# Senior Design 1 Divide and Conquer Document

RC Lawn Mower


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Department of Electrical and Computer Engineering

**<u>Group 17</u>**

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## Background:

The lawn mower dates all the way back to the early 19th century, when an English engineer named Edwin Beard Budding created the first patent of the first mechanical mower in 1830 with the purpose to cut and trim grass and gardens. He was inspired by textile machine that was used to trim cloth, Budding started by developing a device that could be hand-pushed while in a cylindrical shape so the grass would be cut in a nice even uniform way. This was a revolutionary invention for the maintenance and taking care of lawns for playing fields and gardens. It was a way more practical approach to the labor-intensive ways of using scythes or livestock to keep the grass at a reasonable length.

With the decades following Budding, technology in the lawn mower industry evolved with the rise of public and residential grass areas. By the time of the 19th century, businesses had made improvements such as adding an adjustable blade height and putting cast-iron frames around blades for better safety. Then once the introduction of gasoline engines came around in the early 20th century, once again lawn mower technology made a significant leap forward, making them more powerful and less dependent on a pushing force from a person. Gasoline engine mowers became very popular and quite normal in households because it gave a relatively affordable and convenient way to maintain a clean and neat lawn.

In the second half of the 20th century, electric mowers were created and gained traction. This helped cure the concerns around emissions from gasoline fumes, along with noise levels, and maintenance costs and challenges. During this time, mowers also became more robotic and autonomous, and they started to add and rely on sensors, navigation systems, and some even had wireless controls to automatically manage grass cutting. All of these innovations helped create a broader movement toward smarter, eco-friendly solutions that help ease the wear and tear on human labor while also improving efficiency and safety for people.

This brings us to today, lawn mowers come in a huge range of types from the basic manual reel mowers like the early creations, gas powered walk-behinds, tractor type styles that can be driven or ridden on, and now a days, fully autonomous mowers with systems that cater to different lawn sizes, terrains, and business preferences. While technology continues to become more and more advanced, modern lawn mowers often integrate more and more advanced features like speed controls, digital user interfaces, and more enhanced safety measures such as blade sensors and automatic shutoff switches. These advancements address both consumer demand for convenience and an industry push toward smarter, more sustainable outdoor equipment.

## Motivation:

As a group, we decided early that we wanted to build something that we were able to ride on, like some form of a cart but we wanted something with more of a function. We eventually got an idea to take our ridable cart idea and turn it into a lawn mower. We are looking to develop a lawn mower with a more modern day twist focused on safety measures. We want to have an enhanced drive train, along with a sensor system that will incorporate LEDs notifying the rider of objects within a certain and then ending with an emergency stop function. We also have ideas of possibly adding other advancements such as a remote control start power feature, and a user interface equipped with camera capabilities.

For us as a group, this can be an exciting and worthwhile endeavor for several reasons. Starting with, these innovations directly address safety concerns for the modern family. By integrating sensors and an emergency stop, operators can minimize the risk of accidents particularly when mowing difficult terrain or with the numerous obstacles in a yard.

The ability to remotely control our mower appeals to people seeking convenience, efficiency, and also fun. There are groups of people that enjoy creating and modifying mowers, so this idea has unlimited potential. Whether someone is managing a landscaping business with basic needs or tackling a massive residential lawn area, a mower that can be started, guided, or even partially automated from any distance will significantly ease the workload on someone. Additionally, our possible power management system could help the mower operate at peak efficiency, by completely balancing energy demands with fuel or battery capacity. This type of synergy will contribute to lower operating costs and help reduce wear and tear on our system.

To continue on possible additions to our mower, we are pondering a camera-based user interface that can further help the drivers awareness and this could help remote viewing capabilities. This can be especially advantageous in large or intricate landscapes where operators need real-time visual feedback to maneuver safely. By bringing together these different kinds of technological features, our new lawn mower will help people take a forward-thinking approach to their yard care while prioritizing safety, efficiency, and the user comfort first. In the end, this modern, tech-focused design makes mowing more precise, easier to use, and kinder to the environment.

## Existing Projects:

It's no secret that there are plenty of different types of designs and machines in today's lawn mower market. It offers a wide variety of options, from simple classic manual push mowers and then going to advanced, high-end commercial units. When we look at the most basic level, manual reel mowers rely solely on person to push and power the machine; these are quiet, eco-friendly, and will have very low maintenance, which makes them appealing for small lawns and people with an environmentally conscious mind. Then we have traditional walk-behind mowers, that are powered by either gas engines or electric motors, these tend to be found in many residential areas and applications due to how affordable they are, along with moderate power consumption, and ease of use. As lawns increase in size, ride-on or lawn tractor mowers become more popular, providing more substantial power and speed for wider cutting decks, and more comfort for the operator.

