Joshua Crafton & Manuel Dogbatse

University Of East Anglia

**Embedded Application: We-Bike**

Contents

[Abstract 2](#_Toc104692730)

[Introduction 2](#_Toc104692731)

[Market Analysis 2](#_Toc104692732)

[Motorcyclist 3](#_Toc104692733)

[Motorcycle Manufactures 3](#_Toc104692734)

[Product Analysis 4](#_Toc104692735)

[System Architecture 5](#_Toc104692736)

[UI design and flow chart 6](#_Toc104692737)

[GLCD sCREEN 6](#_Toc104692738)

[Exterior view 6](#_Toc104692739)

[Peripheral integration 7](#_Toc104692740)

[KNOWN PERIPHERALS 7](#_Toc104692741)

[Buzzer 7](#_Toc104692742)

[LED 7](#_Toc104692743)

[GLCD Screen (display) 7](#_Toc104692744)

[GLCD Screen (Touch) 7](#_Toc104692745)

[Unknown Peripherals 8](#_Toc104692746)

[MPU-6050 3-Axis accelerometer + Gyroscope 8](#_Toc104692747)

[HCSR04 Ultrasonic Sensors 8](#_Toc104692748)

[DS18B20 Digital Temperature Sensor 8](#_Toc104692749)

[Project management 10](#_Toc104692750)

[References 11](#_Toc104692751)

# Abstract

In the UK motorcyclists are constantly at risk from unaware drivers on the road. 90% of vehicle collisions that include a motorbike are due to drivers failing to look properly and entering the rider’s path of travel. The product that we are proposing will attempt to shorten the perception time of road hazards by predicting the distance from another vehicle or hazard. It will also show useful vehicle data like lean angle from an MPU-6050 and engine temperature from a DS18B20 to inform the rider of potentially dangerous hazards.

# Introduction

Motorcycles are typically non-informant when it comes to road safety and therefore put their drivers at risk from being fatally or seriously injured in a vehicle accident. We plan to use an MPU-6050 accelerometer, a DS18B20 digital temperature thermometer and a HC-SR04 ultrasonic sensor to collect important surrounding information. Then an assortment of LEDs and buzzers will be used to alert the rider. This will all be connected to a STM32F746G-Discovery Board that includes a GLCD display that we will create a suitable user interface for.



Figure – STM32F746G-Discovery

The sensor that we are going to add will assist in many different situations. Firstly, a digital temperature sensor we can use to measure how hot the engine is going to be and display a warning to the user that the engine and its connected parts will be too hot to touch. Another example use of the sensor is an ultrasonic reading from both sides of the machine that could return the potential size of a gap and inform a user that they cannot fit through.

# Market Analysis

Our main target user for this product would be motorcycle riders, they would benefit from having a device that will predict a hazard for them and allow them to focus on acting on the problem. This can be passed through to motorcycle manufacturers as they could integrate the device into their bikes.

## Motorcyclist

There are approximately 1.4 million people that use motorcycles in the UK and most journeys taken are for commuting. These riders already look for efficient ways to protect themselves and be safer when out on the road; for example they will use high visibility jackets and loud exhaust pipes to get the attention of other road users.

As for detecting lean angle, it is well known that motorcycle enthusiasts that use racing motorcycles enjoy getting their bike as low to the ground as possible so that they can take a tight corner at high speeds. A person like this may like the ability to record the lowest angle they were able to bring it down to and share it with their friends. Therefore, we believe that this product would be useful to both daily commuters and casual drivers.

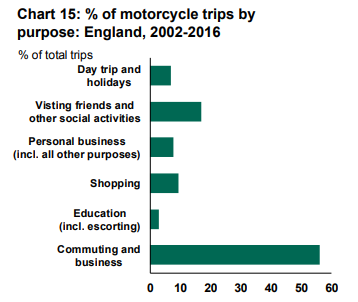


Figure – Graph from the GOV.UK website (ref 2)

## Motorcycle Manufactures

Many manufactures have taken interest in lean angle data and they display it in multiple different ways. Aprilia uses a small icon on the display of their Tuono V4 1100 bike to show the rider what angle they have leaned down too (fig.3). BMW take another approach, they use their onboard machine to log data so that a phone app can retrieve it and display it after the fact. In fig.4 you can see the lean angle that rider was able to achieve in that specific moment.

