Autonomous LSEV Platform Development (Year 2)

Standards and Risks

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1 Standards, Codes, and Regulations

The Woodpecker Autonomous Low-Speed Electric Vehicle (LSEV) is a project governed by laws and adheres to codes and standards that affect all electric and autonomous vehicles. Each of the various codes and standards defines the vehicle and its requirements and regulations that must be adhered to. Below is a list of the standards and codes that directly affect the project.

Table 1: Standards of Practice as Applied to this Project

Standard Number or Code	**Title of Standard**	**How it applies to Project**
ASNI/AAMI HE 74:2001	Human Factors Design Process for Medical Devices	Helps in the design of how the device with interface with the user in a safe manner [1].
ORS Title 59 Ch 8 801.331	"Low-speed vehicle"	Defines a low-Speed Electric Vehicle under Oregon law and sets a maximum speed of 25mph for this type of vehicle [2]. The project must therefore adhere to these definition and maximum speed limitation.
SAE J2929	Safety Standard for Electric and Hybrid Vehicle Propulsion Battery Systems Utilizing Lithium-based Rechargeable Cells	This standard defines safety criteria for lithium based rechargeable batteries [3]. Although the Woodpecker is currently operating with Lead Acid batteries, there has been discussion in potentially changing toa different set of batteries. The Woodpecker most followed this standard in case a change to Lithium based batteries occurs.
NHTSA, DOT: Federal Motor Vehicle Safety Standard	Standard No. 305a; Electric-powered Vehicles: Electric Powertrain Integrity	Sets a standard for Light Electric Vehicles (<10,000 lbs.) which includes the Woodpecker Vehicle [4]. These standards are intended to reduce and prevent deaths and injuries from electrical shock during normal vehicle operation, post-crash situations, and fire risks from Rechargeable Electrical Energy Storage Systems (REESS).
NHPA 70 (NEC) art. 625	Article 625 Electric Vehicle Power Transfer System	Delineates guidelines for wiring (for charging purposes), power export, and bi-directional current flow in Electric Vehicles [5]. This also includes listing of permanent marking on electric vehicle supply equipment for filed operation.
NFPA 556	Guide on Methods for Evaluating Fire Hazard to Occupants of Passenger Road Vehicles	Provides guidance for identifying major safety concerns in passenger road vehicles [6]. The Woodpecker wooden frame, and battery systems can become fire hazards under different scenarios. This standard provides guidance for investigating typical fire scenarios, evaluating methods and tools withing testing, and overall design considerations, as a modular design for different cabins, the woodpecker must be safe for an ample range of

		applications with different fire scenarios.
Transportation Safety Office - Chapter 737	Division 10: VEHICLE EQUIPMENT AND SAFETY STANDARDS 737-010-0000	Similar to ORS Title 59 Ch 8 801.331 Title 59, this statute provides a legal definition by the Department of Transportation for a “low-speed vehicle” under state law [7]. As a project built within Oregon. The Woodpecker LSEV falls under this definition
SAE J1772-2017	SAE Electric Vehicle and Plug in Hybrid Electric Vehicle Conductive Charge Couple	This standard delineates the essential charging connector standard for North America [8]. As an Electric Vehicle with rechargeable batteries, the Woodpecker LSEV must have a charging inlet that complies with this standard for compatibility with charging infrastructure in North America
UL 2580	Batteries for Use in Electric Vehicles	This standard is a safety citification standard for EC battery packs based on construction, electrical, mechanical (impact, vibration), and thermal safety, as well as environmental testing, and protections against faults such as a shot circuit. The woodpecker mut align with this standard as any faults with the battery can produce catastrophic hazards to the vehicle and users due to flammable elements in the build.
ISO 6469	Electrically propelled road vehicles - Safety specifications	International standards aligned with FMVSS 305a requirements [9] which were previously discussed in relation to the Woodpecker.
ASTM F3200-25	Standard Terminology for Robotics, Automation, and Autonomous Systems	Defines practical terms for various functions, metrics, and designations of autonomous vehicles. Terms that will be important for documentation [11].
NHTSA, DOT: Federal Automated Vehicles Policy	Federal Automated Vehicles Policy	Defines levels of autonomy, necessary registration of autonomous vehicles, and various other requirements of autonomous vehicles in the US. While mostly applicable to the automotive industry, much of it will affect the project [10].

