June 13, 2022
Dr. Craig Scratchley
School of Engineering Science
Simon Fraser University
British Columbia, V5A 1S6

Re: ENSC405W/440 Requirements Specification for Echo's Proximity Entrance System™

Dear Dr. Craig Scratchley,

The provided document details the requirement specifications of the Echo company's Proximity Entrance System™ (PES) for the course ENSC 405W Capstone A: Project Design, Management, and Documentation. The Proximity Entrance System™ is a keyless entry system to be used with motorcycles. This system will be able to detect when a user intends to start their motorcycle and unlock the bike without the need to insert a key.

This document will outline the requirements of Echo's Proximity Entrance System™ product.

The Echo team is composed of five senior Computer Engineering students: Shawn Baltar, Olivia Kuninaka, Spencer Karjala, Spencer Pauls, and Miller Solis.

Thank you for your time in reviewing and assessing the requirements documentation for the Proximity Entrance System™. Questions or comments concerning our product may be directed towards Spencer Karjala at skarjala@sfu.ca.

Sincerely,

Spencer Karjala
Chief Executive Officer
Echo

PES

PROXIMITY ENTRANCE SYSTEM™

Requirements Specification

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Submitted to:
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Abstract

Electric vehicle users are often subjected to long wait times when starting their vehicle due to the process of initializing multiple on-board complex systems. For manufacturers of premium brands, with a focus on user experience, these wait times are unacceptable. In the case of electric motorcycles, Echo has created the Proximity Entrance System™ to eliminate this problem. Interested manufacturers can license the system to be installed into their motorcycle's digital network.

The Proximity Entrance System™ is composed of a Remote Identifier, similar to a key fob, and a Proximity Detection Module that is installed on the bike. These two components communicate with one another to determine whether a registered user intends to go for a ride and, on intent detection, signals to the motorcycle that it should prepare its systems to drive. By the time the user reaches their motorcycle, the bike is initialized and ready to go with no wait time.

This document specifies a high-level overview of this process and details the various requirements around both devices' physical structure, hardware, and software. It also includes a cradle-to-cradle plan for component reusability and an acceptance test plan for said requirements.

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Changelog

Version	Description of Change	Date Modified	Modified By
1.0	Initial Document	June 13/2022	Team Echo

List of Figures and Tables

1. Introduction

Echo is developing the Proximity Entrance System™ (PES) to provide the ultimate user-friendly experience for motorcyclists who want to just sit down and start riding. This means as little interaction as possible - the PES™ aims to anticipate the rider's intent and to be ready to go at any given moment. By utilizing a bike-mounted embedded device, paired with a small and user-friendly wearable component, the PES™ will use proximity information to notify the bike of an impending boot. That way, the electronic control units (ECUs) onboard the bike can be given a forward-warning "wake-up" signal, starting the tedious boot-up processes as early as possible.

With any form of entry and exit mechanism comes a heightened need for security. As a premium product, the PES™ takes this expectation seriously, and will only wake up when the owner or any authorized co-owners are nearby. This will be done by storing encrypted identifiers on each wearable device that will engage in encrypted communication with the on-bike system. With authentication effectively built into the infrastructure of the device, the PES™ can remember its user's preferences if they choose, providing each rider with agency over their ideal startup experience. The PES™ aims to make this process as easy as possible with a sleek and easy-to-use mobile application that manages the user's preferences in the cloud.

As the PES™ is a single module, Echo aims to license this device to motorcycle manufacturers looking to maximize their user experience by minimizing wait times. By viewing the bike as a black box, the PES™ will come with a simple interface to be integrated into any electric motorcycle. By focusing on the rapidly growing market of electric motorcycle manufacturing [1], the user experience afforded by the PES™ is positioned to become the new standard for vehicle entry and exit.

1.1 Background

The rapid development of modern electronics has dramatically altered the standard architecture of a motor vehicle. Large mechanical combustion engines are no longer the most complex components of a vehicle - doubly so for the increasingly popular electric vehicle. With large governments like Canada [2] and the European Union [3] banning new gasoline vehicle sales by 2035, it seems that gas-powered vehicles may soon be obsolete.

Today's electric vehicles are coordinated by a network of electronic control units (ECUs), coordinated by a single ECU that works as the "brain" of the machine. Each of the component ECUs is a small computer that is placed in charge of a subsystem of the vehicle. For example, in a car, there will typically be an ECU in charge of managing the dashboard: displaying information about the vehicle, powering the display, etc. By communicating with the central ECU, any of the component ECUs can make changes to the state of the vehicle, respond to changes in the state of the vehicle, or even transmit data outside of the vehicle's local ECU network.

