# Smart Grid Integrated Digital License Plate

## Capstone Team Retrospective Report


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# Abstract

In recent years, it has become evident that traditional license plates have many flaws such as security, durability, and functionality. Current license plates have proven time and time again that it is time for an update. The world is quickly going digital as technological advancements are being made every day. License plates have not yet caught up to the times. A smart digital license plate would be a tremendous upgrade moving into this electric and digital world. Current technologies such as displays, communications, and electric vehicles have created a possibility for revolutionary smart digital license plates with features such as theft detection, renewal updates, smart grid integration, and web information access. The following capstone retrospective report focuses on the many difficult challenges we have faced and how well we overcame them. It also reviews the many aspects that went well in combination with all the lessons we have learned. Lastly, we look back upon the schoolyear and make conclusions and justify our final thoughts.

# Dedication

We would like to dedicate this report to each of our group members' families who have continuously supported us throughout the university in both moral and material needs. Moreover, we would like to dedicate this report to all our professors, peers, and friends for their consistent encouragement and motivation.

# Acknowledgments

We would like to express our gratitude to our supervisor Dr. Tarlochan Sidhu who made this project possible. With his guidance, we were able to get a thorough understanding of the project and how to execute our ideas. His continuous support fed our ambition to take this project above and beyond.

We would also like to acknowledge our capstone coordinator Dr. Vijay Sood. He was able to give us a detailed outline for producing strong and competent reports and complete presentations for our project.

Our sincere appreciation to Dr. Sheldon Williamson for offering his knowledge and guidance with this project. In our first meeting, he provided us with many ideas on smart grid technology and possible recommendations on how to implement them.

A special thank you to Mr. Peter Kahr for helping us with the 3D printing for our casing and creating badges for our prototype as well.

Lastly, we would like to thank our friends and family for their continued support, especially Siear Lutfi for attending some of our meetings and encouraging us throughout the project.

We will be forever grateful for this capstone project as it has not only challenged us but helped us understand the process of designing, testing, building, and implementing a product from start to finish.

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# List of Acronyms Used

| Acronym | Meaning |
|---|---|
| **3D** | Three-Dimensional |
| **CSS** | Cascading Style Sheets |
| **GPS** | Global Positioning System |
| **HTML** | Hypertext Markup Language |
| **IP** | Internet Protocol |
| **JSON** | JavaScript Object Notation |
| **LTE** | Long Term Evolution |
| **PHP** | Hypertext Preprocessor |
| **RFID** | Radio Frequency Identification |
| **SIRC** | Software and Informatics Research Centre |
| **SQL** | Structured Query Language |
| **UI** | User Interface |
| **UX** | User Experience |
| **Wi-Fi** | Wireless Fidelity |

# 1 Introduction

This capstone project aimed to create a smart digital license plate that will present an innovative design for displaying all the requirements needed for a traditional license plate on a digital screen with the integration of smart grid and various other improvements. Given current technological advancements, it is highly possible to add features that allow clients to be kept up to date and alerted about things such as battery life, plate renewal, theft, and other useful information. The digital license plate will be used to display the characters needed for a legal license plate clearly for any law enforcement to read and customize in any way of the owner's choosing. Our plate will have many digital features but will simultaneously be very visually appealing and pleasing. A website is available for all the services a user might need, such as fulfilling the requirements to renew a vehicle owner's license plate, tracking where the license plate is and whether it has been removed/stolen.

Teamwork is a key component in engineering, and it defines the efficiency and performance in completing a project in a timely manner. The progress made this far into the project outlines each team member's hard work and endless resilience in completing many difficult tasks. The positive criticism and reinforcement received not only from each other but from our supervisor Dr. Sidhu, has also propelled us further into making progress in completing the project. This report explores the difficult challenges we faced in creating, designing, and implementing the capstone project. Moreover, it also explains many lessons learned in conjunction with elements that surprised us.

## Problem Statement

Many advancements have been made in technology and there is no reason for vehicles today not to be equipped with smart license plates. The current license plates endure issues such as peeling, theft, and legibility. Moreover, the province of Ontario had recently updated its plates to blue ones with a new slogan. The goal was to refresh the plates and solve the peeling issue but, instead, it made matters worse as law authorities found it difficult to see the plates at night as they were not reflective. These new plates cost the province about one million dollars and shortly after were discontinued. Introducing a smart digital license plate would automatically eliminate all the problems with the current license plates. Furthermore, designing, integrating, and implementing digital license plates would not only save the province issues like legibility at night, but also create cost-effective solutions for plate updates in the future.

