UNIVERSITY of GREENWICH

Undergraduate Final Year Proposal

Project Title: Toll Collection System for the Malawi Roads Fund Administration (RFA)

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1 OVERVIEW

The Roads Fund Administration (RFA) was established under the Roads Fund Administration Act No. 4 of 2006, commencing operations on December 1, 2006, with the mandate to raise, administer, and account for funds dedicated to the construction, maintenance, and rehabilitation of public roads in Malawi. Their main achievements include the establishment of a robust monitoring system for road works, the introduction of punitive measures for contractors' non-compliance, and successful partnerships with private financiers to fund major infrastructure projects such as the Kenyatta-Mzimba road upgrade, Malawi's first six-lane highway. The Roads Fund Administration is the main factor that has led to the development of toll gates across Malawi to ensure efficient fund management and foster partnerships.

At present, toll collection at Roads Fund Administration (RFA) toll gates operates predominantly as a manual process with minimal technological support. Vehicles approaching the toll gate slow down and stop at the toll booth. Drivers must observe large physical boards that display static toll prices categorized by vehicle type, such as standard cars, buses, and trucks. There is no electronic vehicle categorization; all classification and charge determination rely on manual observation by toll collectors. Payment is almost exclusively in cash. Drivers hand over cash payments directly to toll booth staff, who manually count and verify the money. Mobile money payments are rarely accepted due to infrastructural limitations. Once payment is received, toll booth operators physically press a button to open the toll gate, allowing the vehicle to pass. Toll collectors issue handwritten or printed physical receipts as proof of payment. Staff also manually record the total number of vehicles processed and the cash collected on paper logs during their shifts. This data is then later compiled into manual reports submitted to RFA management for financial reconciliation and auditing. Dispute resolution, such as toll fee disagreements or payment issues, is handled face-to-face at the booth by staff. There is no automated system for notifications or reminders regarding toll price changes or payment dues. Additionally, no real-time traffic monitoring or analytics exist within the system, limiting operational insights. Security mechanisms for user authentication or verification of vehicle identity are absent. The system relies entirely on human observation and manual record-keeping. Traffic congestion often results from slow manual processing and cash handling, and the manual nature exposes the system to human error and potential fraud.

Despite its foundational role, the current toll collection system suffers from several weaknesses. It lacks proper user authentication, raising security risks and making it vulnerable to fraud. Manual vehicle classification leads to inefficiencies. The lack of automated vehicle categorization forces reliance on human judgment, causing delays and inaccuracies in toll charge assessments. Cash-only payments limit convenience and increase risks. Dependence on cash transactions increases vulnerability to theft, fraud, and errors, while limiting payment options convenient to users. Manual toll gate operation causes traffic delays. Toll gate opening by manual button control slows traffic flow and increases queue times during peak hours, reducing efficiency. Paper-based record keeping is prone to errors and delays. Manual logging and report compilation introduce risks of mistakes, fraud, and delayed data availability for management decisions. Lack of user authentication and vehicle identification reduces security. Without digital verification, driver identity and vehicle legitimacy cannot be guaranteed, increasing susceptibility to fraudulent activities. No automated notifications or communication limits user awareness. Important updates on toll price changes or account balances are communicated manually or infrequently, reducing timely user action. No Real-Time reporting or analytics impairs operational oversight. Absence of immediate data on collections and traffic patterns prevents proactive management and system optimization. Dispute resolution is manual and inefficient. Handling payment or classification disputes face-to-face is time-consuming and may cause extended traffic disruptions. Static toll pricing does not adapt to traffic or market conditions. Current toll charges remain fixed, missing opportunities to optimize revenue or manage congestion through variable pricing.

The proposed system seeks to transform toll collection into a comprehensive, automated web application accessible on mobile and desktop devices. It will incorporate multiple user roles, including Drivers, Staff, and Admin, each authenticated securely for access control. The system will feature real-time notifications and reminders for drivers about toll price changes, low balance alerts, and upcoming road maintenance or policy updates. Advanced analytics and reporting dashboards will provide administrators with daily collections, traffic patterns, vehicle classifications, revenue trends, and system health metrics. Vehicle categorization will be automated by size, with dedicated toll rates assigned dynamically based on traffic conditions, special dates, or inflationary adjustments. Car weight measurement stations will assess vehicles approaching toll booths to apply correct charges and penalties for overweight vehicles. Payment gate control will prevent gate opening if vehicle accounts have insufficient funds, enforcing payment compliance. A grace period of up to one week will be allowed for overdue payments before penalties are applied. Multiple payment channels will be supported, including online payments, mobile money integration, bank cards, and cashless wallets to maximize convenience. Exemption rules will be included for government vehicles, emergency responders, and frequent users. OCR cameras and RFID tags on number plates will automate vehicle identification, speeding up processing and enabling real-time tracking. Invoices and receipts will be generated electronically alongside physical copies for redundancies. Overall, the proposed system addresses the current system’s security, efficiency, scalability, and data management weaknesses by leveraging automation, digital payments, and intelligent vehicle monitoring technologies.