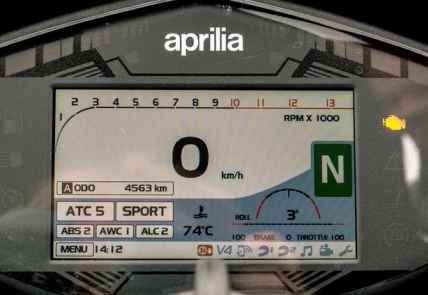
 

Figure – Aprilia Tuono V4 1100 HUD Figure 4 – BMW Motorrad Connected App

We believe that more manufacturers may benefit from interfacing with our system as there is a space in the motorcycle market for communicated sensor data between users and companies.

# Product Analysis

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Component | Quantity | Price | Total Cost | URL (The table below) |
| stm32f746g-disco | 1 | £42.06 (ex VAT) | £42.06 | 1 |
| MPU-6050 | 1 - 2 | £3.66 | £7.32 | 2 |
| HC-SR04 | 2 | £1.40 | £2.80 | 3 |
| DS18B20 3 Meters | 1 | £2.75 | £2.75 | 4 |
| LED – water resistant | 4-8 | £0.16 | £2.75 | 5 |
| Buzzer – 85dB | 1 | £5.92 | £5.92 | 6 |
| Relay | 1 | £7.99 | £7.99 | 7 |
| Total |  |  |  |  |

Figure – Table of components for WeBike product

|  |  |
| --- | --- |
| Index | URL |
| 1 | https://uk.farnell.com/stmicroelectronics/stm32f746g-disco/dev-board-cortex-m7-discovery/dp/2480961?gclid=Cj0KCQjw1ZeUBhDyARIsAOzAqQJPkw7lLPC\_zyecAF5148HP0u06amiizHqhuNgf7rteitfQkD00HAsaArg\_EALw\_wcB&mckv=sZwkGfXVa\_dc|pcrid|378007684243|kword|stm32f746g%20disco|match|p|plid||slid||product||pgrid|18635715368|ptaid|kwd-143106988638|&CMP=KNC-GUK-GEN-SKU-MDC-Test787 |
| 2 | https://smile.amazon.co.uk/gp/product/B09NY4V4LN/ref=ppx\_yo\_dt\_b\_asin\_title\_o05\_s00?ie=UTF8&psc=1 |
| 3 | https://smile.amazon.co.uk/HC-SR04-Ultrasonic-Module-Distance-Raspberry/dp/B0928JDNYK/ref=pd\_sbs\_sccl\_3\_3/262-4799109-5386109?pd\_rd\_w=1H7s1&pf\_rd\_p=a5204ade-56b1-48fa-aada-fff2fff34f0a&pf\_rd\_r=1TTVXE7RJVEGRP65YAC3&pd\_rd\_r=9c9c22bf-3398-47e9-b86b-578abf66e662&pd\_rd\_wg=t098I&pd\_rd\_i=B0928JDNYK&psc=1 |
| 4 | https://smile.amazon.co.uk/gp/product/B07KNQJ3D7/ref=ppx\_yo\_dt\_b\_asin\_title\_o02\_s00?ie=UTF8&th=1 |
| 5 | https://smile.amazon.co.uk/Light-Emitting-Diodes-9-12V-Wired/dp/B07SRTTN1B/ref=sr\_1\_29?crid=1R2WAB9H8WHA3&keywords=ultra%2Bbright%2BLEDs%2Bfor%2Barduino&qid=1653016743&s=industrial&sprefix=ultra%2Bbright%2Bleds%2Bfor%2Barduino%2Cindustrial%2C49&sr=1-29&th=1 |
| 6 | https://smile.amazon.co.uk/GLOGLOW-Electronic-Buzzer，3-24V-Active-Continuous/dp/B07F5LB8K9/ref=sr\_1\_7\_sspa?crid=3GSVY5WZDN75M&keywords=arduino+buzzer&qid=1653016942&s=industrial&sprefix=arduino+buzzer%2Cindustrial%2C55&sr=1-7-spons&psc=1&smid=A2QDVE2OGM9E0I&spLa=ZW5jcnlwdGVkUXVhbGlmaWVyPUEyR0xPWTY1NElIMVRRJmVuY3J5cHRlZElkPUEwNTM4NzQ3OENHQU8zM083MUs5JmVuY3J5cHRlZEFkSWQ9QTA5Njc2NDUxSUZPSERJNk5JME1BJndpZGdldE5hbWU9c3BfbXRmJmFjdGlvbj1jbGlja1JlZGlyZWN0JmRvTm90TG9nQ2xpY2s9dHJ1ZQ== |
| 7 | https://www.amazon.co.uk/ELEGOO-Optocoupler-Compatible-Official-Raspberry/dp/B06XK6HCQC/ref=asc\_df\_B06XK6HCQC/?tag=googshopuk-21&linkCode=df0&hvadid=310818960639&hvpos=&hvnetw=g&hvrand=6328423275614935041&hvpone=&hvptwo=&hvqmt=&hvdev=c&hvdvcmdl=&hvlocint=&hvlocphy=1006964&hvtargid=pla-562517395562&th=1 |

