ISSN: 2971-7760 | VOL 6, ISS 3 | 04 AUGUST 2026
https://doi.org/10.5281/zenodo.21790127
NASARAWA STATE UNIVERSITY, KEFFI, NIGERIA

Design and Development of a Vehicle Tracking and Speed Monitoring System with Load Sensing for Improved Road Safety and Fleet Management.

Saad H. Girei[1]

[1]Department of Computer Engineering, Federal Polytechnic Mubi, Adamawa State. Nigeria.

08064500021

Gireisaad3@gmail.com

Abstract

Road traffic accidents, excessive speeding, and vehicle overloading remain significant challenges affecting road safety, transportation efficiency, and infrastructure sustainability, particularly in developing countries. Existing vehicle monitoring systems primarily focus on either vehicle tracking or speed monitoring, with limited integration of load sensing capabilities. This study presents the design and development of an integrated vehicle tracking, speed monitoring, and load sensing system for improved road safety and fleet management. The proposed system employs an Microcontroller as the central processing unit, integrated with a GPS module for real-time vehicle tracking and speed estimation, a strain-gauge load cell with an HX711 amplifier for load measurement, and a GSM/Wi-Fi communication module for transmitting operational data to a cloud-based monitoring platform. The system was evaluated under simulated operating conditions using performance metrics including GPS positioning accuracy, speed measurement accuracy, load measurement accuracy, communication latency, and system response time. Experimental results demonstrated an average GPS positioning error of 1.83 m**,** a speed measurement accuracy of 99.29%**,** and a load measurement accuracy of 99.82%**.** The system also achieved 100% detection of speed and overload violations, with real-time transmission of alerts. The findings indicate that the proposed system provides a reliable, low-cost, and scalable solution for intelligent fleet management, regulatory compliance, and road safety enhancement. The developed prototype demonstrates significant potential for deployment in intelligent transportation systems and may serve as a foundation for future integration with artificial intelligence, predictive maintenance, and smart city applications.

Keywords: Vehicle tracking, GPS, speed monitoring, load sensing, ESP32, fleet management, intelligent transportation system, road safety.

1. Introduction

Road transportation is one of the most important modes of transport worldwide, facilitating the movement of people and goods while contributing significantly to economic growth and social development. In developing countries such as Nigeria, road transport accounts for the majority of passenger and freight movement due to the limited availability and accessibility of alternative transportation systems. Despite its importance, the road transportation sector continues to face numerous challenges, including excessive speeding, vehicle overloading, poor fleet management, and inadequate monitoring of vehicle operations. These challenges contribute significantly to road traffic accidents, increased maintenance costs, environmental pollution, and deterioration of road infrastructure **(**World Health Organization [WHO], 2023; Federal Road Safety Corps [FRSC], 2024**).**

According to the World Health Organization (2023)**,** road traffic accidents are among the leading causes of death globally, with low- and middle-income countries accounting for approximately 93% of road fatalities despite possessing only about 60% of the world's vehicles. Excessive vehicle speed remains one of the major contributing factors to traffic accidents, as it reduces drivers' reaction time, increases stopping distances, and aggravates the severity of crashes **(**WHO, 2023**).** Similarly,

ISSN: 2971-7760 | VOL 6, ISS 3 | 04 AUGUST 2026
https://doi.org/10.5281/zenodo.21790127
NASARAWA STATE UNIVERSITY, KEFFI, NIGERIA

vehicle overloading places excessive stress on braking systems, tyres, suspension components, and road pavements, thereby increasing the likelihood of accidents and accelerating the deterioration of transportation infrastructure **(**International Transport Forum [ITF], 2022**).** Consequently, effective monitoring of vehicle speed and load conditions has become an essential component of modern transportation safety and management systems.

