Affordable 3D LIDAR

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Project Plan Outline

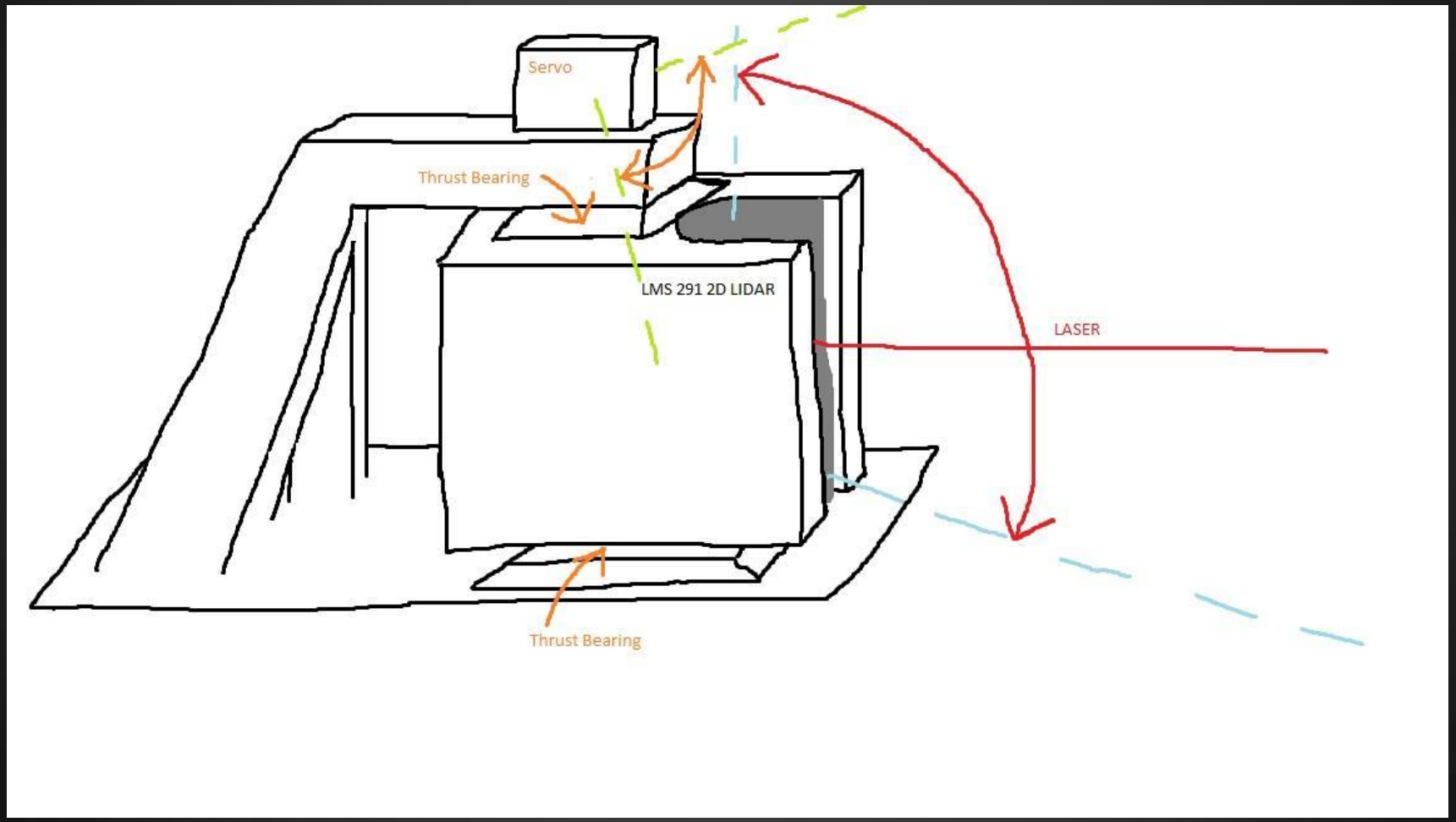
- Problem Statement
- Conceptual Sketch
- Functional Requirements
- Non-Functional Requirements
- Market Survey
- Potential Risks & Mitigation
- Resource/Cost Estimate
- Project Milestones & Schedule

