Technical Report - The Smart Boda Device

Group 7

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Course: CSC 1304 Practical Skills Development
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Contents

Abstract

Uganda faces a high rate of road traffic accidents, with emergency response and reporting often delayed due to a lack of real-time detection and communication tools. The Smart Boda Device is a low-cost, sensor-based solution designed to detect likely accidents involving boda bodas in real time. By fusing data from accelerometers, gyroscopes, force sensors, and GPS, the device identifies crash events and transmits critical data to a Flutter-based web platform using Firebase and Firestore [5]. This enables emergency responders and authorities to monitor incidents,

analyze accident hotspots, and inform infrastructure improvements. The system is scalable and accessible, with potential for integration into fleet management and urban safety planning.

1 Introduction

1.1 User Challenge

Uganda's urban transport sector, particularly the boda boda industry, suffers from frequent accidents and delayed emergency responses. Current interventions lack real-time, automated detection and reporting, making it difficult for emergency services to respond promptly and for authorities to gather actionable data for policy and infrastructure improvements.

1.2 Project Goals

- Develop a real-time accident detection system using sensor fusion (impact force, orientation, velocity, and acceleration) [3].
- Build a web-based platform for monitoring and alerting emergency responders using Flutter [4].
- Gather and analyze accident data to support future infrastructure and safety planning.
- Prototype a scalable, low-cost, and accessible hardware-software solution for widespread adoption.

1.3 Functional Requirements

- **Accident Detection:** Identify crashes using data from accelerometer, gyroscope, force sensor, and GPS [3].
- **Data Transmission:** Send incident data to a web application in real time using GSM and cloud services.
- **Web Platform:** Visualize accident locations, historical data, and analytics for authorized users.
- **Data Storage:** Securely store all incident records using Firebase and Firestore [5].
- **Usability:** Ensure easy installation, low power consumption, and minimal rider interaction.

2 Project Results

2.1 Product Design

Hardware Components:

- MPU6050 Sensor: 3-axis accelerometer and gyroscope for motion and orientation sensing [3].
- NEO-6MV2 GPS Module: Provides real-time location and velocity data.

- Force Sensor (FSR402/Piezoelectric): Detects impact magnitude, reducing false positives.
- ESP32 Microcontroller: Manages sensor data acquisition and processing.
- SIM800L GSM Module: Enables data transmission via cellular network.
- LiPo Battery: Rechargeable power source with voltage regulation.

Software Components:

- Firmware: Implements sensor fusion, thresholding, and communication protocols.
- Web Application: Developed in Flutter, displays real-time alerts, mapping, and analytics [4].
- Backend: Firebase and Firestore for secure, scalable data storage and management [5].

System Architecture:

The Smart Boda system is composed of three core components: the physical device, the Firebase cloud backend, and a Flutter-based web interface. Crash events detected by the device are uploaded to the cloud in real-time. The web interface then retrieves and displays this information for emergency response and monitoring.