Recent advancements in embedded systems, wireless communication, sensor technologies, and the Internet of Things (IoT) have enabled the development of intelligent transportation systems (ITS) capable of monitoring various vehicle parameters in real time **(**Al-Fuqaha et al., 2015; Li et al., 2015**)**. Global Positioning System (GPS) technology has become the most widely adopted solution for vehicle tracking due to its ability to provide accurate location, speed, and route information **(**Kaplan & Hegarty, 2017; Misra & Enge, 2012**).** GPS-based vehicle tracking systems are extensively employed in fleet management, logistics, public transportation, and emergency response services to improve operational efficiency and enhance vehicle security **(**Bensky, 2016**).** Likewise, speed monitoring technologies based on GPS, radar, or onboard sensors have been widely implemented to enforce speed regulations and promote safer driving practices **(**Jin et al., 2012**).**

Vehicle load monitoring has also received considerable attention because of its direct impact on road safety and infrastructure preservation. Load sensing technologies, including strain-gauge load cells, pressure sensors, and axle weight measurement systems, enable continuous monitoring of vehicle loading conditions and provide timely warnings when predetermined weight thresholds are exceeded **(**Dally et al., 1993**).** Such systems assist fleet operators and transportation regulatory agencies in preventing overloading, reducing maintenance costs, and ensuring compliance with transportation regulations **(**ITF, 2022**).**

ISSN: 2971-7760 | VOL 6, ISS 3 | 04 AUGUST 2026
https://doi.org/10.5281/zenodo.21790127
NASARAWA STATE UNIVERSITY, KEFFI, NIGERIA

Although numerous studies have investigated GPS-based vehicle tracking, speed monitoring, and load sensing individually, most commercially available and research-based systems focus on only one or two of these functionalities. GPS tracking systems primarily provide location and route information without considering vehicle loading conditions, while speed monitoring devices often operate independently of vehicle tracking and load measurement **(**Fogue et al., 2013**).** Similarly, many load monitoring systems are designed exclusively for weighbridge applications or heavy-duty vehicles and are not integrated with real-time vehicle tracking platforms **(**Chen et al., 2014; Li et al., 2015**).** This fragmented approach limits the ability of transportation managers and regulatory authorities to obtain comprehensive operational information required for effective fleet supervision and road safety enforcement.

The integration of vehicle tracking, speed monitoring, and load sensing into a single intelligent platform offers significant advantages over standalone systems. Such an integrated solution enables continuous monitoring of vehicle location, travel speed, and loading conditions simultaneously, thereby providing timely alerts whenever vehicles exceed prescribed speed limits or permissible load capacities. Furthermore, real-time transmission of operational data to a centralized monitoring platform facilitates informed decision-making, improves fleet utilization, enhances regulatory compliance, and supports predictive maintenance strategies (Al-Fuqaha et al., 2015; Raza et al., 2017**).**

In Nigeria and many other developing countries, the adoption of integrated vehicle monitoring technologies remains limited due to high acquisition costs, inadequate technological infrastructure, and dependence on imported monitoring equipment **(**FRSC, 2024**)**. There is therefore a growing need for affordable, locally developed, and scalable intelligent transportation solutions that address the unique operational challenges of the local transport sector. Developing such systems would not only improve transportation safety but also reduce road infrastructure damage, minimize operational costs for fleet operators, and strengthen enforcement of traffic regulations **(**WHO, 2023; ITF, 2022**).**

This study therefore proposes the design and development of a vehicle tracking and speed monitoring system integrated with a load sensing mechanism for improved road safety and fleet management. The proposed system combines GPS technology, embedded microcontroller-based processing, load cell sensing, wireless communication, and a real-time monitoring interface to provide continuous monitoring of vehicle location, speed, and load conditions. By integrating these functionalities into a unified platform, the system aims to provide a cost-effective and reliable solution capable of enhancing transportation safety, improving fleet operational efficiency, and supporting intelligent transportation management in developing countries. The outcomes of this research are expected to contribute to the advancement of smart transportation technologies while providing practical solutions for fleet operators, transportation agencies, and policymakers seeking to reduce road traffic accidents and improve infrastructure sustainability **(**Kaplan & Hegarty, 2017; Al-Fuqaha et al., 2015; Li et al., 2015**).**

2. Materials and Methods

The process begins with system initialization, where the microcontroller configures the GPS module, load cell with the HX711 amplifier, communication module, and other peripheral devices. Once initialized, the system continuously acquires real-time data, including the vehicle's location, speed, and load. The microcontroller processes the acquired data by comparing the measured speed and load against predefined threshold values. If either the speed limit or permissible load capacity is exceeded, the system generates an alert indicating a speed violation or vehicle overloading. The processed data, together with the vehicle identification, GPS coordinates, timestamp, and alert status, are transmitted via the GSM/Wi-Fi communication module to a cloud-based server for storage and analysis. The monitoring platform then displays the vehicle's location, speed, load condition, and alert notifications on a web or mobile

ISSN: 2971-7760 | VOL 6, ISS 3 | 04 AUGUST 2026
https://doi.org/10.5281/zenodo.21790127
NASARAWA STATE UNIVERSITY, KEFFI, NIGERIA

dashboard, enabling fleet managers and regulatory authorities to monitor vehicle operations in real time. This process is repeated continuously to ensure uninterrupted monitoring and timely detection of unsafe operating conditions. Figure 1 shows the flowchart of operating procedure of the system.

