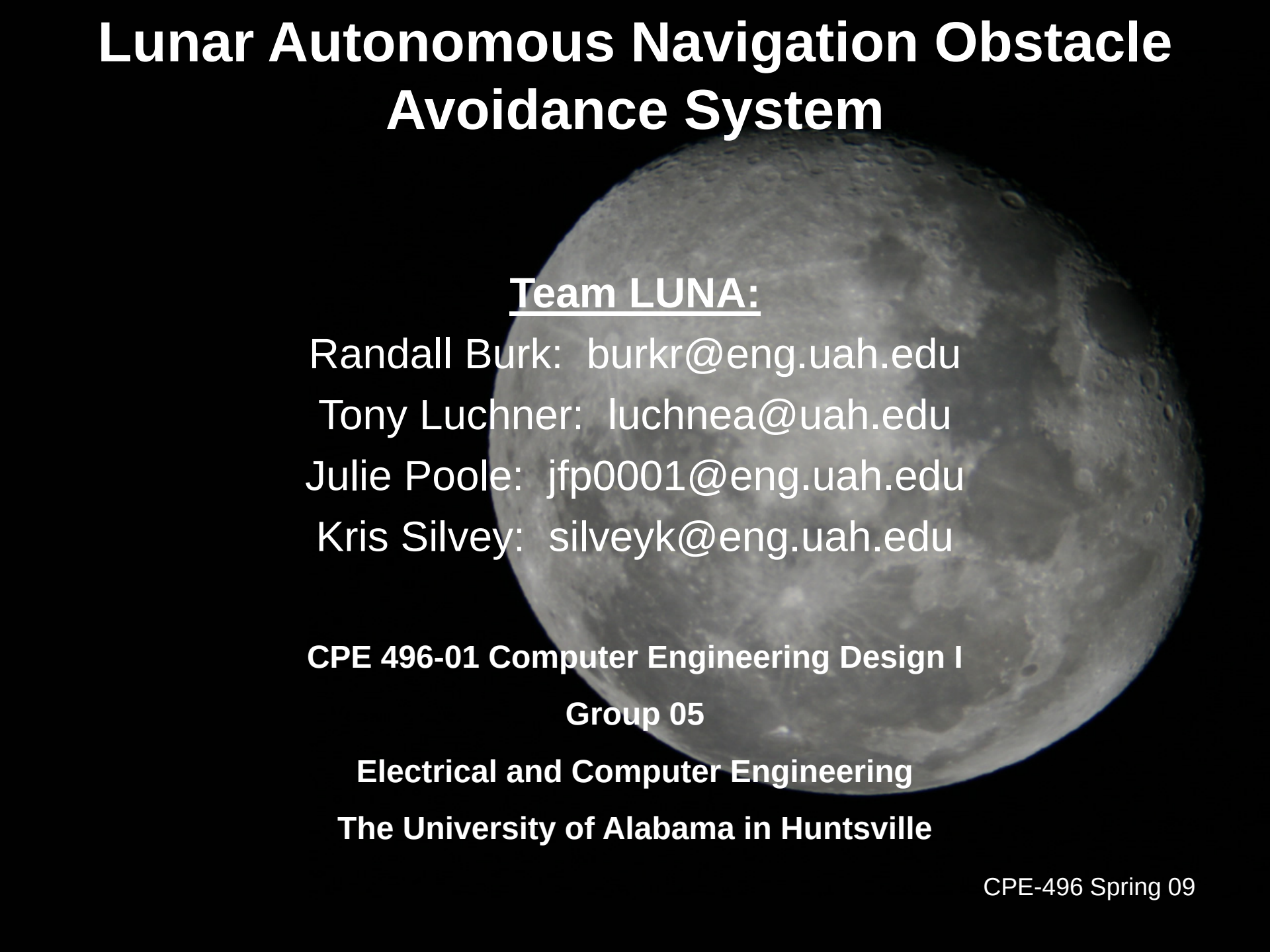
Lunar Autonomous Navigation Obstacle Avoidance System



