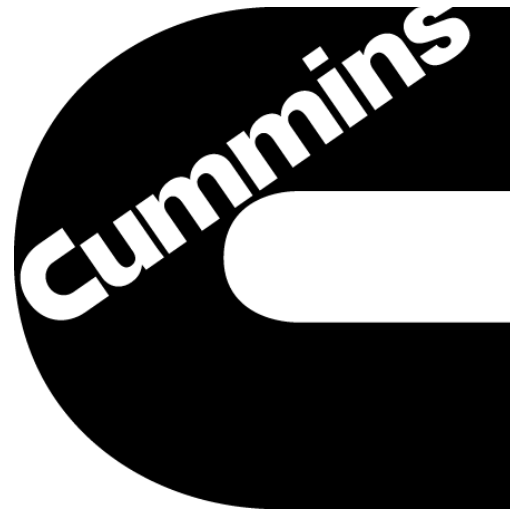


Electric Vehicle Optimization

Team 2



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Overview

- **Cummins, Inc. & Electrical Power System Performance**
 - Advanced Batteries
 - Upgraded Electronics
 - Gas Generators
 - Non-Traditional Power Adding Methods
- **Tasked with extending the range of a electric vehicle**
 - Tomberlin 48V Electric Low Speed Vehicle
 - 6 – 8V Lead/Acid Batteries
 - Range: 30+ miles
 - Max Speed: 25mph
 - Rated for 1700 lbs. (incl. vehicle weight)



Figure 1. Tomberlin Electric Vehicle

Overview

Goal Statement

“To increase the range of the electric vehicle by at least 15% through non-traditional power adders while minimizing the reduction in acceleration or top speed.”

Objectives

- Document current vehicle performance
- Research variety of possible power adders
- Procure/incorporate additional sources
- Reconfigure overall vehicle circuitry
- Increase vehicle range by 15%

Constraints

- Fuel supply cannot be increased
- Vehicle must be able to carry 4 people
- Top speed cannot be reduced by more than 10%
- Acceleration cannot be reduced by more than 10%

House of Quality (HOQ)

CR \ EC	Efficiency	Safety	Durability	Power	Weight
Reliability	2	3	4	1	0
Performance	5	1	2	5	2
Cost	4	2	4	4	0
Capacity	1	1	2	1	2
Range	5	1	3	5	3
Total	17	8	15	16	7
Rank	1	4	3	2	5

Figure 2. House of Quality

Background

Last Year's Progress

- **Similarities/Differences**
 - Different constraints/goal
- **Timeline**
 - Due to the difference in our main objectives, our priorities were also different
- **How they started**
 - Cart was in its original factory conditions
 - Generator was given to last years team free of charge
 - Ordered new set of batteries for the cart

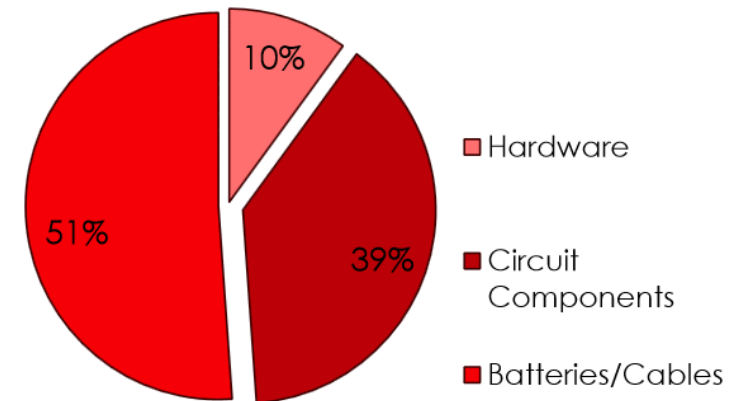


Figure 3. Last Year's Budget Allocation

Background (cont.)

Generator Requirements

- Can output a minimum of 1,600 Watts
- Size must be less than: 685mm×360mm×400mm
- Must operate at freezing temperature
- Lightweight/Inexpensive

Generator Specifications (QG2800)

- Output 2,800 watts
- Size: 560 mm × 415mm × 325mm
- Able to operate at -29°C
- Mass is 56.7 kg
- Uses Natural gas as its fuel source



Figure 4. Cummins QG2800 Generator

Background (cont.)