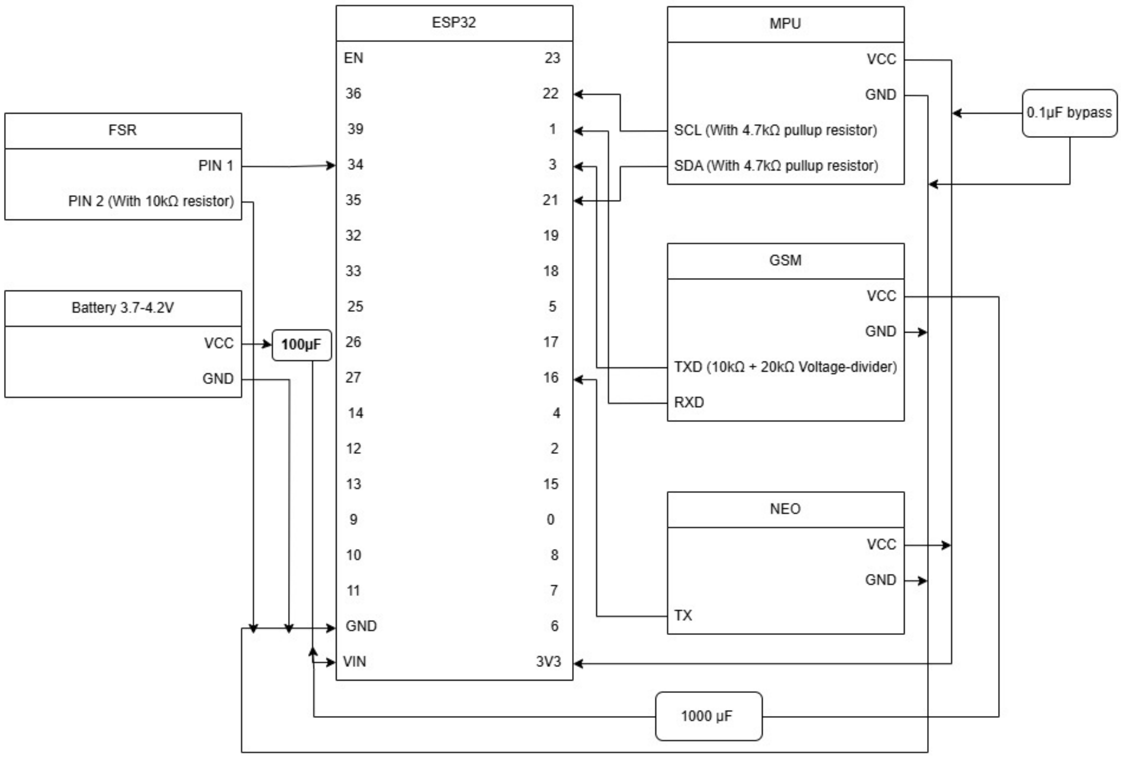


Figure 1: System Architecture: Hardware and sensor setup

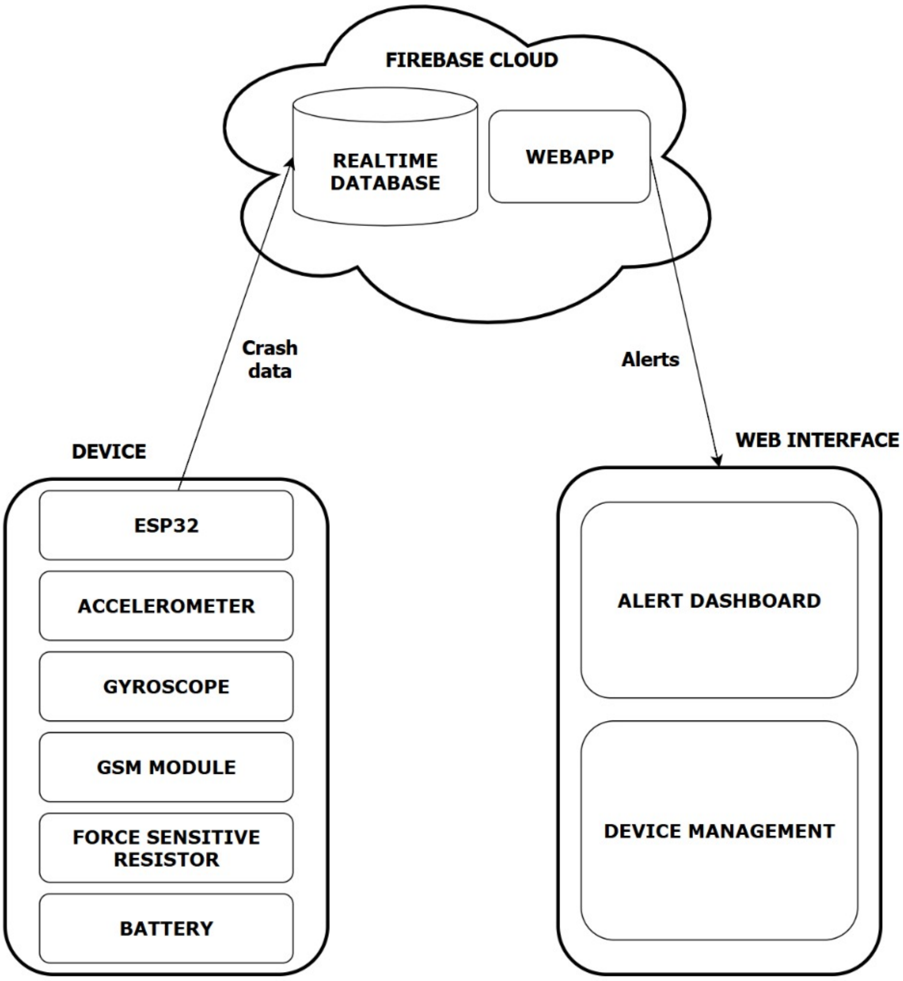


Figure 2: Smart boda device and web platform.

2.2 Product Functionality

- **Real-Time Alerts:** Immediate notification of detected accidents on the web platform.
- **Incident Mapping:** Visualization of accident locations for rapid response and analysis.