Figure – URL indexing

# System Architecture

In fig.6 you will find the system architecture for our product. The board MCU in the centre is the STM32F746G – Discovery and the orange arrow pointing into it dictates the Keil MDK software that is used to flash the device with the WeBike firmware. The blue arrows are for inputs: MPU 6050, DS18B20 and the HC-SR04 sensors. The green arrow is for system outputs, the LED and buzzer will be used to alert other drivers of the bikes presence.

Finally, the red arrow outputs data to the LCD screen and displays the UI seen on the right side of the figure. This UI will take the inputs from the sensors and display it in a suitable format so that the user can glance at it to obtain lean angle or potential nearby hazards.

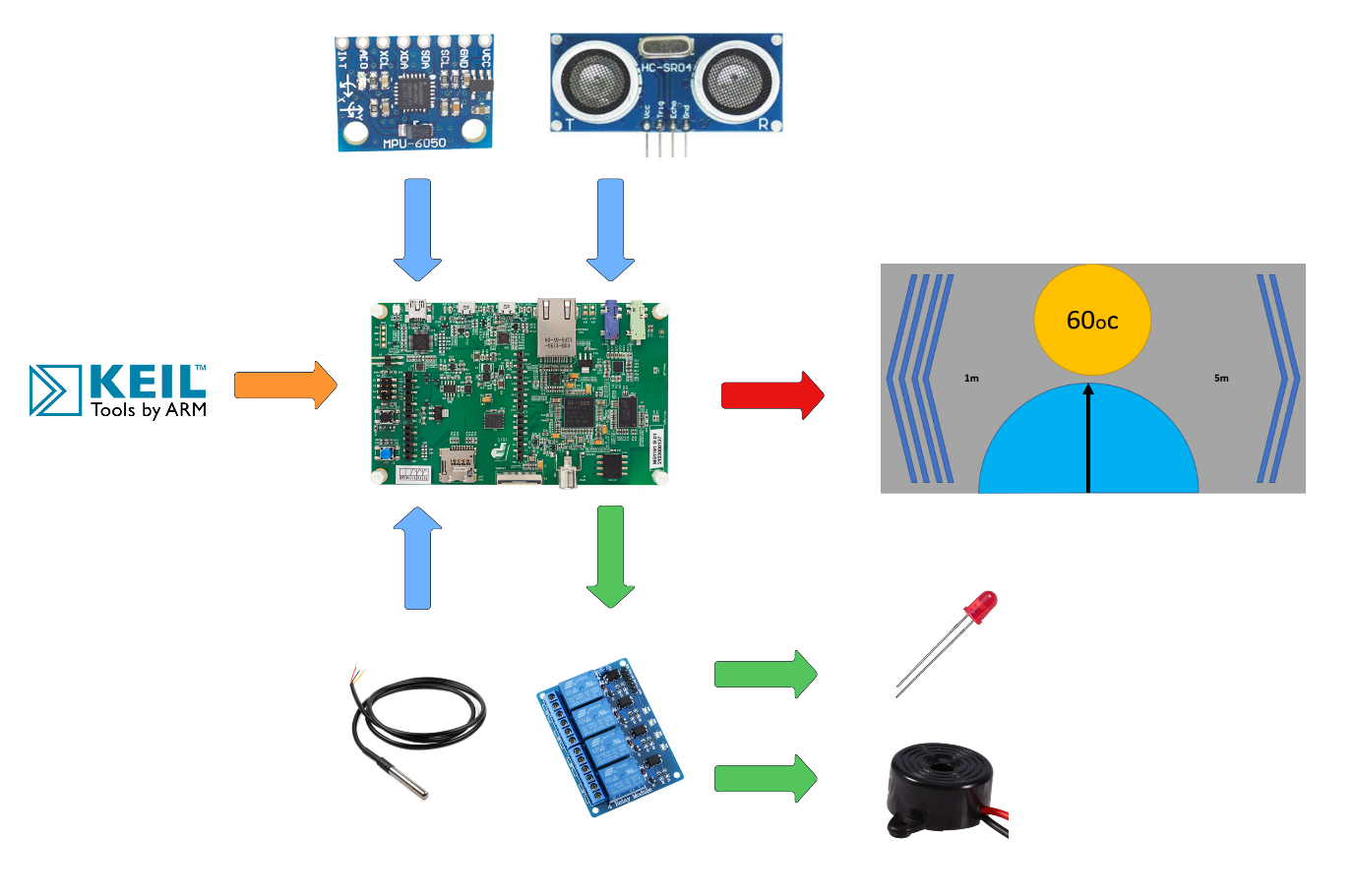


Figure – System Architecture for WeBike

# UI design and flow chart

## GLCD sCREEN

Diagram

Description automatically generated

Figure – GLCD Screen

## Exterior view

Diagram

Description automatically generated

Figure – Exterior View

# Peripheral integration

## KNOWN PERIPHERALS

### Buzzer

The buzzer works in a very simple way, because all that is required for the buzzer to make noise is an input value of 1 (3.3V) through its I/O port. Therefore, the pin configuration is as follows:

* VCC Pin 🡪 3.3V Arduino Pin
* GND Pin 🡪 GND Arduino Pin
* I/O Pin 🡪 Arduino Pin D7 / STM32 Pin PI3

We chose pin PI3 because it has no additional functions added to it, which gives way to the other sensors to use the internal functions of the STM32F746-Discovery Board.

