# Electric Vehicle Optimization Team #2

Presentation By: Jakob Consoliver-Zack, Samantha Beeler, Jeremy Randolph, Tyler Mitchell

Sponsor: Dr. Michael Hays

Advisor: Dr. Juan Ordonez

# Background

- Cabin electronics drain semi-truck batteries
- Cold weather conditions reduce battery output
- Hotel System of Charging

- Dr. Hays presented the design team with two major problems:
  - Current range is unsatisfactory
  - Cannot operate in -29°C (-20°F)

Presenter: Samantha Beeler

# Overview

**Goal Statement:**

- "To increase the current range and operable conditions of the electric vehicle by utilizing a secondary power source in efforts to apply this to semi-trucks."

**Objectives**

- Increase the lower temperature limit to -29°C
- Document current system
- Incorporate generator
- Integrate a battery monitoring system
- Model design for ISX-15 diesel engine.

Presenter: Samantha Beeler

# Golf Cart Features

## Current Features

- Powered by 6 8-V lead/acid batteries
- On-Board Charging System

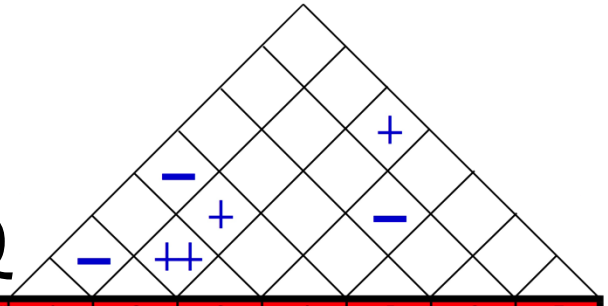
## To Be Added

- Generator
  - Battery monitoring system
- New batteries

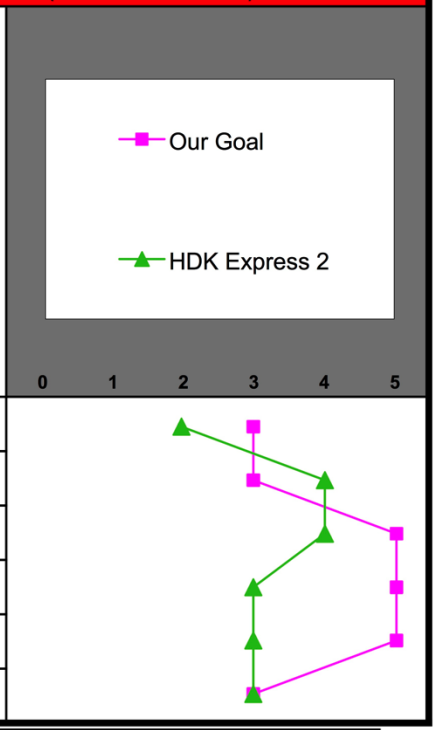
Figure 1. Picture of golf cart

Presenter: Samantha Beeler

# Figure 2. HOQ




| Row # | Relative Weight | Weight / Importance | Engineering Characteristics (a.k.a. "Functional Requirements" or "Hows") / Demanded Quality (a.k.a. "Customer Requirements" or "Whats") | Charge Time (hr) | Cost ($) | Durability | Battery Life (yr) | Noise Level (dB) | Operable Temperature Range (ΔT) | Weight (kg) | Our Goal | HDK Express 2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Column # | 1 | 2 | 3 | 4 | 5 | 6 | 7 | Competitive Analysis (0=Worst, 5=Best) | |
| | | | Direction of Improvement: Minimize (▼) or Maximize (▲) | ▼ | ▼ | ▲ | ▲ | ▼ | ▲ | ▼ | | |
| 1 | 4.5 | 1.0 | Aesthetics | | ▲ | | | | | ▲ | 3 | 2 |
| 2 | 13.6 | 3.0 | Cost | ▲ | Θ | O | ▲ | | | | 3 | 4 |
| 3 | 22.7 | 5.0 | Ease of Use | O | | | | ▲ | O | | 5 | 4 |
| 4 | 18.2 | 4.0 | Reliability | | ▲ | O | Θ | | Θ | | 5 | 3 |
| 5 | 22.7 | 5.0 | Safety | ▲ | | O | | O | | O | 5 | 3 |
| 6 | 18.2 | 4.0 | Serviceability | | | ▲ | ▲ | | | | 3 | 3 |
| | | | Target or Limit Value | 10 | <2000 | N/A | 6 | <70 | -40°C to 40°C | 100 | | |
| | | | Weight / Importance | 104.5 | 145.5 | 181.8 | 195.5 | 90.9 | 231.8 | 72.7 | | |
| | | | Relative Weight | 10.2 | 14.2 | 17.8 | 19.1 | 8.9 | 22.7 | 7.1 | | |




