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# Building A Smart Campus: Designing An Architectural Framework For Campus Security Gates And Vehicle Asset Management With GPS Tracking Technology

Journal of Electrical Systems

***Abstract: -*** Modern technology must be integrated into educational institutions as they develop into "smart campuses" in order to guarantee the security and effectiveness of day-to-day operations. This study combines GPS tracking technology to present an architectural framework for the deployment of intelligent security gates and automotive asset management systems. The objective is to build a secure and effective environment that improves campus security and maximizes the use of available resources. The suggested architecture combines a centralized software platform with innovative hardware elements, including GPS trackers, RFID readers, and security cameras. RFID-enabled security gates improve access control by limiting entrance to the college grounds to only authorized people and vehicles. Surveillance cameras simultaneously offer real-time monitoring to guarantee adherence to security procedures.

The vehicle asset management system utilizes GPS technology to monitor campus vehicles in real-time, increasing fleet management efficiency and enhancing general campus security. GPS tracking integration allows scheduling maintenance, optimizing routes, and notifying authorities of unwanted vehicle movements.

***Keywords:*** Smart Campus, GPS Tracking, Vehicle Management, Security Gates, RFID

## I.INTRODUCTION

Security measurement in an organization such as a private, government, commercial, or educational institution is essential to guarantee the safety of all the resources within the organization, including the people inside the vicinity of the institutions. Most universities and colleges have long been known as a safe haven for students. universities and colleges have long been known as safe havens for students. Section 28 of the Commission on Higher Education Memorandum No. 09, series of 2013, mandates the safety and security services for educational institutions. Section 28.1 states that "there should be a safe, accessible, and secure environment; buildings and facilities shall comply with government standards." Furthermore, Section 28.5 of the Commission on Higher Education Memorandum No. 09, series of 2013, states that "There shall be an established mechanism for the students to help with crime prevention, safety, and security of the concerned higher education institution (CMO 09, s2013)"[1].

However, various problems and concerns regarding the safety and security of its visitors are significant issues nowadays, and those educational institutions face numerous challenges in their efforts to provide a safe and secure campus [2]. If not properly monitored, the increasing number of vehicles, employees, students, and visitors entering the campus vicinity can threaten the safety of those on campus. One of the top three problems encountered regarding school security is the need for more consistency in implementing the NO-ID NO Entry Policy, Visitor's ID and logbook, and Gate Pass policy, along with limited CCTV cameras installed in strategic locations. With these issues, there is no total security[3]. Typically, security personnel stationed at the entrance gate or checkpoint visually inspect vehicles, examine identification documents and confirm the purpose of entry when checking vehicles entering the campus area. If necessary, they may also conduct physical searches. With the uncontrolled number of people entering the campus area, security guards cannot distinguish between students, staff, lecturers, and visitors as people pass through the campus area, causing inconvenience as well as a high risk of theft of campus assets, either inside or outside the building or rooms. Once a university increases its population, it is also high in risk and security issues.

In addition to the importance of monitoring vehicles entering and exiting the campus, institution-owned vehicles also require protection. Vehicles owned by a campus or educational institution and used to transport students, faculty, and staff to training sessions or seminars are crucial in facilitating academic and professional development, so they must be protected and monitored to ensure effective use. Using campus vehicles for non-business purposes

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can also have several impacts that lead to increased wear and tear, regular maintenance costs, repairs, and potential vehicle downtime due to damages can escalate, impacting the overall budget allocated for vehicle management [4][5]. This can strain resources and divert funds from other essential areas. Accidents or damages that occur during personal use may not be covered under the university's insurance policy, potentially resulting in financial burdens for the institution or individuals involved. This can strain resources and divert funds from other essential areas. Accidents or damages that occur during personal use may not be covered under the university's insurance policy, potentially resulting in financial burdens for the institution or individuals involved.

