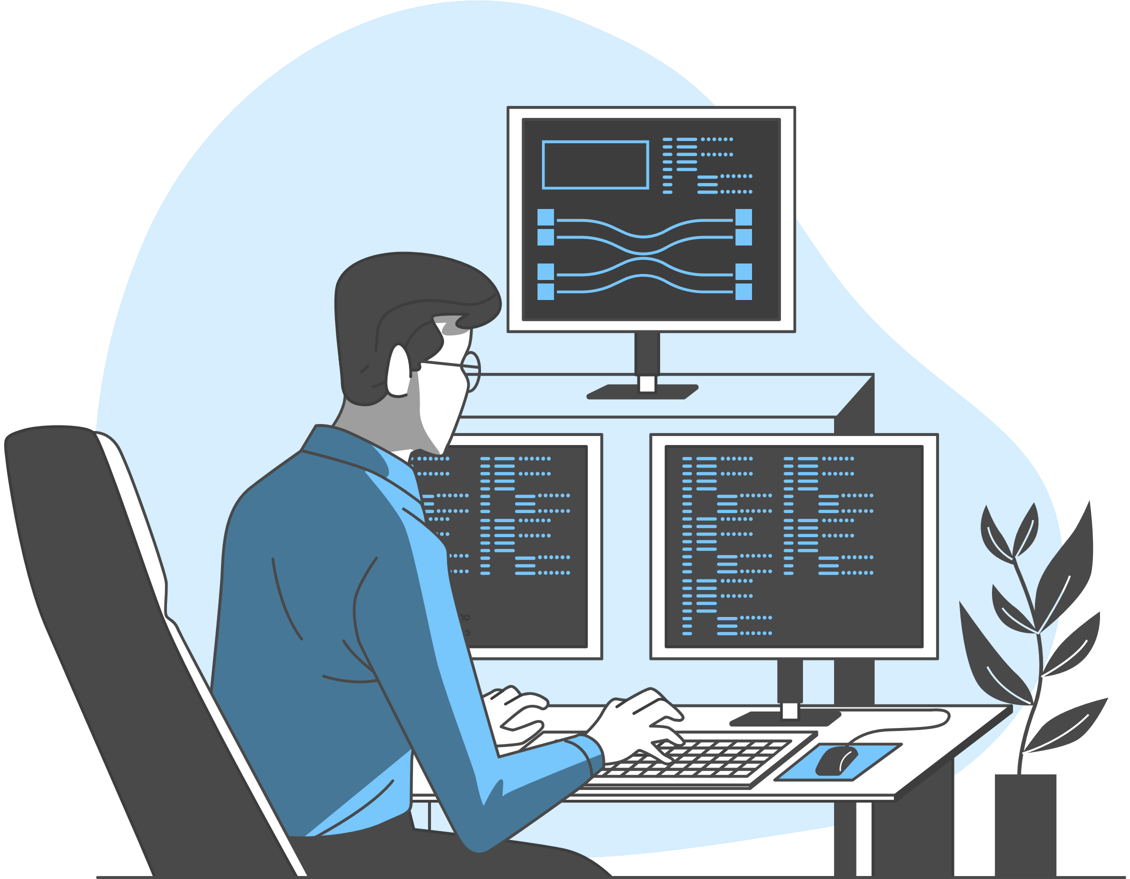

Final Presentation

A Capstone Presentation

By ECHO

Meet the team

CEO

Spencer Karjala

CTO

Miller Solis

CFO

Olivia Kuninaka

COO

Spencer Pauls

CMO

Shawn Baltar

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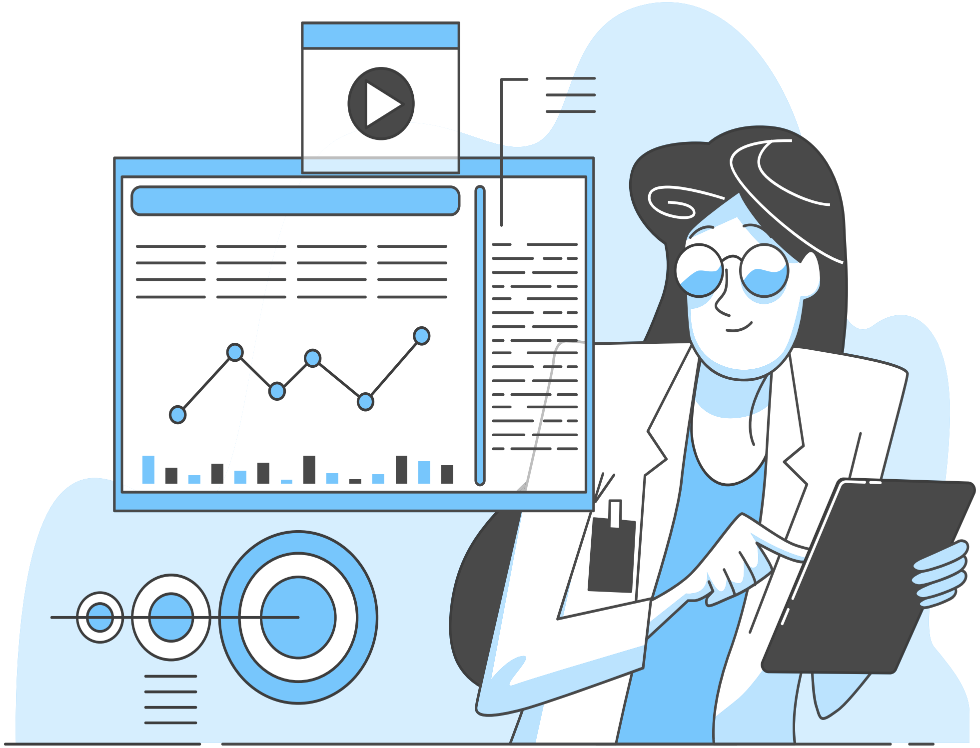


01
Introduction

Purpose

Problem: as a user, I would like to be able to unlock and start my motorcycle automatically as I walk toward it, while minimizing accidental unlocks (eg. walking past it in the garage to mow the lawn)