| Legend | | |
|---|---|---|
| Θ | Strong Relationship | 9 |
| O | Moderate Relationship | 3 |
| ▲ | Weak Relationship | 1 |
| ++ | Strong Positive Correlation | |
| + | Positive Correlation | |
| − | Negative Correlation | |
| ▼ | Strong Negative Correlation | |

Presenter: Samantha Beeler

# Design Concepts

Table 1. Morphological Chart

| Parameter | Option 1 | Option 2 | Option 3 |
|---|---|---|---|
| **Generator Location** | Under back seat | On a Carriage | In place of the back seat |
| **How to warm the batteries** | Use generator exhaust | Use heating pad | Insulate the batteries |
| **Ensure generator operation** | Synthetic oil | Oil pan heater | Oil dipstick heater |
| **Charging system** | Use onboard charger system | Develop new charger system | Modify present charger system |

Presenter: Jakob Consoliver-Zack

# Decision Matrices

## Table 2. Generator Location

| Criteria | Option 1 | Option 2 | Option 3 |
|---|---|---|---|
| Cost | S | – | S |
| Weight | S | – | + |
| Noninvasive | S | – | – |
| Safety | S | – | – |
| Total | 0 | –4 | –1 |

## Table 3. How to warm the batteries

| Criteria | Option 1 | Option 2 | Option 3 |
|---|---|---|---|
| Cost | S | + | + |
| Weight | S | + | + |
| Noninvasive | S | + | + |
| Safety | S | + | + |
| Total | 0 | +4 | +4 |

## Table 4. Ensure Generator Operation

| Criteria | Option 1 | Option 2 | Option 3 |
|---|---|---|---|
| Cost | S | – | – |
| Weight | S | – | – |
| Noninvasive | S | – | – |
| Safety | S | – | – |
| Total | 0 | –4 | –4 |

## Table 5. Charging System

| Criteria | Option 1 | Option 2 | Option 3 |
|---|---|---|---|
| Cost | S | – | S |
| Weight | S | S | S |
| Noninvasive | S | S | + |
| Safety | S | + | + |
| Total | 0 | 0 | +2 |

Figure 3. Photo of the back of the golf cart with recessed region under the rear seat.