Using RFID and GPS tracking systems on those campuses can help mitigate the abovementioned problems, providing convenience and security to those utilizing the technology. RFID (Radio Frequency Identification) technology is frequently used in security gates to improve safety and simplify access control systems. It is used to quickly and accurately identify and authenticate people passing through security gates. Each RFID card or tag has a unique identification code that can be linked to an individual's profile, including relevant data such as name, access permissions, credentials, and vehicle information. It enables security personnel to validate individuals' identities efficiently and determine their level of authorization [6][7][8].

Some universities, such as the Islamic University of Riau in Indonesia, use an RFID gate pass system that is integrated into all gates on campus to use the ID function, create a single card to access the campus area, and track and record every transaction made by students passing through the campus vicinity [9]. A vehicle access control and security system were also implemented at the University of Lagos in Nigeria to track who, what car, and when people entered and exited the school grounds [10].

Nowadays, fleet managers and private car owners use vehicle tracking systems, which are well-established technologies for tracking and positioning any vehicle using the Global Positioning System (GPS) [11][12][13]. GPS technology can be a very useful tool when used on campus vehicles. It improves vehicle security by providing real-time location data. This data can help manage the campus vehicle fleet, ensure optimal utilization, and schedule maintenance and repairs [14][15]. The GPS can assist authorities in quickly locating and recovering a vehicle in the event of theft or unauthorized use. GPS tracking is a reliable method of monitoring and verifying campus personnel's vehicle usage. It can improve accountability, prevent misuse, and ensure campus policies and regulations are followed.

GPS tracking enables efficient asset management by recording vehicle locations and movements. It allows for real-time monitoring and tracing of vehicles entering or leaving campus, ensuring higher security and control. This information can assist in managing the campus vehicle fleet, ensuring optimal utilization, scheduling maintenance and repairs, and providing a reliable means of monitoring and verifying vehicle usage by campus personnel. It can enhance accountability, prevent misuse, and ensure compliance with campus policies and regulations. In emergencies, GPS data can aid in locating assets or vehicles, allowing for a quicker and more effective response.

In light of the above, this study designs an architectural framework for campus security gates and vehicle management while integrating GPS tracking and RFID technology. RFID technology can create a digital record of people and vehicles who pass through security gates and help restrict entry to authorized individuals or vehicles, enhancing security and controlling access to the campus vicinity, which enables quick identification without physical contact. The system records the access event's date, time, and location. This information can be used to create audit trails, allowing security personnel to review and analyze access patterns, detect anomalies or security breaches, and investigate incidents. It can be linked to other security systems like video surveillance, alarms, and intercoms.

Establishing a smart campus can achieve several goals, including delivering highly innovative and high-quality services, enhancing environmental sustainability, reducing expenses, and improving communication and education in general[16].

## II.MATERIALS AND METHODS

For the initiative to accomplish the objectives of the project, approval from the president of Bulacan Agricultural State College is needed where the project is implemented. For the security gates, the projects require a fully automated vertical tripod turnstile, access controller, RFID card reader, plug-and-play ID reader, RFID card, boom barrier, infrared photo beam, single loop detector, UHF (ultra-high frequency) middle-range integrated reader, and

UHF RFID tag for the vehicle. For the management of vehicles owned by the institutions, the devices installed are GPS/GPRS/GSM positioning tracking. Combining these technologies created a comprehensive and effective system for real-time tracking, remote monitoring, two-way communication, and alerts and notifications.

Figure 1 shows the materials and equipment required for the security gates to record and monitor student entry into the campus. Students entering the campus must first scan their ID and can only enter if they are authorized or allowed based on their current status in the school profile. Students not permitted to enter will be stopped at the gate and questioned by security personnel. Visitors must provide information such as their name, purpose of visit, and the person or department they are visiting before security personnel issue them a temporary pass.


**Figure 1: Material and Equipment for the Student Entrance**

Figure 2 shows the materials and equipment needed for recording and monitoring all vehicles entering the campus area. Only authorized vehicles with RFID tags are permitted to enter the campus, while the guards question those without RFID tags or visitors before being allowed or denied entry.