Problem/Need Statement

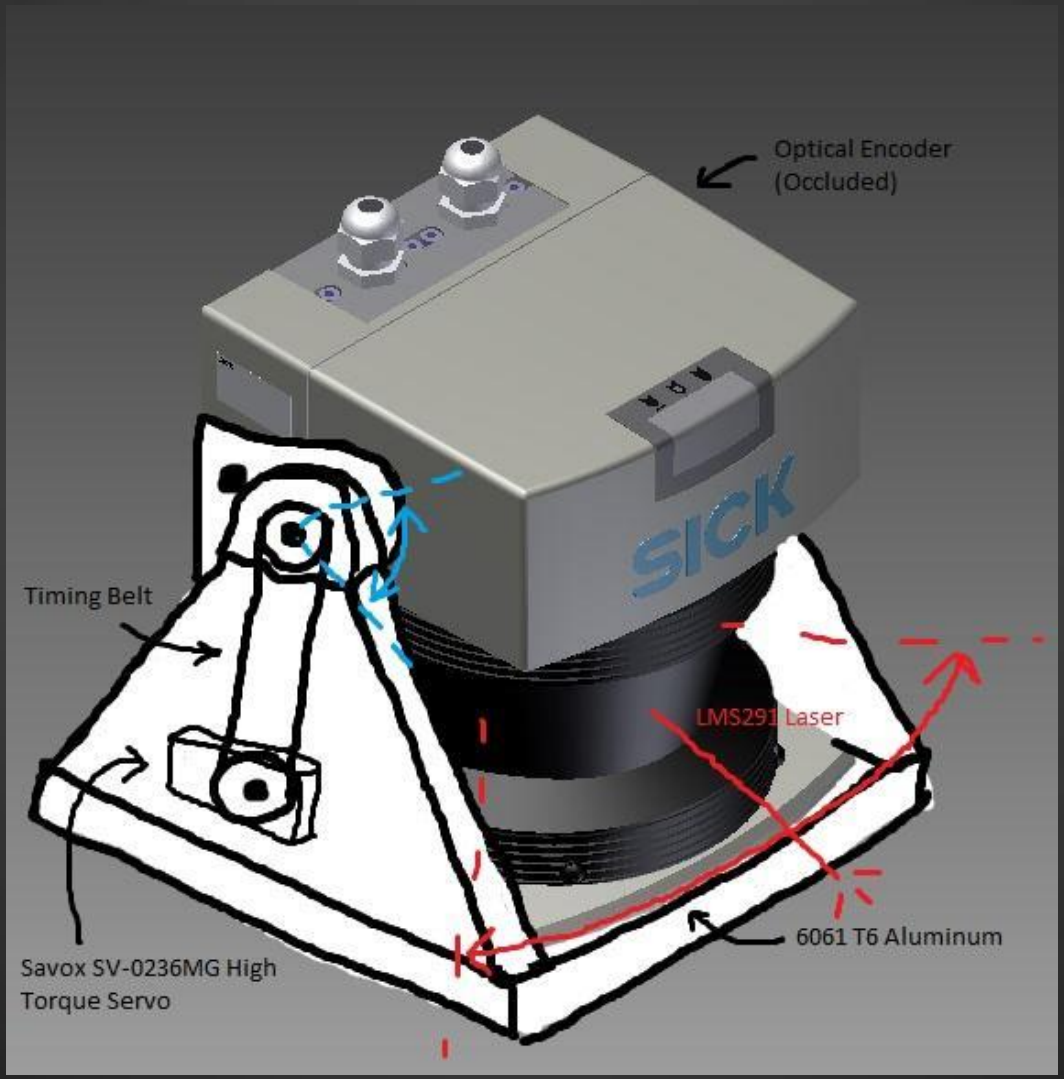
- 3D LIDAR is expensive but is advantageous for small/medium scale robotics research
- 2D LIDAR is much cheaper but doesn't provide enough data for effective navigation
- Ultimately, how can we create a 3D point cloud using a 2D device?

- Target Customers: Lunabotics, Vermeer Corporation

Conceptual Sketch



Conceptual Sketch



Functional Requirements

- Scanning
  - Each scan must take less than 1 second to complete
  - Each scan must start no more than 0.5 seconds after the previous scan completes
- Mechanical
  - Servo setup must provide positional feedback (ie - be closed-loop)
  - Servo must withstand 600 oz/in of torque
  - Scanning apparatus must scan at least 120 degrees
- Software
  - Deliver scan results in a human-readable format
  - Use RS-422 protocol to communicate with LIDAR to achieve necessary baud rate
  - Scan results should be visible to the user no more than 0.5 seconds after a scan completes

Non-Functional Requirements

- Hardware
  - Hardware should connect to PC via USB
  - The LIDAR should be a SICK LMS-291
  - Prototype should be tested while mounted on the provided wheeled cart
- Software
  - User should be able to operate the system with one window
- Cost
  - Any needed software should be open source or widely available
  - Cost of prototype must be much less than a 3D LIDAR
  - Cost of servo should be less than $100

Market Survey

- 2D to 3D LIDAR conversions have been done before
  - Many academic attempts and applications
    - Robotics, esp.
  - Commercial conversions are available
- Our implementation is unique
  - Lower cost than commercial kits for LMS-291 LIDAR
  - Increased robustness
    - Tilting (or ‘nodding’) the LIDAR as opposed to a continuous rotation eliminates need for a rotating electrical connection