Team LUNA:

Randall Burk: burkr@eng.uah.edu

Tony Luchner: luchnea@uah.edu

Julie Poole: jfp0001@eng.uah.edu

Kris Silvey: silveyk@eng.uah.edu

CPE 496-01 Computer Engineering Design I

Group 05

Electrical and Computer Engineering

The University of Alabama in Huntsville

Team Luna

- Randall Burk:
  - Interests: hardware-software integration
  - Expertise: mechanical re-fabrication, multi-level programming
  - Role: mechanical re-fabrication, Propeller programming
- Tony Luchner:
  - Interests: robotics and embedded system
  - Expertise: embedded programming
  - Role: LADAR implementation and integration
- Julie Poole:
  - Interests: high level programming
  - Expertise: object-oriented design
  - Role: UWB implementation and integration
- Kris Silvey:
  - Interests: simulation and development
  - Expertise: system level programming
  - Role: data-log development, Propeller programming

The Need

- Today, space exploration goals include lunar and Martian landings and exploration.
- Unmanned exploration will need to be done first.
- To accomplish this, autonomous rovers will need to be developed for different tasks.

State of the Art:

- Mars Rover
  - 32-bit Rad 6000 microprocessor
  - 20 cameras (vision)
  - Stereo Vision (safe NAV)
  - UHF Radio (communication)
  - Inertial Measurement Unit (for balance)

Fundamental Requirements:

- The rover's navigational sensors shall be limited to those capable of lunar operation.
- The system shall use a LINUX based laptop containing localization, obstacle detection, and fuzzy-logic navigational algorithms.
- The system shall use two or three stationary and one mobile Time Domain Ultra-Wide-Band radios to create localization system.
- The rover shall use a Sick LADAR for obstacle detection.
- The rover shall have the ability to autonomously avoid pre-defined hazard areas.
- The rover shall have the ability to autonomously avoid unknown obstacles limited to the LADAR's scanning height.
- The system shall have a remote radio controlled override system.
- The system shall have a data-logging system for information and troubleshooting purposes.
- The upper chassis of the rover shall be re-fabricated to support additional rover hardware.

Possible Solution 1:

- Use current configuration, implementing navigational algorithms on the Parallax microcontroller.

- PROBLEM 1: Parallax microcontroller is not robust enough to handle real-time autonomous navigation.
- PROBLEM 2: Parallax microcontroller's memory is currently at 80% of capacity.

Possible Solution 2:

- Maintain current rover configuration, using laptop for navigational algorithm only.

- PROBLEM 1: Data transmission latency will decrease performance of real-time autonomous navigation
- PROBLEM 2: With latency issues, the rover would risk collisions with objects and be unable to obtain accurate rover location data.