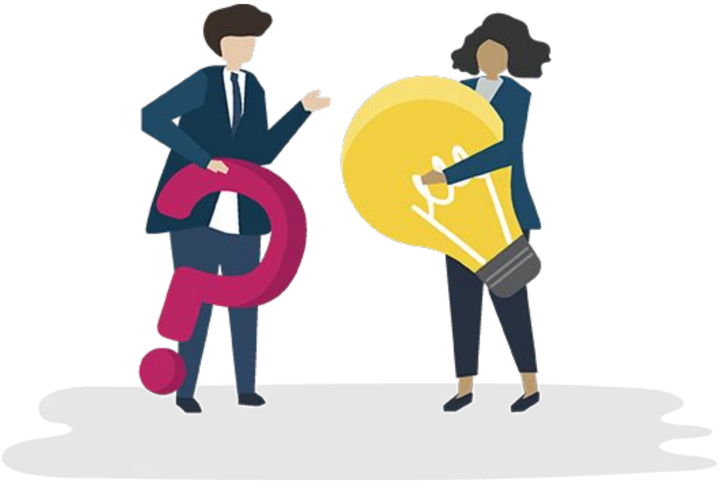
Solution: a keyless entry system that tracks user position information to determine their intent by communicating securely with a low-power wearable device

Background Information

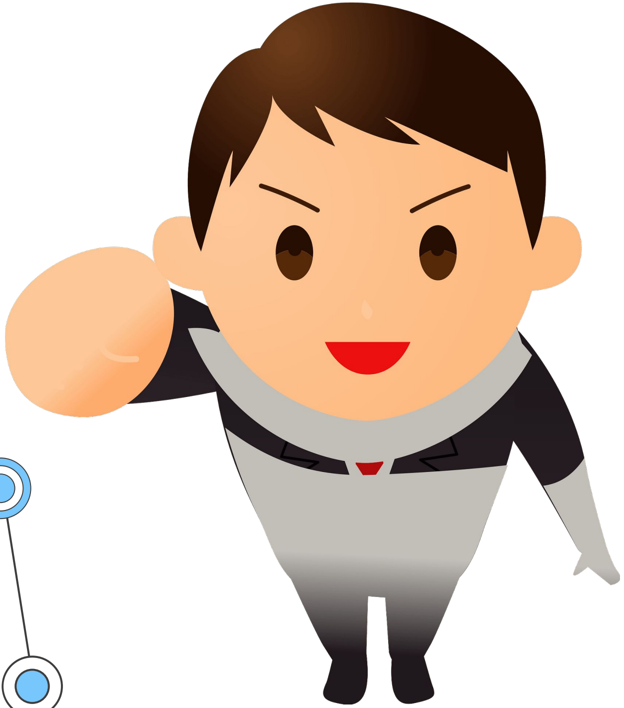
- Electric vehicles controlled by a central Electronic Control Unit (**ECU**) controlling the other ECUs (up to 150 total) [1]
  - Leads to slow boot times - around **5-10 seconds**