Then we have the higher end machines with commercial and professional models that will often have feature zero-turn technology for making it easier to move, enhanced durability, and along with faster cutting speeds. These machines are created to handle heavy daily use and typically incorporate features that help the operator stay comfortable and less fatigued. Now in the current day, robotic or autonomous lawn mowers are starting to enter the market and are targeting both residential and commercial settings and offering automated grass cutting and advanced sensor systems for obstacle detection.

Then it brings us to our realm of the 'Do It Yourself' (DIY) realm, that has hobbyists and enthusiasts who have explored different ways to modify their machines for efficiency and also aesthetics. These custom projects build upon existing commercial mower components which can include custom electric conversions, LED lights, remote control modifications, sensor integrations to improve safety and control, and even a sound system. These DIY projects bridge the gap between commercial features and personalized innovations, enabling unique creations for specialized lawn care challenges. By using open-source hardware and software, as well as off-the-shelf components, many creators have successfully crafted advanced, tech-forward mowers that rival or even surpass some commercially available models.

## Goals:

- **Team Goals for the RC Lawn Mower Project**
- **Develop a Safe and Reliable System**
    - Make sure that the drive train, sensor system, and emergency stop mechanisms integrate seamlessly, prioritizing safety.
    - Follow all safety standards and best practices in both our design and assembly of the lawn mower.
- **User Convenience and Control**
    - Make our system that can drive and navigate correctly with intuitive handling and no manual effort.
    - Incorporate a user-friendly interface with a handheld controller or a smart device application to streamline control and feedback.
    - Look at different scenarios as what happens with our system when out of range and when the controller is out of line of sight.
- **Optimize Performance and Efficiency**
    - Design the drive train to handle varied terrain while maintaining consistent cutting quality.
    - Integrate power management solutions for extended run times and reduced energy consumption.
- **Sensor Technology for Operation**
    - Deploy a sensor system that can detect obstacles, triggering LED warnings and automatic shutdown when necessary.
    - Explore opportunities for additional sensing capabilities (e.g., terrain mapping, distance measurement) to improve overall mowing precision.
- **Create a Scalable Design**
    - Structure the mower so that additional components such as cameras, AI-based navigation, or future sensor upgrades can be integrated in the future.
    - Document design processes and component selection to facilitate future enhancements or customization.

- **Collaboration and Skill Development**
  - Open communication among team members, ensuring knowledge is shared across electrical, mechanical, and software domains.
  - Provide opportunities for team members to learn new skills and techniques, from sensor integration to user interface design.
- **Deliver a Proof of Concept within Scope and Budget**
  - Set realistic milestones for prototyping, testing, and final production to keep the project on schedule and within financial constraints.
  - Conduct thorough testing to validate performance, safety, and reliability before final deployment.

## Stretch Goals:

If the core functionalities of our mower are met such as the drive train, sensor system with emergency warnings and a stop, and remote control are successfully implemented, our team may pursue additional features and enhancements that can elevate our project to a while other level. Two such stretch goals include a power management system and a user interface (UI) incorporating live camera feeds.

**1. Power Management System (PMS)**
A power management system can help run times, optimize energy usage, and provide real-time feedback on the mower's performance while it's running. By monitoring battery health or fuel consumption, the PMS can dynamically allocate resources for critical components such as the motor, sensors, and control units. Adding these types of features can help us prevent unnecessary wear and tear on our battery and our machine to prolong its life span. We can also ponder the Integration of a detailed status display app based off the alerts of battery/fuel levels, temperature, and system strain would offer users greater awareness and control over the mower's performance.

**2. Camera-Enabled User Interface**
A camera while also being equipped with a friendly user interface could significantly expand the mower's remote and safety capabilities. Placing cameras strategically around the mower would provide a live visual feed to the operator, which in turn can help enhance situational awareness. This can be particularly valuable when navigating tight spaces or monitoring obstacles that sensors alone might not fully be able to capture. The camera feed could be integrated into a handheld controller's screen or a mobile application,

allowing for both manual oversight and a potential future autonomous navigation in later iterations of the machine. Additionally, recording footage for lawn inspection or documenting the mower's performance would prove useful for troubleshooting, maintenance, or future design improvements.

