SENIOR CAPSTONE/
SENIOR DESIGN EXPERIENCE
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Autonomous Polaris Ranger Mower

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Executive Summary

To reduce labor demands at Purdue's ACRE, our team set out to develop an autonomous Polaris Ranger with a pull-behind mower utilizing DataSpeed's NavRoute software. We initially aimed to create a fully autonomous mowing solution but found significant limitations in the vehicle's object detection and route adaptation. After field testing, the project pivoted to documenting capabilities, limitations, and creating a user guide to support future research teams. The solution demonstrates the potential of agricultural autonomy, while also highlighting current system boundaries and areas for improvement.

Image 1: Polaris Ranger UTV equipped with DataSpeed's autonomous drive-by-wire system

Project Research & Context

Background research focused on robotic operating systems (ROS), hardware integration, and safety standards. The team evaluated DataSpeed's Polaris Ranger platform and its compatibility with RTK GPS and LiDAR. Standards like ANSI/UL 4600 and ISO 18497 informed safety considerations. Market and public perception research reinforced the relevance of autonomous solutions in agriculture. This context shaped our system design and justified the need for an adaptable, user-friendly mowing automation system.

Project Characteristics & Limits

Constraints:

- Total budget: $1,000
- Equipment must meet IP55 weatherproofing standards
- Minimum operational speed: 2 mph
- Real-time obstacle detection and fail-safes required

Criteria:

- Level of autonomy
- Ease of use
- Cost efficiency
- Operational accuracy

Deliverables:

i. System Capability Summary
ii. Hardware & Software Limitations Report
iii. Quick-Start User Guide

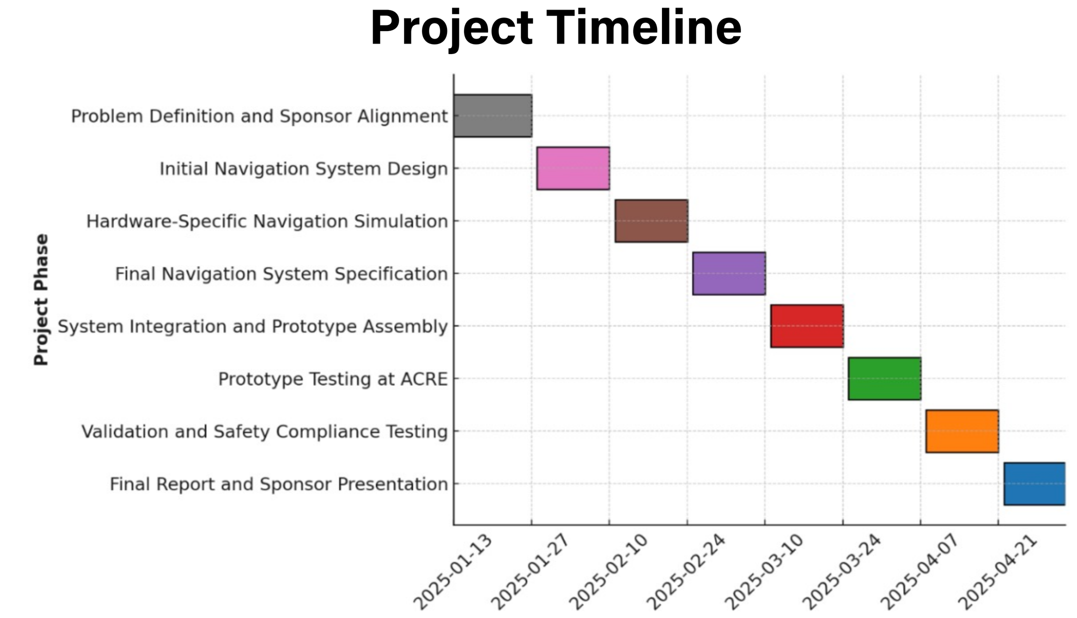

Image 2: Gannt Chart Project Timeline

Project Solution Ideas & Selection

Three solution paths were considered:

I. **Waypoint Navigation System** – Used RTK GPS to follow a set of manually programmed waypoints. This method was cost-effective but less adaptive to real-time conditions.
II. **Intelligent Lane Detection System** – Combined LiDAR and camera-based vision to dynamically recognize lanes and respond to environmental changes. Although highly autonomous, it was too complex and exceeded both our timeline and technical constraints.
III. **Adaptive Path Following System** (*Selected Solution*) – Enabled the Ranger to record a manually driven route using DataSpeed's pre-installed NavRoute software. The machine could then autonomously replay the exact path using RTK GPS and monitor for obstacles using onboard LiDAR sensors.