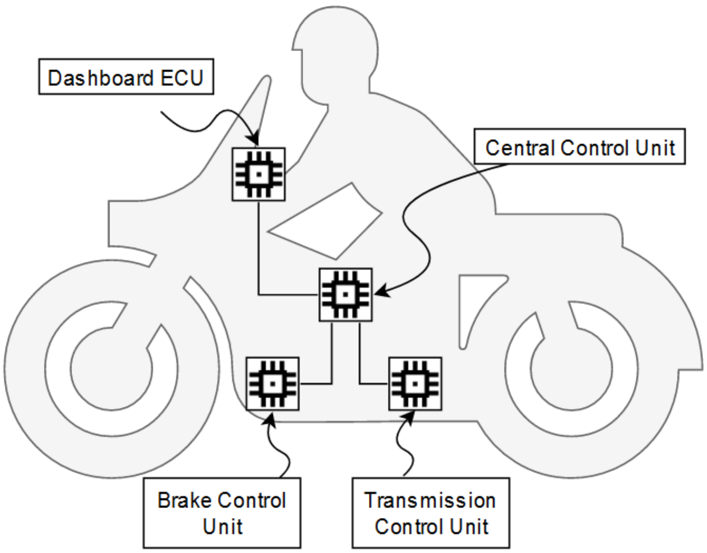

Fig. 1.1.1: Simple Example ECU Network

One problem with splitting a large and complicated system like a motorcycle into smaller components managed by computers is that the state of the system needs to be managed. Specifically, when starting the bike, each system must complete its entire boot-up sequence, then synchronize its local state with the central ECU. When a system can contain up to around 150 ECUs [4], the central ECU can take quite some time to boot itself up, transmit and receive messages on its local busses, and catch up on the state of all the local systems. This can take around 5-10 seconds [5], which can feel like a long time to wait for such an expensive device.

1.2 Overview

The PES™ is built to challenge the problem of waiting for vehicle boot times by reducing them to zero, while minimizing the number of accidental starts. The system is split into two components: the Proximity Detection Module (PDM), which is mounted on the bike, and a Remote Identifier (RID), which is held by the user.

When a user approaches their bike while holding their RID, the PDM and RID communicate with one another to determine the location of the RID. If the RID is approaching the bike and not walking past the bike, then the user likely intends to go for a ride. At this point, the PDM sends a "wake-up" signal to the system - not necessarily to perform a full boot, but to give the system an advanced warning that a user is approaching. This gives the system a chance to run through any lengthy boot-up processes so the user can get on and go.

1.3 Scope

This document aims to completely specify the behavioral requirements of the PES™ through its alpha, beta, and planned release product development stages. This is done by specifying the individual requirements of the PDM and RID components, for any communications between the PDM and RID, and any communications between the PDM and the motorcycle. These requirements will cover issues involving electrical and mechanical performance, data transmission performance, software algorithms, embedded operating systems, sustainability, and safety.

1.4 Requirements Format

All requirements in this document will be specified as follows:

`[R-W.X.Y.Z.V]`

This format can be interpreted as follows:

- `W` is the requirement class;
- `X` is the requirement subclass (eg. weight, size);
- `Y` is the requirement device, where '0' is for the entire product, '1' is for the RID and '2' is for the PDM;
- `Z` is the requirement number; and
- `V` is the product development version, where 'a' is for alpha phase, 'b' is for beta phase, and 'c' is for the planned release phase.

2. High Level Overview

The Proximity Entrance System™ (PES) is physically divided into two separate systems: the Proximity Detection Module (PDM) and the Remote Identifier (RID). The PDM is an embedded system that can be mounted on and integrated into the ECU system of an electric motorcycle. The RID is a small, lightweight transceiver module that is carried by the user like a key. For the initial development stages, the automotive ECU system will be simulated by a laptop. This system configuration is summarized in Figure 2.0.1.

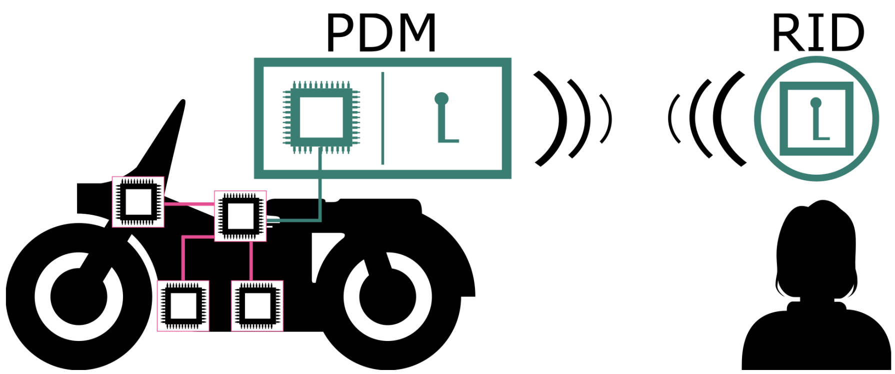

Fig. 2.0.1: High-Level PES™ Architecture

As a rider approaches their motorcycle, the PDM calculates motion vectors by tracking the relative position of the RID over time. If the motion vector of the RID movement lines up with the sensors on the PDM for a long enough period of time, then the PES™ assumes the user wishes to go for a ride. At this point, the PDM issues a wakeup signal to the bike's ECU system, allowing the bike to initialize its systems before the user sits down. Once the user hits the start switch on the handlebars, then a final start signal will be sent to the bike, and it will start nearly instantaneously. If the user doesn't hit the switch, then after a certain timeout period the PDM can issue a sleep signal to the bike.