- **Historical Data Access:** Review and export past incident data for trend analysis.
- **User Management:** Access control for emergency responders, authorities, and analysts.

2.2.1 Web Application Interface and Screenshots

Below are screenshots of the Smart Boda web application demonstrating key interface views.

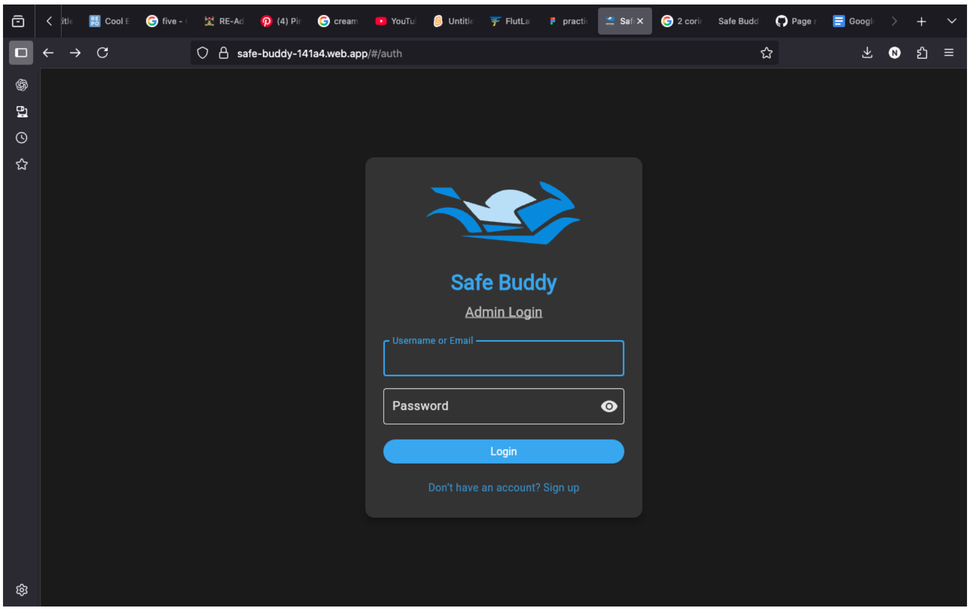
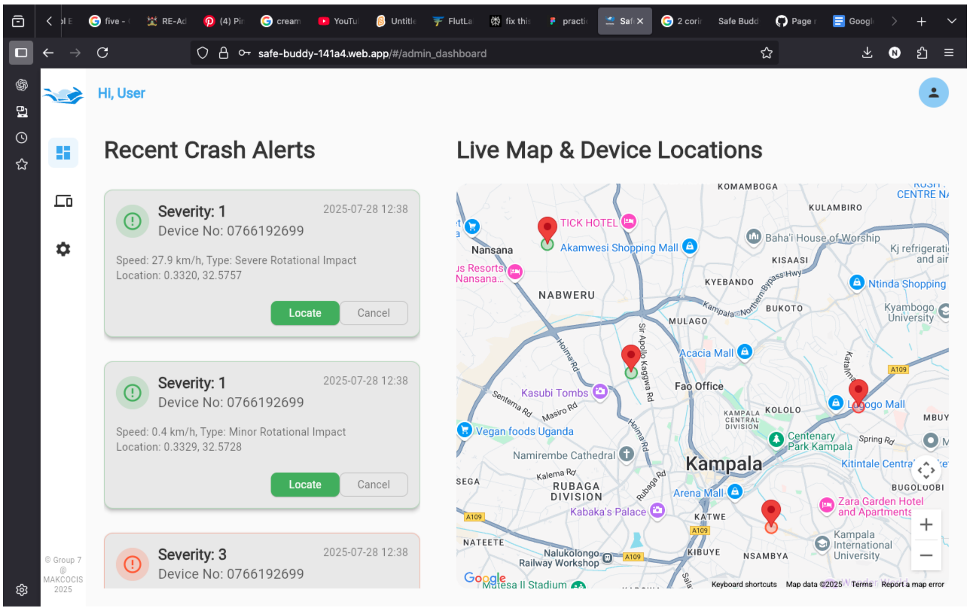