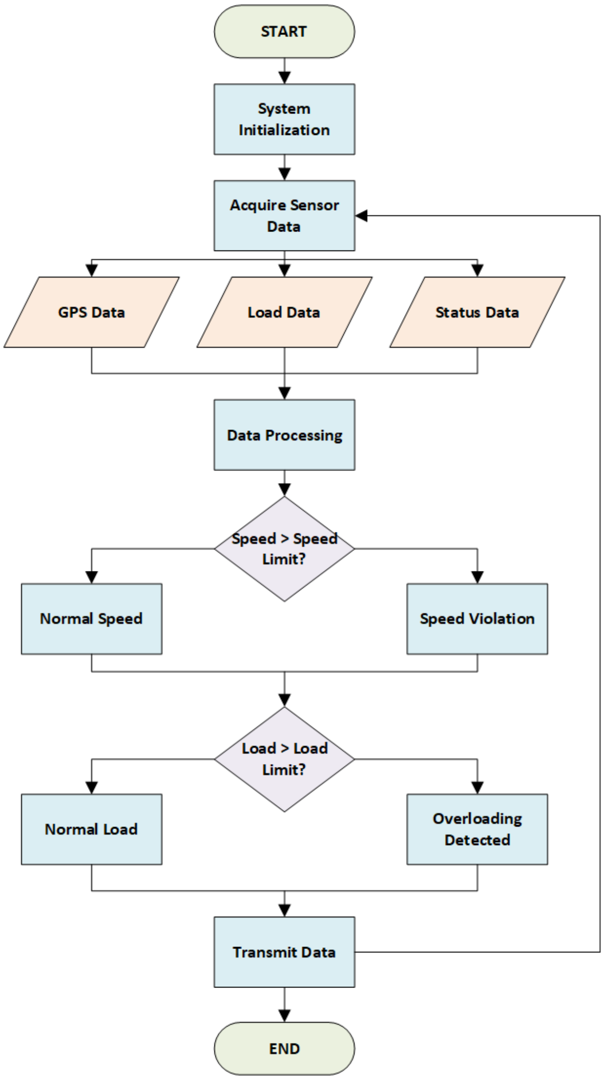

Figure 1. The System Flowchart

2.1 System Architecture

The proposed vehicle tracking and speed monitoring system with load sensing is designed as an integrated intelligent transportation platform capable of acquiring, processing, transmitting, and displaying real-time vehicle operational data. The system combines Global Positioning System (GPS) technology, load sensing, speed monitoring, wireless communication, and cloud-based data visualization to improve road safety and fleet management. The overall architecture consists of five functional layers: the sensing layer, processing layer, communication layer, cloud/server layer, and user interface layer, as illustrated in Figure 1.