Note: because Echo is an OEM for the PES™, it is up to the motorcycle manufacturer to decide how the bike will handle any signals sent by the PDM.

In a user experience survey conducted by Echo, it was found that users will often share keys with family members [6]. Because of this, the PES™ can identify users based on their personal RID, which will enable motorcycle manufacturers to manage unique per-user configuration preferences. Motorcycle manufacturers can then connect the system to the internet to interact with a cloud database, which can sync up with the user's iOS or Android device. Through this connection, manufacturers can give users the ability to customize their startup sequence with whatever features the bike supports.

However, an internet connection will not be required to use the PES™ outside of a first-time connection, and only if the motorcycle vendor desires this.

A general view of this architecture is shown in Figure 2.0.2.

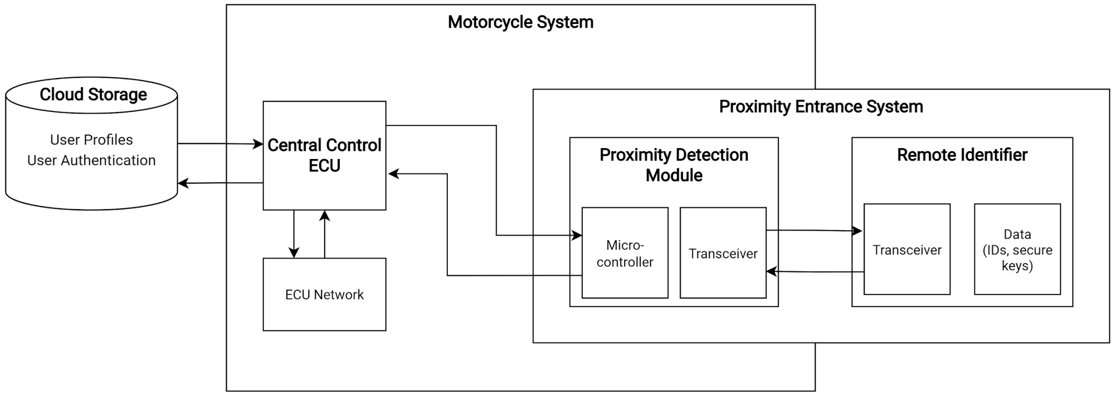

Fig. 2.0.2: PES™ Architecture

2.1 Remote Identifier (RID)

The Remote Identifier (RID) component of the PES™ is a small, low-power system that contains two primary functional components: a transceiver, and some form of data storage. The transceiver is used to communicate with the PDM installed on the motorcycle, and the small data store is used to hold an identifier to uniquely identify the user, and any keys needed for encrypted data exchange with the PDM. To enable encryption and decryption of transceiver messages, each RID will also be equipped with a small operating system to implement data transfer.

Fig. 2.1.1: Remote Identifier High-Level Structure

In the planned product release stage, the RID will have a low-profile casing that allows it to be mounted to various surfaces. For example, a user could potentially mount their RID to their helmet or leave it in their purse or wallet to reduce the number of items they need to carry.

In addition to these components, the RID may include a backup activation button in case of software failure.

2.2 Proximity Detection Module (PDM)

The Proximity Detection Module (PDM) component of the PES™ is an embedded system installed into a motorcycle's ECU network. It is composed of three primary functional components: a microcontroller, a transceiver, and a bus. The microcontroller handles all proximity detection logic and manages data transfer between the PDM, RID, and ECU network, the transceiver is used to communicate with the RID, and the bus is used to communicate with the ECU network on the motorcycle. The transceiver may be made up of one or more antennas.

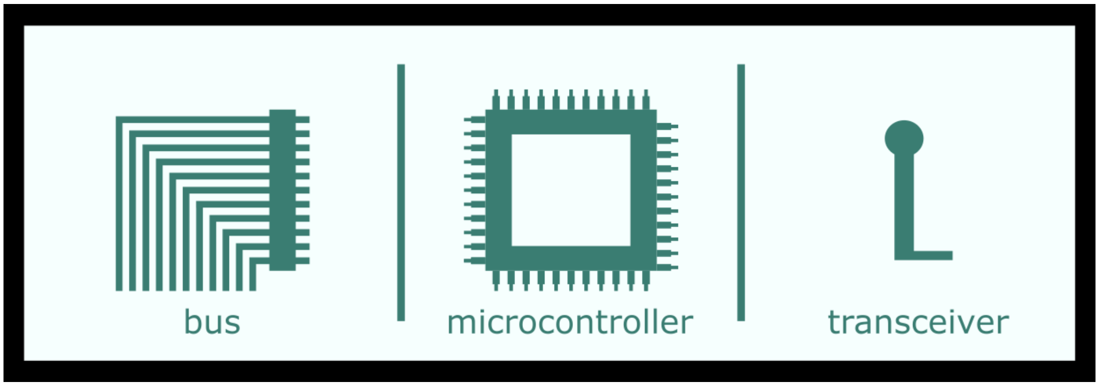

Fig. 2.2.1: Proximity Detection Module High-Level Structure

In the planned product release stage, the PDM will be contained within a low-profile casing used to simplify installation into a motorcycle. Its antennas may be contained within its housing, or they may be installed elsewhere on the motorcycle to maximize connectivity and data accuracy.