Generator Location

- Rear side of the cart, set behind the rear seats in recessed region
- Used hot rolled steel with 90° angle to reinforce

How They Left It

- Generator runs while batteries are fully charged
- Wires left un labeled and unmounted
- Code not running as intended

How to Improve

- Operating generator by using alternative methods
- Label and permanently mount wires



Figure 5. Location of Generator

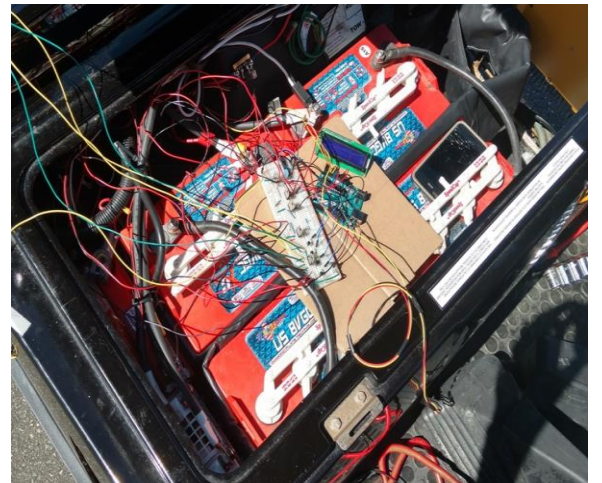
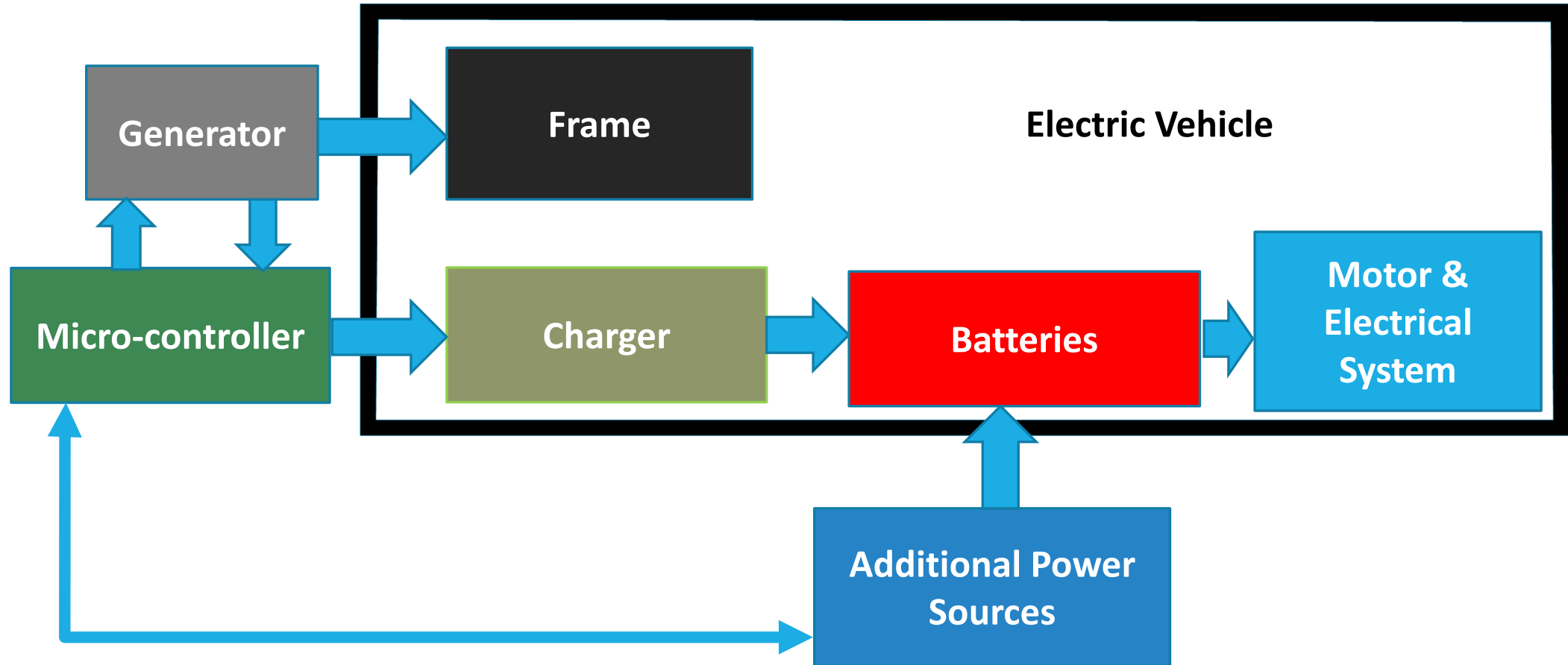


Figure 6. Circuit Condition

System Diagram



Design Options

Photovoltaics

- Range increase of up to 25%
- Easy installation
- Available in 36/48/72 Volt setup producing 100-360 Watts
- **Size/Dimensions**
- Free energy directly from sunlight
- Lightweight system