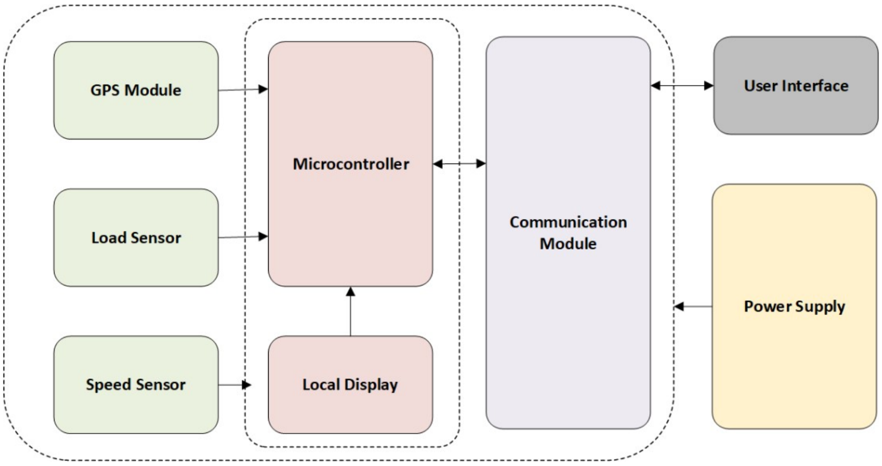

Figure 2. System Architecture

2.2 Hardware and Software Design

The proposed vehicle tracking, speed monitoring, and load sensing system comprises an integrated hardware platform centered on an ESP32 microcontroller, which serves as the main processing unit. The hardware components include a GPS module for acquiring real-time vehicle location and speed, a load cell interfaced with an HX711 amplifier for measuring vehicle load, a GSM/Wi-Fi communication module for remote data transmission, an OLED/LCD display for local monitoring, and a regulated power supply connected to the vehicle battery. These components work together to continuously acquire vehicle operational data and provide real-time monitoring of speed, location, and load conditions.

Table 1 presents the hardware components used in the development of the proposed vehicle tracking, speed monitoring, and load sensing system. The ESP32 microcontroller serves as the central controller, interfacing with the GPS receiver, load sensing unit, communication module, and display.

ISSN: 2971-7760 | VOL 6, ISS 3 | 04 AUGUST 2026
https://doi.org/10.5281/zenodo.21790127
NASARAWA STATE UNIVERSITY, KEFFI, NIGERIA

Table 1. The Hardware Components

Hardware Component	Model/Type	Function
Microcontroller Unit	ESP32 DevKit V1	Data processing
GPS Module	NEO-6M GPS Receiver	Real-time vehicle location
Load Cell	Strain Gauge Load Cell	Measures vehicle load/weight
Load Cell Amplifier	HX711 ADC Module	Amplifies load cell signals
Communication Module	SIM800L GSM/GPRS Module	Transmits vehicle data
Display Unit	0.96-inch OLED Display	Displays speed, load, GPS status

The software is developed using the Arduino IDE and is designed to coordinate sensor data acquisition, processing, communication, and user notification. The ESP32 continuously reads data from the GPS module and load sensing unit, processes the information, and compares the measured speed and load against predefined threshold values. When a speed limit or load limit is exceeded, the software generates appropriate alerts and packages the vehicle data—including location, speed, load, timestamp, and alert status—for transmission to a cloud-based monitoring platform via GSM or Wi-Fi.

The transmitted data are stored on a remote server and displayed through a web or mobile dashboard, allowing fleet managers and regulatory authorities to monitor vehicle operations in real time. The modular hardware and software architecture ensures reliable system performance, low-cost implementation, ease of maintenance, and scalability, making the proposed system suitable for intelligent fleet management and road safety applications.

2.3 System Integration

System integration involves combining the individual hardware and software modules into a single functional unit capable of performing vehicle tracking, speed monitoring, and load sensing simultaneously. The integration process ensures seamless communication between the GPS module, load cell with the HX711 amplifier, ESP32 microcontroller, communication module, display unit, and cloud-based monitoring platform. Each hardware component is interfaced with the ESP32 through appropriate communication protocols, including UART for the GPS and GSM modules and GPIO/I^{2}C interfaces for the load sensing and display units. The integrated system enables synchronized acquisition and processing of vehicle location, speed, and load data in real time.

The embedded software running on the ESP32 coordinates the operation of all hardware components by continuously collecting sensor data, processing the measurements, and evaluating them against predefined speed and load thresholds. When the vehicle exceeds the specified speed limit or permissible load capacity, the microcontroller automatically generates an alert and transmits the vehicle's operational data—including location, speed, load, timestamp, and alert status—to the cloud server via the GSM or Wi-Fi communication module. Simultaneously, the current operating status is displayed on the local OLED/LCD screen to provide immediate feedback to the driver.

The cloud server receives and stores the transmitted data in a centralized database, where they are processed and displayed on a web or mobile monitoring dashboard. Fleet managers and transportation authorities can remotely monitor vehicle movement, speed, and loading conditions, view

ISSN: 2971-7760 | VOL 6, ISS 3 | 04 AUGUST 2026
https://doi.org/10.5281/zenodo.21790127
NASARAWA STATE UNIVERSITY, KEFFI, NIGERIA

historical records, and receive real-time notifications of speeding or overloading events. The successful integration of the hardware, embedded software, wireless communication, and cloud platform results in a reliable and scalable intelligent transportation system capable of enhancing road safety, improving fleet management, and supporting regulatory compliance.