Potential Risks & Mitigations

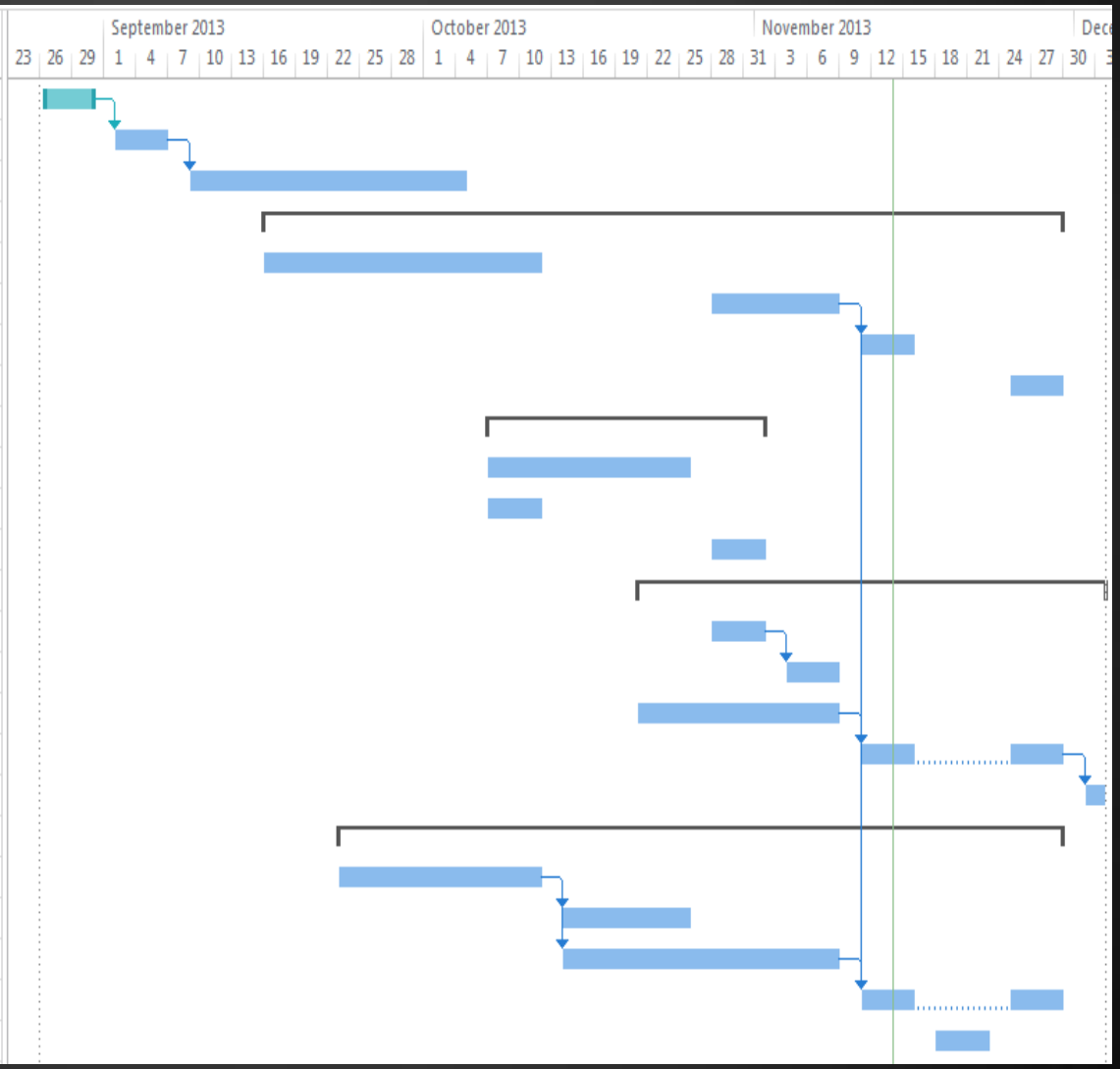
- The system might not be fast enough to be usable
  - We can reduce resolution as needed to meet speed requirements
- The parts required may exceed the originally planned budget
  - We can use surplus parts or find sponsorships if the budget becomes an issue
- The inherent risk of injury from working with lab equipment
  - Follow lab policies and procedures
  - Receive proper training

Resource/Cost Estimate

	Market Value	Our Cost
SICK LMS-291 LIDAR	$6000	
RS-422 Cable and Adapter	$20	
Savox SV-0236MG Servo Motor	$110	$100
Servo Controller	(Varies)	
Parts		$40
PCB Fabrication		$30
Desktop Computer	(Varies)	
Software	$0	
Power Supplies	$100	$100
Optical Encoder	$30	$30
Total	$6260+	$300

Project Milestones & Schedule

Task Name	Duration	Start	Finish
Project Selection	4.5 days	Mon 8/26/13	Fri 8/30/13
Meet Advisor	5 days	Mon 9/2/13	Fri 9/6/13
Lab Resource Allocation	20 days	Mon 9/9/13	Fri 10/4/13
Documentation	**55 days**	**Mon 9/16/13**	**Fri 11/29/13**
Project Plan	20 days	Mon 9/16/13	Fri 10/11/13
Design Documentation	10 days	Mon 10/28/13	Fri 11/8/13
Project Plan v2	5 days	Mon 11/11/13	Fri 11/15/13
Final Documentation	5 days	Mon 11/25/13	Fri 11/29/13
Mechanical	**20 days**	**Mon 10/7/13**	**Fri 11/1/13**
Servo Research	15 days	Mon 10/7/13	Fri 10/25/13
Software Setup	5 days	Mon 10/7/13	Fri 10/11/13
Apparatus Sketchup	5 days	Mon 10/28/13	Fri 11/1/13
Electrical	**32 days**	**Mon 10/21/13**	**Tue 12/3/13**
Compile Tech Specs	5 days	Mon 10/28/13	Fri 11/1/13
Tech Spec Review	5 days	Mon 11/4/13	Fri 11/8/13
Design PCB	15 days	Mon 10/21/13	Fri 11/8/13
Breadboard PCB	10 days	Mon 11/11/13	Fri 11/29/13
Order PCB	2 days	Mon 12/2/13	Tue 12/3/13
Software	**50 days**	**Mon 9/23/13**	**Fri 11/29/13**
Software Research	15 days	Mon 9/23/13	Fri 10/11/13
Computer Setup	10 days	Mon 10/14/13	Fri 10/25/13
ROS Tutorials	20 days	Mon 10/14/13	Fri 11/8/13
Proof of Concept in Lab	10 days	Mon 11/11/13	Fri 11/29/13
BREAK	5 days	Mon 11/18/13	Fri 11/22/13



