**Electric Scooter Requirements Specification**

|  |  |  |
| --- | --- | --- |
| Preparation: | Reviewers: | Approval: |
| Jon del Olmo | Iosu Aizpuru | Paul Aretxederreta |

*Table of Contents*

[1 Introduction 3](#_Toc135031952)

[2 Purpose 3](#_Toc135031953)

[2.1 Background and Context 3](#_Toc135031954)

[2.2 Traceability and Notation 4](#_Toc135031955)

[3 Definitions 4](#_Toc135031956)

[3.1 Acronyms 4](#_Toc135031957)

[3.2 Definitions 5](#_Toc135031958)

[4 References 5](#_Toc135031959)

[4.1 Documents 5](#_Toc135031960)

[5 General Description 5](#_Toc135031961)

[5.1 Users and Use cases 5](#_Toc135031962)

[5.2 System Boundary and Interfaces 6](#_Toc135031963)

[5.3 Assumptions and non-goals 7](#_Toc135031964)

[6 System Functions 8](#_Toc135031965)

[7 System Requirements 8](#_Toc135031966)

[7.1 Function: Turn on 8](#_Toc135031967)

[7.2 Function: Turn off 9](#_Toc135031968)

[7.3 Function: Accelerate 9](#_Toc135031969)

[7.4 Function: Brake 9](#_Toc135031970)

[7.5 Function: Ride 9](#_Toc135031971)

[7.6 Function: Display speed 10](#_Toc135031972)

[7.7 Function: Display SOC 10](#_Toc135031973)

[7.8 Function: Charge battery 10](#_Toc135031974)

[7.9 Function: Limit propulsion torque 11](#_Toc135031975)

[7.10 Function: Fold/Unfold scooter 11](#_Toc135031976)

[7.11 Function: Install/Remove battery. 11](#_Toc135031977)

[7.12 Function: Install/Remove wheels 12](#_Toc135031978)

[7.13 Miscellaneous 12](#_Toc135031979)