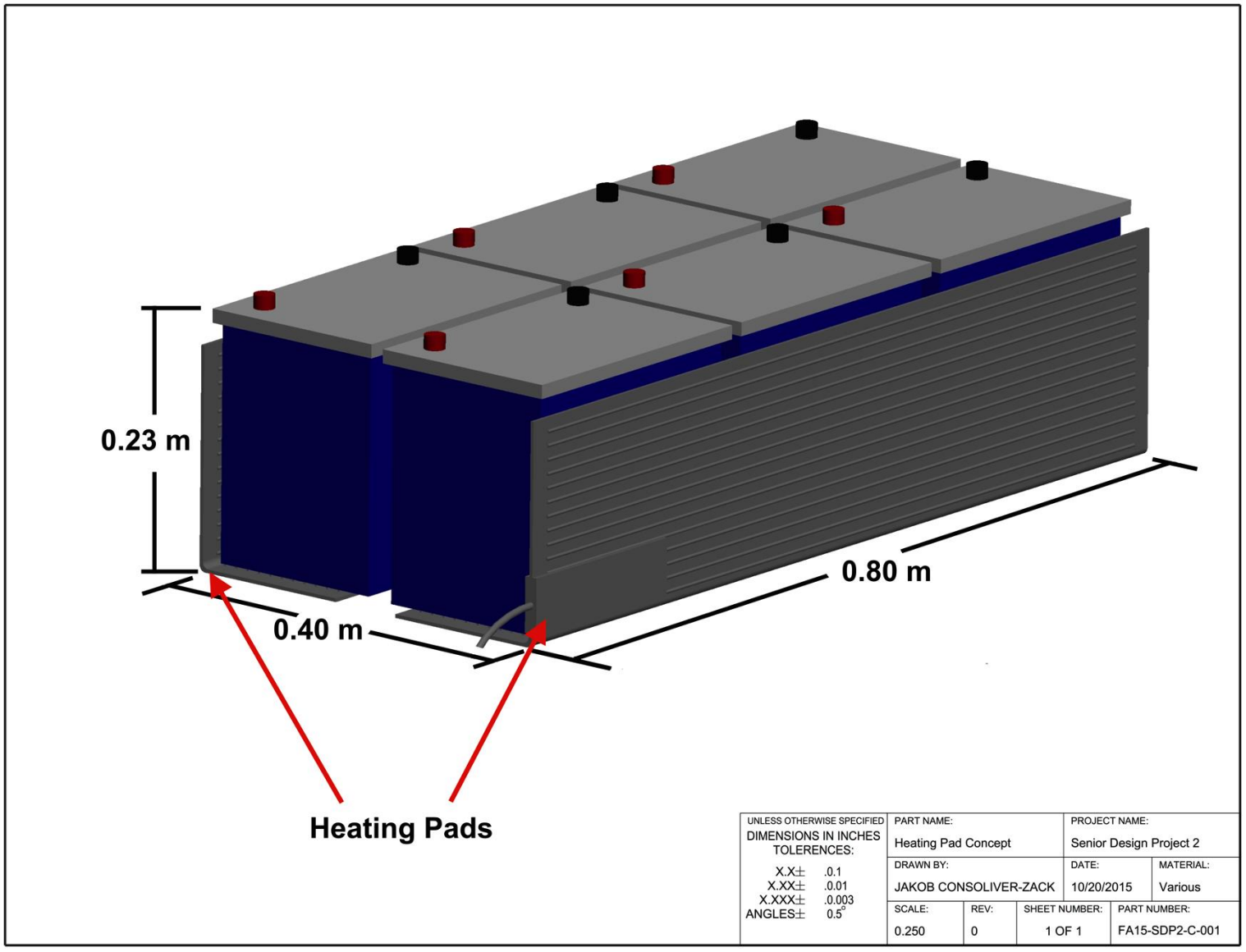



Figure 4. Concept of batteries and heating pads

Presenter: Jakob Consoliver-Zack

# Generator Selection Criteria

- Can output a minimum of 1,600 Watts
- Dimensions should not exceed 685-mm x 360-mm x 400-mm
- Can operate at -29°C (-20°F)
- Lightweight
- Inexpensive

Presenter: Jakob Consoliver-Zack

# Our Choice of Generator

- Can output 2,800 Watts
- Dimensions: 560-mm x 415-mm x 325-mm
- Can operate at -29°C (-20°F)
- QG2800 Generator is 56.7kg
- Provided free of charge


Figure 5. Cummins QG2800 Generator [1]