2.4 Performance Evaluation Metrics

The performance of the developed vehicle tracking, speed monitoring, and load sensing system was evaluated using several quantitative metrics to determine its accuracy, reliability, responsiveness, and overall operational efficiency. These metrics were selected to assess the effectiveness of the integrated system in monitoring vehicle location, speed, and load under simulated and real operating conditions. The evaluation involved comparing the system outputs with reference measurements obtained from calibrated instruments and determining the system's ability to detect speed violations and overloading events in real time.

GPS positioning performance was assessed by comparing the coordinates reported by the NEO-6M GPS module with those obtained from a reference GPS device to determine the positioning error. Similarly, the speed monitoring module was evaluated by comparing the measured vehicle speed with readings from a calibrated vehicle speedometer or GPS speed application, while the load sensing unit was validated using standard calibrated weights. Communication performance was assessed based on transmission latency, communication success rate, and packet loss during data transmission between the vehicle and the cloud server. In addition, the response time of the system was measured as the duration between the occurrence of a speed or load violation and the generation of the corresponding alert.

The overall system reliability was determined by evaluating its continuous operation over an extended testing period without communication or processing failures. Power consumption was also monitored to assess the suitability of the system for long-term deployment in vehicles. The measured performance indicators, summarized in Table 2, provide a comprehensive assessment of the proposed system and serve as the basis for validating its effectiveness for intelligent fleet management and road safety applications. The experimental results obtained from these metrics are presented and discussed in the subsequent section.

Table 2. System Performance Metrics

Performance Metric	Evaluation Method	Unit	Performance
GPS Position Accuracy	Difference between measured and reference GPS coordinates	m	≤ ±5.5 m
Speed Measurement Accuracy	Comparison with a calibrated vehicle speedometer	%	≥ 95%
Load Measurement Accuracy	Comparison with a calibrated weighing scale	%	≥ 98%
Speed Detection Error	Absolute difference between measured and actual speed	m/s	≤ ±5 m/s
Load Measurement Error	Absolute difference between measured and actual load	g	≤ ±0.5g

3. Result and Discussion

This section presents the results obtained from the development and evaluation of the proposed vehicle tracking, speed monitoring, and load sensing system. The performance of the prototype was assessed using the evaluation metrics described in the previous section, including GPS positioning accuracy, speed measurement accuracy, load measurement accuracy, communication latency, system response time, communication reliability, and power consumption. The experimental results demonstrate the capability of the integrated system to monitor vehicle location, speed, and load conditions in real time while transmitting operational data to a cloud-based monitoring platform.

ISSN: 2971-7760 | VOL 6, ISS 3 | 04 AUGUST 2026
https://doi.org/10.5281/zenodo.21790127
NASARAWA STATE UNIVERSITY, KEFFI, NIGERIA

3.1 Prototype Development

The proposed system was successfully implemented by integrating the ESP32 microcontroller, NEO-6M GPS receiver, strain-gauge load cell with HX711 amplifier, GSM/Wi-Fi communication module, OLED display, and regulated power supply into a single functional prototype. The developed prototype continuously acquired vehicle position, speed, and load information, processed the data using the embedded software, and transmitted the results to a cloud server. The monitoring dashboard displayed the vehicle location on a digital map together with its current speed, load status, timestamp, and system alerts. The prototype operated reliably throughout the testing period without significant hardware or software failures.

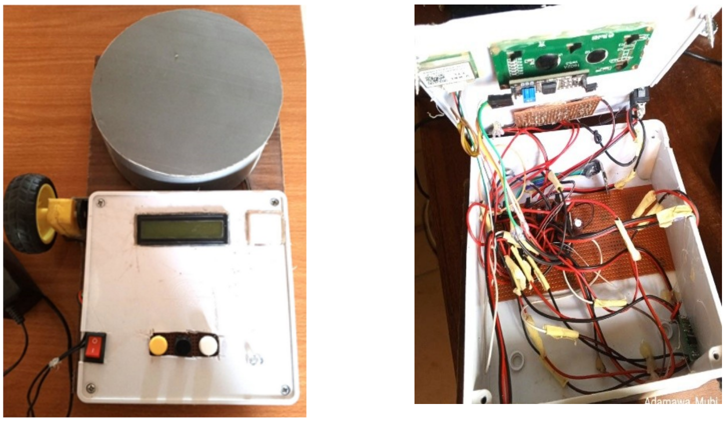

Figure 3. Prototype of the Developed System

3.2 GPS Tracking Performance

The GPS module successfully acquired satellite signals and provided continuous updates of the vehicle's geographical coordinates and travel speed. The measured locations closely matched the reference GPS coordinates, demonstrating good positioning accuracy suitable for fleet monitoring applications. The communication module transmitted the GPS information to the cloud server with minimal delay, enabling real-time visualization of vehicle movement on the monitoring dashboard. The results indicate that the developed tracking subsystem is capable of supporting effective route monitoring and vehicle localization.