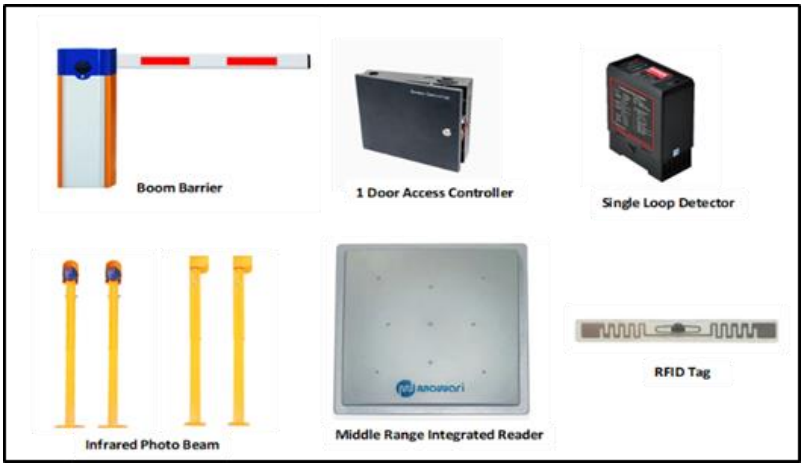


**Figure 2: Material and Equipment for the Vehicle Entrance**

The programming language to be used is PHP to integrate those devices and equipment and MySQL for the database. PHP is compatible with the initial software included in the devices and equipment of security gates and GPS tracking.

The iterative software development life cycle model (SDLC) is applied to this endeavor, which consists of the following phases: requirements analysis and planning, system design, development, testing, implementation, and maintenance. [17]. Under requirements analysis, the proponent conducted an in-depth interview with the various respondents to identify the project's different users, features, and system requirements. The design of the system is a user-friendly and easy-to-use dashboard with a comprehensive overview of data from various sources. Figure 3 shows the iterative life cycle model applied in the development of the project.

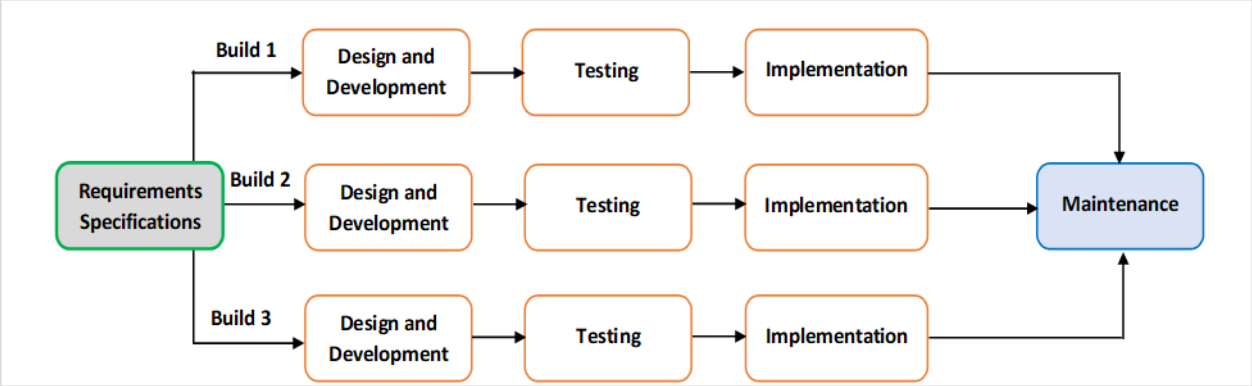


Figure 3: System Development Life Cycle for the Project (Iterative model)

This study aims to design an architectural framework in campus assets management in terms of a.) architectural frameworks, b.) system features, c.) system requirements, and d.) determining the system users. The in-depth interview identifies the different users of the system and the needed content, features, and requirements to develop smart campus security gates and management of vehicles owned by the institutions. The acceptability of the system will be measured using the Likert Scale. The evaluation criteria questionnaire is based on the International Organization for Standardization ISO/IEC 25010:2011 Systems and Software Quality Requirements and Evaluation (SQuaRE), specifically the Software Product Quality Model [18]

## III.3. RESULT AND DISCUSSIONS

Campus security frequently relies on more manual and traditional methods to regulate vehicle and student entry. Guards stationed at main entrances or checkpoints would manually inspect incoming vehicles and often maintained log books or registers to record details of vehicles entering and exiting the campus. Figure 4 illustrates how the Bulacan Agricultural State College manages its entrance security. The figure shows that anyone who wants to enter the Campus, including visitors, students, employees, and vehicles, must show their Identification Card and sign the log book. Additionally, the rider must wear a helmet if the vehicle is a motorcycle. The Security Guard checks their credentials and allows them to pass. The Security Guards then submit the log book to the School Officials for review.