| **ID** | **Object Type** |  | **Parent Requirement** | **Rationale** |
| --- | --- | --- | --- | --- |
| Req\_1 | Title | Introduction |  | N.A |
| Req\_2 | Title | Purpose |  | N.A |
| Req\_3 | Info | The purpose of this specification is to describe the functionality for the system Electric Scooter The system will be developed within the scope of Validation and Testing Platforms. |  | N.A |
| Req\_248 | Title | Background and Context |  | N.A |
| Req\_250 | Info | This document describes the requirements specification of an electric scooter manufactured and sold by MU Scooters Inc. The following figure shows the general structure of the scooter.    The scooter is sold with the charger and it will be prepared to charge from the common 230 V utility grid.  The scooter will be connected to an app in a smartphone via Bluetooth. The app will record information about rides and will have access to GPS coordinates.  Using GPS coordinates, the app will send a speed limitation command to the scooter in certain areas. |  | N.A |
| Req\_246 | Title | Traceability and Notation |  | N.A |
| Req\_247 | Info | *Parent Requirement* attribute may be used to identify the requirement(s) of the higher level of abstraction that justify the existence of a requirement. Requirements from which a requirement derives.  To say it differently, a requirement must justify the compliance with the requirement(s) of the superior level listed in its Parent Requirement attribute. |  | N.A |
| Req\_211 | Info | The *Rationale* attribute may be used to write down the reasons that justify the existence of a requirement without Parent Requirements.  That is, there may be requirements that do not derive from requirements of a superior level; they may respond to arbitrary design decisions, design restrictions of different types etc. These cases may be explained in the *Rationale* attribute.  Rationale shall be N.A (not applicable) if not used. |  | N.A |
| Req\_64 | Info | Describe here any special notation that will be used in this specification |  | N.A |
| Req\_5 | Title | Definitions |  | N.A |
| Req\_7 | Title | Acronyms |  | N.A |
| Req\_8 | Info | SOC: State-of-Charge  GAP: Generic Access Profile  GATT: Generic Attribute Profile  SPP: Serial Port Profile |  | N.A |
| Req\_9 | Title | Definitions |  | N.A |
| Req\_10 | Info | List and describe here the terms that may not be common knowledge |  | N.A |
| Req\_11 | Title | References |  | N.A |
| Req\_68 | Title | Documents |  | N.A |
| Req\_96 | Info | List here any external document that may be cited in the specification. Make sure the document referenced is available for the reader (via hyperlink or similar). |  | N.A |
| Req\_14 | Title | General Description |  | N.A |
| Req\_15 | Title | Users and Use cases |  | N.A |
| Req\_237 | Info | The following system users are identified:   * Driver. * Maintainer. * Utility grid. * Smartphone. |  | N.A |
| Req\_236 | Info | Use case diagram. |  | N.A |
| Req\_16 | Title | System Boundary and Interfaces |  | N.A |
| Req\_200 | Info | Electric scooter Boundary |  |  |
| Req\_238 | Info | System interfaces diagram |  | N.A |
| Req\_239 | Info | The following are the system interfaces.  **Bluetooth comms**: Bluetooth communications will be used to exchange information between the scooter and a smartphone. They mainly will exchange information about location coordinates. On the one hand, an application will store the location of the scooter every 5 seconds. For that, the application will be linked to the scooter using a QR code present in the handle. On the other hand, depending on the coordinates of the scooter, the application may send a speed limitation command to the scooter.  **Charger plug**: The battery will be charged from the conventional low voltage grid (230 Vrms) using a Type F electrical plug.  **Throttle**: The user will stablish an acceleration command using a mechanical throttle installed in the handle. Depending on the angle of the throttle, it will send an electrical signal readable by the control board.  **Brake**: A mechanical friction brake will be used to stop the scooter. It will be installed in the rear wheel and the user will control it with a lever in the handle of the scooter.  **Display**: A display will be used to show the status of the scooter to the driver and maintainer. It may be used to show speed and battery SOC information.  **Rear wheel**: Wheel with embedded mechanical brake.  **Front wheel**: Wheel with embedded electric motor. |  | N.A |
| Req\_240 | Title | Assumptions and non-goals |  | N.A |
| Req\_241 | Info | Write here the non-obvious assumptions that have been made when doing this specification, if there are any. |  | N.A |
| Req\_242 | Info | Write here the non-obvious non-goals that have been set in relation to the <SYSTEM>, if there are any. |  | N.A |
| Req\_74 | Title | System Functions |  | N.A |
| Req\_75 | Info | Major system functions are:   1. Turn on: turns on the electric scooter. 2. Turn off: turns off the electric scooter. 3. Accelerate: driver pushes throttle and scooter accelerates. Increase scooter speed by certain amount. 4. Brake: driver pushes brake and scooter decelerates. Decrease scooter speed by certain amount. 5. Ride: Move forward with the current speed. 6. Display speed: show actual speed in display. 7. Display SOC: show actual SOC in display. 8. Charge battery: charge battery to 100 % of SOC. 9. Limit propulsion torque: limit propulsion torque depending on the location. 10. Fold/Unfold scooter. 11. Install/Remove battery. 12. Install/Remove wheels. |  | N.A |
| Req\_18 | Title | System Requirements |  | N.A |
| Req\_19 | Title | Function: Turn on |  | N.A |
| Req\_535 | Requirement | Users shall be able to turn on/off the scooter. |  | N.A |
| Req\_536 | Requirement | The scooter shall have only one mechanical turn on/off switch. |  | N.A |
| Req\_537 | Requirement | The scooter shall connect the battery to the electronics when the turn on/off button is in ON position while SOC is more than 10 %. |  | N.A |
| Req\_539 | Requirement | The scooter shall display initial SOC when the turn on/off button is in ON position while SOC is more than 10 %. |  | N.A |