2 Risk Analysis and Mitigation

Of the parts added by the Autonomous team for the Woodpecker Autonomous LSEV project each adds an inherent risk of failure that comes with most any part of any device or machine. To analyze the potential dangers and effects of various methods of failure for each of the parts added to the Autonomous LSEV, the team has used an FMEA to represent the potential risk of each part added.

2.1 FMEA

Part # and Functions	Potential Failure Mode	Potential Effect(s) of Failure	Potential Causes and Mechanisms of Failure	RPN	Recommended Action
1. CAN Communication Bus and Data Logger	Faulty Electric Component	Vehicle Inoperable or Loss of Functionality	Faulty Product/Shipping Handling	120	Be Prepared for Part Replacement
2. Emergency Brake System	Faulty Electric Component	Extreme Safety Hazard in Case of Emergency	Faulty Product/Shipping Handling	150	Be Prepared for Part Replacement
2. Emergency Brake System	Rust/Corrosive Failure of Brake Line	Extreme Safety Hazard in Case of Emergency	Improper Rust Maintenance	80	Set regular Maintenance Schedule
3. Primary Computer and Controller	Faulty Electric Component	Vehicle Inoperable or Loss of Functionality	Faulty Product/Shipping Handling	135	Be Prepared for Part Replacement
4. Electrical Connectors	Faulty Wire/ Electrical Connection	Vehicle Inoperable or Loss of Functionality	Faulty Product/Shipping Handling	72	Be Prepared for Part Replacement
4. Wiring Protection	Abrasive Wear	Vulnerable/Damaged Wires, Potential Loss of functionality	Exposure to Moving Parts	8	Set regular Maintenance Schedule
5. Remote Controller for E-Stop	Faulty Electric Component	Extreme Safety Hazard in Case of Emergency	Faulty Product/Shipping Handling	135	Be Prepared for Part Replacement
6. Brake Lines and Fittings	Rust/ Corrosive Failure of Brake Line	Braking and Slowing Failure, Safety Hazard	Improper Rust Maintenance	72	Set regular Maintenance Schedule
7. LiDAR	Faulty	Loss of Obstacle	Faulty	120	Be Prepared

Sensor	Electric Component	Detection, Safety Hazard	Product/Shipping Handling		for Part Replacement
7. LiDAR Sensor	Sensor Blockage	Loss of Obstacle Detection, Safety Hazard	Falling Debris	12	Plan Sensor Placement to Avoid
7. LiDAR Sensor	Sensor Damage	Loss of Obstacle Detection, Safety Hazard	Falling Debris	8	Create Sensor Protection
8. USB to CAN Adapter	Faulty Electric Component	Vehicle Inoperable or Loss of Functionality	Faulty Product/Shipping Handling	120	Be Prepared for Part Replacement
9. Parking Brake Cable	Rust/ Corrosive Failure of Brake Line	Vehicle Could Roll While Parked	Improper Rust Maintenance	60	Set regular Maintenance Schedule
9. Parking Brake Cable	Laceration/ Wear	Vehicle Could Roll While Parked	Debris and Failure of Protection	90	Set regular Maintenance Schedule
10. E-Stop Button	Faulty Electric Component	Extreme Safety Hazard in Case of Emergency	Faulty Product/Shipping Handling	150	Be Prepared for Part Replacement
11. Line Detection Camera	Faulty Electric Component	Vehicle Incapable of Pathfinding	Faulty Product/Shipping Handling	120	Be Prepared for Part Replacement
11. Line Detection Camera	Sensor Blockage	Vehicle Incapable of Pathfinding	Undercarriage Debris	15	Plan Sensor Placement to Avoid
11. Line Detection Camera	Sensor Damage	Vehicle Incapable of Pathfinding	Undercarriage Debris	16	Create Sensor Protection
12. Speed and Direction Sensor	Faulty Electric Component	Vehicle Inoperable or Loss of Functionality	Faulty Product/Shipping Handling	105	Be Prepared for Part Replacement
1. CAN Communication Bus and Data Logger	User Wiring / Electrical Error	Component Destroyed,	User Error	16	Take all Safety Precautions Against Poor Wiring
2. Emergency Brake	User Wiring / Electrical Error	Component Destroyed,	User Error	16	Take all Safety Precautions

