# Project Configurability and Field Deployment Plan:

## Project Configurability:

### Reusability:

The reusability of this product stems from the use of generally accessible, standard protocols and methods, with communication methods and operating systems such as MQTT, UART, ROS and Zephyr OS being central to the product. Through utilising this functionality, this product’s firmware can be integrated onto a wide variety of hardware, promoting reusability.

Specifically, almost all microcontrollers and development boards are capable of UART, and a significant number also allow for Zephyr integration. So, the use of these schemes promotes reusability, with the Nucleo-L496ZG board can easily be replaced.

Additionally, MQTT – a lightweight IoT messaging protocol – can be utilized by a variety of microcontrollers, provided they have internet access. This enables the M5Core to be replaced by any WI-FI enabled microcontrollers, enhancing the project’s adaptability in IoT applications.

Further, ROS is the industry standard for autonomous robotic devices, so the TurtleBot can be swapped for almost any autonomous robot, provided they meet the low barrier of entry – having an integrated LiDAR sensor or having the potential to communicate to an externally added LiDAR. From these hardware selections it allows our project to be utilized on many different platforms maximizing its reusability. Finally, to further the reusability of our project the PC code is run through a python script with a custom launch file to start up all necessary ROS nodes. This can be converted into an executable file allowing any device capable of installing ROS humble to drive the code.

### Reconfigurations or possible addition features:

As a direct consequence of the emphasis placed on reusability in this product, reconfiguration options are simplistic. To begin, the system’s inputs can be simply modified, as the ultrasonic sensors can be replaced, or added to, by other sensors which can communicate with the chosen microcontroller through a variety of communication protocols such as I2C, SPI, UART, etc.

For example, replacing an ultrasonic sensor with a camera accompanied by a machine learning model could enable the system to recognize more intricate gestures. Unlike ultrasonic sensors, which only provide distance measurements, a camera can capture additional information such as depth, colour, and shape. This enhancement would allow the system to interpret more sophisticated gestures and perform more complex tasks.

Another hardware reconfiguration that could be performed is replacing the Nucleo-L496ZG with a microcontroller which supports MQTT communication. This would eliminate the wired communication node of the Nucleo-L49Zg to M5Core. This opens up many different configuration such as retaining the M5Core to display the TurtleBot’s position, or removing the M5Core in favour of an external screen like an LCD or OLED to display the grid and position. This would be easy to achieve with the use of Zephyr OS, as only the device tree file would need to be adjusted if a microcontroller supported by Zephyr is used.

For further features the programmable board used could also have other features such as being able to utilise low energy Bluetooth capabilities, which could promote communication to multiple different autonomous robot systems, or to communicate with ranging sensors to further guide the robot. These enhancements promote greater flexibility and expand the range of applications for the system.

## Field Deployment Plan:

### Ease of use:

To ensure ease of field deployment of this product, some steps have, and can be, taken. To begin, the PC python script can be converted into a python executable file, which will automatically launch the required ROS nodes and begin listening to the relevant MQTT topics. This process will enhance efficiency and simplicity, as the deployment team will not be required to input ROS2 Commands in the terminal to start the device. Furthermore, the microcontrollers will be pre-flashed with the firmware to ensure that only powering the device is required for its operation.

Additionally, a manual has been created to describe the gesture actions performed to the Ultrasonic sensors, and what the TurtleBot’s responses to these gestures will be. This allows a deployment team to prepare their actions ahead of deployment, in order to seamlessly deploy the product. Furthermore, despite the intentional simplicity of wiring this device, a wiring manual has been created, which will further aid the deployment team in efficiently setting up the product.