- Proximity Entrance System (PES) aims to eliminate the **problem of waiting for these boot times**

- Aftermarket systems exist with varying functionality
  - However, they must be **installed by the user** - unreachable by a majority of the market
  - **Not fully integrated** with the onboard network - cannot communicate securely



Motivation



- Original interest came from smart home applications using **proximity based detection**
- **Ultra-Wideband technology** more appealing than Bluetooth or Wireless LAN
- PES conceived after discussion with industry expert at **Damon Motorcycles** - Rob Chartier
- **Alleviating the slow wait times** for electric motorcycle boot up would greatly appease the Damon clientele

02
Technical Case

High-level description

- The PES™ is built to eliminate the problem of waiting for vehicle boot times while minimizing the number of accidental starts

- The system is split into two components:
  - **Proximity Detection Module (PDM)** - mounted on the bike
  - **Remote Identifier (RID)** - held by the user

- As a **user approaches** their bike with their RID, the PDM and RID communicate to determine the location of the RID

- The PDM will send **multiple signals** to the motorcycle to **indicate events**. For example when the RID is approaching the bike, the PDM sends a "**wake-up**" signal to the motorcycle system, giving it an advanced warning to start up its necessary systems

Remote Identifier (RID)

The **user-held component** that enables intent detection and includes:

- Microcontroller
  - Coordinates secure **encrypted communication** with the PDM to uniquely identify each rider
- Ultra-wideband (UWB) transceiver
  - Performs **communication** and **timestamping** to allow the PDM to perform time-of-flight calculations

Proximity Detection Module (PDM)

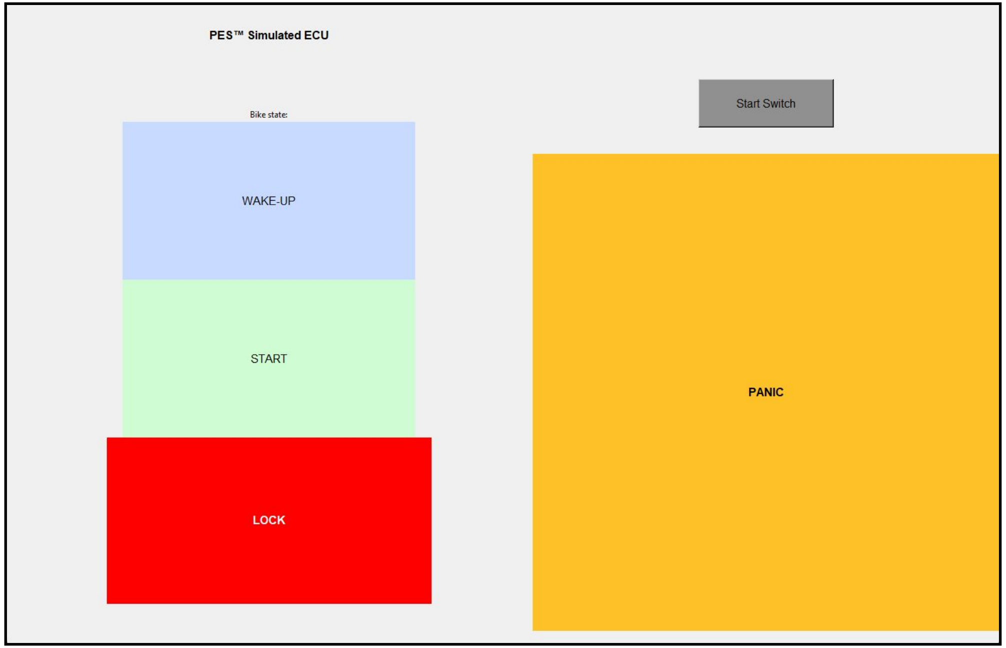
The **embedded system** installed into the motorcycle's ECU network. Its main components include:

- Microcontroller
  - Handles **proximity detection** logic, encrypted communication, security logic, time-of-flight calculations and database communication requests
- CAN transceiver
  - **Interfaces with the motorcycle's** central control unit
- UWB transceiver
  - Provides **wireless communication** with registered RIDs

Simulated ECU (demonstration only)

Simulates how a main ECU would behave in a real-world electric motorcycle, enabling **isolated development and testing** of the PDM and RID.