However, the college operates three campuses within Bulacan. The College of Agriculture Campus is located in Brgy. Poblacion, San Ildefonso, and the DRT Campus was inaugurated in 2005 in Brgy. Sapang Bulak, Dona Remedios Trinidad. The main campus in Pinaod, San Ildefonso, has an area of 192.5 hectares and caters to 350 employees, including faculty and staff, and almost 7,000 students. According to the data gathered, 95% of students and 98% of employees have vehicles that enter the campus.

Guards visually inspect the driver's credentials and check for proper identification, such as a parking permit or a university-issued sticker. Students were required to present their physical student ID cards to access the campus areas, and guards would manually inspect them for authenticity. They also keep track of the number of visitors, recording their names, the purpose of their visit, and the time of entry. Students and faculty must often obtain and display physical permits or passes on their vehicles to be allowed on campus. Students and vehicles enter and exit the campus through two gates. The campus is located in the center of a municipality, connecting barangays within the city. The two gates allow vehicles to cross the other barangays. The campus has become a service road, particularly for tricycles that pass through the area. While only having one guard per gate, inspecting everyone thoroughly with the current system is not feasible. It is noteworthy to mention that, unfortunately, there are instances where the Security Guards may not notice some outsiders entering the campus, posing a significant concern to the school's security. This lapse in vigilance is particularly critical, as outsiders are more likely to cause commotions or incidents inside the school premises. The situations mentioned above increase the campus's vulnerability and compromise its safety.

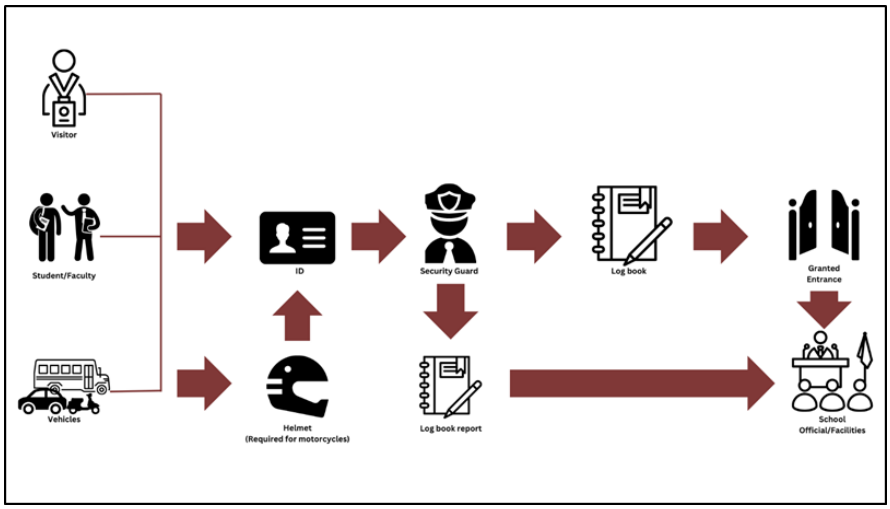


**Figure 4: Current Technical Situation**

Guards stationed at the entrance gate record the information about visitors and vehicles entering the campus area in the logbooks. The logbooks include the visitor's name, the date and time of entry, the purpose of the visit, and the concerned office that they will visit, including those visitors who will see one of the campus households. The logbook also keeps track of the vehicles that visitors bring onto campus. However, most vehicles owned by employees or students are not recorded because the guards are familiar with them. Logging that vehicle is optional and saves them time. The curfew is midnight, and the entrances are open as early as 4:00 in the morning. There are eight (8) CCTV cameras within the vicinity of the campus, and there are also 20 households on the main campus, all of which are school employees who have been granted permission to rent available housing on campus.