safe-buddy-141a4.web.app/#/auth
Safe Buddy
Admin Login
Username or Email
Password
Login
Don't have an account? Sign up

Figure 3: Authentication page of web app.

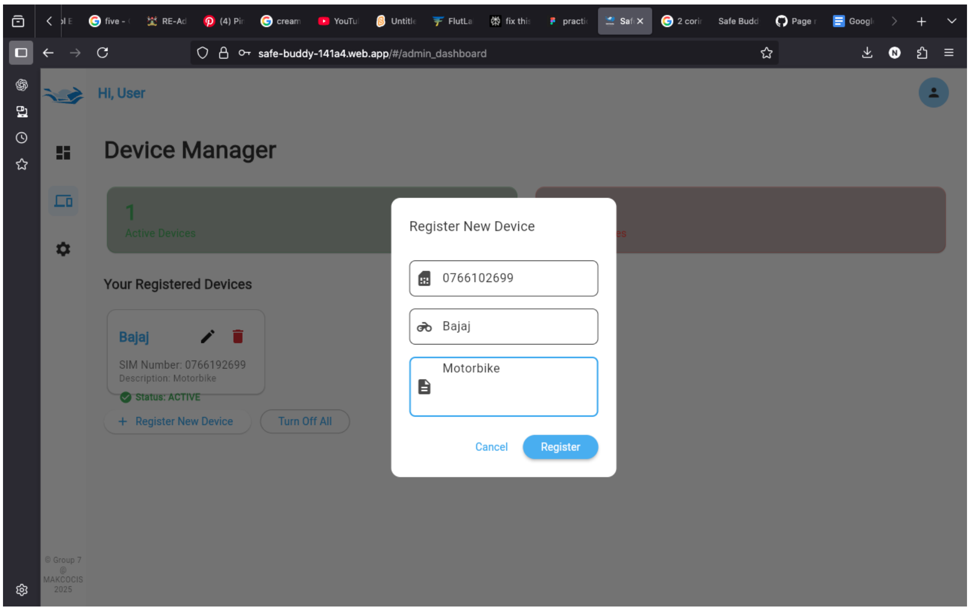


Severity: 1
Device No: 0766192699
2025-07-28 12:38
Speed: 27.9 km/h, Type: Severe Rotational Impact
Location: 0.3320, 32.5757

Severity: 1
Device No: 0766192699
2025-07-28 12:38
Speed: 0.4 km/h, Type: Minor Rotational Impact
Location: 0.3329, 32.5728

Severity: 3
Device No: 0766192699
2025-07-28 12:38

Figure 4: Live dashboard with crash alerts, device telemetry and detailed accident metadata on map.