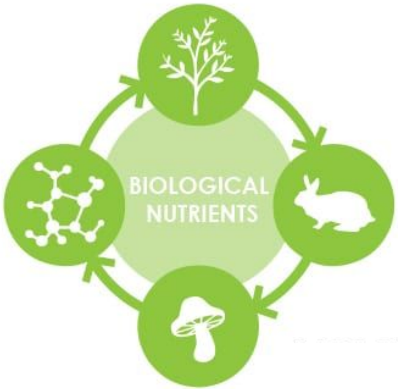
- Receives and sends CAN messages to the PDM
- Interprets signals and displays the current state of the motorcycle



Changes in Scope

- **RID development was prioritized** due to critical size constraints
  - PDM size and enclosure lower priority than RID
- **Authentication for button actions** has not been developed
- PCB **reliability** and component selection was prioritized for the automotive industry (voltage spikes, high temperatures, etc)
- **Low power mode** for the **RID** can be developed in the future
- Intent detection implementation **does not include triangulation**
- RID battery changed from **coin cell to AAA**
- **Web-app** not developed (not part of the product anymore)

Cradle-to-Cradle Design



- Outer casing:
  - Will be made from **recyclable** plastic
  - Durable

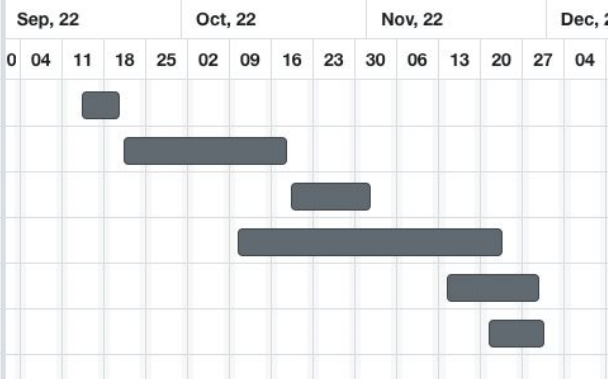
- Electronic components:
  - Recyclable materials are prioritized
  - Minimize electrical components composed of environmentally-unfriendly heavy metals

- Components/parts in general are **replaceable** and **reusable**

Scheduling (Gantt Chart)

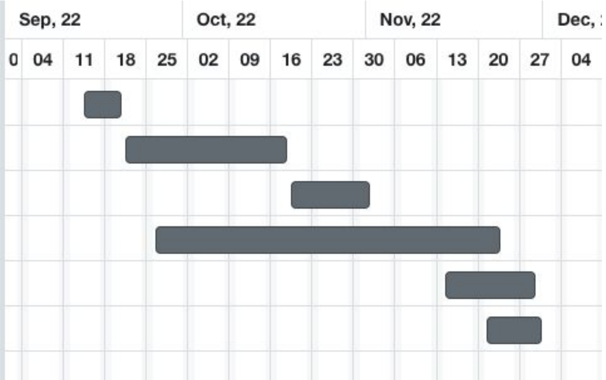
Estimated:

Name	Start Date	End Date ↑
Prototype Refinement Report	Sep 14, 2022	Sep 20, 2022
Future-Proofing Report	Sep 21, 2022	Oct 18, 2022
Business Pitch Report	Oct 19, 2022	Nov 01, 2022
Implement design changes to prototype	Oct 10, 2022	Nov 23, 2022
Employ tests	Nov 14, 2022	Nov 29, 2022
Final Presentation	Nov 21, 2022	Nov 30, 2022



Actual:

Name	Start Date	End Date
Prototype Refinement Report	Sep 14, 2022	Sep 20, 2022
Future-Proofing Report	Sep 21, 2022	Oct 18, 2022
Business Pitch Report	Oct 19, 2022	Nov 01, 2022
Implement design changes to prototype	Sep 26, 2022	Nov 23, 2022
Employ tests	Nov 14, 2022	Nov 29, 2022
Final presentation	Nov 21, 2022	Nov 30, 2022