Presenter: Jakob Consoliver-Zack

# Golf Cart Charging System

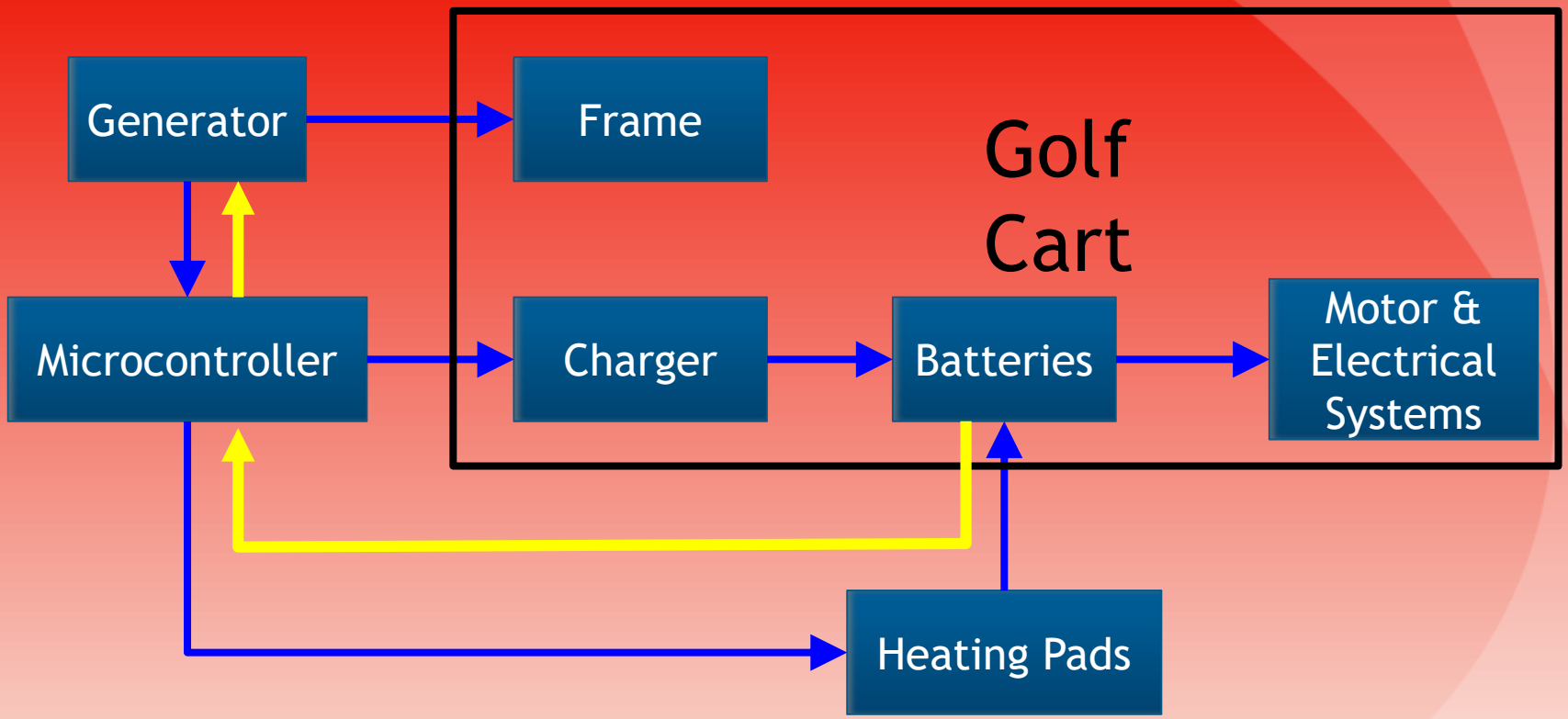



Figure 6. Golf cart system diagram

Presenter: Jakob Consoliver-Zack

# Truck Charging System

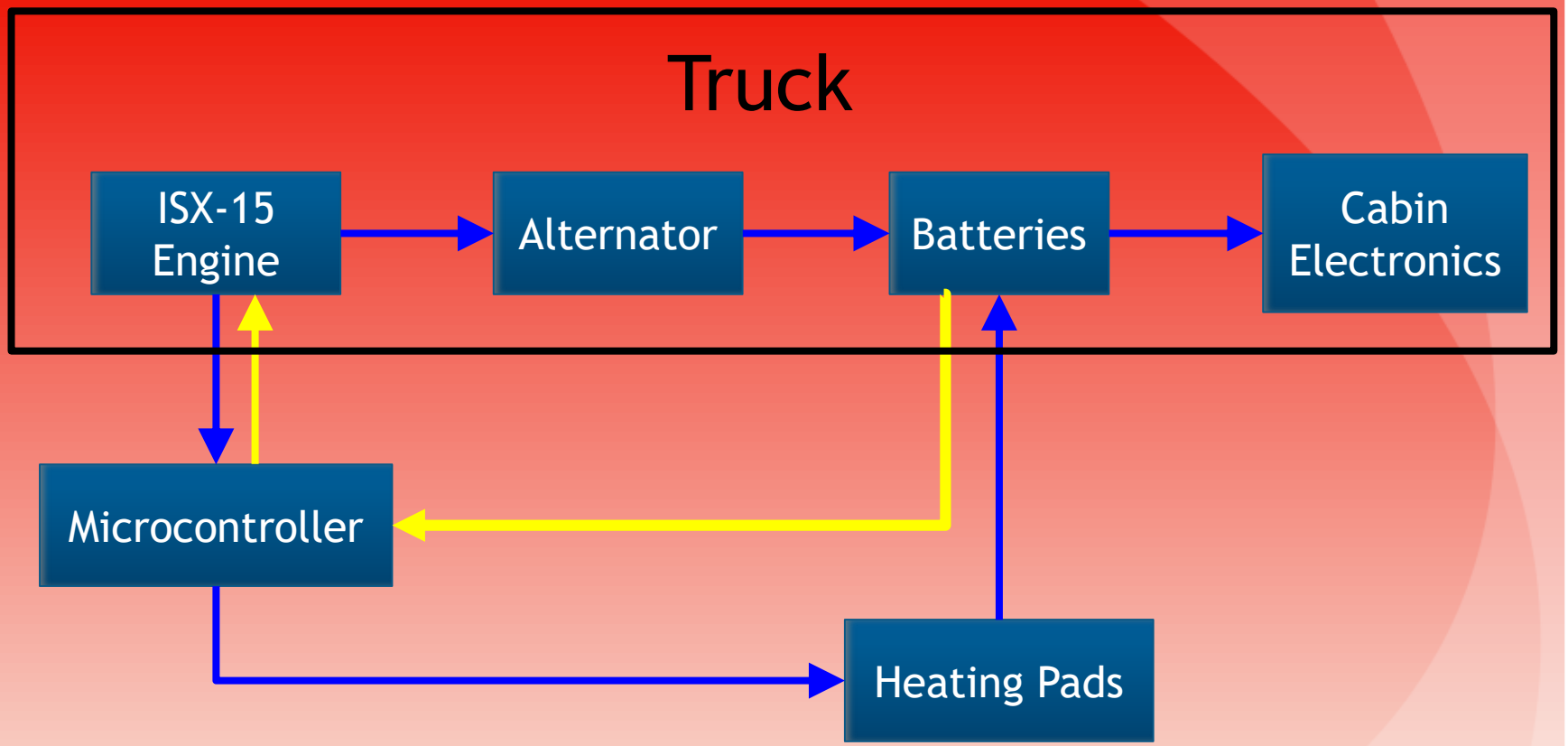



Figure 7. Truck system diagram

Presenter: Jakob Consoliver-Zack

# Potential Challenges and Risks

- Current system does not operate
- Short circuit the system
  - Conduct detailed FMEA analysis
- Difficult to test entire system at cold temperatures
- Over straining the batteries
- Ensure design compatibility with ISX-15 engine

Presenter: Jakob Consoliver-Zack

# Future Plans

- Await delivery of generator.
- Create detailed design of how to mount generator to the cart.
- Conduct heat transfer analysis from pads to batteries.
- Select or program microcontroller.