These stretch goals offer the potential to transform the mower into a smarter, more interactive piece of equipment. Although they may not be critical to the basic functionality, implementing these features would significantly improve the user experience, add safety benefits, and pave the way for future innovations.

## Specifications / Engineering Requirements

| Specification | Requirement |
|---|---|
| **Functionality** | • Cuts grass up to ~3–4 inches high |
| | • Uses a cutting width of ~14–20 inches |
| | • Moves forward and backward |
| **Performance** | • Operates for ~1 hour on one battery charge |
| | • Maintains consistent cutting speed |
| | • Covers ~2,000–3,000 sq. ft. on one charge |
| **Operational** | • Fully remote-controlled with a range of ~50–100 ft |
| | • Stops safely if signal is lost |
| | • Can handle light damp conditions |
| **Maintainability** | • Main upkeep is battery recharging |
| | • Blade needs sharpening every ~20–30 hours of cutting |
| | • Components are accessible for quick repairs |
| **Environmental** | • 100% electric, zero direct emissions |
| | • Quieter than gas mowers (~80–85 dB) |
| | • Uses efficient motors to save energy |
| **Usability** | • Simple controller with labeled functions |
| | • No steep learning curve after a basic tutorial |
| | • Quick startup in ~1 minute |

## Budget :

| Item | Qty (Approx) | Cost (Estimate) | Details & Notes |
|---|---|---|---|
| **1. Lawn Mower** | 1 | $150–$300 | - A modest push electric mower (could be corded or battery) to repurpose. |
| | | | - New vs. used can reduce costs. |
| | | | - Budget figure: **$250** |
| **2. Motors** | 4 | $60–$100 each | - DC or brushless gear motors for drive. |
| | | | - 4 motors if going for a 4WD design. |
| | | | - Higher torque = higher cost. |
| | | | - Budget figure: **$320** (4 × $80) |
| **3. Motor Controllers** | 4 | $30–$60 each | - Brushed or brushless controllers. |
| | | | - Must handle required voltage/current. |
| | | | - Budget figure: **$180** total. |
| **4. Electronic Components** | ~7 distinct items | $30–$50 each (avg) | - Could include sensors (e.g., ultrasonic, IMU, GPS, etc.), relays, power modules, antennas, or other modules. |
| | | | - Large range depending on complexity (e.g., camera-based sensor can be $200+ alone). |
| | | | - Budget figure: **$250** total. |
| **5. Battery** | 1 | $80–$150 | - Standard 12V lead-acid, AGM, or deep-cycle “camper battery.” |
| | | | |
| | | | - Budget figure: **$100** |
| **6. PCB & Components** | 5 (batch) | $10–$30 each | - Custom PCB fabrication (small run) plus discrete electronics (capacitors, resistors, connectors, etc.). |
| | | | - Budget figure: **$100** total. |
| **7. Tools** | ~5 major tools | $30–$100 each | - Soldering station, multimeter, wire cutters/strippers, wrenches, safety gear, possibly a small drill press or Dremel. |
| | | | - Budget figure: **$300** total. |

| | | | |
|---|---|---|---|
| **8. Mechanical Components** | ~10 items | \$5–\$30 each | - This includes brackets, bearings, wheels, spare sheet metal, acrylic sheets, fasteners, bushings, couplings, etc. |
| | | | - Budget figure: **\$150** total. |

# Estimated Max Cost: \$1,650.

## List of Materials:

- 2 or 4 Motors (brushed or unbrushed)
- Power Distribution Board
- 2 or 4 Motor Controllers
- Antenna
- Controller
- Thermal Circuit Breaker
- Car Battery or Camper Battery
- Inverter (depending on the battery)
- Various Gauge Wire (24-14)
- Mounts for all Drive Train Components
- Wheels
- Spare Metal for Potential Frame Extension
- Acrylic for electronic mounting
- Cheap Electric Push Lawn Mower
- Custom PCB
- Components for PCB (Resistors, LEDs, Speakers, Capacitors, etc…)
- Sensors (limelight, Ultrasonic Ranging Sensor, or something else)
- Tools (Solder Station, Wrenches, Wire Cutters/Strippers, Solder, etc…)