3. Physical Requirements

The physical requirements specify the physical structure, durability, and longevity standards of each component of the PES™. This includes its standards of weight, sizing, mechanical durability, waterproofing, and windproofing.

In general, the RID must be fairly durable - as a wearable device, it will be exposed to rough outdoor elements like heavy rain, wind, and dramatic temperature changes. Its enclosure must also be low-profile enough that it can be attached to user's belongings like a helmet, or placed into a user's wallet. The RID will need a self contained power source that allows users to replace batteries when needed.

The PDM enclosure must also be durable, since motorcycle manufacturers may not necessarily want to take on the risk of waterproofing an external device. The power for the PDM enclosure should also be drawn directly from the motorcycle.

3.1 Weight

[R-3.1.1.1.b]: RID must weigh less than 40 grams

[R-3.1.2.1.b]: PDM Unit must weigh less than 500 grams

3.2 Size

[R-3.2.1.1.b]: RID must have a surface area less than 40 cm^2

[R-3.2.1.2.b]: RID must be less than 0.5 centimeters thick

[R-3.2.2.1.b]: PDM must have a surface area less than 100 cm^2

[R-3.2.2.1.b]: PDM must be less than 5 centimeters deep

3.3 Durability

[R-3.3.1.1.b]: RID must be impact resistant from a drop height of 1 meter

[R-3.3.1.2.b]: RID must be water resistant for a light rainfall (~0.1 millimeters per hour)

[R-3.3.1.3.b]: RID must be operational in environments with up to 65% humidity

[R-3.3.1.4.b]: RID must be operational in environments with up to 50 kilometers per hour wind speed

[R-3.3.1.5.b]: RID must be operational in environments with a temperature in the range of -10 to 40 degrees celsius

[R-3.3.2.1.b]: PDM must contain an outer casing accessible via screws only allowing for component access for repairs.

[R-3.3.2.2.b]: PDM must be water resistant for a heavy rainfall (~0.5 millimeters per hour)

[R-3.3.2.3.b]: PDM must be operational in environments with up to 50 kilometers per hour wind speed

[R-3.3.2.4.b]: PDM must be operational in environments with up to 65% humidity

[R-3.3.2.5.b]: PDM must be operational in environments with a temperature in the range of -10 to 40 degrees celsius

3.4 Power

[R-3.4.1.1.a]: RID must be powered by a non-rechargeable small battery that supplies up to 3 Volts

[R-3.4.1.2.b]: RID must have a battery life of minimum 12 months to meet with industry standards [8]

[R-3.4.1.3.b]: RID must provide an access hatch to replace the non-rechargeable battery, fastened by screws

[R-3.4.2.1.a]: PDM must be powered by the motorcycle through a standard 12 Volt input

3.5 Mounting

[R-3.5.2.1.b]: The PDM must be fastened onto a motorcycle able to withstand speeds up to 140 kilometers per hour

[R-3.5.2.2.b]: The PDM must be mountable on convex surfaces

[R-3.5.2.3.b]: The PDM must allow for additional external antennas to be mounted in multiple locations on the motorcycle

4. Hardware Requirements

To successfully implement a solution compatible with automotive products, both the PDM and the RID need to be developed in conjunction with a simple implementation of a simulated central control ECU that would be connected to the same network as the PDM as if they both were placed in a motorcycle.

4.1 Remote Identifier (RID)

[R-4.1.1.1.a]: RID must use a transceiver capable of communicating accurate position information with its registered PDM

[R-4.1.1.2.a]: RID must store an encrypted unique identifier

[R-4.1.1.3.a]: RID must be capable of encrypting and decrypting messages exchanged with its registered PDM

[R-4.1.1.4.b]: RID must implement a low-powered sleep mode to increase battery efficiency

[R-4.1.1.5.b]: RID must contain an interface to provide visual feedback to users after an interaction is detected

4.2 Proximity Detection Module (PDM)

[R-4.2.2.1.a]: PDM must use a transceiver capable of communicating position and identification information with its registered RIDs

[R-4.2.2.2.a]: PDM must store encrypted keys to implement encrypted communication with registered RIDs and with the central ECU

[R-4.2.2.3.a]: PDM must have a bus capable of communicating with a central ECU communicate to signal proximity events based on nearby RIDs

[R-4.2.2.4.c]: PDM should be able to identify a user and signal the central ECU about which user profile to use for the driver

R-4.2.2.5.a]: PDM must be able to receive and store a user profile and RID device list record coming from the central ECU

5. Software Requirements

The microcontroller inside of the PDM forms the bulk of the software requirements. The central process that drives the microcontroller must be able to asynchronously handle any of the data streams shown in Figure 5.0.1. This specifies the behavior for only the minimally viable product, which does not include long-term potential features like cloud connectivity or a mobile application.