2 AIM

To develop a web app that will help in toll collection through vehicle categorization, car weight measurement, payment gate control, payment grace period, dynamic toll pricing based on traffic and time, multi-channel payment options, penalty and enforcement system, emergency vehicle priority, and exception rules, which will greatly improve the system to an extent.

3 OBJECTIVES

3.1 Planning

3.1.1 Concept paper and project proposal

- This is the first step of the project, which involves gathering ideas for the system to be developed from stakeholders.
- Research the current system and find a matching proposed system with valid sources, which includes reviewing operational documents and industry reports.

3.2 Investigate and Analyze Current System

3.2.1 System requirements and specifications

- Finding the problem scope and proposing a suggested solution.
- Conducting interviews with the system users for information and requirements gathering.
- Analyze the gathered information and convert it into diagrams, data flow, class diagrams, and use cases for a visual representation of how the system will be used by the users.

3.3 Design the System

3.3.1 System architecture design, detailed design specifications

- Producing a system architecture using the system's requirements.
- Produce a use case for the requirements.
- Sketch the system interface.
- Design the database and data dictionary with specified sources that are valid.

3.4 Test and Implement the System

3.4.1 Code and test the system.

- Developing the interface of the system.
- Coding the actual working system.
- Developing the final database.
- Debugging the system.
- Testing each functionality in the system and verifying the functionality with the gathered requirements.

3.5 Documentation

3.5.1 User manual, technical report, and final report

- Writing a detailed user manual and documentation of the system on how to use the system and how it works.

4 PLAN AND METHODOLOGY

The suggested methodology for developing the proposed system is an object-oriented methodology. Object-oriented methodology is a programming method that focuses on objects rather than the actual methods and functions used within the system. (Object Oriented Methodology, 2024). Object-oriented programming works by modeling real-world entities as objects, for instance: "Staff" and "Drivers" with specific attributes and behaviors. This allows for simple, reusable code, where each object handles its data and interactions, thereby simplifying development, maintenance, and scalability of the app by allowing easy adding and removal of new features to the existing ones without entirely affecting the system. Below are some of the advantages of Object-oriented methodology.

Reusability: object-oriented methodology employs the ability for code within the system to be reused (Object Oriented Methodology, 2024) This works in such a way that the same features and functionalities that are in one class can be reused in another class by just calling the already created object.

Modularity. The object-oriented methodology will allow the development of the proposed system to be in a modular fashion (Urdhwareshe A, 2016). This means that the different codes within the system will be easier to understand and maintain, as each object will represent a specific part of the system, and the relationship between objects will be easier to visualize.

Easily upgradable and scalable in a way that system functionalities can be implemented independently using classes. When you want to add the functionalities, you can easily call the class. (Object Oriented Methodology, 2024).

In conclusion, the use of object-oriented methodology will improve modularity, allow reusability of code, flexibility, and security, and this will make the system more productive, easy to maintain, and scalable.

4.1 Work Breakdown Structure

The work breakdown structure is an important part of the project planning process. It provides a clear and organized framework for defining and organizing the work that needs to be done. This can help the project team to better understand the scope and requirements of the project and to identify any potential risks or challenges. (Work-Breakdown Structure, 2021) It can also help to facilitate communication and coordination among the various team members and to ensure that everyone is working towards the same goals. See *Table 2 Work Breakdown Structure*.

4.2 Gantt Chart

A Gantt chart is a visual project management tool that illustrates a project schedule. It displays tasks or activities on the vertical axis and time intervals on the horizontal axis. Each task is represented by a horizontal bar, with the length of the bar indicating the duration of the task. It also shows the beginning and ending dates of various project components, including resources, planning, and dependencies. The bars are color-coded to indicate the state of each task and to aid in the identification of task interdependence. (Investopedia, 2022). The Gantt chart for this system is on *Figure 1Gantt Chart*.