safe-buddy-141a4.web.app/#/admin_dashboard

Hi, User

Device Manager

1 Active Devices

Your Registered Devices

Bajaj
SIM Number: 0766192699
Description: Motorbike
Status: ACTIVE

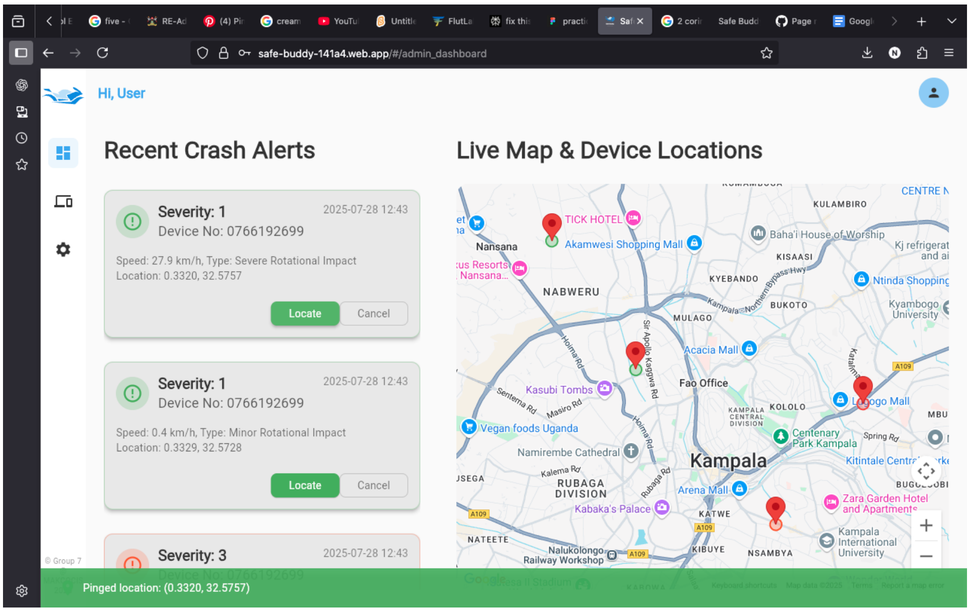
Register New Device

0766102699

Bajaj

Motorbike

Figure 5: Device registration interface for adding new Smart Boda units.



safe-buddy-141a4.web.app/#/admin_dashboard

Hi, User

Recent Crash Alerts

Severity: 1 2025-07-28 12:43
Device No: 0766192699
Speed: 27.9 km/h, Type: Severe Rotational Impact
Location: 0.3320, 32.5757

Severity: 1 2025-07-28 12:43
Device No: 0766192699
Speed: 0.4 km/h, Type: Minor Rotational Impact
Location: 0.3329, 32.5728

Severity: 3 2025-07-28 12:43
Device No: 0766192699

Live Map & Device Locations

Pinged location: (0.3320, 32.5757)

Figure 6: Real-time ping with location, severity, timestamp and device ID

2.2.2 Our basis for accident detection

Our accident detection is based upon the following sensor readings and logic:

- **Impact-force Readings:** Readings above 3g (29.43 m/s^2) indicate a significant impact, likely caused by a collision.
- **Gyroscope Readings:** A sharp spike in angular velocity suggests abnormal rotation typical during a crash.
- **Accelerometer Readings:** High acceleration paired with force and gyro data confirms an accident event.

- **Sensor Fusion Logic:** Combines data to eliminate false positives from bumps or sharp turns.

3 Limitations and Next Steps

3.1 Limitations

- Device operation depends on reliable cellular network coverage.
- False positives may occur due to terrain vibration, though mitigated by sensor fusion.
- Current testing is limited in scope and geography.

3.2 Next Steps

- Calibrate detection thresholds based on real-world data.
- Expand pilot testing across different regions and terrain types.
- Explore AI-enhanced pattern detection.
- Integrate automated dispatch notification system.