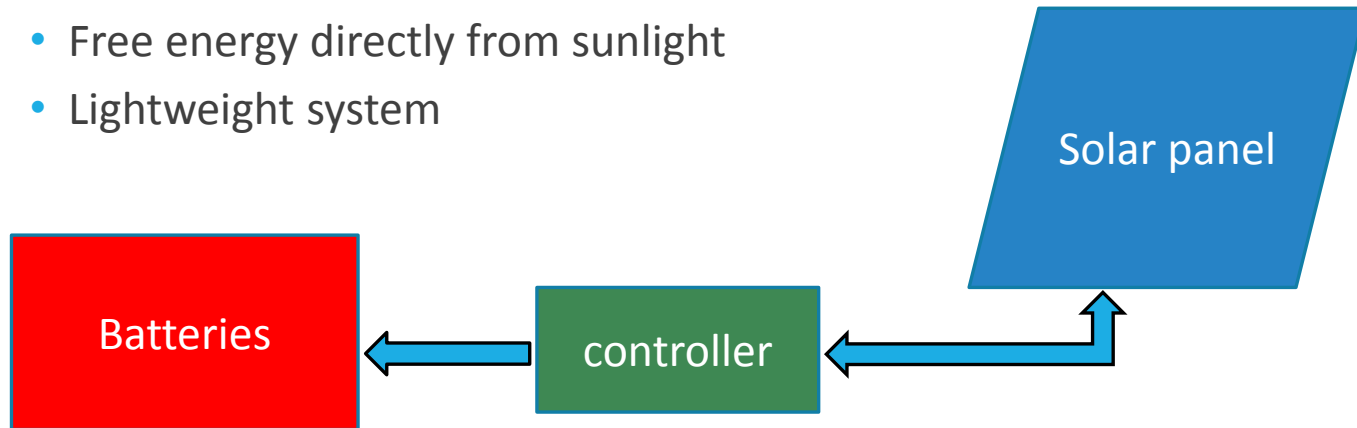
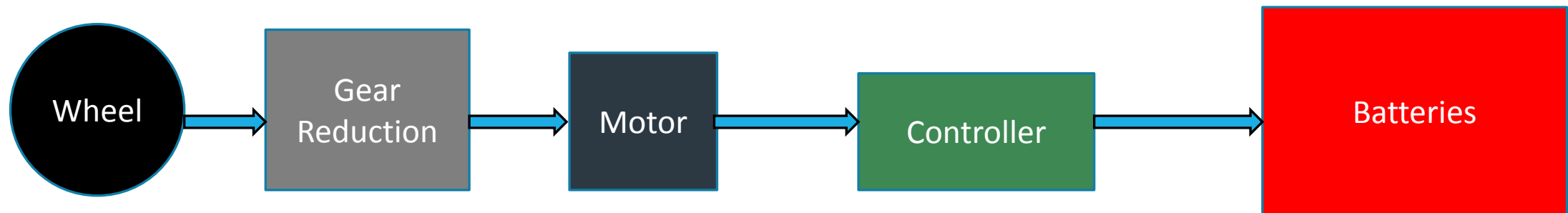


Figure 8. EV Solar Roof Example

Design Options

Regenerative Braking

- Regenerative braking is an energy recovering mechanism that converts kinetic energy into a form of electrical energy that can be either used immediately or stored until needed.
 - Maximize performance by allowing power back into the battery pack.
 - The control system regulates the amount of current going to the batteries.
 - Every regenerative braking system consists of an actuator and an energy storage device.
 - Reduces brake wear



Design Options

Geographic Regeneration

- Autonomous power cutoff based on pitch of golf cart
- Converting kinetic energy into electrical energy
- Once back to level, normal operation instantly resumes
- Having a fully electric motor allows this idea to be conveniently achievable