03

Business Case

Market and Sales Strategy

- The **target consumers** for the PES™ who are motorcyclists who are willing to **spend more for premium features**

- **TAM** - Automotive Keyless Entry (US) - (352.2M) [2]
- **SAM** - Motorcycle Keyless Entry (US) - (10.58M) [3]
- **SOM** - Echo Market Share (30%) - (3.17M)

- The major barriers to entry are: **switching costs** (for OEMs), **government policy**, and **patents**

- Collaborating with OEMs allows for a **long term relationship** to be built

- **Premium product** represents a higher return on investment

Ideal Customer

- Enough income to purchase **motorcycles for leisure**

- From **PRIZM5's Marketer's Handbook** - upper middle class who reside in large cities and suburbs

- **Higher income** customers are more likely to purchase our product

- Demographic Marketing Risks:
  - New technology **typically attracts younger demographic**
    - This demographic may be unable to afford our product

  - Target demographic may be **resistant to change**
    - New marketing tactics (social media/internet marketing) may be less effective

Competition

- Aftermarket **keyless remote start devices** that consumers can install into their vehicles to unlock, lock, and start their vehicle over **Bluetooth**
  - **iDataLink CMHCXA0** (often paired with ArcticStart EDGE 2X)
  - **Viper DS4** remote start system

- Our Advantages
  - Integrated at **manufacturer level**
  - **Ultra-wideband** vs Bluetooth technology
  - Designed for **electric motorcycles** specifically
  - **Communicate directly** with main electronic control unit

Price (PCBa Only)

Qty		Part	Part Qty	Part Qty Sold	Supplier	Description	Cost (ea.)
1	PDM	STM32F103C8T6	1	1000	DigiKey [8]	Microcontroller	$4.679
		DecaWave DWM1000	2	500	Mouser [9]	UWB transceiver for RID communication	$13.18
		Texas Instruments SN65HVD230QDR	1	2500	Mouser [10]	CAN transceiver for bike communication	$2.35
		10μF SMD Capacitor	2	8000	DigiKey [11]	0603 Capacitors	$0.021
		0603 49.9Ω SMD Resistor	4	125,000	DigiKey [12]	0603 Resistors	$0.00211
		Printed Circuit Board	1	1500	PCBWay [13]	Custom PCB for PDM	$0.69
		Assembly Service	1	1500	PCBWay [13]	SMD component soldering	$1.33
2	RID	STM32F103C8T6	1	1000	DigiKey [8]	Microcontroller	$4.679
		DecaWave DWM1000	1	500	Mouser [9]	UWB transceiver for PDM communication	$13.18
		10μF SMD Capacitor	2	8000	Mouser [11]	0603 Capacitors	$0.021
		49.9Ω SMD Resistor	4	125,000	Digikey [12]	0603 Resistors	$0.00211
		MJTP1230 Pushbutton Switch	2	5000	DigiKey[14]	Button Switches	$0.05
		Printed Circuit Board	1	1500	PCBWay [13]	Custom PCB for RID	$0.42
		Assembly Service	1	1500	PCBWay [13]	SMD component soldering	$1.35
						Total	**$75.02**

Price (Mass Production)

Qty		Part	Part Qty	Description	Cost (ea.)
1	**PDM**	PCBA	1	PCB, components and assembly cost for PDM	$35.46
		Enclosure	1	Plastic casing for PDM	$3.00
2	**RID**	PCBA	1	PCB, components and assembly cost for RID	$19.77
		Enclosure	1	Plastic casing for RID	$2.00
				Total	**$82.00**

Break-even analysis

- Gamma Prototype - **$205.25**
- Mass Production - **$128.10**
  - Variable Cost - **$82.00**
  - Mass Production Cost includes fixed costs:
    - Salary, Office Space, Packaging, Marketing, Patents
- Break Even Point - **3200** units sold at **$199.99** per unit

Financing

- Loans
  - BDC **small business loans** [4]
  - Bank loans
- Grants
  - Government of Canada **business grants** and financing [5]
  - Innovate BC [7]
- Angel Investors
  - National Angel Capital Organization (**NACO**) [6]
  - "**Love Money**" - loans from friends and family
- **Damon Motorcycles**
  - Damon motorcycles may want access to the IP to mass produce

