

Table 1: Revision History

Date	Developer(s)	Change
Oct 14, 2022	Elsa	Added FMEA
Oct 14, 2022	Abi	Added Critical Assumptions & Safety Reqs

# Hazard Analysis

## 4TB6 - Mechatronics Capstone

Team 5, Locked and Loaded

Abi Nevo

Elsa Bassi

Steffi Ralph

Abdul Iqbal

Stephen De Jong

Anthony Shenouda

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# Contents

1	Introduction	2
2	Scope and Purpose of Hazard Analysis	2
3	System Boundaries and Components	2
4	Critical Assumptions	2
5	Failure Modes and Effects Analysis	2
6	Safety and Security Requirements	4
7	Roadmap	4

## **1 Introduction**

## **2 Scope and Purpose of Hazard Analysis**

## **3 System Boundaries and Components**

## **4 Critical Assumptions**

CA1: Assume operator is not tampering or purposefully damaging the product.

CA2: Assume weather is typical of Canada (i.e., no natural disasters).

CA3: Assume operator's smartphone (including all integrated technologies, like GPS) is functioning properly.

CA4: Assume GPS and Bluetooth signals are receivable and transmittable; operator is in a location that can be properly triangulated (i.e., operator is not underground, etc.).

CA5: Assume operator's bicycle has standard frame and dimensions, and functions properly.

CA6: Assume operator's smartphone has power/is charged.

## **5 Failure Modes and Effects Analysis**

Table 2: Failure Modes and Effects Analysis

Design Function	Failure Mode	Failure Effects	Failure Causes	Detection	Recommended Actions	Design Controls	Safety Requirement	Reference
Engages and disengages bike to external frame or bike rack	Male and female locking ends not secured together; structural integrity of lock compromised	Bike not secured (vulnerable to theft or loss)	1.Faulty electromagnetic coil 2.Battery supply disrupted by faulty wire 3.Battery can no longer supply voltage 4.Misshapen mechanical locking component 5.Improper use 6.Water, cold temperature or dirt damage	Perform inspection of locking mechanism internally by opening it up with simple tools. Signs of deformation and/or breaking due to torsional shear stress may be visible	1.Replace faulty electromagnetic coil 2.Replace any faulty wires 3.Replace faulty battery 4.Replace misshapen mechanical locking component	Mechanism to manually disengage provided		
Attaches bike to external frame or bike rack	1.Lock does not fit around external frame 2.Lock is broken along its body and cannot move as intended	Bike cannot be secured to external frame (vulnerable to theft or loss)	1.Lock is too short 2.Lock is too rigid or not flexible enough to fit 3.Piece of lock has become stuck, loose or fallen off 4.Lock is too wide to fit through external frame 5.Improper use	1.Attempt to fit lock to external frame. 2.Perform inspection of physical lock to detect any components compromising structural integrity or any signs of deformation or breaking due to bending stress	1.Find a different external frame that fits the lock 2.Repair lock with spare pieces, tightening loose pieces or lubricating moving parts	Lock will be designed with high flexibility		
Transmits and receives signal to engage/disengage or locking mechanism from the App to the lock	Locking mechanism fails to engage or disengage; lock remains in undesired state	1.If fails to engage, bike not secured (vulnerable to theft or loss) 2.If fails to disengage, bike cannot be detached from external frame	1.App malfunction; unable to prepare or receive signal 2.Wireless connection from SmartLock to smartphone disrupted by external force 3.Communication protocol error 4.Battery supply disrupted by faulty wire 5.Battery can no longer supply voltage to transmitting/receiving unit	Locking mechanism stuck in undesired state after multiple attempts to engage or disengage	1.Reboot app 2.Replace any faulty wires 3.Replace faulty battery 4.Manually move smartphone and Smartlock such that they are in closer proximity to each other	Long-lasting battery installed		
Transmits, receives and displays status information (engaged/disengaged, battery percentage) from the lock to the App	Status information not shown on App or is inaccurate	Accurate information not known; battery may be low or require replacement and/or bike may not be secured (vulnerable to theft or loss)	1.Internal app malfunction or high latency 2.Status information not transmitted or received (see 'Transmits and receives engagement /disengagement signal from the App' above) 3.Smartphone malfunction or battery depletion 4.Faulty status sensors	1.App appears to be malfunctioning (not loading, screen frozen or information appears to be inaccurate or lagging). 2.Status information is inaccurate upon inspection of actual status of lock internals	1.Reboot Smartphone 2.Reboot App 3.Replace faulty status sensors 4.Charge smartphone	Ability to manually check status information		
Withstands water from rainfall	Water appears to have permeated SmartLock	1.Electronics damaged 2.Locking mechanism damaged 3.Mechanical components rusted	1.Ineffective waterproofing (impermeable sealing) of locking mechanism, electronics and mechanical components 2.Improper use (in inclement weather more severe than average rainfall)	Perform inspection of locking mechanism, electronics and mechanical components. Corrosion, damaged components or water observed.	Replace water-damaged components	1.System is well sealed against environment. 2.Aside from housing, lock system is composed of materials which resist corrosion		
'Geocaches' location of bike and displays on App	Location information not shown on App or is inaccurate	Accurate location information not known; user may not be able to locate bike	1.Smartphone GPS software malfunction (inaccurate location recorded) 2.Internal app malfunction 3.Smartphone battery depletion 4.Location geocached somewhere with poor satellite triangulation capabilities or poor cellphone service 5.Data sharing issue with smartphone GPS software	1.App appears to be malfunctioning (not loading, screen frozen or information appears to be inaccurate or lagging). 2.Geocached location is inaccurate when compared to actual location 3.Smartphone indicates battery or data sharing issue	1.Reboot GPS software app 2.Reboot smartphone 3.Reboot App 4.Charge smartphone 5.Move to a location with better service and satellite triangulation capabilities	None		
Contains and carries all physical lock components on bike when not in use	Some or all physical lock components cannot safely fit or be mounted on the bike due to the absence of a proper storage system that accommodates all components	1.Components must be placed on inappropriate storing locations such that they dangle off the bike or asymmetrically weigh down the bike 2.Components must be carried separately by the user	1.Physical lock component storage system lacks space for all components 2.Broken or malfunctioning physical lock component storage system 3.Physical lock components too large to be mounted safely on bike	Physical lock components cannot be stored safely on bike	Repair and/or expand faulty storage system	Initial check to ensure mounting system and corresponding components function as intended		

## **6 Safety and Security Requirements**

SR1: Internal parts of locking mechanism shall be accessible and replaceable.

SR2: The locking mechanism shall be able to disengage manually (e.g., with a key), in addition to remotely.

SR3: Product shall be adaptable and be able to fit a wide variety of external frames/bike racks.

SR4: Product shall be made from anti-corrosive materials.

## **7 Roadmap**