5 RESOURCE REQUIREMENT and TOOLS

Below is a table summarizing all the resources and tools required to properly implement and run the proposed system as intended:

Table 1 Resource Requirement and Tools

Resource/Tool	**Description**	**Use**
HP ProBook 645 G4	A laptop with AMD Ryzen 5 PRO 2500U, 8GB RAM, Windows 11	Main development machine for coding, testing, and running all software
Arduino Board	Microcontroller board (Arduino Uno) with USB connectivity	Hardware interface for sensors/actuators at the toll gate
Sensors/Actuators	IR sensors, RFID readers, servo motors, breadboard, jumper wires	Detect vehicle presence, read vehicle IDs
PHPStorm	Integrated Development Environment (IDE) for PHP and web development	Writing, debugging, and managing backend code.
Arduino IDE	Development environment for Arduino boards	Writing and uploading code to the Arduino hardware.
Beekeeper Studio	Graphical User Interface (GUI) tool for managing SQLite databases	Creating, editing, and querying the project database.
Figma	Web development tool with visual design and coding features	Designing and editing web pages, especially for visual layout.
Visual Studio Code Insiders	Lightweight code editor supporting multiple languages	Alternative code editing and quick prototyping
StarUML	UML modeling tool	Designing system architecture, class, and sequence diagrams.
EDraw Max	A diagramming tool for flowcharts, ERDs, and system diagrams	Creating visual representations of system processes and data flows.
Git	Version control system	Tracking code changes.
GitHub/GitLab	Online repository hosting services	Storing code, managing issues, and documentation.
Node.js and npm	JavaScript runtime and package manager	Running React apps and managing frontend dependencies

Composer	Dependency manager for PHP	Managing Laravel and PHP package dependencies
Laravel Herd	Laravel GUI	For running Laravel apps, making custom URLs, managing, and running Laravel commands.
HTTPie	API development and testing tool	Testing backend APIs and endpoints.
Web Browser	Zen, Edge, Chrome, Firefox	Testing and running the web application.
Official Documentation	Online resources for Laravel, React, Arduino, and SQLite	Reference for development and troubleshooting.

6 OTHER ISSUES and CONSIDERATIONS

6.1 Legal Issues

The implementation of an automated toll collection and speed control system must comply with existing laws and regulations governing data protection, privacy, and transparency in Malawi. The collection and storage of personal data, such as vehicle registration, driver identification, and travel history, require strict adherence to the Malawi Data Protection Act and related statutes to ensure the confidentiality and lawful processing of user information. Additionally, the use of surveillance technologies like OCR cameras and GPS tracking must align with legal standards for surveillance and road safety enforcement. Any integration with online payment systems must also comply with financial regulations to prevent fraud and secure transactions.

6.2 Social Issues

The system will have significant social implications. While automation can improve efficiency and reduce congestion, it may also lead to job displacement for toll booth staff, affecting their livelihoods. There is a need for public awareness campaigns to educate road users about the new system, its benefits, and how to use it effectively. Accessibility considerations must be made for users who may not have access to digital payment methods or the internet. Ensuring equitable access and a smooth transition to the automated system (Daniel, 2024).

6.3 Ethical Issues

The ethical considerations center on privacy, transparency, and fairness. The system's ability to track vehicle movements and store personal data raises concerns about surveillance and potential misuse of information. It is essential to implement robust data security measures and transparent policies on data usage, retention, and sharing. Ethical deployment also requires clear communication with users about what data is collected, how it is used, and their rights regarding their information. Furthermore, the system should be designed to avoid discrimination or bias in toll pricing, enforcement, or access to services.

6.4 Professional Issues

Professionals involved in the design, implementation, and maintenance of the system must adhere to recognized standards of practice, including integrity, accountability, and competence. This includes following best practices in system development, cybersecurity, and user interface design to ensure the system is reliable, secure, and user-friendly. Ongoing training and professional development will be necessary for staff to manage and support the new technology. Collaboration with stakeholders, including government agencies, road users, and advocacy groups, is essential to address concerns and ensure the system meets public needs and expectations. (Studocu, 2023).

7 Conclusion

The Automated Toll Collection and Speed Control System for the Roads Fund Administration represents a transformative step forward in Malawi’s road infrastructure management, addressing the inefficiencies, security concerns, and limitations of the current manual system by leveraging advanced technologies such as RFID, OCR cameras, laser vehicle detection, GPS tracking, and an integrated online payment system. The system will significantly enhance operational efficiency through faster vehicle processing, reduce congestion, and minimize human error, while also ensuring cost-effectiveness by decreasing reliance on manual labor, improving revenue accuracy, and enabling dynamic pricing models. Additionally, the system’s real-time data and analytics capabilities will empower the RFA to make more informed decisions and optimize resource allocation, leading to improved traffic flow and safer journeys for all road users. Looking to the future, the system provides a solid foundation for further enhancements, such as integrating mobile payment solutions, employing artificial intelligence for predictive traffic management, and expanding coverage to additional road networks. Overall, the automated system is poised to deliver lasting benefits in efficiency, cost savings, and user experience, while supporting ongoing innovation and sustainable growth in Malawi’s transportation sector.