System Design Outline

- Functional Decomposition
- Detailed Design
  - Hardware
  - Software
  - Mechanical
- Test Plan

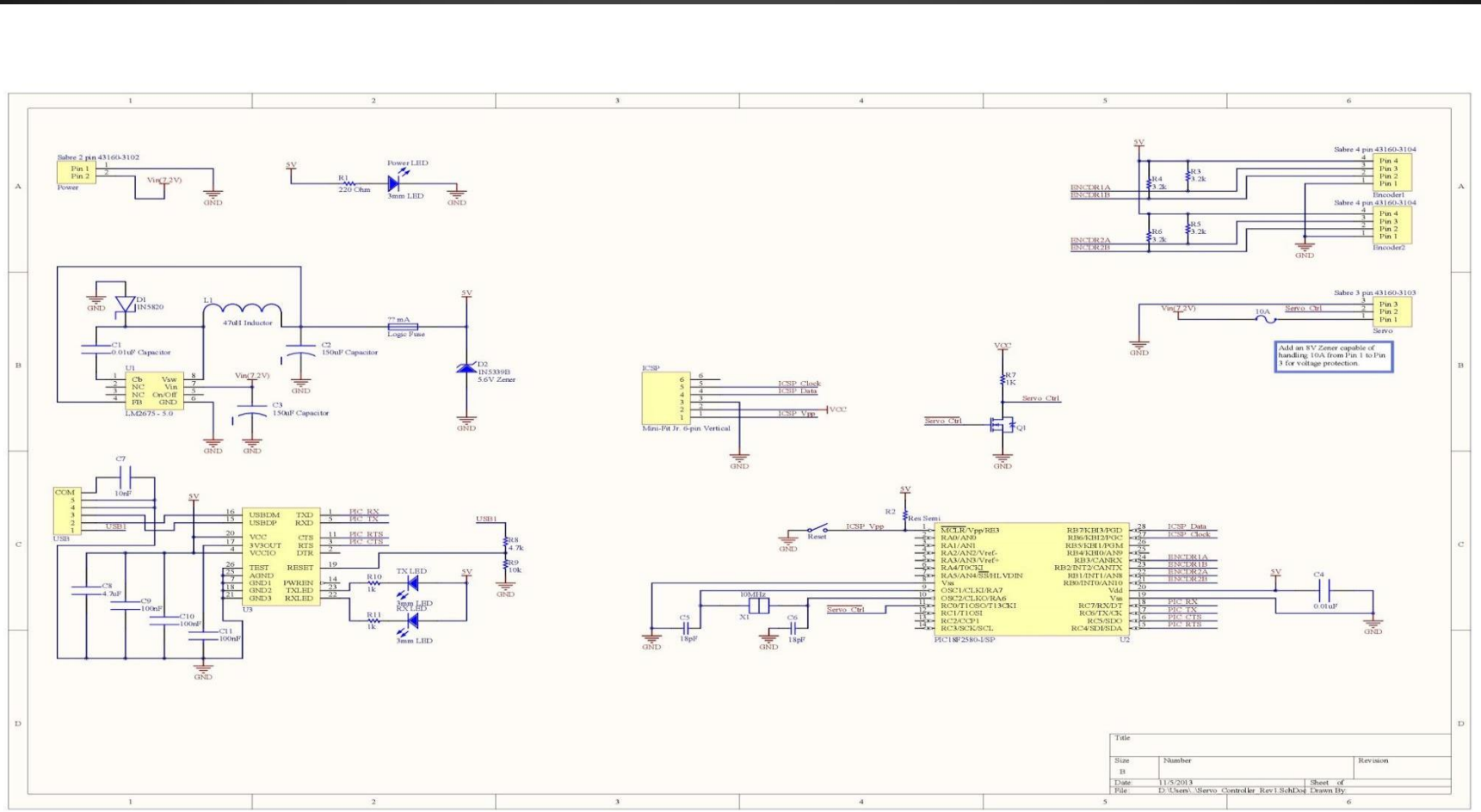
Functional Decomposition

- Interface Software
  - Display
  - Communication
  - Data Processing
- Scanning
  - Signal Converter (USB to RS-422)
  - SICK LMS-291 LIDAR
- Structure and Movement
  - Mechanical Apparatus
  - Servo
  - Servo Controller
- Power Supplies

Hardware Design

- Servo Controller
  - PIC18F2580 Microcontroller
  - FT232RL USB to Serial UART Interface
  - LM2675 Voltage Regulator
- Servo Motor
  - Savox SV-0236MG
- Optical Encoder
  - Quadrature Encoded
  - At Least 1° Resolution
- Power Supply
  - 24V 10A DC Power Supply (LIDAR)
  - 0-30V 13A 400W Adjustable DC Power Supply (Servo and Controller)