System					Against Poor Wiring
3. Primary Computer and Controller	User Wiring / Electrical Error	Component Destroyed,	User Error	16	Take all Safety Precautions Against Poor Wiring
5. Remote Controller for E-Stop	User Wiring / Electrical Error	Component Destroyed,	User Error	16	Take all Safety Precautions Against Poor Wiring
7. LiDAR Sensor	User Wiring / Electrical Error	Component Destroyed,	User Error	16	Take all Safety Precautions Against Poor Wiring
8. USB to CAN Adapter	User Wiring / Electrical Error	Component Destroyed,	User Error	16	Take all Safety Precautions Against Poor Wiring
10. E-Stop Button	User Wiring / Electrical Error	Component Destroyed,	User Error	16	Take all Safety Precautions Against Poor Wiring
11. Line Detection Camera	User Wiring / Electrical Error	Component Destroyed,	User Error	16	Take all Safety Precautions Against Poor Wiring
12. Speed and Direction Sensor	User Wiring / Electrical Error	Component Destroyed,	User Error	16	Take all Safety Precautions Against Poor Wiring

Critical Failures

Most critical failures identified across the existing systems of the Autonomous LSEV's new parts are electrical in nature, specifically the common potential failure for any electrical component that is not manufactured in house is the chance of being a faulty product or having faulty parts within. This is an issue that haunts most of the tech space in the world, as there is not much recourse aside from part replacement or repairs, which can cost money or time. To combat this, the team will need to do research on how and where to replace or return all the electrical parts ordered. Even with this in mind there is a

chance that parts that on a surface level seem operational but could fail very early into their lifespan, and so the team will also need to conduct extensive testing for all of the electrical parts in order to both stress test them as well as ensure they meet all functional needs.

Aside from that issue, one of the most important failure preventions is regular maintenance of the vehicle, as many of the parts can succumb to various acts of weathering, such as rust on the brake lines and damage or malfunctions for any of the sensors.

2.2 Risks and Trade-offs Analysis

The way our risks correlate to another mainly revolves around the safety of the electrical subsystem composing the battery pack, wiring, and control. The electrical risks such as faulty sensors or damage to the wiring pose major risks to safety and accuracy of the autonomous driving capability. Considering this, the team introduced the emergency braking system as a critical engineering requirement. The brake mitigates the risk of failure of the drive-by-wire system by working independently from the CAN bus and remote-control input.

The risk mitigation strategy that the team proposes is to conduct regular maintenance of the vehicle and its subsystems. This involves documenting a robust testing and maintenance procedure that should be iterated and updated to ensure safety. By keeping organized documentation of our vehicle, we open the door towards further iterations and design improvements between subsystems without confusion or damage to the vehicle architecture.

3 REFERENCES

[1] American National Standards Institute, "Automotive - Electric," ANSI Webstore. [Online]. Available: https://webstore.ansi.org/industry/automotive/electric

[2] Oregon Secretary of State, "Definitions Relating to Low-Speed Vehicles and Medium-Speed Electric Vehicles," Oregon Administrative Rules, Rule 737-010-0000, Jul. 2021. [Online]. Available: https://secure.sos.state.or.us/oard/viewSingleRule.action?ruleVrsnRsn=280086

[3] SAE International, "Safety Standard for Electric and Hybrid Vehicle Propulsion Battery Systems Utilizing Lithium-based Rechargeable Cells," SAE Standard J2929, Rev. Feb. 2013.