## Hardware Flowchart:

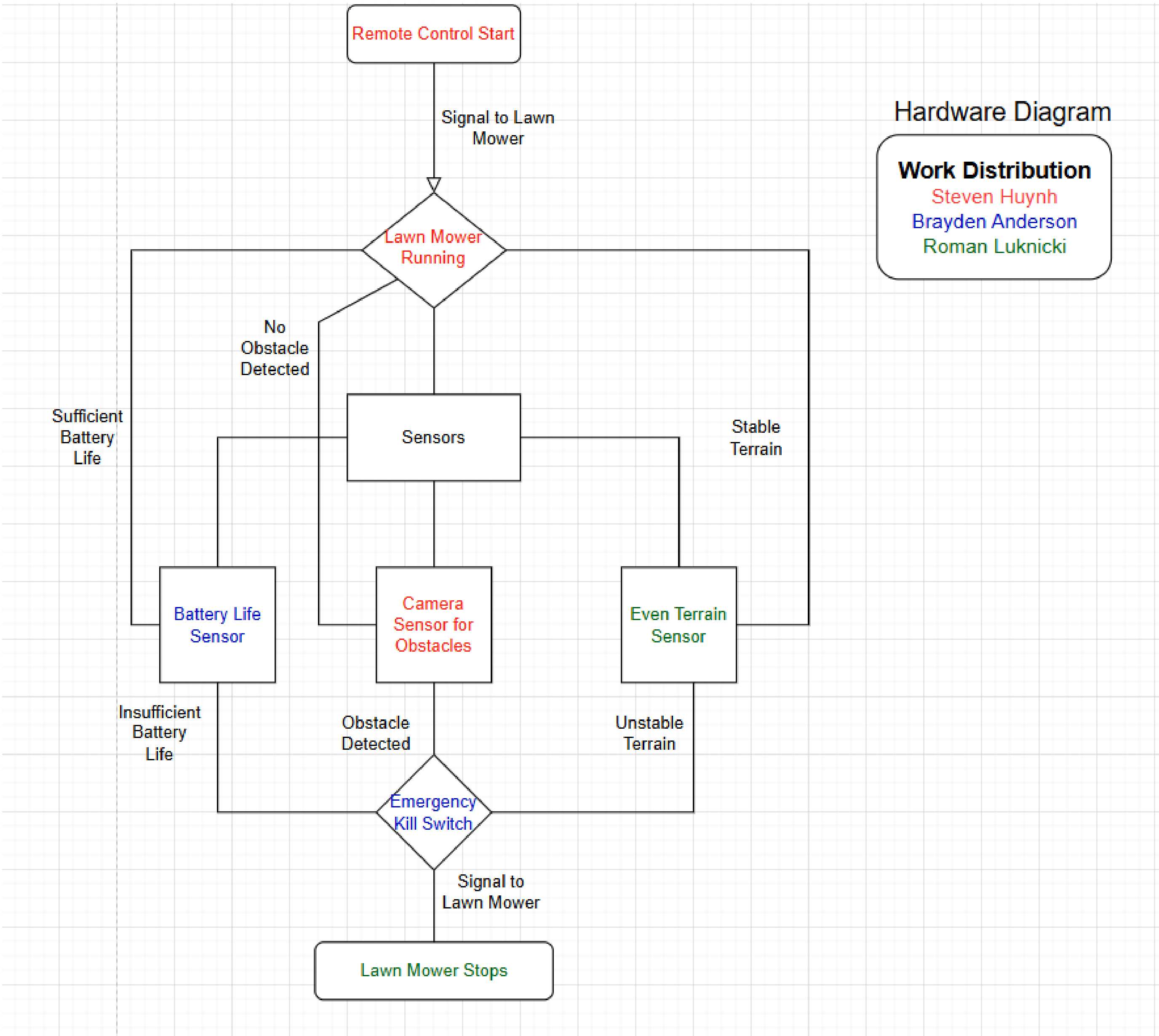


*Figure 1: Hardware Diagram*

## Software Flowchart:

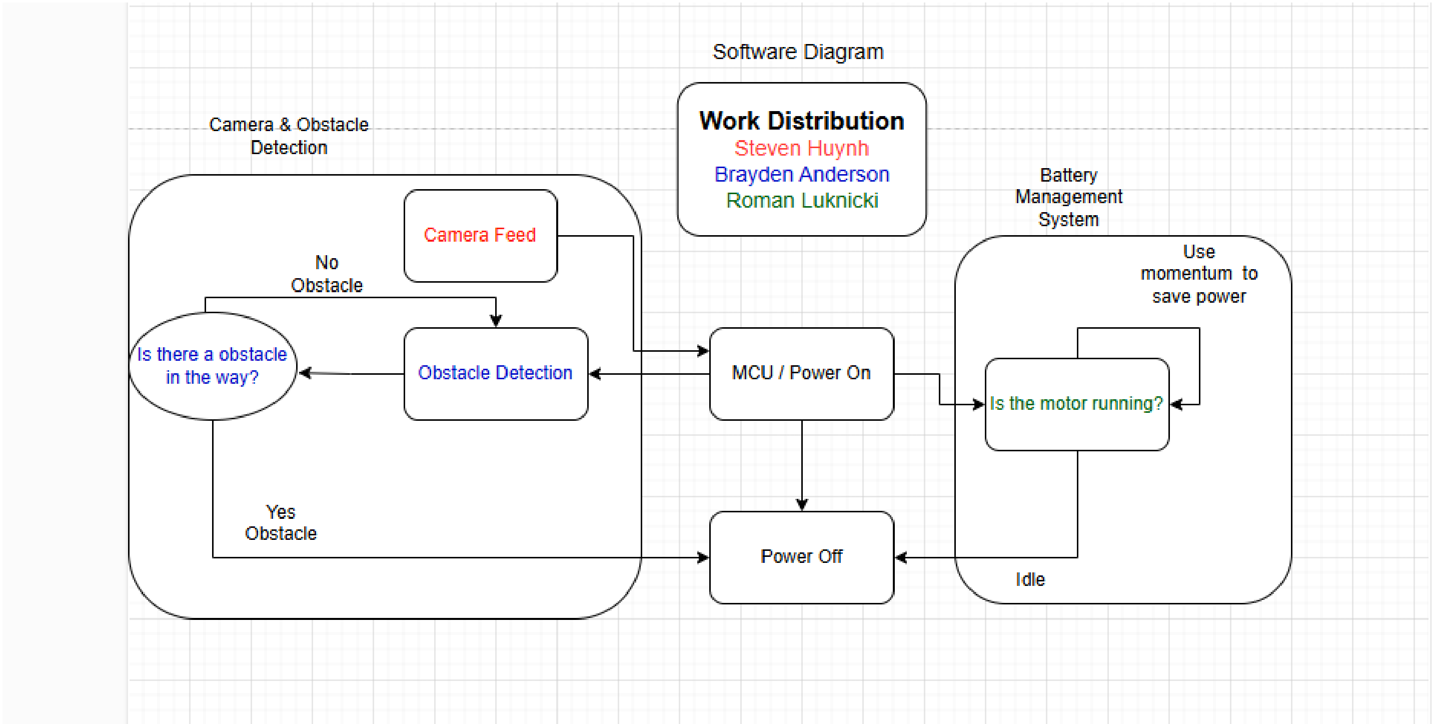


*Figure 2: Software Diagram*

## Senior Design 1 Project Documentation Milestones:

| Task | Start Date | End Date | Duration |
|---|---|---|---|
| **Form Groups and Discuss Ideas** | 01/06/2025 | 01/17/2025 | 2 Weeks |
| **Finish and Write Divide and Conquer Document** | 01/17/2025 | 01/24/2025 | 1 Week |
| **Look for reviewers and form committees** | 01/17/2025 | 01/24/2025 | 1 Week |
| **Midterm report meeting** | 03/26/2025 | 03/28/2025 | 2 Days |
| **Midterm report deadline** | 03/26/2025 | 04/04/2025 | 1 Week |
| **Final report deadline** | 04/14/2025 | 04/22/2025 | 1 Week |
| **Demo video deadline** | 04/14/2025 | 04/14/2025 | 1 Week |

## Senior Design 2 Project Execution Milestones:

| Task | Start Date | End Date | Duration |
|---|---|---|---|
| **PCB & Sensor Experimentation** | 05/12/2025 | 05/26/2025 | 2 Weeks |
| **Device Prototyping** | 05/26/2025 | 06/09/2025 | 2 Weeks |
| **Research & Improvements** | 06/09/2025 | 06/23/2025 | 2 Weeks |
| **Test Trials & Errors** | 06/23/2025 | 07/07/2025 | 2 Weeks |
| **Improvements & Prototyping** | 07/07/2025 | 07/21/2025 | 2 Weeks |
| **Final Week of Improvements** | 07/21/2025 | 07/28/2025 | 1 Week |
| **Demonstration to SD and Reviewers** | 07/28/2025 | 07/28/2025 | 1 Week |