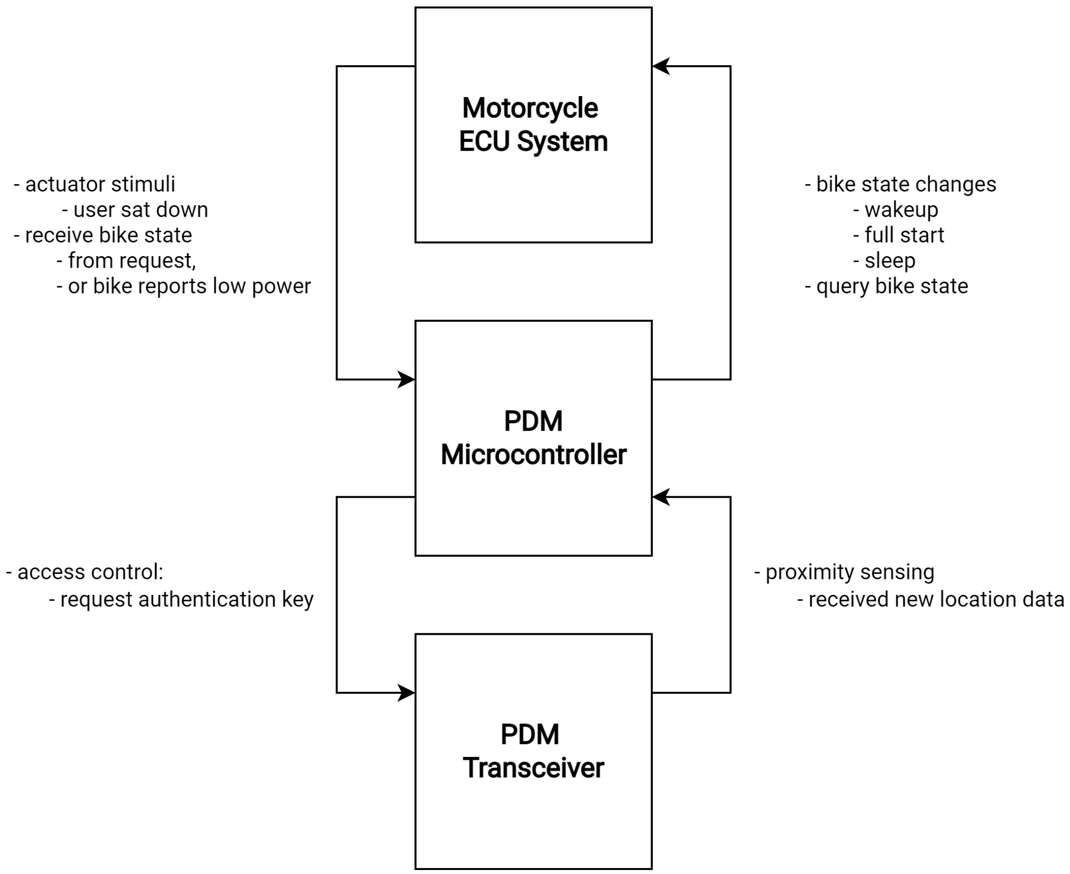

Fig. 5.0.1: PDM Data Streams

A general implementation for the behavior shown in Figure 5.0.1 is provided in Figure 5.0.2 in the form of a flow diagram. In general, the software requirements can be separated into problems relating to general behavior, performance, and communication.

