Autonomous LSEV Platform Development (Year 2)

Implementation Plan

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Proposed Design

1. Design Description

The proposed system is an autonomous electric vehicle (EV) platform designed to follow a predefined path using onboard sensing, computation, and control. The system integrates LiDAR-based perception, vision and/or IR-based line detection, and actuator control to enable reliable navigation without direct human input.

the vehicle architecture is divided into the following primary subsystems:

- **Sensing System:** LiDAR sensors are used for environmental perception and obstacle detection, while line-following capability is achieved through IR sensors and/or camera-based vision. These sensors provide the necessary inputs for both navigation and safety.
- **Computation System:** A central processing unit, the NVIDIA Jetson Orin Nano, performs high-level tasks including sensor fusion, line detection, and decision-making. This enables real-time processing and path-planning capability.
- **Control System:** An Arduino-based microcontroller is used for low-level control and serves as the primary interface to vehicle actuators. It executes commands related to steering, throttle, and braking.
- **Communication System:** Communication between the Jetson and Arduino is handled through serial and/or CAN protocols, enabling reliable transmission of control commands and system feedback.
- **Mechanical Platform:** A modified EV chassis serves as the base platform for integrating all hardware components.

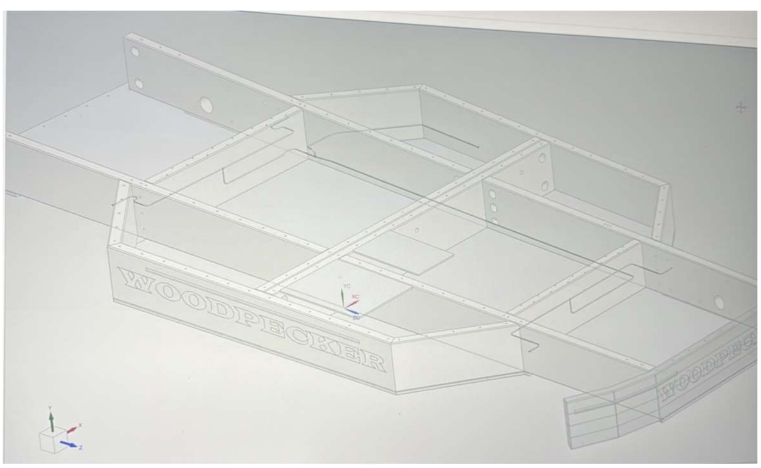

Figure 1: Assembly view of the proposed EV chassis and structural frame. The figure shows the integrated mounting structure used to house the sensing, computation, and control subsystems. Key features include reinforced side panels, mounting points for electronics, and internal compartments for component organization.

As shown in Figure 1, the chassis is designed to support modular integration of all subsystems while maintaining structural integrity. The internal layout provides dedicated space for electronics, sensors, and wiring, enabling efficient packaging and accessibility during assembly and maintenance. This configuration supports future modifications and simplifies system integration.

Design Rationale:
The system architecture is designed to decouple high-level computation from low-level control. The Jetson Orin Nano handles computationally intensive tasks such as perception and decision-making, while the Arduino manages real-time actuator control. This separation improves system reliability, simplifies debugging, and allows for scalable development. LiDAR was selected over ultrasonic sensors due to its improved accuracy and reliability in outdoor environments.

2. Prototype Discussion

Due to delays in receiving critical hardware components and the EV chassis, a full physical prototype has not yet been constructed. Instead, the team has developed a **system-level integration plan and proof-of-concept framework** to guide implementation.

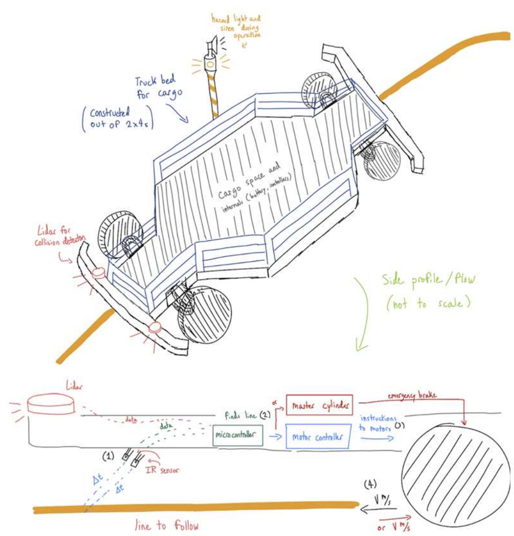

Figure 2: System integration plan and proof-of-concept layout for the autonomous EV platform. The diagram illustrates the interaction between sensing systems (LiDAR and line detection), high-level computation (Jetson Orin Nano), and low-level control (Arduino-based CAN interface and motor controller), enabling autonomous navigation and emergency braking functionality.