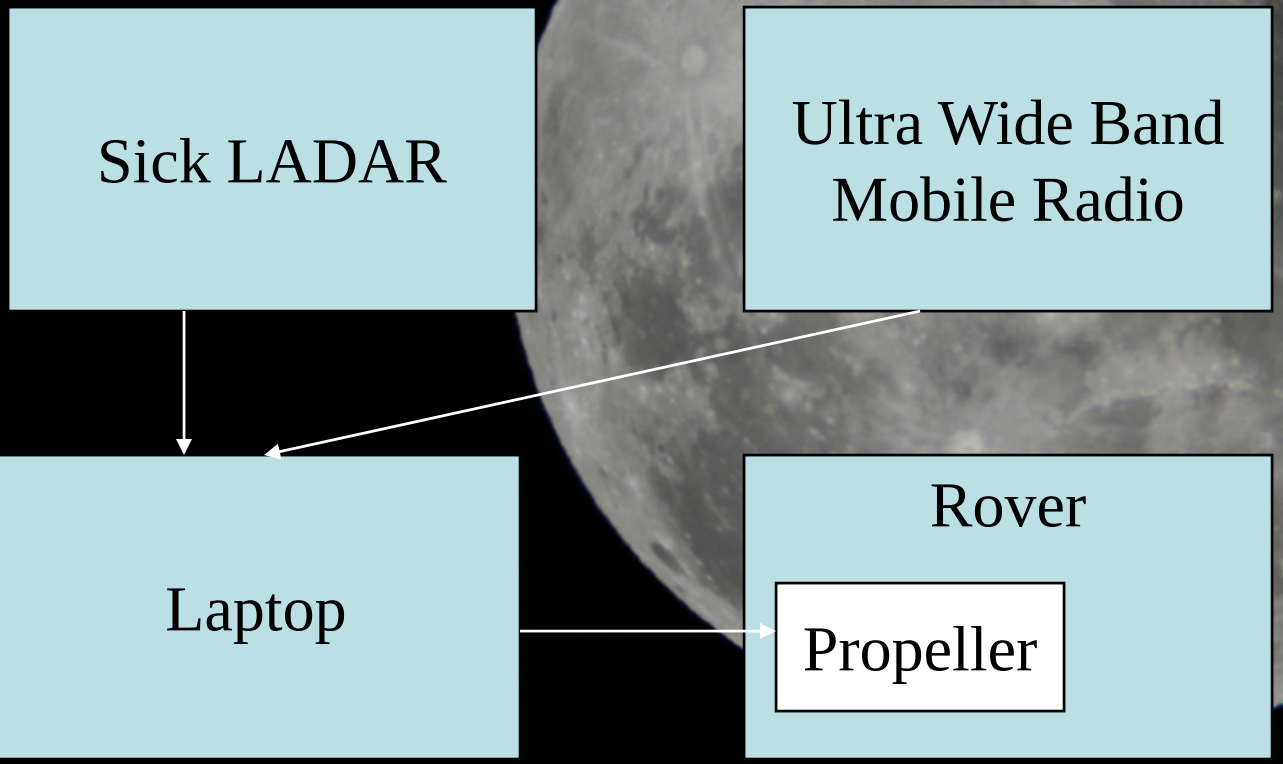
Proposed Solution:

- Remove existing software from Parallax microcontroller except for rover servo / actuator commands and remote control override.
- Implement localization, obstacle detection, and navigational algorithms on LINUX based laptop.
- Use laptop serial communication to relay commands to the Parallax microcontroller.

Functional Design

- Hardware
  - Rover
    - Propeller
    - Control servos/actuators
  - Laptop
  - Sick LADAR
  - UWB Radios
  - Power Distribution Box