| Req\_540 | Requirement | The scooter shall display a no battery sign in the display when the SOC is less than 10 %. |  | Operation with low SOC is not recommended |
| Req\_100 | Title | Function: Turn off |  | N.A |
| Req\_101 | Requirement | The scooter shall disconnect the battery from the electric drive when the turn on/off button is in OFF position. |  | N.A |
| Req\_102 | Title | Function: Accelerate |  | N.A |
| Req\_103 | Requirement | The scooter shall have a mechanical throttle actionable by hand. |  | N.A |
| Req\_104 | Requirement | The scooter shall control motor torque proportionally to the angle of the mechanical throttle. |  | N.A |
| Req\_105 | Requirement | The scooter shall accelerate from 0 to maximum speed in 6 seconds at the following conditions: maximum rider weight, 100 % SOC, tires inflated to the manufacture specifications, flat ground, maximum performance configuration. |  | N.A |
| Req\_106 | Title | Function: Brake |  | N.A |
| Req\_107 | Requirement | The scooter shall have a mechanical brake installed in the rear wheel. |  | N.A |
| Req\_108 | Requirement | The scooter shall decelerate from maximum speed to zero in 6 seconds at the following conditions: maximum rider weight, 100 % SOC, tires inflated to the manufacture specifications, flat ground, maximum performance configuration. |  | N.A |
| Req\_109 | Requirement | The scooter shall be able to stop form 25 km/h within a maximum distance of 2 m when the mechanical brake is applied. |  | N.A |
| Req\_110 | Title | Function: Ride |  | N.A |
| Req\_111 | Requirement | The scooter shall be able to ride at maximum top speed of 25 km/h ± 2 km/h |  | City law |
| Req\_112 | Requirement | The scooter shall be able to climb an 80 m long 10 % average grade hill in a maximum of 10 s with an average speed of 10 km/h. |  | N.A |
| Req\_113 | Requirement | The scooter shall be able to accelerate until maximum speed, ride 10 seconds in maximum speed, and decelerate until stop at the following conditions: maximum rider weight, fully charged, tires inflated to the manufacture specifications, flat ground, maximum performance configuration. |  | N.A |
| Req\_114 | Requirement | The scooter shall have a range of at least 80 km under the following conditions: 5 % average slope hill, maximum rider weight, fully charged, tires inflated to the manufacture specifications, maximum performance configuration (no energy saving mode), maximum acceleration requested in all the accelerations. The scooter is ridden until battery dies completely. |  | N.A |
| Req\_115 | Title | Function: Display speed |  | N.A |
| Req\_116 | Requirement | The scooter shall display its actual speed in km/h. |  | N.A |
| Req\_117 | Requirement | The scooter shall display its actual speed in 2 km/h steps. |  | N.A |
| Req\_118 | Requirement | The scooter shall measure its actual speed with a maximum error of 2% with respect to the real speed. |  | N.A |
| Req\_119 | Title | Function: Display SOC |  | N.A |
| Req\_120 | Requirement | The scooter shall display its actual SOC in percentage respect to its full battery state. |  | N.A |
| Req\_121 | Requirement | The scooter shall display its actual SOC in 5 % steps. |  | N.A |
| Req\_122 | Requirement | The scooter shall estimate its actual SOC with a maximum error of 5 % with respect to the real SOC. |  | N.A |
| Req\_123 | Title | Function: Charge battery |  | N.A |
| Req\_124 | Requirement | The scooter shall charge the battery from the utility grid. |  | N.A |
| Req\_125 | Requirement | The scooter shall charge the battery from 30 % to 80 % of SOC in 2 hours. |  | N.A |
| Req\_126 | Title | Function: Limit propulsion torque |  | N.A |
| Req\_127 | Requirement | The system shall establish the torque limit as per data received via its bluetooth interface. |  | N.A |
| Req\_128 | Requirement | The system's Bluetooth interface shall have the following characteristics:   * Bluetooth 5.0 or superior version. * Support for GATT and GAP protocols. |  | N.A |
| Req\_129 | Requirement | The system shall use SPP protocol to receive the torque limit data, where the system is the server and the smartphone or sendind device shall be the client. |  | N.A |
| Req\_130 | Requirement | The torque limit shall be interpreted as an Unsigned Integer of 8 bits, where the value represents the torque in Newton-meters. |  | N.A |
| Req\_131 | Requirement | The scooter shall limit its propulsion torque to 50 % of its maximum torque while the limit torque flag is activated. |  | N.A |
| Req\_132 | Title | Function: Fold/Unfold scooter |  | N.A |
| Req\_133 | Requirement | The scooter shall be foldable. |  | N.A |
| Req\_134 | Requirement | Folded size shall be length 45.5 x height 46.1 x width 19.8 inches |  | N.A |
| Req\_135 | Requirement | Unfolded size shall be length 45.5 x height 46.1 x width 21.3 inches |  | N.A |
| Req\_136 | Title | Function: Install/Remove battery. |  | N.A |
| Req\_137 | Requirement | The battery shall be removable. |  | N.A |
| Req\_138 | Requirement | The battery shall be replaced. |  | N.A |
| Req\_139 | Requirement | The battery shall include safety measures to avoid short-circuiting it while installing/removing. |  | N.A |
| Req\_140 | Title | Function: Install/Remove wheels |  | N.A |
| Req\_141 | Requirement | Front and rear wheels shall be removed |  | N.A |
| Req\_142 | Requirement | Front and rear wheel shall be replaced |  | N.A |
| Req\_143 |  | Miscellaneous |  | N.A |
| Req\_144 | Requirement | Maximum scooter weight shall be 20 kg ± 2 kg |  | N.A |
| Req\_145 | Requirement | Maximum wheel diameter shall be 125 mm |  | N.A |
| Req\_146 | Requirement | Motor shall be embedded in the front wheel |  | N.A |
| Req\_147 | Requirement | The rider shall weight a maximum of 100 kg |  | N.A |
| Req\_148 | Requirement | The scooter shall be able to give rated power at an ambient temperature between -10 °C and 40 °C at the following conditions: maximum rider weight, fully charged, tires inflated to the manufacture specifications, flat ground, maximum performance configuration. |  | N.A |