An innovative campus combines different components and technologies to establish an intelligent and interconnected setting that enhances overall efficiency, security, and experience for students, faculty, and staff. An emerging trend in higher education is the integration of intelligent technologies with physical infrastructure to improve campus sustainability, decision-making, and other aspects. [19] [20]. This study focused on establishing a smart campus safety and security framework that integrates security gates using RFID technology and vehicle management using GPS technology. In light of recent tragic incidents and mass shootings, university communities in the United States and numerous other nations are becoming increasingly concerned about campus safety. Regardless of the size or location of the campus (rural or urban, large or small), ensuring the safety of both students and employees should consistently be the foremost concern, particularly in light of the evident apprehension among numerous students regarding their personal security on campus [21].

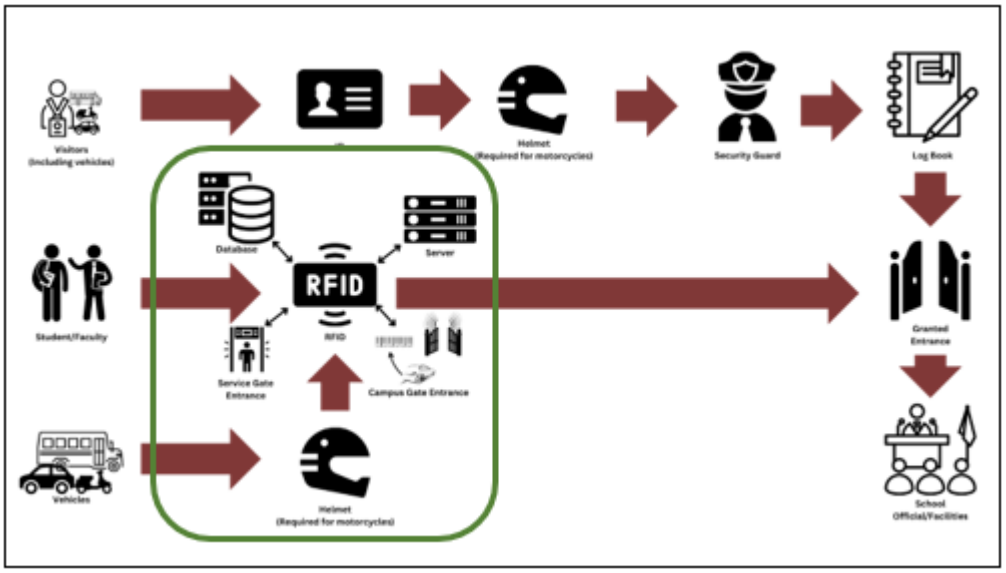


**Figure 5: Proposed Technical Situation**

Figure 5 showcases the proposed improvement to entrance security at Bulacan Agricultural State College by integrating RFID technology. The illustration demonstrates that individuals, including students, employees, and their vehicles, will be equipped with RFID devices. As they approach the campus gates, the RFID system will automatically detect their credentials, facilitating a seamless and efficient entry process. This innovative approach eliminates manual inspection, simplifying the entry procedure for authorized personnel.

However, the existing security protocol remains in place for visitors without RFID credentials. This involves presenting identification, signing the logbook, and undergoing manual inspection, especially for motorcycle riders, who must adhere to the mandatory helmet-wearing policy. This dual-tiered security system aims to balance the need for heightened security with the practicality of managing a substantial population of nearly 7,000 students, employees, and visitors.

The proposed RFID system offers a proactive solution to the challenge of a limited workforce and the potential oversight of unauthorized individuals entering the campus. By automating the verification process for authorized personnel, the system significantly reduces the burden on security personnel and enhances the overall efficiency of the entrance security protocol. This technological upgrade addresses the critical concern of maintaining a secure environment within the campus, minimizing the risk of unauthorized access and potential disturbances caused by external individuals.