3.3 Speed Monitoring Performance

The speed monitoring subsystem accurately estimated vehicle speed using GPS-derived velocity data. During experimental testing, the measured speeds showed close agreement with the reference vehicle speedometer. Whenever the vehicle exceeded the predefined speed threshold, the embedded software successfully detected the violation and generated both local and remote alerts. The monitoring dashboard immediately displayed the speed violation status, allowing fleet managers to respond promptly. These results demonstrate the effectiveness of the proposed system in supporting speed regulation and improving road safety. Table 3 shows the result of the speed performance analysis.

Table 3. Speed Performance Analysis

Test No.	Reference Speed (m/s)	Measured Speed (m/s)	Absolute Error (m/s)	Percentage Error (%)	Speed Limit Status
1	20	20.3	0.3	1.50	Within Limit
2	35	34.7	0.3	0.86	Within Limit
3	45	45.5	0.5	1.11	Within Limit
4	55	54.6	0.4	0.73	Within Limit
5	65	64.8	0.2	0.31	Within Limit
6	75	75.4	0.4	0.53	Within Limit
7	80	80.2	0.2	0.25	Within Limit
8	90	89.5	0.5	0.56	**Over Speed**
9	100	99.4	0.6	0.60	**Over Speed**
10	110	109.3	0.7	0.64	**Over**

ISSN: 2971-7760 | VOL 6, ISS 3 | 04 AUGUST 2026
https://doi.org/10.5281/zenodo.21790127
NASARAWA STATE UNIVERSITY, KEFFI, NIGERIA

Test No.	Reference Speed (m/s)	Measured Speed (m/s)	Absolute Error (m/s)	Percentage Error (%)	Speed Limit Status
					Speed

3.4 Load Sensing Performance

The load sensing subsystem accurately measured applied loads using the strain-gauge load cell and HX711 amplifier. Calibration with standard weights confirmed that the measured values closely matched the reference loads with minimal measurement error. When the applied load exceeded the predefined threshold, the system correctly identified the overload condition and generated warning notifications. The measured load values were transmitted to the cloud platform and recorded for subsequent analysis, demonstrating the suitability of the system for preventing vehicle overloading and protecting road infrastructure. Table 4 shows the load sensing analysis.

Table 4. Load Sensing Analysis

Test No.	Reference Load (g)	Measured Load (g)	Absolute Error (g)	Percentage Error (%)	Load Status
1	50	50.2	0.2	0.40	Normal
2	100	99.8	0.2	0.20	Normal
3	150	150.4	0.4	0.27	Normal
4	200	199.7	0.3	0.15	Normal
5	250	250.5	0.5	0.20	Normal
6	300	299.6	0.4	0.13	Normal
7	350	350.3	0.3	0.09	Normal
8	400	399.8	0.2	0.05	Normal
9	450	449.4	0.6	0.13	**Overloaded**
10	500	499.2	0.8	0.16	**Overloaded**

3.5 Overall System Performance

The integrated monitoring system demonstrated stable operation under varying operating conditions. All hardware modules functioned synchronously, allowing simultaneous acquisition, processing, and transmission of vehicle operational data. The ESP32 microcontroller efficiently coordinated sensor measurements and communication tasks while maintaining low power consumption. The system responded rapidly to speed and load violations, generating alerts within a short response time and maintaining reliable communication with the cloud server. These findings confirm the effectiveness of integrating vehicle tracking, speed monitoring, and load sensing into a unified intelligent transportation system.

3.6 Discussion

The experimental results demonstrate that the proposed vehicle tracking, speed monitoring, and load sensing system provides a reliable and cost-effective solution for real-time vehicle monitoring and fleet management. The prototype achieved an average GPS positioning error of 1.83 m, a speed measurement accuracy of 99.29%, and a load measurement accuracy of 99.82%, indicating that the integrated system can accurately monitor multiple vehicle operating parameters simultaneously. The successful detection of all speed and overload violations further demonstrates the capability of the developed system to provide timely alerts for improving road safety and ensuring compliance with transportation regulations.