04
Risk Analysis

Potential Risks and Mitigation

- Safety Risk: **UWB communication protocol vulnerability**
  - ensure all UWB transmissions are encrypted and implemented via industry standard security practices
- Safety Risk: **CAN protocol security vulnerability**
  - CAN follows an industry standard by maintaining direct relationships with industry experts new attack vectors can be quickly combated with forced endpoint updates
- Design: **Bugs in transceiver manufacturer code**
  - Increase time estimate for integration with external firmware
- Design/Safety Risk: **RID system control signal reliability**
  - ensuring the Intent detection algorithm is fully functional
- Design: **Intent detection algorithm reliability**
  - augmentation with Bluetooth can eliminate common flaws

Risk Probability
High
Medium
Low

Potential Risks and Mitigation

- Design: **Practicality of key fob battery life**
  - feature RID low power mode to maximize battery life
- Design/Safety Risk: **Electromagnetic compatibility form RID**
  - comply with industry & government standards
  - requires third-party testing to ensure standards and regulations are met
- Design: **RID Case Tolerance (drop/shake test and heat dissipation)**
  - ensure case is strong and secure
  - PCB gives off minimal heat
- Design: **Connectors coming loose (roadway vibration)**
  - Connectors and components connected securely, low risk of disconnection

Risk Probability
High
Medium
Low

Plan B

- The following list of "**backup**" **plans** can be pivoted to while still **maintaining use of the core Echo technologies**
  - Smart home systems - **proximity detection** can be deployed for automatic smart home solutions
  - Expand to the **entire automotive industry**, not just limiting to electric motorcycles
  - Security solutions - **detect when users are within range** of a restricted area
  - **Tracking device** - similar to apples AirTag
- In the case of no viable pivots, Echo **intellectual property** can be sold to exiting automotive R&D teams

05
Standards

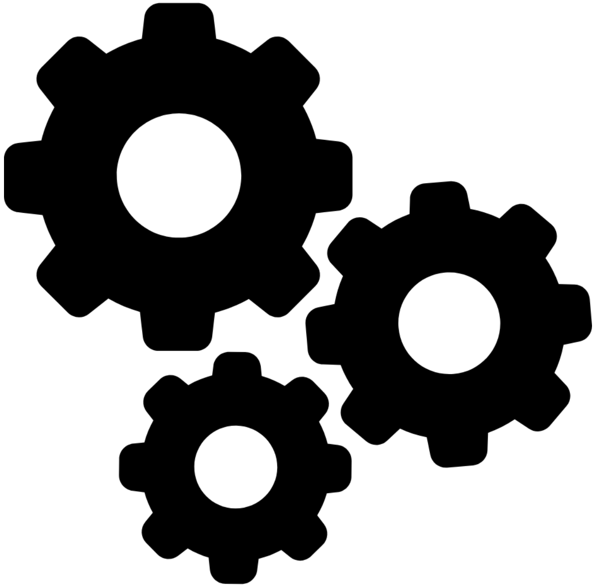
Engineering Standards

- **IEEE 802.15.4-2011:** IEEE Standard for Local and metropolitan area networks—Part 15.4: Low-Rate Wireless Personal Area Networks (LR-WPANs)
    - Software implications on **protocol used for UWB**

- **ISO-26262-1:2018:** Road Vehicles - Functional Safety
    - Functional **safety standards** that primarily impacts the software design and testing methodology.

- **67 FR 34856:** A Rule by the Federal Communications Commission - Ultra-Wideband Transmission Systems
    - Impacts the **hardware design and system validation processes.**

- **RSS-220:** Federal Regulations for Devices Using Ultra-Wideband (UWB) Technology in Canada
    - This primarily impacts the **hardware design and system validation processes.**



Engineering Standards Cont'd

- **ISO 21956:2019**: Road vehicles — Ergonomics aspects of transport information and control systems — Human machine interface specifications for keyless ignition systems
    - RID working in normal, abnormal, and low-battery conditions, with accidental usage handled.
    - One effect of this was the addition of the **emergency unlock** button in case of software failure.