### LED

The LED, just like the buzzer, only requires an input signal of 3.3V for it to light up. Therefore, the LED is configured similarly to the buzzer, which is as follows:

* +ve Pin 🡪 Arduino Pin D7 / STM32 Pin PI3
* -ve Pin 🡪 GND Arduino Pin

### GLCD Screen (display)

The GLCD Screen is already embedded in the system, however for the screen to work alongside the MPU-6050 accelerometer and the other advanced sensors, the PLL values must go as follows:

* PLLM = 25
* PLLN = 336
* PLLQ = 7

To use the GLCD screen for display, add this line of code to the main function:

GLCD\_Initialize(); // Initialises the GLCD screen

### GLCD Screen (Touch)

The GLCD Touch Screen is also already embedded in the system, so there aren’t any pin configurations. All that is required to use the touch screen is by adding these lines of code to the main function:

TOUCH\_STATE tsc\_state; // Stores the user touch state  
Touch\_Initialize(); // Initialises the touch screen

## Unknown Peripherals

### MPU-6050 3-Axis accelerometer + Gyroscope

The MPU-6050 is both an accelerometer and a gyroscope. For the MPU-6050 to work, it needs the SCL and SDA pins that are using the I2C driver. The I2C driver is used to establish communication between two or more integrated circuits. The SCL (Serial Clock) pin is responsible for sending a pulse to the accelerometer for it to read with, and the SDA (Serial Data) pin is responsible for sending the input data to the circuit board for interpretation. The pin configuration is as follows:

* VCC Pin 🡪 3.3V Arduino Pin
* GND Pin 🡪 GND Arduino Pin
* SCL Pin 🡪 Arduino Pin D15 / STM32 Pin PB8
* SDA Pin 🡪 Arduino Pin D14 / STM32 Pin PB9

### HCSR04 Ultrasonic Sensors

The HCSR04 Ultrasonic Sensor require a TRIG pin and an ECHO pin. The TRIG pin is set to HIGH (3.3V) for 10 ɥs and then set to LOW (0V) to force the sensor to start the measurement. The ultrasonic sensor’s then send an 8-cycle sonic burst from the transmitter and the receiver picks up the returned sonic signals through the ECHO pin, in which the length of the signal is proportional to the distance between the ultrasonic receiver and the nearest object that has bounced the sonic burst back. Therefore, the pin configuration for each ultrasonic sensor is as follows:

* VCC Pin 🡪 3.3V Arduino Pin
* GND Pin 🡪 GND Arduino Pin
* TRIG Pin (Both) 🡪 Arduino Pin D8 / STM32 Pin PI2
* ECHO Pin (L) 🡪 Arduino Pin D10 / STM32 Pin PA8
* ECHO Pin (R) 🡪 Arduino Pin D9 / STM32 Pin PA15

### DS18B20 Digital Temperature Sensor

The DS18B20 Digital Temperature Sensor provides 9-bit to 12-bit Celsius temperature measurements and communicates over a 1-Wire bus that requires only one DATA line to communicate with the board. For the sensor to work, the sensor must be initialised every time. The initialisation is done by setting the DATA pin to LOW for 480 ɥs and then reading the pin for the presence pulse sent by the sensor. Therefore, the pin configuration is as follows:

* VCC Pin 🡪 3.3V Arduino Pin
* GND Pin 🡪 GND Arduino Pin
* DATA Pin 🡪 Arduino Pin A1 / STM32 Pin PF10

# Project management

Chart

Description automatically generated

Figure – Project Management

# References

1. Motorcyclist Casualties Facts from the GOV.UK site.

* <https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&cad=rja&uact=8&ved=2ahUKEwjXi4WA9uv3AhUIesAKHdalD3kQFnoECAsQAQ&url=https%3A%2F%2Fassets.publishing.service.gov.uk%2Fgovernment%2Fuploads%2Fsystem%2Fuploads%2Fattachment_data%2Ffile%2F447673%2Fmotorcyclist-casualties-2013-data.pdf&usg=AOvVaw0XE6WpgP78MofoT75j04pB>

1. Motorcycling in the UK

* <https://hansard.parliament.uk/commons/2021-10-26/debates/B1E415EB-6CD4-421F-A21E-FDE3E1599AD0/MotorcyclingGovernmentSupport#:~:text=In%20the%20UK%2C%201.4%20million,small%20percentage%20of%20overall%20traffic>

1. Temperature sensors

* <https://www.amazon.co.uk/thermometer-voltmeter-temperature-motorcycle-snowmobile/dp/B01M1K2SS7>
* <https://www.bikermart.co.uk/Oxford-Micro-Waterproof-Digital-Motorbike-Clock-Temperature-Gauge>
* <https://www.bikermart.co.uk/10mm-LED-Motorcycle-ATV-Dashboard-Warning-Lights>

1. Aprilia Lean Angle on HUD

* <https://teamthrottle.com/2018/11/20/review-aprilia-tuono-v4-1100-factory-2018/>

1. BMW Motorrad

* <https://www.youtube.com/watch?v=4JrYrhNEBic>

1. Pin Configuration

* MPU-6050 - <https://controllerstech.com/how-to-interface-mpu6050-gy-521-with-stm32/>
* HCSR04 - <https://controllerstech.com/hcsr04-ultrasonic-sensor-and-stm32/>
* DS18B20 - <https://controllerstech.com/ds18b20-and-stm32/>