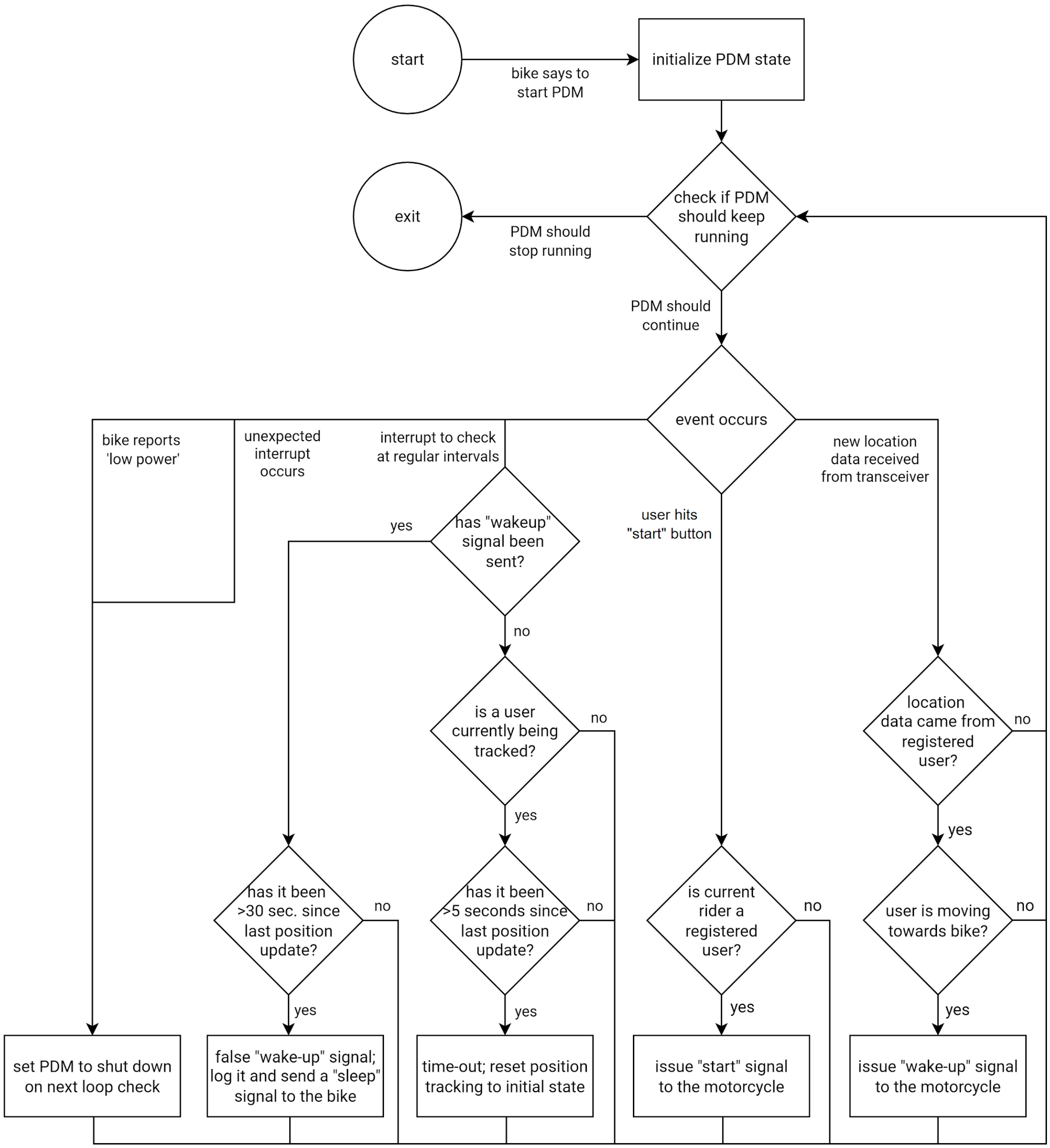

Fig. 5.0.2: PDM Algorithm Flow Diagram

The software for each RID is more simplistic. Unlike the PDM, all it needs to do is encrypt and decrypt transceiver data, transmit and receive data, and serve its unique identifier stored on the RID. It also holds no state information.

5.1 General

[R-5.1.1.1.a]: RID software must be able to run on an embedded operating system

[R-5.1.1.2.b]: RID software must automatically start on system wake-up

[R-5.1.1.3.a]: RID system must automatically restart the RID process if the system detects it is not running

[R-5.1.1.4.b]: RID system must enter a low-power sleeping state if no transmissions are detected for 2 minutes

[R-5.1.1.5.a]: RID process must be stable in the presence of any interrupts

[R-5.1.1.6.b]: RID process must log diagnostic information in the event of unexpected interrupts

[R-5.1.2.1.a]: PDM software must be able to run on an embedded operating system

[R-5.1.2.2.a]: PDM software must initialize a clean working state when enabled by the central control ECU

[R-5.1.2.3.b]: PDM process must automatically start on system boot

[R-5.1.2.4.b]: PDM system must automatically restart the PDM process if the system detects it is not running

[R-5.1.2.5.b]: PDM process must shut down its host system if a “low power” event is received from the central control ECU

[R-5.1.2.6.a]: PDM process must release all allocated resources on shutdown

[R-5.1.2.7.a]: PDM process must be stable in the presence of any interrupts

[R-5.1.2.8.b]: PDM process must log diagnostic information in the event of unexpected interrupts

5.2 Performance

[R-5.2.1.1.a]: RID software must maintain communication with any registered PDM within 10 meters with a clear line of sight

[R-5.2.2.1.a]: PDM software must maintain tracking for any registered RID within 10 meters with a clear line of sight

[R-5.2.2.2.a]: PDM software must issue a “wake-up” event to the ECU bus at least 5 seconds prior to any registered user sitting on the bike

[R-5.2.2.3.a]: PDM software must not issue any “wake-up” events to the ECU bus without connection to a registered RID

[R-5.2.2.4.a]: PDM software must not issue any “start” events to the ECU bus without a registered RID user seated on the bike

[R-5.2.2.5.b]: PDM software should not issue “wake-up” events to the ECU bus for any nearby registered users that are not going to sit on the bike
[R-5.2.2.6.b]: PDM software must time out after an issued “wake-up” event if the registered RID is not detected for 30 seconds
[R-5.2.2.7.b]: PDM software must issue a “sleep” event to the ECU bus once it’s been determined that a false “wake-up” event was issued
[R-5.2.2.8.b]: PDM software must log diagnostic information for any false “wake-up” events issued
[R-5.2.2.9.a]: PDM software must issue a “start” event to the ECU bus if a registered user hits the start switch on the handlebars
[R-5.2.2.10.a]: PDM software must time out and reset state if no registered RID is detected within range for at least 5 seconds