[4] National Highway Traffic Safety Administration, "Federal Motor Vehicle Safety Standards; FMVSS No. 305a Electric-Powered Vehicles: Electric Powertrain Integrity Global Technical Regulation No. 20 Incorporation by Reference," Federal Register, vol. 89, no. 245, pp. 104318-104425, Dec. 20, 2024. [Online]. Available: https://www.govinfo.gov/content/pkg/FR-2024-12-20/pdf/2024-28707.pdf

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[6] National Fire Protection Association, "NFPA 556: Standard for the Installation of Photovoltaic Systems," Quincy, MA. [Online]. Available: https://www.nfpa.org/codes-and-standards/nfpa-556-standard-development/556

[7] Oregon Secretary of State, "Definitions Relating to Low-Speed Vehicles and Medium-Speed Electric Vehicles," Oregon Administrative Rules, Rule 737-010-0000, Jul. 2021. [Online]. Available: https://secure.sos.state.or.us/oard/viewSingleRule.action?ruleVrsnRsn=280086

[8] SAE International, "SAE Electric Vehicle and Plug in Hybrid Electric Vehicle Conductive Charge Coupler," SAE Standard J1772, Rev. Oct. 2017.

[9] International Organization for Standardization, "Electrically propelled road vehicles — Safety specifications — Part 3: Electrical safety," ISO Standard 6469-3:2021. [Online]. Available: https://www.iso.org/standard/81746.html

[10] “NHTSA Federal Automated Vehicles Policy.” NHTSA. Available: NHTSA Federal Automated Vehicles Policy

[11] ASTM, “Standard Terminology for Robotics, Automation, and Autonomous Systems,” Compass ASTM, https://compass.astm.org/content-access?contentCode=ASTM%7CF3200-25%7Cen-US (accessed Mar. 20, 2026).

4 APPENDIX

Part # and Functions	Potential Failure Mode	Potential Effect(s) of Failure	Severity	Potential Causes and Mechanisms of Failure	Occurrence	Current Design Controls Test	Detection	RPN	Recommended Action
1. CAN Communication Bus and Data Logger	Faulty Electric Component	Vehicle Inoperable or Loss of Functionality	8	Faulty Product/ Shipping Handling	5	Extensive Part Testing	3	120	Be Prepared for Part Replacement
2. Emergency Brake System	Faulty Electric Component	Extreme Safety Hazard in Case of Emergency	10	Faulty Product/ Shipping Handling	5	Extensive Part Testing	3	150	Be Prepared for Part Replacement
2. Emergency Brake System	Rust/Corrosive Failure of Brake Line	Extreme Safety Hazard in Case of Emergency	10	Improper Rust Maintenance	2	Regular Maintenance	4	80	Set regular Maintenance Schedule
3. Primary Computer and Controller	Faulty Electric Component	Vehicle Inoperable or Loss of Functionality	9	Faulty Product/ Shipping Handling	5	Extensive Part Testing	3	135	Be Prepared for Part Replacement
4. Electrical Connectors	Faulty Wire/Electrical Connection	Vehicle Inoperable or Loss of Functionality	8	Faulty Product/ Shipping Handling	3	Extensive Part Testing	3	72	Be Prepared for Part Replacement
4. Wiring Protection	Abrasive Wear	Vulnerable/ Damaged Wires, Potential Loss of functionality	2	Exposure to Moving Parts	1	Regular Maintenance	4	8	Set regular Maintenance Schedule
5. Remote	Faulty Electric	Extreme Safety	9	Faulty Product/	5	Extensive	3	135	Be Prepare

