk Consequence (1-5)	Risk Likelihood (1-5)	Issue	Risk and Mitigation
1	4	3	Autonomous Capabilities	The robot can't function properly without autonomous movement. This risk is mitigated by allocating the majority of our efforts into implementing this topic. This subject is also our advisors specialty, so she will be able to offer guidance.
2	5	2	Communication between rovers	If rovers are not able to communicate with each other, then the 'master' will not be able to split up time intensive tasks between multiple rovers. Risk is mitigated by allocating the majority of our efforts into implementing this topic. This subject is also our advisors specialty, so she will be able to offer guidance.
3	3	3	Image Processing	Image Processing allows us to implement cameras for localization to move our rovers autonomously, without it we will be stuck to

				manual movement. We mitigate this risk by perfecting it in a ROS simulation.
4	3	2	Optimal Distance between master and worker(s)	Optimal distance between rovers is key to transferring data as efficiently as possible. We mitigate this risk by constantly checking that our rovers are 10-75 meters apart (from specifications).
5	4	3	Software Implementation	Errors in implementation of our Message Passing Interface code can make computational errors. Incorrect debugging of autonomous code can lead to incorrect pathing. We mitigate this risk by diligently debugging and reviewing our design code.
6	4	3	Circuit Design / PCB	We are currently anticipating multiple design iterations of our PCB. This risk is mitigated by allocating multiple opportunities to fix flaws in our design by thorough testing and evaluation of each iteration.
7	2	3	Project exceeds budget	Unexpected contingencies would be caused by insufficient testing/handling of our hardware. This risk is mitigated by careful pre-calculations as well as adherence to lab rules. Our advisor is also willing to cover any extra costs.

8	5	1	Environmental Hazards	Unexpected environmental hazards can occur without notice. For example, our rover is not waterproof so rain would be an issue. To mitigate this we do our testing indoors.
9	4	2	Human Handling Errors	Human errors such as dropping equipment and mishandling of parts can lead to permanent physical damage of our robots. We mitigate this risk by always abiding by lab rules and careful handling of equipment.

Table 7 - Risks and Mitigation

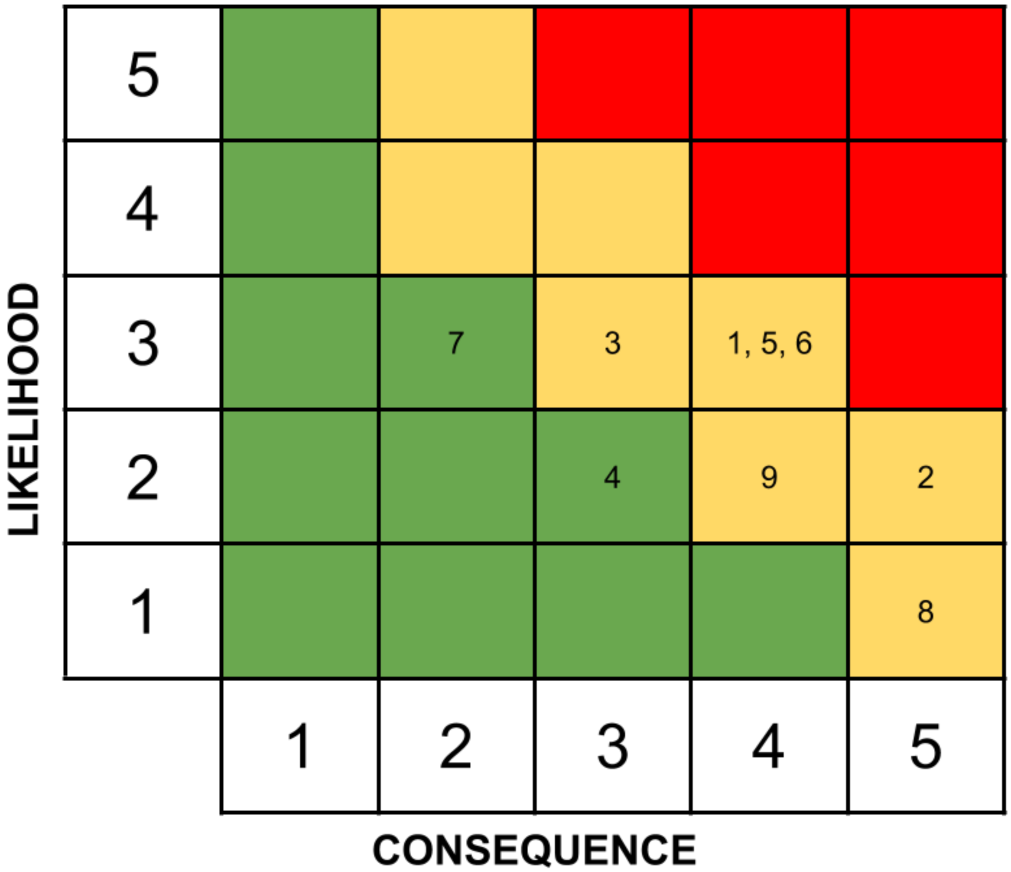

Figure 2 - Risk Cube