A weighted decision matrix evaluated cost, autonomy, accuracy, and ease of implementation. The Adaptive Path Following System was selected due to its simplicity, sponsor preference, and reliable performance.

Project Value Proposition

This project reduces labor demands at ACRE and frees student workers for research. ABE gains a real-world platform to explore agricultural autonomy, while Polaris and DataSpeed benefit from field-tested insights. The system shows promise for broader use in farms, solar fields, and orchards. Short-term risks include limited obstacle detection and lack of dynamic rerouting, which must be improved before full deployment.

Project Design & Development

The final design features a Polaris Ranger UTV equipped with DataSpeed's drive-by-wire system, RTK GPS, and LiDAR sensors, integrated through the NavRoute path-following software. The system allows users to manually record a route, then autonomously replay it with high positional accuracy. Key design features include real-time localization, obstacle detection, and manual override controls for safety.
Development began with virtual testing using Gazebo and RViz to simulate routes and validate software performance before field trials. Once simulated paths proved viable, the system was calibrated and tested on-site at Purdue's ACRE.

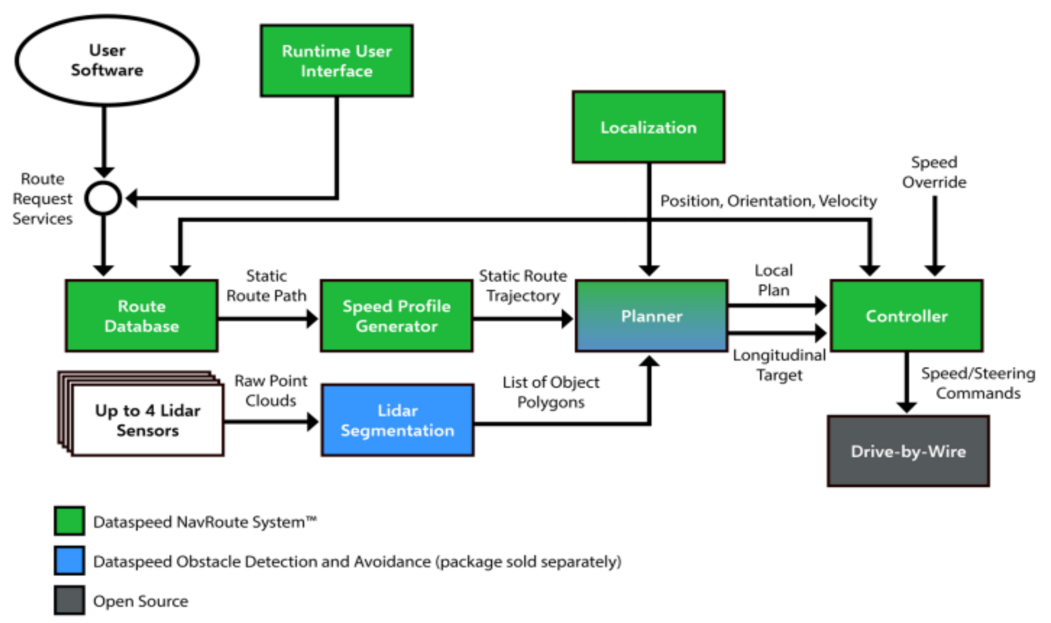

Image 3: Flow chart displaying how the NavRoute system operates.

Maximizing Project Impact

With a working prototype and clear documentation, this project gives future teams a strong starting point. The quick-start guide and testing results minimize onboarding and support continued development. Next steps include improving obstacle detection, adding mower actuating control, and enabling rerouting. Future iterations could integrate additional cameras or machine learning to boost autonomy.

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