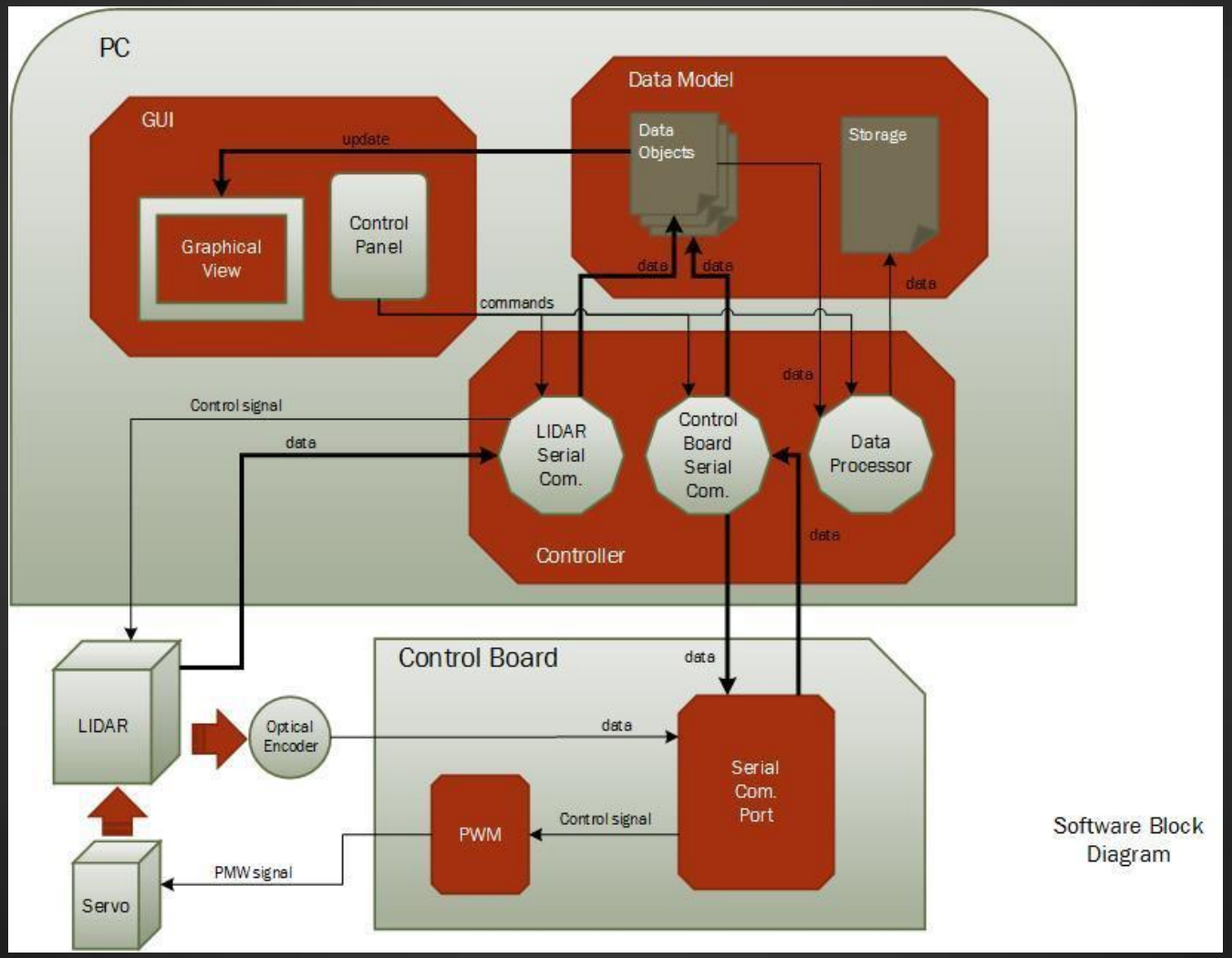
Servo Controller Schematic



Software Design

- Robot Operating System (ROS)
  - Open source
  - Compatible with Linux
  - Written in C++
  - Well documented
  - Existing libraries
    - interface with LIDAR
    - serial communication
    - 3D Point Cloud
  - Build tool
  - rviz

Software Diagram



Mechanical Design

- 6061 T6 Aluminum construction
- Savox SV-0236MG High Torque Servo
  - Timing Belt used to rotate LIDAR
- LMS-291 LIDAR

Final design will be completed in the beginning of Spring Semester

Test Plan

- Software
  - gtest
  - unit test
  - functional test
- Mechanical
  - stress test
- Hardware
  - breadboard testing
  - environment test

Conclusion

- Current Project Status
- Work Distribution
- Plan for Next Semester

Current Project Status

Done

- Planned project
- Designs
  - PCB design
- Concept
  - Mechanical Apparatus
- Parts ordered
- Servo controller prototype
- Software prototype
  - Obtain data from the LIDAR
  - Plot point cloud

Current Project Status (cont'd)

To-do

- Add optical encoder
- Test servo controller prototype
- Order and assemble PCB of controller
- Build and test the mechanical apparatus
- Integrate physical subcomponents
- Software implementation
- Functional testing

Task Responsibilities

Nicolas:

- Team Leader
- LIDAR Software
- Website

Todd:

- Communications
- Electrical Design
- Mechanical Design
- Parts Ordering

Eric:

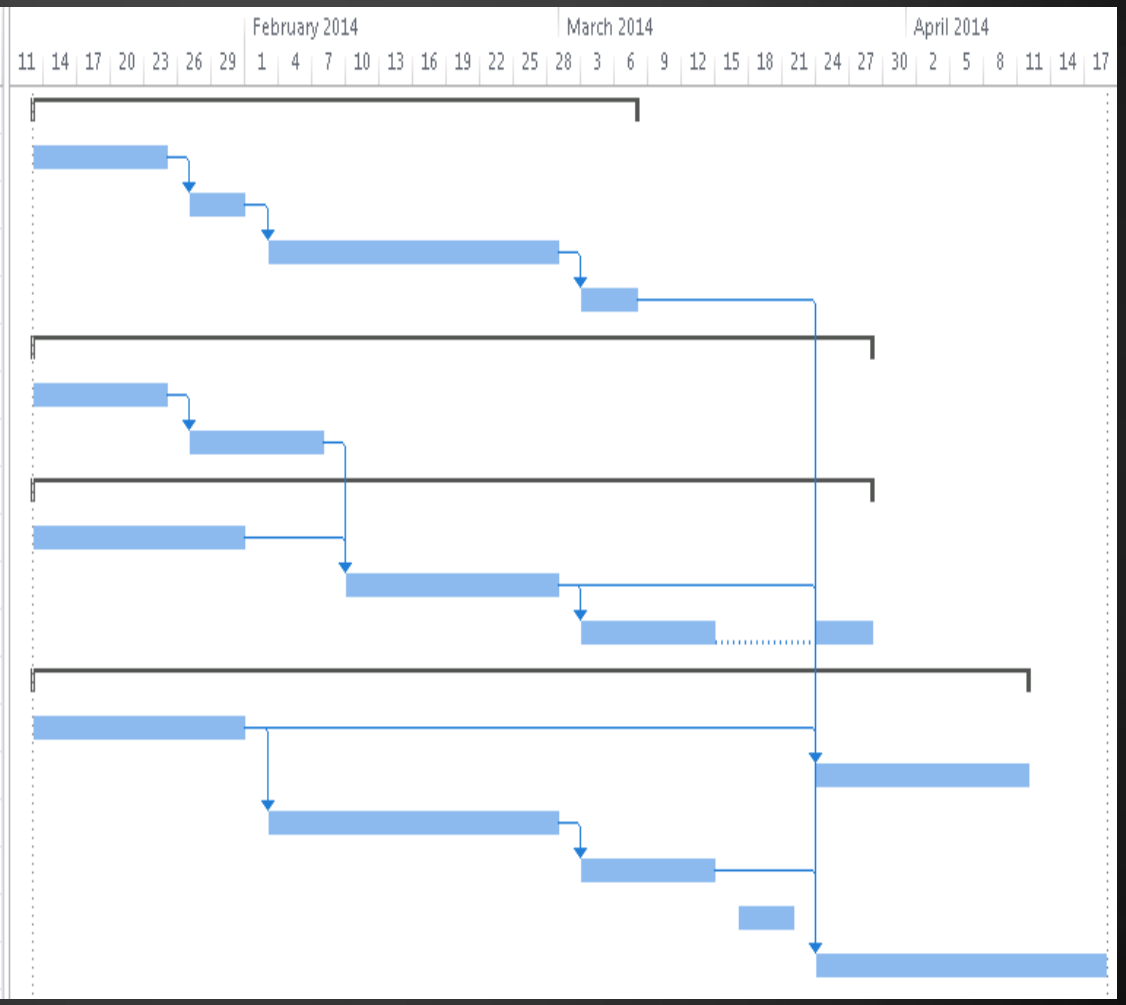
- Servo Ordering
- Electrical Design
- Breadboarding

Peter:

- LIDAR Software
- User Interface Design

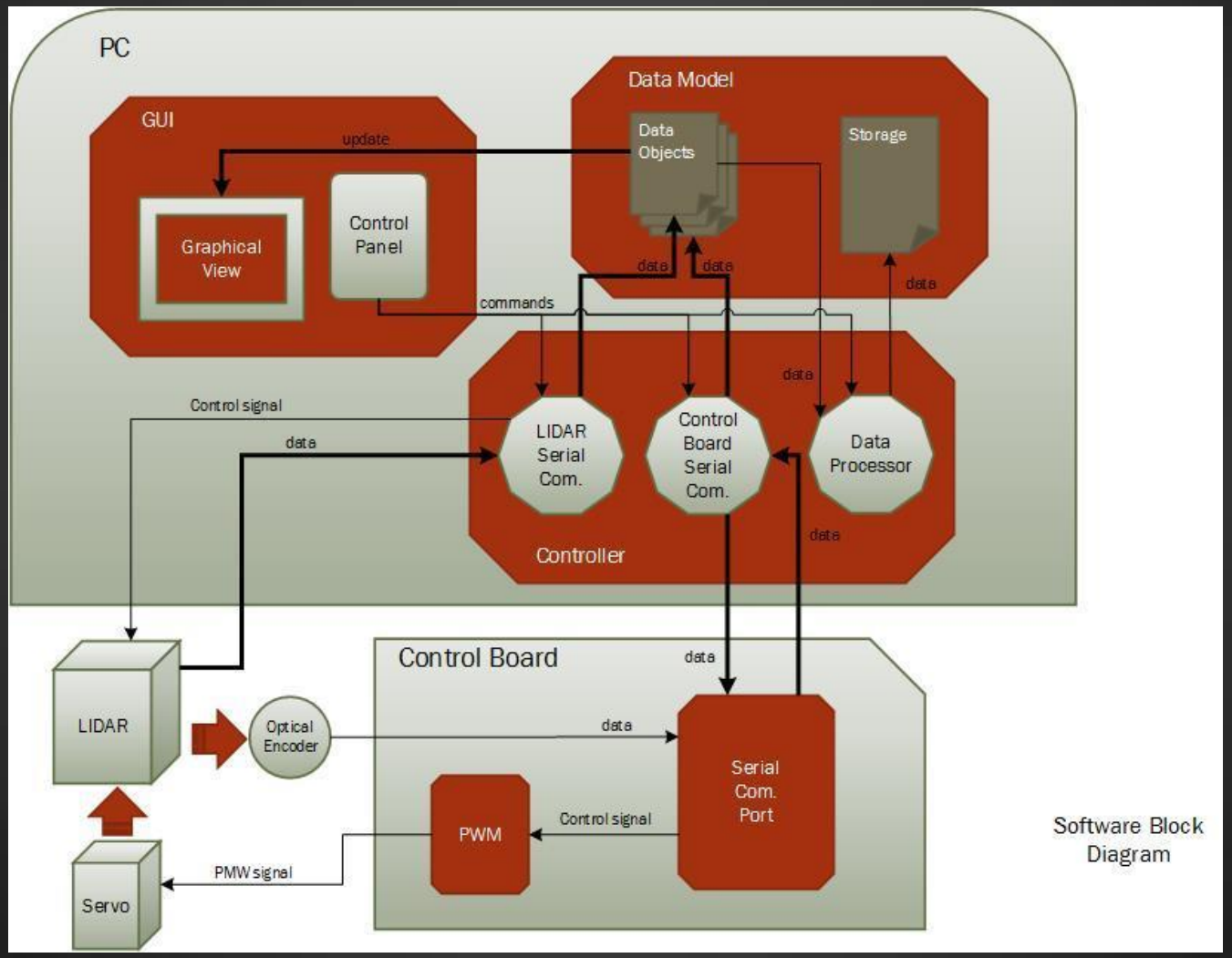
Plan for Next Semester

Task Name	Duration	Start	Finish
Mechanical (Apparatus)	**40 days**	**Mon 1/13/14**	**Fri 3/7/14**
CAD Design	10 days	Mon 1/13/14	Fri 1/24/14
CAD Review	5 days	Mon 1/27/14	Fri 1/31/14
Fabrication	20 days	Mon 2/3/14	Fri 2/28/14
Manual Testing	5 days	Mon 3/3/14	Fri 3/7/14
Electrical (Control Board)	**55 days**	**Mon 1/13/14**	**Fri 3/28/14**
Board Fabrication	10 days	Mon 1/13/14	Fri 1/24/14
Board ElectricalTesting	10 days	Mon 1/27/14	Fri 2/7/14
Programming	**55 days**	**Mon 1/13/14**	**Fri 3/28/14**
with Breadboard	15 days	Mon 1/13/14	Fri 1/31/14
with PCB	15 days	Mon 2/10/14	Fri 2/28/14
Testing	15 days	Mon 3/3/14	Fri 3/28/14
Software (ROS)	**65 days**	**Mon 1/13/14**	**Fri 4/11/14**
Format Scan Data (2D)	15 days	Mon 1/13/14	Fri 1/31/14
Format Scan Data (3D)	15 days	Mon 3/24/14	Fri 4/11/14
Coorelate LIDAR & Servo	20 days	Mon 2/3/14	Fri 2/28/14
Design Control Panel	10 days	Mon 3/3/14	Fri 3/14/14
BREAK	5 days	Mon 3/17/14	Fri 3/21/14
Full Testing	20 days	Mon 3/24/14	Fri 4/18/14