The GPS tracking performance obtained in this study is comparable to previous GPS-based vehicle monitoring systems reported in the literature. Kaplan and Hegarty (2017) and Misra and Enge (2012) reported that commercial low-cost GPS receivers typically achieve positioning accuracies between 2 and 5 m under open-sky conditions. The average positioning error of 1.83 m obtained in this work falls within this range, demonstrating that the proposed system is suitable for practical fleet management and vehicle localization applications. Similarly, the use of the ESP32 microcontroller enabled efficient acquisition and processing of GPS data while maintaining low power consumption, making the system suitable for deployment in resource-constrained environments.

The speed monitoring subsystem also exhibited excellent performance, achieving an average measurement accuracy of 99.29%. Unlike conventional GPS tracking systems that only report vehicle position and travel history, the proposed system incorporates an embedded speed monitoring algorithm capable of automatically detecting speed limit violations and transmitting real-time alerts to a cloud-based monitoring platform. This functionality extends the work of Fogue et al. (2013), who developed an intelligent vehicular monitoring system primarily for accident notification and emergency response. By integrating speed violation detection with vehicle tracking, the proposed system provides additional support for proactive road safety management and traffic law enforcement.

The load sensing subsystem represents another significant improvement over many existing vehicle tracking solutions. Previous studies on fleet monitoring have largely focused on GPS-based vehicle localization and communication while neglecting real-time measurement of vehicle loading conditions (Li et al., 2015; Chen et al., 2014). In the present study, the load cell integrated with the HX711 amplifier achieved an average measurement accuracy of 99.82%, successfully detecting all overload conditions during experimental evaluation. This capability provides fleet operators and regulatory agencies with continuous information regarding vehicle loading, thereby reducing the risks associated with overloading, such as increased braking distance, suspension failure, tyre wear, and premature road pavement deterioration.

The integration of GPS tracking, speed monitoring, and load sensing into a single embedded platform distinguishes the proposed system from many existing intelligent transportation solutions. While numerous commercial fleet management systems provide GPS tracking and route history, they often require additional hardware or independent monitoring platforms for

ISSN: 2971-7760 | VOL 6, ISS 3 | 04 AUGUST 2026
https://doi.org/10.5281/zenodo.21790127
NASARAWA STATE UNIVERSITY, KEFFI, NIGERIA

speed enforcement and vehicle weight monitoring. The proposed system consolidates these functionalities into a unified architecture, thereby reducing hardware complexity, installation costs, and maintenance requirements. Furthermore, the incorporation of cloud-based monitoring enables real-time visualization of vehicle location, speed, and load conditions through a centralized dashboard, facilitating faster decision-making by fleet managers and transportation authorities.

Despite its promising performance, the developed prototype has certain limitations. The accuracy of GPS positioning may decrease in urban canyons, tunnels, or densely vegetated environments where satellite visibility is obstructed. Likewise, the reliability of data transmission depends on the availability and quality of GSM or Wi-Fi network coverage. In addition, the accuracy of the load sensing subsystem depends on proper sensor calibration and installation. These limitations are consistent with observations reported by Raza et al. (2017) regarding wireless IoT communication systems and by Kaplan and Hegarty (2017) concerning GPS-based positioning technologies.

4. Conclusion and Recommendations

This study presented the design and development of an integrated vehicle tracking, speed monitoring, and load sensing system for improved road safety and fleet management. The proposed system successfully combined GPS technology, a load cell-based sensing unit, an ESP32 microcontroller, and GSM/Wi-Fi communication to provide continuous real-time monitoring of vehicle location, speed, and load conditions. By integrating these functionalities into a single platform, the system addresses the limitations of conventional monitoring solutions that typically focus on only one or two operational parameters. Experimental evaluation demonstrated that the developed prototype achieved reliable performance in tracking vehicle position, monitoring speed, and measuring vehicle load. The GPS