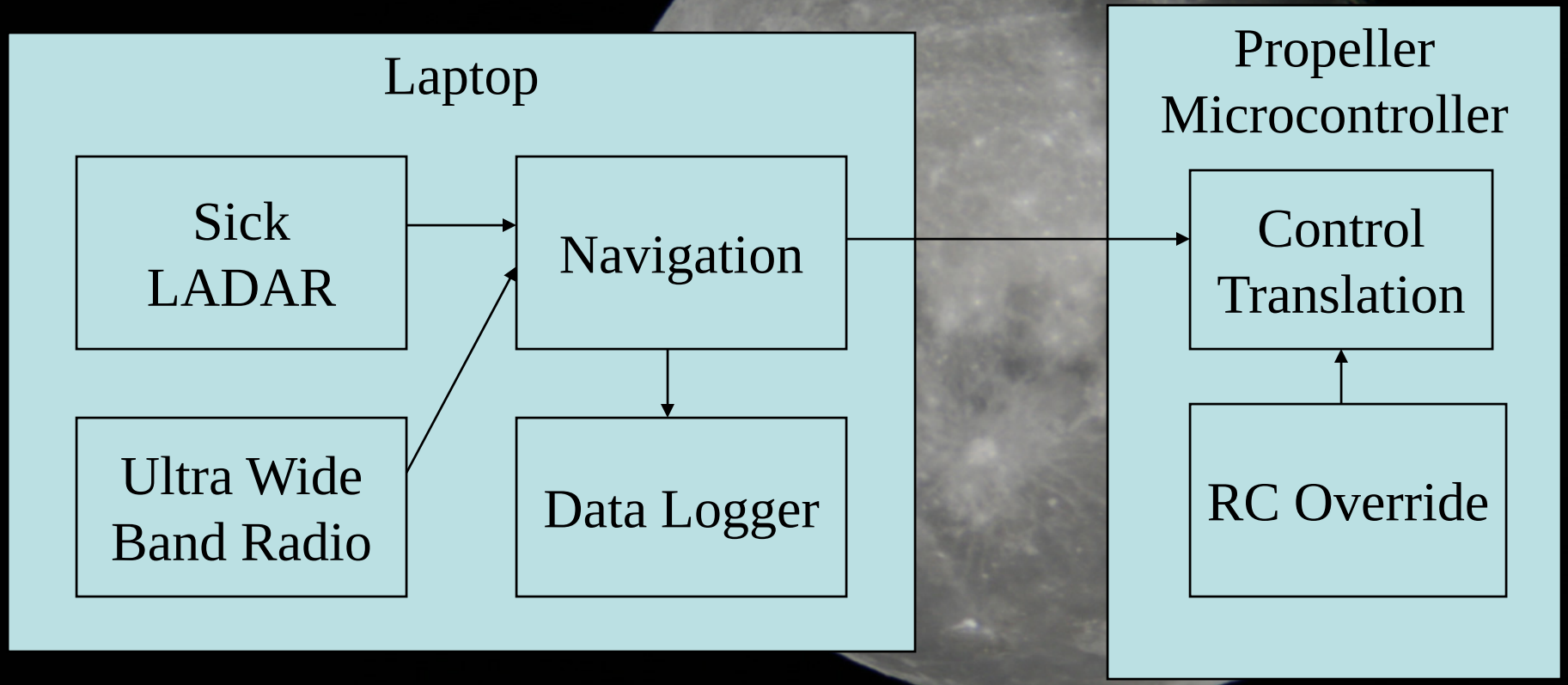
Functional Design (HW Inputs/Outputs)



Functional Design

- Software
  - Propeller microcontroller
    - Remote control override
    - Control translator
  - Laptop Software
    - LADAR Control
    - UWB Control
    - Navigation and Fuzzy Logic Algorithms
    - Data Logger

Functional Design (SW Inputs/Outputs)



Innovation

- Use PROPELLER to control vehicle movements
- Use UWB to create a navigation grid
  - Use 2-3 stationary UWB radios for grid setup
  - Use 1 mobile UWB radio to determine current position
- Use LADAR for detecting unknown objects
- Use a laptop to take inputs from peripherals and determine proper navigation using fuzzy logic

Project Summary

Team LUNA will remove existing software from Parallax microcontroller and implement localization, obstacle detection, and navigational algorithms on LINUX based laptop. All navigational decisions will be dependent upon the laptop. The system will use laptop serial communication to relay commands to the Parallax microcontroller. The Parallax microcontroller will be used for controlling vehicle movement only.