Presenter: Jakob Consoliver-Zack

# Gantt Chart

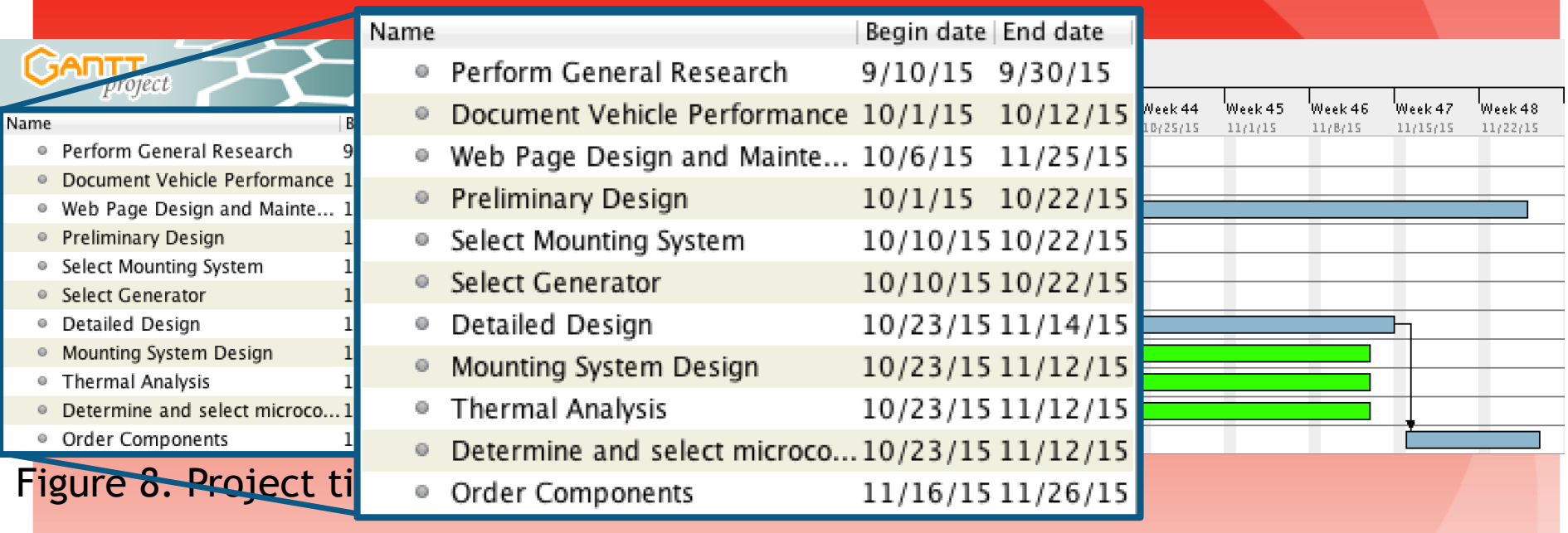



Figure 8. Project ti

Presenter: Jakob Consoliver-Zack

# Summary

- Integrate a generator into the present system.
- Install new low-temperature batteries into the golf cart.
- Warm the batteries with heating pads.
- Difficult to test the performance at low temperatures.
- Model this technology for semi-trucks with ISX-15 diesel engine.

# References

[1] Cummins. *RV Generator Set Quiet GasolineTM Series RV QG 2800*. N.p.: Cummins, n.d. *Cummins Powersuite*. Cummins. Web. 20 Oct. 2015.

[2] Sanders, Chris. Question mark. Digital image. *ON THE IMPORTANCE OF QUESTIONS IN AN INVESTIGATION*. N.p., n.d. Web. 20 Oct. 2015.

[3] "HDK Express 2." Axlegeeks.com. N.p., n.d. Web. 20 Oct. 2015.

# Questions?