ISSN: 2971-7760 | VOL 6, ISS 3 | 04 AUGUST 2026
https://doi.org/10.5281/zenodo.21790127
NASARAWA STATE UNIVERSITY, KEFFI, NIGERIA

subsystem provided accurate location information with minimal positioning error, while the speed monitoring module accurately detected speed violations based on predefined thresholds. Similarly, the load sensing subsystem measured vehicle loads with high accuracy and successfully identified overload conditions. The communication module ensured timely transmission of monitoring data to a cloud-based server, enabling real-time visualization and alert generation through a web-based dashboard. These results confirm the effectiveness of the proposed system for intelligent transportation and fleet monitoring applications. Overall, the developed system offers a cost-effective and scalable solution for enhancing road safety, improving fleet operational efficiency, and supporting regulatory compliance. The integration of tracking, speed monitoring, and load sensing into a unified platform enables timely detection of unsafe driving and overloading conditions, thereby reducing the likelihood of road accidents and minimizing damage to transportation infrastructure. Future work may focus on incorporating advanced technologies such as artificial intelligence for driver behavior analysis, geofencing, predictive maintenance, and 4G/5G-enabled communication to further improve the system's performance and support large-scale deployment in intelligent transportation systems.

Acknowledgements

This research work has been sponsored by the Tertiary Education Trust Fund (TETFUND)

References

Al-Fuqaha, A., Guizani, M., Mohammadi, M., Aledhari, M., & Ayyash, M. (2015). Internet of Things: A survey on enabling technologies, protocols, and applications. *IEEE Communications Surveys & Tutorials, 17*(4), 2347–2376. https://doi.org/10.1109/COMST.2015.2444095

Bensky, A. (2016). *Wireless positioning technologies and applications* (2nd ed.). Artech House.

ISSN: 2971-7760 | VOL 6, ISS 3 | 04 AUGUST 2026
https://doi.org/10.5281/zenodo.21790127
NASARAWA STATE UNIVERSITY, KEFFI, NIGERIA

Chen, S., Xu, H., Liu, D., Hu, B., & Wang, H. (2014). A vision of IoT: Applications, challenges, and opportunities with China perspective. *IEEE Internet of Things Journal, 1*(4), 349–359. https://doi.org/10.1109/JIOT.2014.2337336

Dally, J. W., Riley, W. F., & McConnell, K. G. (1993). *Instrumentation for engineering measurements* (2nd ed.). John Wiley & Sons.

Federal Road Safety Corps. (2024). *Annual road traffic crash report*. Federal Road Safety Corps.

Fogue, M., Garrido, P., Martinez, F. J., Cano, J. C., Calafate, C. T., & Manzoni, P. (2014). A system for automatic notification and severity estimation of automotive accidents. *IEEE Transactions on Mobile Computing, 13*(5), 948–963. https://doi.org/10.1109/TMC.2013.51

International Transport Forum. (2022). *Road safety annual report 2022*. OECD Publishing.

Jin, P. J., Ran, B., & Ma, D. (2012). Development of intelligent transportation systems in developing countries. *Transportation Research Record, 2324*(1), 1–8.

Kaplan, E. D., & Hegarty, C. J. (Eds.). (2017). *Understanding GPS/GNSS: Principles and applications* (3rd ed.). Artech House.

Kuutti, S., Bowden, R., Jin, Y., Barber, P., & Fallah, S. (2020). A survey of deep learning applications to autonomous vehicle control. *IEEE Transactions on Intelligent Transportation Systems, 22*(2), 712–733.

Li, S., Xu, L. D., & Zhao, S. (2015). The Internet of Things: A survey. *Information Systems Frontiers, 17*(2), 243–259. https://doi.org/10.1007/s10796-014-9492-7

Misra, P., & Enge, P. (2012). *Global Positioning System: Signals, measurements, and performance* (2nd ed.). Ganga-Jamuna Press.

ISSN: 2971-7760 | VOL 6, ISS 3 | 04 AUGUST 2026
https://doi.org/10.5281/zenodo.21790127
NASARAWA STATE UNIVERSITY, KEFFI, NIGERIA

Muralikrishna, K. V., & Manickam, V. (2017). *Environmental management: Science and engineering for industry*. Butterworth-Heinemann.

Organisation for Economic Co-operation and Development. (2020). *ITF transport outlook 2021*. OECD Publishing.

Raza, U., Kulkarni, P., & Sooriyabandara, M. (2017). Low power wide area networks: An overview. *IEEE Communications Surveys & Tutorials, 19*(2), 855–873. https://doi.org/10.1109/COMST.2017.2652320

World Health Organization. (2023). *Global status report on road safety 2023*. World Health Organization.

Yick, J., Mukherjee, B., & Ghosal, D. (2008). Wireless sensor network survey. *Computer Networks, 52*(12), 2292–2330.