Project Plan: Work Breakdown Structure

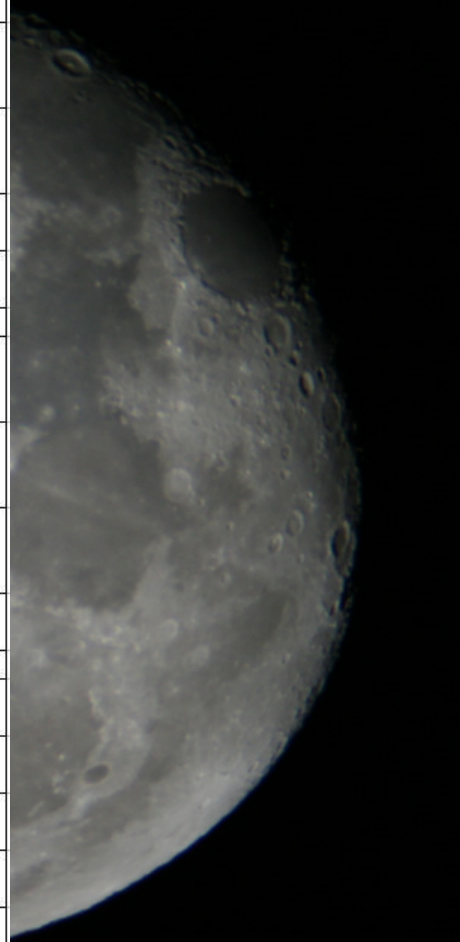
ID	Activity	Deliverables/Checkpoints	Duration (Days)	People	Resources	Predecessors
1	Technical/ Familiarization of Rover		24			
1.1	Review Current System Configuration	Review functionality of Rover and components	24	Tony, Kris, Randall, Julie	Rover, UWB, LADAR, RC Controller, Power Supply	
1.2	Read Manuals		24	Tony, Kris, Randall, Julie	Technical Manuals	
1.3	Understand Mechanics of Rover		24	Tony, Kris, Randall, Julie	Rover and manuals	
2	Refabrication and Maintenance		45			
2.1	Design of Refabrication for chassis		9	Randall	Technical POC	
2.2	Cost of Refabrication	Re-Fabricated Chassis	2	Randall	Fabrication Shop	2.1
2.3	Detect Maintenance issues		8	Randall	Rover	
2.4	Correct or Propose solution for issues	Maintenance issues fixed or proposed solution in place	16	Randall		2.3
2.5	Test Maintenance	Maintenance issues completed	9	Randall	Rover	2.4
2.6	Test Refabrication	Refabrication finished	9	Randall	Rover	2.2
3	Laptop - Microcontroller Interface		36			
3.1	Review possible options for Laptop		5	Kris	Internet	
3.2	Submit Laptop possibilities and Cost		2	Kris	Sponsor POC	3.1
3.3	Receive Laptop and set-up	Laptop	21	Randall		3.2
4	Data Logger		28			
4.1	Propose Design for Data Logger		7	Kris		
4.2	Write Code for implementation	Data Logger Code	14	Kris	C-compiler, text editor	4.1
4.3	Test Data Logger	Test Plans complete	5	Kris	Laptop, Code	4.2

Project Plan: Work Breakdown Structure

ID	Activity	Deliverables/Checkpoints	Duration (Days)	People	Resources	Predecessors
5	UWB Simulation		38			
5.1	Familiarization with UWB		7	Julie	UWB radios and code	
5.2	Attend UWB Lecture	Better understanding of UWB	0	Tony, Kris, Randall, Julie		
5.3	Research Current Implementation		12	Julie	UWB radios and code	
5.4	Write Code for new Implementation	Code for stand alone UWB functionality complete	11	Julie	C-compiler, text editor	5.3
5.5	Write Test Plan for UWB Simulation	Test Plans complete	8	Julie		5.4
6	LADAR Simulation		38			
6.1	Familiarization with LADAR		7	Tony	LADAR	
6.2	Research Current Implementation		12	Tony	LADAR	
6.3	Write Code for new Implementation	Code complete for LADAR	11	Tony	C-compiler, text editor	6.2
6.4	Write Test Plan for LADAR Simulation	Test Plans complete	8	Tony		6.3
7	RC Integration		26			
7.1	Review Previous Configuration		2	Kris, Randall	RC Controller, Rover	
7.2	Test Plan and Procedures for New Configuration	Test Plans complete	8	Kris, Randall		
7.3	Implement Code for New Configuration	Code complete for RC Integration	5	Kris, Randall	C-compiler, text editor	7.2
7.4	Testing of New Integration		11	Kris, Randall	Test Plans, Laptop, Code	7.3