Students and employees who want to install RFID tags in their vehicles must first register or enroll. They provide the BASC's General Services, Security, and Transportation Unit (GSSTU) with necessary identification information, such as their name, student or faculty ID number, and other pertinent details. The GSSTU office reviews the information provided to ensure that the individuals are, in fact, students or faculty members eligible for access. Authorization is granted based on factors such as enrollment, employment, or specific institutional permissions. After verification and authorization, GSSTU distributes and installs RFID tags to qualified individuals. Students and employees must collect their RFID tags in person and provide additional identification for verification.

Students and employees approaching the school service gate should show their identification cards with built-in RFID readily available at the designated point, and they should carry them whenever they enter the campus area. The system determines whether the user is authorized to enter the campus. The gate automation system receives the signal and automatically opens the gate to allow entry after every validation. Once the gate is open, an RFID card holder can pass through seamlessly. The gate will automatically close after a short period to secure the entry point. If the RFID card is invalid, the service gate will not open, and the holder cannot pass. The access control system will be double-checked by security personnel to ensure that the RFID card holder is not authorized to enter. The guard will notify the RFID card holder of the authorization issue and explain why their access has been denied. Suppose the RFID reader cannot read the card due to malfunction or damage; no other reasons are listed in the person's profile. In that case, security personnel may request the holder to present additional identification to verify their identity. This could be a government-issued ID or another type of identification. Suppose the RFID card holder can provide other identification proving their identity. In that case, security personnel may consider issuing a temporary access pass or manually granting entry to the affected individual while the issue is resolved. Checking enrollment status, employment records, or other relevant information may be required. Suppose it is determined that the RFID card holder should be granted access. In that case, their authorization status will be updated in the system prompt by the GSSTU officers, which includes correcting errors, updating records, or resolving any issues. Once the authorization issue has been settled, the cardholder will be notified of the correction and informed that their access has been restored, and they can enter using their RFID card.

Furthermore, the GPS tracking devices installed and activated on every vehicle owned by the campus administration provide real-time visibility into the current location of the campus vehicles on a digital map. These devices include GPS receivers and communication modules. It monitors and records vehicle routes, helping optimize transportation logistics and improve efficiency. It has reporting features that allow users to generate and analyze reports on vehicle usage, routes, and other relevant data. GPS also enhances security by providing real-time location data which, in the event of a security incident, such as theft or unauthorized use, the GPS tracking data can be used to locate and recover the vehicle promptly. GSSTU personnel can access the GPS tracking data through a web-based platform or mobile application provided by the GPS tracking service.

The server and database ensure the system's efficiency, security, and integrity. The server acts as a central hub, facilitating the administration and coordination of the system's various components. It enables real-time communication between different system elements, such as security gates, RFID readers, cameras, and other connected devices. Data is processed from various sensors, devices, and access points. This data includes vehicle access requests, RFID tag readings, and security events. The server determines whether a vehicle should be granted access based on the information received and predefined security policies. It records security events, access attempts, and system activities for auditing, compliance, and forensic analysis. It also manages user authentication for administrators and authorized personnel who must access the system for configuration, monitoring, and reporting.

On the other hand, a database stores and organizes data related to campus vehicles, RFID tags, user profiles, access logs, and additional pertinent information and provides centralized storage to ensure data consistency and integrity. It saves system logs, allowing for the analysis of previous security events, vehicle movements, and access patterns. These logs could be used for reporting and trend analysis. It manages permissions and access levels for different users by storing user profiles. It keeps track of information about campus-owned vehicles, such as vehicle type, registration, maintenance history, and RFID tag associations. Access control rules and policies that govern how the system should respond to various access scenarios are stored here. This includes access rules that grant or deny access based on multiple criteria. The database contains configuration data for the entire security and vehicle management system, including the RFID reader, security gate, and notification preferences, among other things. Allows regular backups of critical data to ensure recovery during system failures, hardware problems, or other unforeseen events. Provides structured data for reporting and analytical functions to generate insights into system performance, security incidents, and overall operational efficiency.

The system provides a reliable and efficient campus security gate and vehicle management system through the server and database. These are the infrastructure's backbone, ensuring access control, monitoring, and reporting functions run smoothly to maintain a secure and well-managed campus environment.