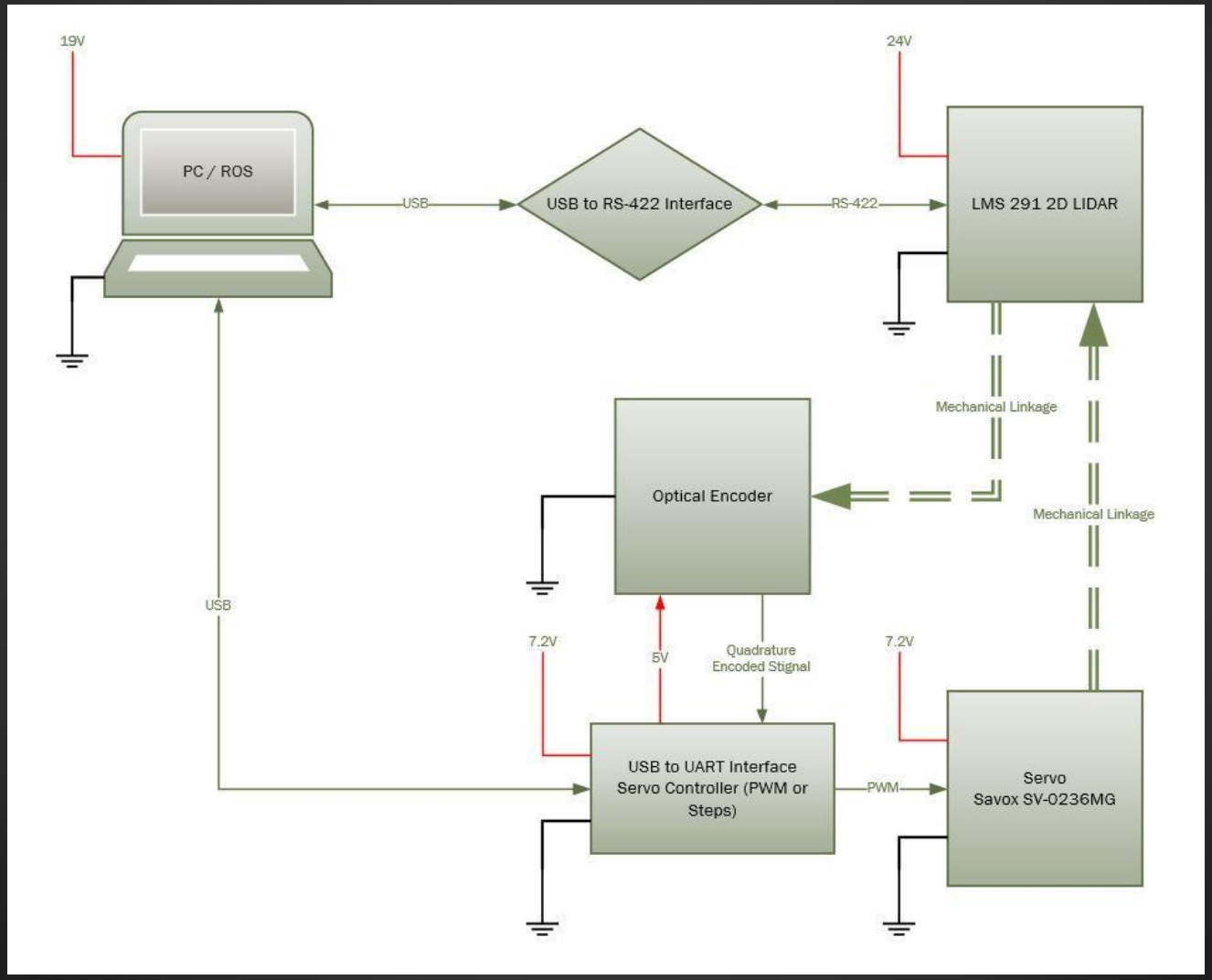



How?
Where?
When?
Why?
Which?
What?
Who?

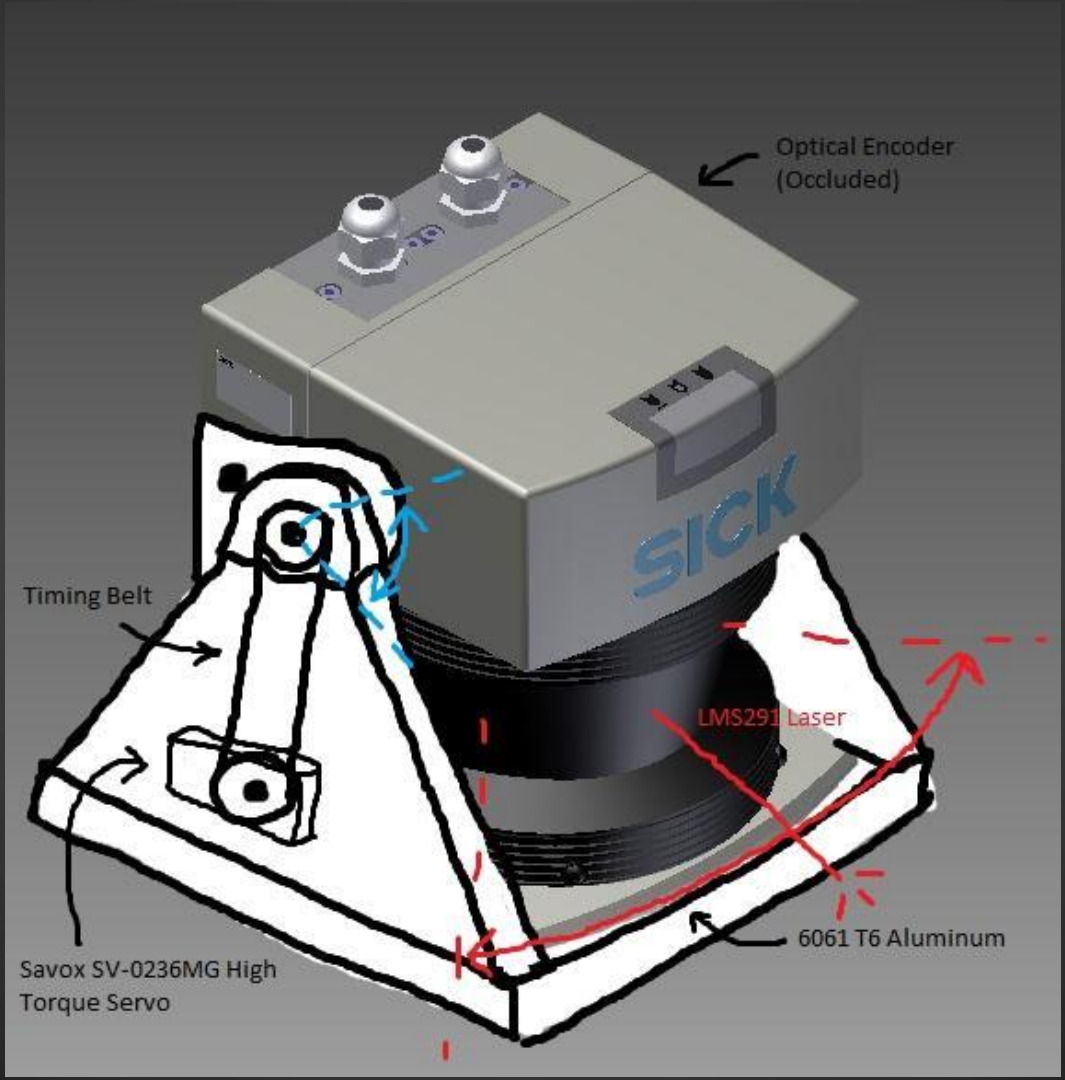
Software Diagram



Block Diagram



Concept Sketch



Electrical Schematic - Servo Controller