References

References

[1] IEEE citation guide, https://ieee.org/documents/ieeecitationref.pdf

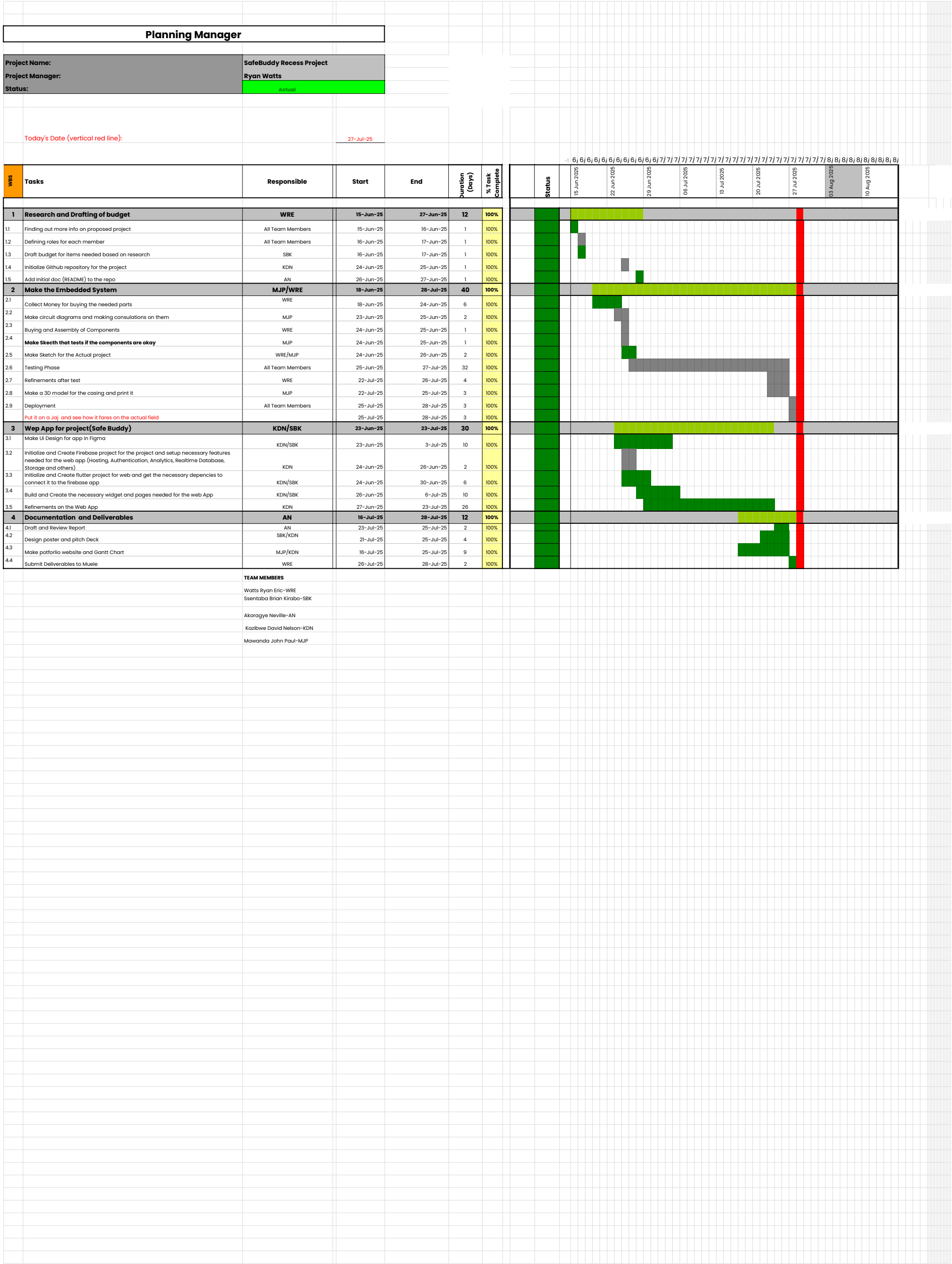
[2] ThingSpeak IoT Analytics, https://thingspeak.com

[3] MPU6050 Datasheet and Application Notes

[4] Flutter Framework Documentation, https://flutter.dev

[5] Firebase Documentation, https://firebase.google.com

Appendix A: Project Work Plan



Planning Manager

Project Name:	SafeBuddy Recess Project
Project Manager:	Ryan Watts
Status:	Actual