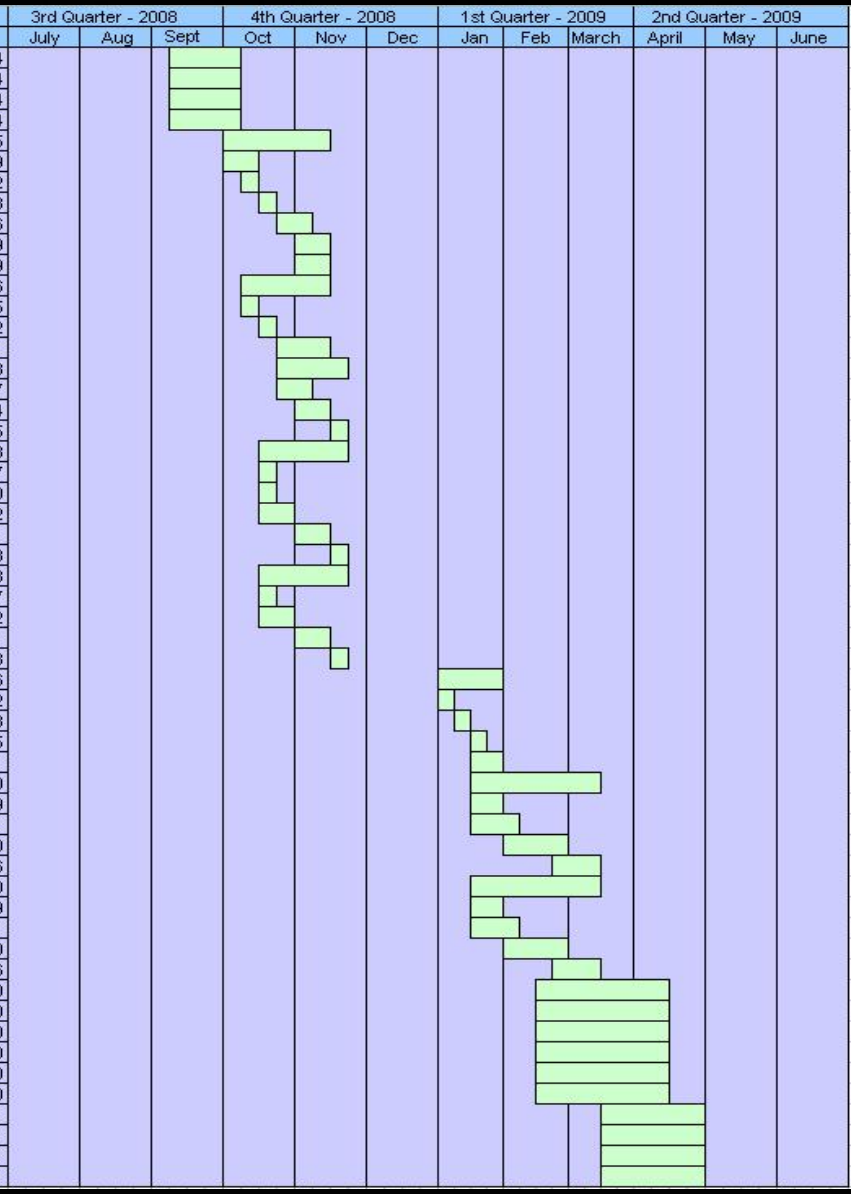
Project Plan: Work Breakdown Structure

ID	Activity	Deliverables/Checkpoints	Duration (Days)	People	Resources	Predecessors
8	UWB Interface		60			
8.1	Use the Simulation code to connect UWB to Nav		19	Julie	Laptop, Code	5
8.2	Generate Test Plan and Procedures for UWB	Test Plans complete	21	Julie		8.1
8.3	Implement new code necessary for Interface	Code complete for UWB integration into NAV	20	Julie	C-compiler, text editor	
8.4	Test UWB functionality		16	Julie	Test Plans, Laptop, Code	8.2
9	LADAR Interface		60			
9.1	Use the Simulation code to connect LADAR to Nav		19	Tony	Laptop, Code	6
9.2	Generate Test Plan and Procedures for LADAR	Test Plans complete	21	Tony		9.1
9.3	Implement new code necessary for Interface	code complete for LADAR integration into NAV	20	Tony	C-compiler, text editor	
9.4	Test LADAR functionality		16	Tony	Test Plans, Laptop, Code	9.2
10	Nav System		60			
10.1	Integration of UWB	System Integration for UWB complete	60	Tony, Kris, Randall, Julie	Laptop, Code	8
10.2	Integration of LADAR	System Integration for LADAR complete	60	Tony, Kris, Randall, Julie	Laptop, Code	9
10.3	Fuzzy Logic Integration	Fuzzy Logic code for Nav System complete	60	Tony, Kris, Randall, Julie	Laptop, Code	
10.4	Integration of Data Logger	System Integration for Data Logger complete	60	Tony, Kris, Randall, Julie	Laptop, Code	4
10.5	Data setup for Integration to Propellor		60	Tony, Kris, Randall, Julie	Laptop, Code	
11	Final Testing		41			
11.1	Test Autonomous Navigation	Final Tests for Autonomous Navigation	41	Tony, Kris, Randall, Julie	Test Plans, Laptop, Code	all previous
11.2	Test Data Logger	Final Tests for Data Logger	41	Tony, Kris, Randall, Julie	Test Plans, Laptop, Code	all previous
11.3	Test Complete Functionality	System Integration Testing Complete	41	Tony, Kris, Randall, Julie	Test Plans, Laptop, Code	all previous