5.3 Communication

[R-5.3.1.1.a]: RID software must communicate with its registered PDM if in range
[R-5.3.1.2.a]: RID software must encrypt and decrypt any messages exchanged with any PDM over its transceiver
[R-5.3.1.3.a]: RID software must not send position information to any PDM it is not registered with
[R-5.3.2.1.a]: PDM software must communicate asynchronously with any registered RIDs in range to determine position information
[R-5.3.2.2.a]: PDM software must encrypt and decrypt any messages exchanged with any RID over its transceiver
[R-5.3.2.3.a]: PDM software must encrypt and decrypt any messages exchanged over its ECU bus
[R-5.3.2.4.a]: PDM software must securely identify any registered RIDs within range and in clear line of sight

6. Economic Requirements

For the PES™ to find success on the market, it is important that it remains affordable for our target demographic as well as financially attainable to manufacture. It is also paramount that the PES™ maintains the respect of our clientele; by delivering a long-lasting and secure product to the end-user. These economic requirements are outlined in the form of a target price, life-span, and packaging for the system.

6.1 Unit Price

[R-6.1.0.1.c]: PES™ must be sold for between $100-$200 CAD per unit to contend with other proximity detection systems [7]

6.2 Life Expectancy

[R-6.2.0.1.a]: PES™ must have a minimum life expectancy of 60 months

6.3 Packaging

[R-6.3.0.1.c]: PES™ external packaging must be secure enough to protect the system when shipping globally

[R-6.3.0.2.c]: PES™ individual packaging must contain an aesthetically recognisable and appealing design to appeal to a premium user demographic

7. Non-Functional Requirements

Echo aims to make the transition from mounting to riding the motorcycle seamless. To meet the standards of our target demographic, it is important that PES™ is intuitive and reliable. The following non-functional requirements are sorted by usability, security, performance, and reliability.

7.1 Usability

[R-7.1.2.1.b]: PDM must indicate when successfully activated

[R-7.1.0.1.b]: PES™ must not require any sort of internet connection

7.2 Security

[R-7.2.2.1.a]: PDM must be unresponsive to removed users

[R-7.2.2.2.b]: PDM must be able to authenticate 5 different RID devices

[R-7.2.2.3.a]: PDM must implement asymmetric encryption using public and private keys for security purposes

7.3 Performance

[R-7.3.2.1.a]: PDM must detect user intent within 5 seconds

[R-7.3.2.2.a]: PDM must authenticate the user within 2 seconds

[R-7.3.2.3.a]: PDM must start the system within 5 seconds

[R-7.3.2.4.a]: PDM must activate when the user is within 5 meters

7.4 Reliability

[R-7.4.2.1.a]: PDM must consistently activate when within range

[R-7.4.1.1.b]: RID battery life must last at least 12 months

8. Engineering Standards

The PES™ will be initially sold in the Canadian market, with a future expansion into the global market. As such, Echo must comply with Canadian and International standards as outlined by ISO, IEEE, IEC, and SPE. Specific software, electrical, environmental, and wireless engineering standards are outlined in the following section.

8.1 Software

ISO/IEC/IEEE 12207:2017 - Systems and software engineering - Software life cycle processes [9]

ISO/IEC 26555:2015 - Software and systems engineering — Tools and methods for product line technical management [10]

ISO/IEC/IEEE 14764:2022 - Software engineering — Software life cycle processes — Maintenance [11]

ISO 11898-1:2015 - Road vehicles — Controller area network (CAN) — Part 1: Data link layer and physical signalling [12]

AUTOSAR R21-11 - Automotive software architecture - Classic platform microcontroller architecture [13]

8.2 Electrical

ISO 17409:2020 - Electrically propelled road vehicles — Conductive power transfer — Safety requirements [14]

8.3 Environmental

SPE-890-15 - A Guideline for accountable management of end-of-life [15]

C2CPII 4.0 - Cradle-to-Cradle global standard for product design [16]

8.4 Wireless

ISO/IEC 26907:2009 - Information technology — Telecommunications and information exchange between systems — High-rate ultra-wideband PHY and MAC standard [17]

8.5 System

ISO 26262 - Road vehicles - Functional safety [18]

9. Sustainability and Safety

Echo is striving towards a sustainable, safe, and eco-friendly product. This involves following a true Cradle-to-Cradle design philosophy, taking careful consideration of the impact on future generations [19]. A thorough review of the design process of the PES™ has been performed to ensure all potential safety hazards are considered. The five categories (material health, product circularity, clean air & climate protection, water & soil stewardship, and social fairness) of sustainable performance are presented in the following sustainability requirements [19].

Echo believes in the electronics right-to-repair, as such, the PES™ will be constructed with replaceable parts/components. Accompanying this, Echo is taking into consideration the material each component of the PES™ is composed of, as well as the appropriate disposal method that leads to the smallest ecological impact, as shown in Table 9.1 below.

Part/Component	Material	Method of Disposal
PDM Casing	Biodegradable Plastic	Municipal Recycling
RID Casing	Biodegradable Plastic	Municipal Recycling
RID PCB	Electronics	Electronics Recycling
RID Battery	Alkaline	Electronics Recycling
PDM Transceiver (Antenna)	Electronics	Electronics Recycling
PDM Microcontroller	Electronics	Electronics Recycling

Table 9.1: Component Materials and Methods of Disposal

Echo will offer a parts-exchange program where manufacturers and users can exchange damaged parts for working parts. The damaged parts will be repaired and used in manufacturing or properly recycled if damaged beyond repair.