The user of the system are be the following entities:

To the Security Personnel

The system will help security personnel verify the identity of users and ensure they have the necessary permissions to enter the campus. They operate and monitor the surveillance systems integrated with the security gates to keep an eye on activities at entry and exit points. The data that smart security gates provide, such as access logs, facial recognition information, or RFID card scans, will guarantee that only authorized individuals are entering the campus. They must ensure the security and confidentiality of the data collected by the smart gates, including access logs, biometric information, and any other sensitive data. They should be aware of and comply with data protection regulations to prevent unauthorized access to or misuse of personal information.

To the Students

Campus security gates help ensure the safety of students by controlling access to campus facilities, including academic buildings, laboratories, and recreational areas. Students must carry and use their identification cards as the smart security system requires. This helps in accurate identification and grants access only to authorized individuals. Students who own a vehicle can obtain RFID tags, enabling them to gain access to the school premises with their vehicles, provided they meet the needed requirements. If the vehicle user is authorized, the gate barrier will lift and allow entry into the campus vicinity.

To the Faculty and Staff

Employees should develop and implement security policies and procedures, offer instruction and training, manage the security gates and vehicle asset management system, examine and analyze security data, and carry out research

on security technologies and best practices—all of which are vital to guarantee the safety of the campus community and its assets.

To the General Services, Security, and Transportation Unit (GSSTU)
Administrators are in charge of the system's general management and supervision. This includes creating and implementing policies and procedures, ensuring rules are followed, handling the finances, employing and educating employees, collaborating with other university departments, and encouraging system usage.

## IV. CONCLUSIONS

Campus security and safety are essential for creating a safe and conducive environment for students, faculty, staff, and the entire educational institution to learn, work, and live. A safe and secure campus environment promotes a learning environment. Students and faculty can focus on academic pursuits without distractions, contributing to a positive and productive educational experience. Bulacan Agricultural State College's implementation of campus security gates and vehicle management creates a comprehensive and adaptive security infrastructure to safeguard their campuses effectively. This innovative approach also contributes to the 17 SDGs' objectives of ensuring inclusive and equitable quality education and promoting lifelong learning opportunities for all, building resilient infrastructure, promoting inclusive and sustainable industrialization and fostering innovation, developing effective, accountable, and transparent institutions at all levels, and significantly reducing all forms of violence and related death rates worldwide [23].

Integrating RFID for access control at security gates and GPS tracking in vehicle management provides a technologically advanced and efficient campus security solution. It not only improves security measures but also optimizes the use of campus vehicles and improves overall safety and control on campus.

Using technological innovation to develop a campus security gate and vehicle asset management system addresses security concerns while also introducing efficiency, flexibility, and adaptability. This innovation equips campus security with the ability to adapt proactively and dynamically in response to the dynamic technological environment.

## V.ACKNOWLEDGMENTS

I want to thank everyone who helped with this research, especially my family, friends, colleagues, and my dear professor, for their unwavering support and understanding. To God be the glory.

## REFERENCES

[1] “Higher Education Institutions’ Security Capability the Leads to the Creation of Standardized Campus Security System,” Journal for Educators, Teachers and Trainers, vol. 14, no. 2, Jan. 2023, doi: 10.47750/jett.2023.14.02.034.

[2] M. Digital Scholar, B. Andrew Carrico, and B. Andrew, “The Effects of Students’ Perceptions of Campus Safety and Security on Student Enrollment Recommended Citation,” 2016. [Online]. Available: http://mds.marshall.edu/etd

[3] “Higher Education Institutions’ Security Capability the Leads to the Creation of Standardized Campus Security System,” Journal for Educators, Teachers and Trainers, vol. 14, no. 2, Jan. 2023, doi: 10.47750/jett.2023.14.02.034.