Project Plan: Gantt Chart

Number	Task	Resource for Task	Start Date	End Date	Duration Days
1	Technical/ Familiarization of Rover	Tony, Kris, Randall, Julie	9/13/2008	10/7/2008	24
1.1	Review Current System Configuration	Tony, Kris, Randall, Julie	9/13/2008	10/7/2008	24
1.2	Read Manuals	Tony, Kris, Randall, Julie	9/13/2008	10/7/2008	24
1.3	Understand Mechanics of Rover	Tony, Kris, Randall, Julie	9/13/2008	10/7/2008	24
2	Refabrication and Maintenance	Randall	10/1/2008	11/15/2008	45
2.1	Design of Refabrication for chassis	Randall	10/1/2008	10/10/2008	9
2.2	Cost of Refabrication	Randall	10/10/2008	10/12/2008	2
2.3	Detect Maintenance issues	Randall	10/12/2008	10/20/2008	8
2.4	Correct or Propose solution for issues	Randall	10/20/2008	11/5/2008	16
2.5	Test Maintenance	Randall	11/6/2008	11/15/2008	9
2.6	Test Refabrication	Randall	11/6/2008	11/15/2008	9
3	Laptop - Microcontroller Interface	Kris, Randall	10/5/2008	11/10/2008	36
3.1	Review possible options for Laptop	Kris	10/5/2008	10/10/2008	5
3.2	Submit Laptop possibilities and Cost	Kris	10/10/2008	10/12/2008	2
3.3	Receive Laptop and set-up	Randall	10/20/2008	11/10/2008	21
4	Data Logger	Kris	10/23/2008	11/20/2008	28
4.1	Propose Design for Data Logger	Kris	10/23/2008	10/30/2008	7
4.2	Write Code for implementation	Kris	11/1/2008	11/15/2008	14
4.3	Test Data Logger	Kris	11/15/2008	11/20/2008	5
5	UWB Simulation	Julie	10/13/2008	11/20/2008	38
5.1	Familiarization with UWB	Julie	10/13/2008	10/20/2008	7
5.2	Attend UWB Lecture	Tony, Kris, Randall, Julie	10/14/2008	10/14/2008	0
5.3	Research Current Implementation	Julie	10/20/2008	11/1/2008	12
5.4	Write Code for new Implementation	Julie	11/1/2008	11/12/2008	11
5.5	Write Test Plan for UWB Simulation	Julie	11/12/2008	11/20/2008	8
6	LADAR Simulation	Tony	10/13/2008	11/20/2008	38
6.1	Familiarization with LADAR	Tony	10/13/2008	10/20/2008	7
6.2	Research Current Implementation	Tony	10/20/2008	11/1/2008	12
6.3	Write Code for new Implementation	Tony	11/1/2008	11/12/2008	11
6.4	Write Test Plan for LADAR Simulation	Tony	11/12/2008	11/20/2008	8
7	RC Integration	Kris, Randall	1/5/2009	1/31/2009	26
7.1	Review Previous Configuration	Kris, Randall	1/5/2009	1/7/2009	2