- **IEC 60529:1989+AMD1:1999+AMD2:2013**: Degrees of protection provided by enclosures (IP Code)
    - design of the **physical enclosure**

- **SO/IEC/IEEE 12207:2017**: Systems and software engineering - Software life cycle processes
    - **Documentation** surrounding the requirements and design specifications

- **ISO 14001:2015**: Environmental Management Systems
    - comply with **vendor expectations** and to exist as a sustainable product.

06
Self-Reflection

Feedback Considered

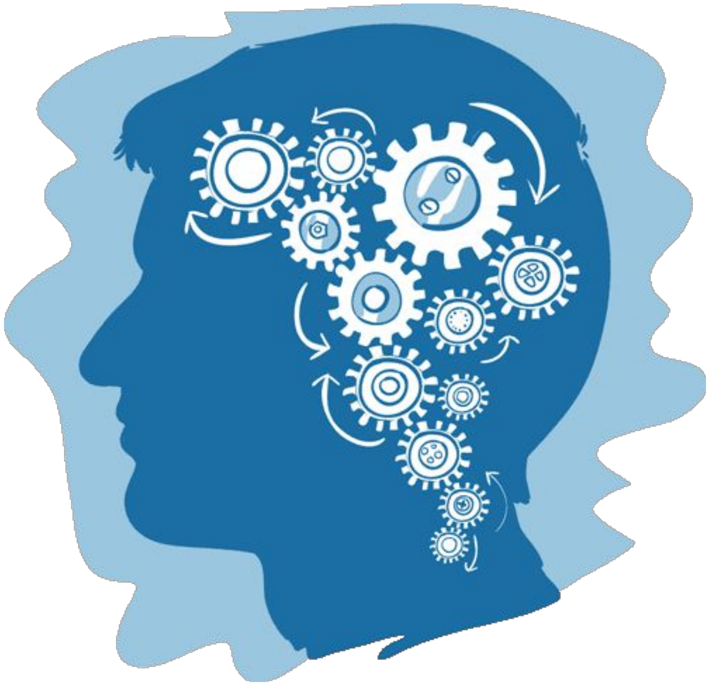
- **Drop Test** - The RID keyfob was iterated and tested for **structural integrity**
- **Heat Dissipation** - The microcontroller and components used were found to produce **negligible heat**
- **Roadway Vibration** - Connections are all **secure** within the PES
- **Component selection** - PCB **reliability** considered as critical to meet automotive industry requirements
- **Power Consumption** - Explored ways to take advantage of our **low power components** but more time and testing is required to develop firmware that fully takes advantage of those features
- **Industry Experience** - Majority of Echo members **lack motorcycle industry experience**, first steps towards commercialization post-capstone would be to connect with industry experts
- **General Business Description** - Echo **lacks business expertise**, hiring a business team would yield further industry success

What we'd do differently

- **Iteratively develop the product**
  - **AGILE** development method would result in less last minute crunch on features
- **Test more and earlier**
  - Applying **unit testing** on core features would help ensure core features are fully functional
- **3D printing is difficult**
  - Start 3D printing process earlier, the repetitive 3D printing prototype approach was time consuming and difficult

Knowledge Gained

- **Technical Skills**: UWB, CAN, Python, C, microcontrollers, PCB manufacturing, soldering, 3D printing, prototyping
- **Collaborative Skills**: Planning, Meeting structure, Teamwork, Documentation, Communication
- Good **documentation takes time and effort**, but saves time in the long run when working in a team
- **Changes of scope will happen**, dropping/adding features is okay and expected
- **Test early and test often**



07
Conclusion

Project Summary

Target Market: Electric Motorcycles

Problem: Slow boot times when starting motorcycle, a user wants to unlock and start automatically as they walk towards the bike

Solution: A keyless entry system, to track users and determine intent by communicating with a low-power keyfob

Future Plans

- Intent detection algorithm
  - Upgrade to “level 3” intent detection with **multiple antennas** and **triangulation**
- RID PCB form factor and casing size
  - **Reduce the size of the casing** and PCB to a more practical key fob size
- PDM enclosure
  - Improve the enclose for the PDM with generic **mounting capabilities**
- **Stress testing** and power optimizations for battery life

Acknowledgements

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- ENSC 405W Professor - **Craig Scratchley**
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- ENSC 440 Professor - **Andrew Rawicz**
- ENSC 440 TA - **Eric Brace**
- Damon Motorcycles - **Rob Chartier**

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Demo

Questions?