[4] “Vehicle Downtime: Understanding, Managing, and Overcoming the Challenge - Axxon.” Accessed: Nov. 02, 2023. [Online]. Available: https://axxon.co/blog/vehicle-downtime-understanding-managing-and-overcoming-the-challenge/

[5] “How to optimise fleet service, maintenance and repair.” Accessed: Nov. 02, 2023. [Online]. Available: https://www.fleetnews.co.uk/features-landing/how-to-optimise-fleet-service-maintenance-and-repair

[6] G. Ikrissi and T. Mazri, “A study of smart campus environment and its security attacks,” in International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences - ISPRS Archives, International Society for Photogrammetry and Remote Sensing, Nov. 2020, pp. 255–261. doi: 10.5194/isprs-archives-XLIV-4-W3-2020-255-2020.

[7] K. Mansur and Z. B. Hasanuddin, “Implementation of NFC for Smart Gate Access Control in Campus Area,” 2018.

[8] B. Pavithra, S. Suchitra, P. Subbulakshmi, and J. Mercy Faustina, RFID based Smart Automatic Vehicle Management System for Healthcare Applications. 2019.

[9] H. Gunawan and E. Abdul Kadir, “Integration protocol student academic information to campus RFID gate pass system,” International Conference on Electrical Engineering, Computer Science and Informatics (EECSI), vol. 2017-December, Dec. 2017, doi: 10.1109/EECSI.2017.8239197.

[10] M. Nwohiri and A. B. Muhammad, “VEHICLE ACCESS CONTROL AND SECURITY SYSTEM: UNIVERSITY OF LAGOS SECURITY GATE AS A CASE,” 2019.

[11] J. Myint Mo Khin and M. Nyein Nyein Oo, “Real-Time Vehicle Tracking System Using Arduino, GPS, GSM and Web-Based Technologies,” 2018. [Online]. Available: www.ijsea.com433

[12] R. Batra, P. Singhal, P. Chauhan, D. Gaur, and V. Kumar, “Vehicle Tracking System for Commercial Vehicles,” 2017.

[13] N. Jahan, K. Hossen, and M. K. H. Patwary, Implementation of a Vehicle Tracking System using Smartphone and SMS service. 2017.

[14] M. Hamidu, “Use of RFID Technology as a Reporting Mechanism in Vehicle Tracking System,” vol. 2, no. 1, pp. 1–10, 2016, doi: 10.11648/j.awcn.20160201.11.

[15] C. Keerthika, M. Singh, and T. Tamizharasi, “Tracking system for vehicles using GPS, GSM and GPRS,” Research Journal of Engineering and Technology, vol. 8, no. 4, p. 453, 2017, doi: 10.5958/2321-581x.2017.00078.2.

[16] G. Ikrissi and T. Mazri, “A study of smart campus environment and its security attacks,” in International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences - ISPRS Archives, International Society for Photogrammetry and Remote Sensing, Nov. 2020, pp. 255–261. doi: 10.5194/isprs-archives-XLIV-4-W3-2020-255-2020.

[17] “SDLC Models: Agile, Waterfall, V-Shaped, Iterative, Spiral - Existek Blog.” Accessed: Nov. 07, 2023. [Online]. Available: https://existek.com/blog/sdlc-models/

[18] “ISO 25010.” Accessed: Nov. 09, 2023. [Online]. Available: https://iso25000.com/index.php/en/iso-25000-standards/iso-25010

[19] N. Min Allah and S. Alrashed, “Smart campus—A sketch,” Sustain Cities Soc, vol. 59, p. 102231, May 2020, doi: 10.1016/j.scs.2020.102231.

[20] K. Palanivel, “Emerging Technologies to Smart Education,” International Journal of Computer Trends and Technology, vol. 68, 2020, [Online]. Available: http://www.ijcttjournal.org

[21] Abdullah, M. Thanoon, and A. Alsulami, “Toward a smart campus using IoT: Framework for safety and security system on a university campus,” Advances in Science, Technology and Engineering Systems, vol. 4, no. 5, pp. 97–103, 2019, doi: 10.25046/aj040512.

[22] “Smart_campus_features_technologies_and_applications_A_systematic_literature_review”.

[23] “Home | Sustainable Development.” Accessed: Dec. 19, 2023. [Online]. Available: https://sdgs.un.org/