8 References

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9 APPENDIX A – Schedule of Work

Table 2 Work Breakdown Structure

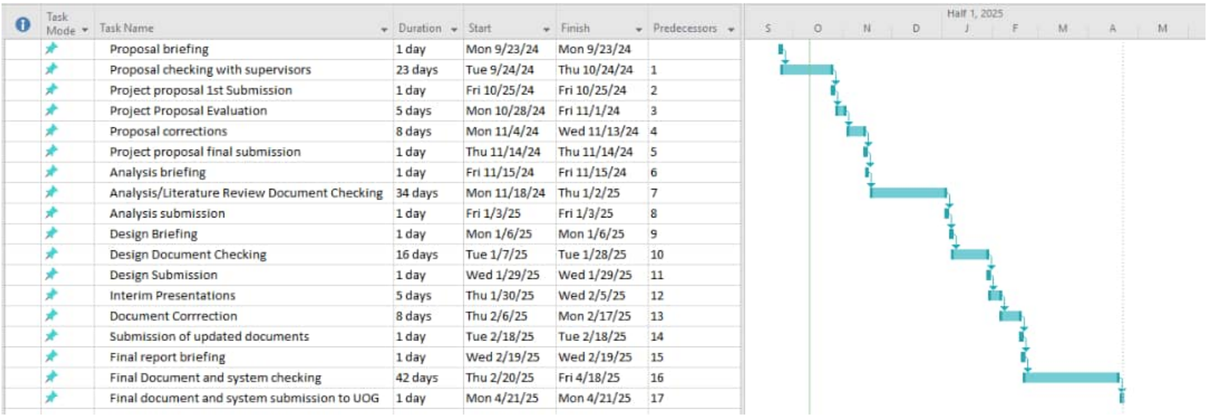
PHASE	**ACTIVITY**	**DURATION**	**MILESTONE**
Planning	• This is the first part of the project, which involves gathering ideas for the system to be developed. • Research the current system and find a matching proposed system with valid sources.	2 May 2025 to 30 May 2025	Concept Paper and Project Proposal
Investigation and Analysis	• Finding the problem scope and proposing a suggested solution. • Conducting interviews with the system users for information and requirements gathering. • Analyze the gathered information and	2 June 2025 to 20 June 2025	System requirements and specifications

	convert it into diagrams, data flow, class diagrams, and use cases, for a visual representation of how the system will be used by the users.		
Design	• Producing a system architecture using the system's requirements. • Produce a use case for the requirements. • Sketch the system interface. • Design the database and data dictionary with specified sources that are valid.	23 June 2025 to 11 July 2025	System architecture design, detailed design specifications
Testing and Implementation	• Developing the interface of the system. • Coding the actual working system.	14 July 2025 to 15 August 2025	Coding and Testing the system

	- Developing the final database. - Debugging the system. - Testing each functionality in the system and verifying the functionality with the gathered requirements.		
Documentation	- Writing a detailed user manual and documentation of the system on how to use the system and how it works.	16 August 2025 to 29 November 2025	User Manual, Technical report, and Final report

9.1 Gantt Chart

Figure 1Gantt Chart



ⓘ	Task Mode	Task Name	Duration	Start	Finish	Predecessors
	📌	Proposal briefing	1 day	Mon 9/23/24	Mon 9/23/24	
	📌	Proposal checking with supervisors	23 days	Tue 9/24/24	Thu 10/24/24	1
	📌	Project proposal 1st Submission	1 day	Fri 10/25/24	Fri 10/25/24	2
	📌	Project Proposal Evaluation	5 days	Mon 10/28/24	Fri 11/1/24	3
	📌	Proposal corrections	8 days	Mon 11/4/24	Wed 11/13/24	4
	📌	Project proposal final submission	1 day	Thu 11/14/24	Thu 11/14/24	5
	📌	Analysis briefing	1 day	Fri 11/15/24	Fri 11/15/24	6
	📌	Analysis/Literature Review Document Checking	34 days	Mon 11/18/24	Thu 1/2/25	7
	📌	Analysis submission	1 day	Fri 1/3/25	Fri 1/3/25	8
	📌	Design Briefing	1 day	Mon 1/6/25	Mon 1/6/25	9
	📌	Design Document Checking	16 days	Tue 1/7/25	Tue 1/28/25	10
	📌	Design Submission	1 day	Wed 1/29/25	Wed 1/29/25	11
	📌	Interim Presentations	5 days	Thu 1/30/25	Wed 2/5/25	12
	📌	Document Corrrection	8 days	Thu 2/6/25	Mon 2/17/25	13
	📌	Submission of updated documents	1 day	Tue 2/18/25	Tue 2/18/25	14
	📌	Final report briefing	1 day	Wed 2/19/25	Wed 2/19/25	15
	📌	Final Document and system checking	42 days	Thu 2/20/25	Fri 4/18/25	16
	📌	Final document and system submission to UOG	1 day	Mon 4/21/25	Mon 4/21/25	17