Today's Date (vertical red line): 27-Jul-25

WBS	Tasks	Responsible	Start	End	Duration (Days)	% Task Complete
1	**Research and Drafting of budget**	**WRE**	**15-Jun-25**	**27-Jun-25**	**12**	**100%**
1.1	Finding out more info on proposed project	All Team Members	15-Jun-25	16-Jun-25	1	100%
1.2	Defining roles for each member	All Team Members	16-Jun-25	17-Jun-25	1	100%
1.3	Draft budget for items needed based on research	SBK	16-Jun-25	17-Jun-25	1	100%
1.4	Initialize Github repository for the project	KDN	24-Jun-25	25-Jun-25	1	100%
1.5	Add Initial doc (README) to the repo	AN	26-Jun-25	27-Jun-25	1	100%
2	**Make the Embedded System**	**MJP/WRE**	**18-Jun-25**	**28-Jul-25**	**40**	**100%**
2.1	Collect Money for buying the needed parts	WRE	18-Jun-25	24-Jun-25	6	100%
2.2	Make circuit diagrams and making consulations on them	MJP	23-Jun-25	25-Jun-25	2	100%
2.3	Buying and Assembly of Components	WRE	24-Jun-25	25-Jun-25	1	100%
2.4	**Make Skecth that tests if the components are okay**	MJP	24-Jun-25	25-Jun-25	1	100%
2.5	Make Sketch for the Actual project	WRE/MJP	24-Jun-25	26-Jun-25	2	100%
2.6	Testing Phase	All Team Members	25-Jun-25	27-Jul-25	32	100%
2.7	Refinements after test	WRE	22-Jul-25	26-Jul-25	4	100%
2.8	Make a 3D model for the casing and print it	MJP	22-Jul-25	25-Jul-25	3	100%
2.9	Deployment	All Team Members	25-Jul-25	28-Jul-25	3	100%
	Put it on a Jaj and see how it fares on the actual field		25-Jul-25	28-Jul-25	3	100%
3	**Wep App for project(Safe Buddy)**	**KDN/SBK**	**23-Jun-25**	**23-Jul-25**	**30**	**100%**
3.1	Make Ui Design for app in Figma	KDN/SBK	23-Jun-25	3-Jul-25	10	100%
3.2	Initialize and Create Firebase project for the project and setup necessary features needed for the web app (Hosting, Authentication, Analytics, Realtime Database, Storage and others)	KDN	24-Jun-25	26-Jun-25	2	100%
3.3	Initialize and Create flutter project for web and get the necessary depencies to connect it to the firebase app	KDN/SBK	24-Jun-25	30-Jun-25	6	100%
3.4	Build and Create the necessary widget and pages needed for the web App	KDN/SBK	26-Jun-25	6-Jul-25	10	100%
3.5	Refinements on the Web App	KDN	27-Jun-25	23-Jul-25	26	100%
4	**Documentation and Deliverables**	**AN**	**16-Jul-25**	**28-Jul-25**	**12**	**100%**
4.1	Draft and Review Report	AN	23-Jul-25	25-Jul-25	2	100%
4.2	Design poster and pitch Deck	SBK/KDN	21-Jul-25	25-Jul-25	4	100%
4.3	Make potforlio website and Gantt Chart	MJP/KDN	16-Jul-25	25-Jul-25	9	100%
4.4	Submit Deliverables to Muele	WRE	26-Jul-25	28-Jul-25	2	100%

TEAM MEMBERS

Watts Ryan Eric-WRE
Ssentaba Brian Kirabo-SBK

Akoragye Neville-AN

Kazibwe David Nelson-KDN

Mawanda John Paul-MJP

Figure 7: Gantt Chart with SafeBuddy project timeline, task breakdown, and team responsibilities.

Appendix B: Contribution by Team Members

Team Member	Contribution
Watts Ryan Eric	Hardware & Sensor integration
Ssentaba Brian Kirabo	GSM/GPS Communication and Backend setup
Akoragye Neville	Documentation and Testing
Kazibwe David Nelson	Web Platform and Flutter UI
Mawanda John Paul	Database integration & Firebase

Appendix C: Project Links

Below are the links to the project's online presence and development resources:

- **Project Website (Showcase and Documentation):** https://safe-buddy-showcase.web.app
- **Live Web App (Real-time Accident Dashboard):** https://safe-buddy-141a4.web.app
- **Simulation Script (Python - GitHub):** https://github.com/Goodvibes74/web$_{a}pp-test-data$ This script was used during testing to simulate accident events and feed mock data into the web application for demonstration and analysis purposes.