Controller for E-Stop	Component	Hazard in Case of Emergency		Shipping Handling		Part Testing			d for Part Replacement
6. Brake Lines and Fittings	Rust/ Corrosive Failure of Brake Line	Braking and Slowing Failure, Safety Hazard	9	Improper Rust Maintenance	2	Regular Maintenance	4	72	Set regular Maintenance Schedule
7. LiDAR Sensor	Faulty Electric Component	Loss of Obstacle Detection, Safety Hazard	8	Faulty Product/ Shipping Handling	5	Extensive Part Testing	3	120	Be Prepared for Part Replacement
7. LiDAR Sensor	Sensor Blockage	Loss of Obstacle Detection, Safety Hazard	3	Falling Debris	4	Software Detection	1	12	Plan Sensor Placement to Avoid
7. LiDAR Sensor	Sensor Damage	Loss of Obstacle Detection, Safety Hazard	8	Falling Debris	1	Software Detection	1	8	Create Sensor Protection
8. USB to CAN Adapter	Faulty Electric Component	Vehicle Inoperable or Loss of Functionality	8	Faulty Product/ Shipping Handling	5	Extensive Part Testing	3	120	Be Prepared for Part Replacement
9. Parking Brake Cable	Rust/Corrosive Failure of Brake Line	Vehicle Could Roll While Parked	10	Improper Rust Maintenance	2	Regular Maintenance	3	60	Set regular Maintenance Schedule
9. Parking Brake Cable	Laceration /Wear	Vehicle Could Roll While Parked	10	Debris and Failure of Protection	3	Regular Maintenance	3	90	Set regular Maintenance Schedule
10. E-	Faulty	Extreme	10	Faulty	5	Extens	3	15	Be

Stop Button	Electric Component	Safety Hazard in Case of Emergency		Product/ Shipping Handling		ive Part Testing		0	Prepared for Part Replacement
11. Line Detection Camera	Faulty Electric Component	Vehicle Incapable of Pathfinding	8	Faulty Product/ Shipping Handling	5	Extensive Part Testing	3	120	Be Prepared for Part Replacement
11. Line Detection Camera	Sensor Blockage	Vehicle Incapable of Pathfinding	3	Undercarriage Debris	5	Software Detection	1	15	Plan Sensor Placement to Avoid
11. Line Detection Camera	Sensor Damage	Vehicle Incapable of Pathfinding	8	Undercarriage Debris	2	Software Detection	1	16	Create Sensor Protection
12. Speed and Direction Sensor	Faulty Electric Component	Vehicle Inoperable or Loss of Functionality	7	Faulty Product/ Shipping Handling	5	Extensive Part Testing	3	105	Be Prepared for Part Replacement
1. CAN Communication Bus and Data Logger	User Wiring / Electrical Error	Component Destroyed,	8	User Error	2	Pre-Planned Wiring	1	16	Take all Safety Precautions Against Poor Wiring
2. Emergency Brake System	User Wiring / Electrical Error	Component Destroyed,	8	User Error	2	Pre-Planned Wiring	1	16	Take all Safety Precautions Against Poor Wiring
3. Primary Computer and Controller	User Wiring / Electrical Error	Component Destroyed,	8	User Error	2	Pre-Planned Wiring	1	16	Take all Safety Precautions Against Poor

									Wiring
5. Remote Controller for E-Stop	User Wiring / Electrical Error	Component Destroyed,	8	User Error	2	Pre-Planned Wiring	1	16	Take all Safety Precautions Against Poor Wiring
7. LiDAR Sensor	User Wiring / Electrical Error	Component Destroyed,	8	User Error	2	Pre-Planned Wiring	1	16	Take all Safety Precautions Against Poor Wiring
8. USB to CAN Adapter	User Wiring / Electrical Error	Component Destroyed,	8	User Error	2	Pre-Planned Wiring	1	16	Take all Safety Precautions Against Poor Wiring
10. E-Stop Button	User Wiring / Electrical Error	Component Destroyed,	8	User Error	2	Pre-Planned Wiring	1	16	Take all Safety Precautions Against Poor Wiring
11. Line Detection Camera	User Wiring / Electrical Error	Component Destroyed,	8	User Error	2	Pre-Planned Wiring	1	16	Take all Safety Precautions Against Poor Wiring
12. Speed and Direction Sensor	User Wiring / Electrical Error	Component Destroyed,	8	User Error	2	Pre-Planned Wiring	1	16	Take all Safety Precautions Against Poor Wiring