7.2	Test Plan and Procedures for New Configuration	Kris, Randall	1/7/2009	1/15/2009	8
7.3	Implement Code for New Configuration	Kris, Randall	1/15/2009	1/20/2009	5
7.4	Testing of New Integration	Kris, Randall	1/20/2009	1/31/2009	11
8	UWB Interface	Julie	1/13/2009	3/14/2009	60
8.1	Use the Simulation code to connect UWB to Nav	Julie	1/13/2009	2/1/2009	19
8.2	Generate Test Plan and Procedures for UWB	Julie	1/15/2009	2/5/2009	21
8.3	Implement new code necessary for Interface	Julie	2/5/2009	2/25/2009	20
8.4	Test UWB functionality	Julie	2/26/2009	3/14/2009	16
9	LADAR Interface	Tony	1/13/2009	3/14/2009	60
9.1	Use the Simulation code to connect LADAR to Nav	Tony	1/13/2009	2/1/2009	19
9.2	Generate Test Plan and Procedures for LADAR	Tony	1/15/2009	2/5/2009	21
9.3	Implement new code necessary for Interface	Tony	2/5/2009	2/25/2009	20
9.4	Test LADAR functionality	Tony	2/26/2009	3/14/2009	16
10	Nav System	Tony, Kris, Randall, Julie	2/13/2009	4/14/2009	60
10.1	Integration of UWB	Tony, Kris, Randall, Julie	2/13/2009	4/14/2009	60
10.2	Integration of LADAR	Tony, Kris, Randall, Julie	2/13/2009	4/14/2009	60
10.3	Fuzzy Logic Integration	Tony, Kris, Randall, Julie	2/13/2009	4/14/2009	60
10.4	Integration of Data Logger	Tony, Kris, Randall, Julie	2/13/2009	4/14/2009	60
10.5	Data setup for Integration to Propellor	Tony, Kris, Randall, Julie	2/13/2009	4/14/2009	60
11	Final Testing	Tony, Kris, Randall, Julie	3/13/2009	4/23/2009	41
11.1	Test Autonomous Navigation	Tony, Kris, Randall, Julie	3/13/2009	4/23/2009	41
11.2	Test Data Logger	Tony, Kris, Randall, Julie	3/13/2009	4/23/2009	41
11.3	Test Complete Functionality	Tony, Kris, Randall, Julie	3/13/2009	4/23/2009	41



Project Plan: Cost

Component Cost	Regular	Our Cost
Quad Rover	$4,999.00	Sponsored
SICK LADAR	$3,000.00	Sponsored
UWB Radios (x4) @ $3,000.00 each	$12,000.00	Sponsored
Laptop **LAWANDA**	$500.00	Sponsored
Total:	$20,499.00	Sponsored

- Labor
  - 10 hours/week per person
  - 4 members on the team
  - 16 weeks to completion
  - Total hours: 640
- Hours completed in CPE 495
  - 10 hours/week per person
  - 4 members
  - 11 weeks
  - Total Hours: 440

Questions?