9.1 Sustainability

[R-9.1.0.1.b]: PES™ systems must have a modular design with components that are repairable and replaceable

[R-9.1.0.2.b]: PES™ must be composed of at least 90% recyclable materials that are safe for both humans and the environment

[R-9.1.0.3.b]: PES™ must allow for variable operation modes to save battery life

[R-9.1.0.4.b]: PES™ production must prioritize recycled components over brand-new components

[R-9.1.0.5.b]: PES™ must use limited power when possible to reduce potential emissions

[R-9.1.0.6.b]: PES™ must minimize electrical components composed of environmentally-unfriendly heavy metals

[R-9.1.0.7.b]: PES™ must be produced using ethical manufacturing practices

[R-9.1.0.8.c]: PES™ packaging must contain 100% recyclable materials and be composed of minimum 50% recycled materials

9.2 Safety

[R-9.2.2.1.b]: PDM outer casing must not contain any sharp edges

[R-9.2.2.2.b]: PDM outer casing must not have any exposed wiring or circuitry

[R-9.2.2.3.b]: PDM inner circuitry must be properly insulated

[R-9.2.2.4.b]: PDM mounting must be secure on the motorcycle and not interfere with the riding experience and safety of the user

[R-9.2.1.1.b]: RID outer casing must not contain any sharp edges

[R-9.2.1.2.b]: RID must not exceed a temperature of 50 degrees celsius

10. Test Plan

10.1 Acceptance Test Plan for Alpha Prototype

The following table contains high level tests to be employed against the Echo alpha prototype.

Test	Acceptance Criteria	Result
Bring registered RID to PDM with expected user intent	System unlocks	
Remove registered RID from PDM range after system was unlocked	System locks	
Bring RID to PDM with no user intent (e.g. passing by)	System remains locked	
A RID registered with a different system enters range	System remains locked	
Two unique registered RIDs (A, B) approach the PDM; RID A meets intent requirements and RID B does not	System unlocks and recognizes user attached to RID A	
Two unique registered RIDs (A, B) approach the PDM; RID A passes intent requirements, then RID B passes intent requirements	System unlocks and recognizes user attached to RID A (the first RID to pass intent requirements)	
Traffic between RID and PDM is intercepted & read	Data transmission is encrypted and unreadable	
Traffic between RID and PDM is intercepted & read	Data transmission is encrypted and unreadable	
External actor tries to read encryption keys and database on PDM	Data is encrypted and unreadable	
External actor tries to read encryption keys and ID on RID	Data is encrypted and unreadable	
Registered user RID hits start switch on the bike	System issues a “start” signal to the motorcycle	
Unregistered user RID hits start switch on the bike	System remains locked and does not start the motorcycle	

Alongside the test plan is the development of a simulated central ECU to use for manual testing during product development. This ECU must be able to interface with the PDM over its ECU communication bus, and be able to send encoded messages and receive decoded messages over this connection. The simulated central ECU will be a console application that can run on a developer's laptop and will be capable of sending any signals that the PDM may receive from a real motorcycle ECU system. During the final product development cycle, it may need to relay requests from the PDM to a cloud server available over the internet.

Conclusion

The Proximity Entrance System™ is built to eliminate startup wait times for premium electric motorcycle brands focused on user experience. As a remote keyless system, the PES™ has a heavy focus on security to ensure user safety, with all external communication with the motorcycle and all internal communication between transceivers being encrypted. It focuses on a robust and low-profile design so users can set-and-forget without the need to troubleshoot. Echo is also prioritizing a lower cost of the PES™ to entice potential manufacturers into licensing the system. Finally, the PES™ ships with 100% recyclable packaging and is right-to-repair friendly, offering a component swap program for future users who may wish to tinker or repair their own damaged hardware.

This document has provided a general overview for how the Proximity Entrance System™ securely eliminates startup wait times for electric motorcycle users, and has specified the product requirements for each component of the system to work together to achieve this goal. These requirements have been carefully considered from three perspectives: functionality, to prioritize ease-of-use; functional safety, to ensure compliance with global automotive standards; and sustainability, to reduce e-waste and to stay aligned with the vision of reducing emissions common in the electric vehicle industry.

Glossary

Asymmetric encryption: A cryptographic system that uses two separated (but algorithmically related) public and private key to encrypt and decrypt data

Cradle-to-Cradle: A design standard focused on sustainability using a circular ecological economy

ECU: Electronic Control Unit; an embedded system in an automotive electrical system that is used to control a single component of the vehicle

OEM: Original Equipment Manufacturer; a company that supplies manufactured parts that are used in another company's larger product system

PCB: Printed Circuit Board; a laminated structure used for condensed wiring in electrical circuits

PDM: Proximity Detection Module; the bike-mounted embedded system component of the Proximity Entrance System™

PES: Proximity Entrance System; an automotive system that predicts user intent to reduce the time waiting for an electric motorcycle to start

RID: Remote Identifier; the user-held wearable component of the Proximity Entrance System™

ECHO

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