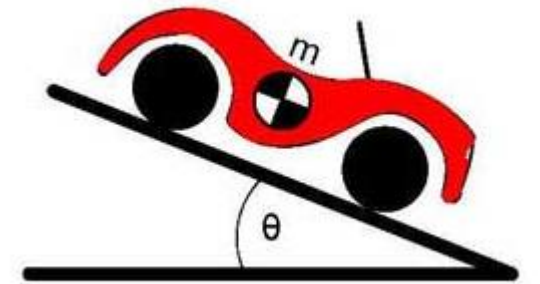


Figure 8. Vehicle Descending

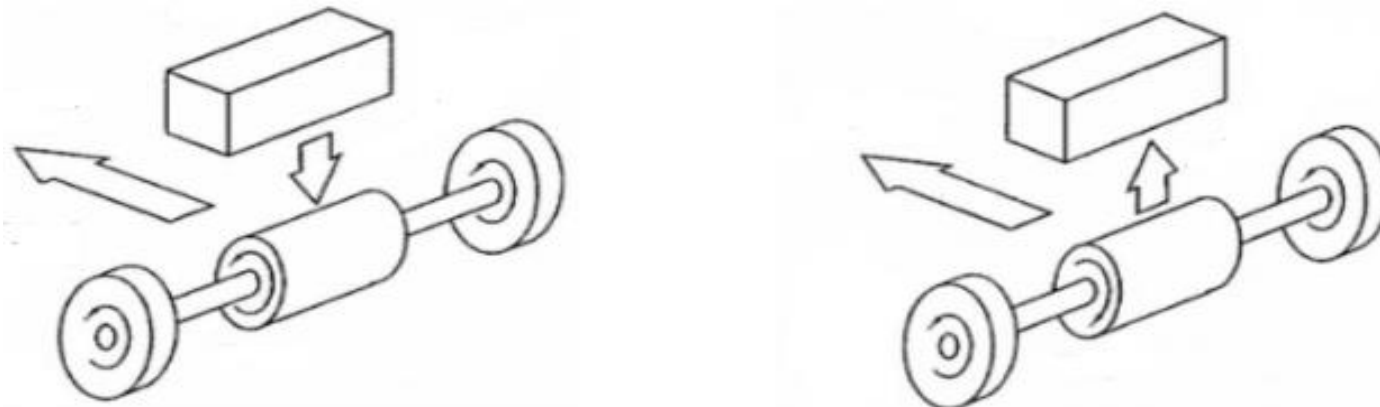


Figure 9. Regenerating Operation

Preliminary Decision Matrix

	Solar	Regenerative Breaking	Geographic Regenerater
Cost			
Weight			
Performance			
Total			

Project Planning

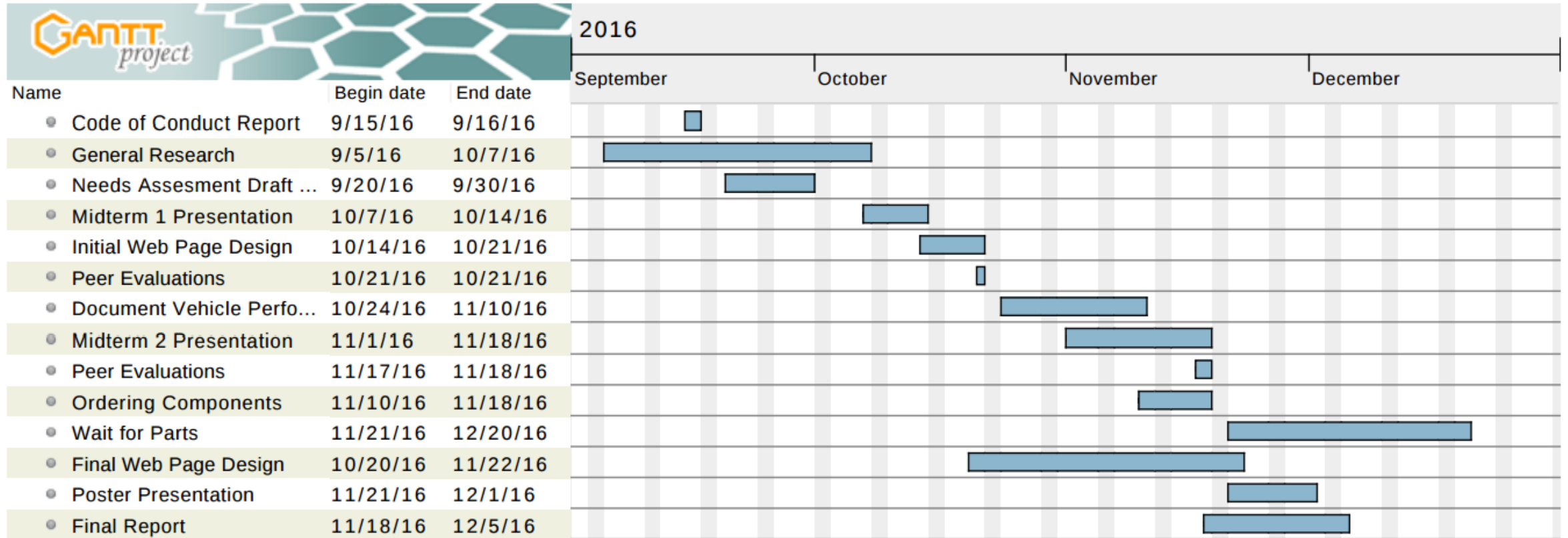


Figure 11. Gantt Chart