As shown in Figure 2, the system is designed around a hierarchical control architecture. The Jetson Orin Nano processes sensor data to determine vehicle position relative to a predefined path and detects obstacles using LiDAR. Based on this information, it generates high-level control commands, which are transmitted to the Arduino. The Arduino then executes these commands through the vehicle's actuators via CAN communication.

The vehicle is designed to follow a predefined line using IR sensors and/or vision-based detection while continuously monitoring its surroundings. If an obstacle is detected within a defined safety threshold, the system will initiate an emergency braking response. This ensures both accurate navigation and safe operation.

Although hardware testing has not yet been conducted, the development of this system architecture has enabled identification of key integration requirements, including communication protocols, sensor placement, and control signal pathways.

Key Design Considerations

- A distributed control architecture is required to balance computational load and ensure real-time responsiveness
- Reliable CAN communication is essential for coordinating actuator commands
- Sensor fusion between LiDAR and line-detection inputs must be robust
- System latency must be minimized for effective control and emergency response

Design Decisions

- LiDAR was selected over ultrasonic sensors due to improved environmental robustness
- A Jetson + Arduino architecture was chosen to separate high-level and low-level control
- The system is designed for scalability, allowing future integration of additional sensors

Path Forward to Physical Prototype

Upon receiving all components listed in the Bill of Materials, the team will proceed with:

1. Individual component validation (Jetson setup, sensor testing, communication testing)
2. Integration of sensing and control subsystems
3. Implementation of line-following and obstacle detection algorithms
4. Full system testing on the EV platform in a controlled environment

3. Implementation Plan

3.1 General Description of Implementation Plan

During the second term, the project will transition from a conceptual design to a fully integrated and tested autonomous EV system. The implementation will follow a structured approach:

1. **Subsystem Preparation**
    a. Configure Jetson environment and software stack

    b. Validate sensors and communication protocols
2. **System Integration**
    a. Integrate sensing, computation, and control subsystems
    b. Establish reliable communication between Jetson and Arduino
3. **Testing and Validation**
    a. Perform controlled testing of line-following and obstacle detection
    b. Tune control algorithms for performance and stability
4. **Final Demonstration**
    a. Demonstrate autonomous navigation and emergency braking
    b. Validate system performance against project requirements

3.2 Resources Needed for Implementation

To begin testing, an approved area is required for safe EV operation. If permanent deployment is desired, a painted waterproof path may be implemented on campus. For proof-of-concept testing, a temporary taped path will be sufficient.

Additional resources include:

- Sensors (LiDAR, camera, IR sensors)
- NVIDIA Jetson Orin Nano
- Arduino microcontroller
- Wiring, connectors, and mounting hardware
- Software tools for perception and control
- Team members, faculty advisor, and lab support

4. Bill of Materials

A preliminary bill of materials has been procured and is provided in the attached spreadsheet. The current total cost is approximately $1,025, covering sensors, computing hardware, and supporting electronics.

Future purchases may include additional LiDAR units and mounting hardware. All labor will be completed by team members, resulting in no additional labor costs.

Bill of Materials					
Item (hyperlink)	Description	Quanitity	Price ($)	Total:	Lead time (preferably before spring term)
https://a.co/d/0jetebBp	(Better) CAN bus data logger	1	108	$108.00	amazon
https://www.classicindustries.com/pro	Emergency brake	1	520	$520.00	standard 5-7days
https://a.co/d/0jdApPEw	Jetson Nano	1	245	$245.00	amazon
https://a.co/d/03maKwBE	DEUTSCH DT Connector kit	1	30	$30.00	amazon
https://a.co/d/0diNBdxM	Protective hose for wiring (40 ft)	1	26	$26.00	amazon
https://a.co/d/03AgvyZR	DC 12V 1CH 433Mhz RF Wireless Relay	1	12.99	$12.99	amazon
https://a.co/d/07cDfzXR	Copper nickle brake lines and fittings	2	31.99	$63.98	amazon
https://a.co/d/03cWtTHm	New lidar sensor	1	70	$70.00	amazon
https://a.co/d/0g2Y3rKM	USB to CAN adapter for Jetson	1	18.99	$18.99	amazon
https://a.co/d/03cxElv5	Parking brake cable	1	37.8	$37.80	amazon
https://a.co/d/07msPgdk	E stop button	1	12.99	$12.99	amazon
already have	USB webcamera - line detection	1	0	$0.00	already have
From ME 351 class	IMU for speed and direction	1	0	$0.00	already have
Total				**$1,024.76**	

5. Schedule of Implementation in Second Term

Week	Task
Weeks 1–2	Finalize design and receive components
Weeks 3–5	Subsystem setup and validation
Weeks 6–8	Full system integration
Weeks 8–9	Testing and debugging
Weeks 9–10	Performance tuning
Weeks 10-11	Final demonstration and documentation