## Overview of this Report

The remaining portion of this report is structured as follows. It starts off with section 2 explaining everything that went well throughout the project. Section 3 explains everything that surprised us from project conception to completion. Section 4 will cover the lessons learned. Lastly, we will discuss our final thoughts and conclusions based on our experience working on our capstone project throughout our final year of undergrad.

# 2 What Went Well

There were many elements that went well during the course of this project. Firstly, we were able to acquire all our hardware components in a timely manner ensuring we were able to test and verify the compatibility of the components together. This also helped us verify all our parts such as the display screen, raspberry pi, power bank, RFID reader and tags, GPS module, and all required cables were functioning as intended thereby, reducing the chances of any issues that may arise later throughout the project.

Moreover, we had to assemble our license plate together using the 3D casing we had printed to ensure proper functionality and fitment of our components. One of the major concerns was making sure none of the components overheated when fully assembled. This was mainly due to the fact we had always tested our components in an open-air environment as this was the first time, we had integrated the components in a closed space. However, after testing all the components in the casing it was deemed to be viable for our prototype.

Lastly, creating a functioning database using a cloud server that stores information regarding the owner's license plate, license plate sticker, and vehicle's energy consumption was one the main components in this project. We managed to get our prototype to accurately display different license plate numbers along with routine sticker updates for multiple distinct owners. The screen was thus able to display various official provincial plates with the correct font and colors. Thankfully, we were able to accomplish this with very minimal issues despite having no expertise in cloud computing.

# 3 Things That Surprised Us

One of the essential things that surprised us was integrating the cloud with the licence plate. It took much work to manage communication with various components, as each time a request was initiated from a new private IP address, the connection was blocked off. This was due to security reasons, but highly frustrating to add external IPs in the firewall to allow access on campus and other locations. Each time a demo was required for our product, the private IP address needed to be allowed to have access to the database. Also, the Raspberry Pi had issues connecting to the campus Wi-Fi, leading to us using our hotspot for each demo and constantly worrying about the LTE connection on campus. Another surprising thing was how much logic was required at each layer of the license plate. Whether it was the front or back end, each application component had logic and required extra attention as sometimes it would seem as if the application was working, but the test cases would fail, and you would be back to the beginning. Lastly, the amount of research and debugging required to implement the application was overwhelming. Not only were our application processing events in real-time, but it also integrated a notification system for the user. The real-time aspect was the most time-consuming and required extra care before pushing any changes to the main branch of our application.

Another thing that surprised us were the issues we faced in 3D printing our weatherproof casing. When we initially designed the 3D casing, we were unaware of the sizing limitations of the 3D printers at the university. We had initially set out to have them 3D printed at the design studio in SIRC but unfortunately, we found out the casing was too large to be printed. Although we were provided with solutions to outsource the printing at a very premium cost, we however, came up with a solution to split each component of the casing in half essentially creating four pieces. This meant that we would eventually combine the pieces back together via an adhesive.

Furthermore, after having all four parts printed, one of the things that also surprised us was the corners of our casing slightly curling. This was mainly due to the fact that it was such a large piece, the lack of heat and size caused them to curl. We came up with a solution to this by adding supports to each corner of the plate and by doing so, it reduced the curling dramatically and helped create a smoother and aligned finish.

Lastly, there were several things that surprised us when working on this project mainly such, the complexity of the website. The website design and development were more complex than expected at first. We had to ensure that the integration between the website and the cloud databases was smooth, but the connection isn't the only goal as we had to provide the best UI/UX design to ensure that the web application was visually appealing and user-friendly. We didn’t assume the number of programming languages we would have to use to develop a working prototype while integrating a cloud-based database would be this much. The front end consisted of HTML, JavaScript, JSON, and CSS. In contrast, the backend consisted of script written in Python, SQL, and PHP. All this required a lot of planning and effort to bring forth the best of our product. The amount of data that was being stored in the cloud was also surprising because we knew but didn’t consider, the amount of information that would need to be stored for each license plate. Each plate had to be connected to certain details that are required for the user’s information such as owner’s information, energy consumption, customization options, etc., and it all added up quickly.

# 4 Lessons Learned

It is crucial to have a clear idea of the project's total cost and to distribute the resources accordingly because we want to make this as affordable as possible. To do that, it must be a cost-effective product. The amount spent on the project was almost maxed out to the limit, and the more expensive it gets, the less appealing it is to the general public. For it to be more available around Canada, we must ensure we bring the price as low as possible and find alternatives to make that possible. Any project, in general, will require you to be on schedule or ahead of it, and doing things earlier is always better than leaving tasks to the last minute. The deadlines should not be overlooked and should be given the necessary attention to ensure the project is completed on time. We also learned the importance of backing up files and code, as this can prevent the loss of important data if something goes wrong while working on the project. The last piece of consideration could have been to think about the demo and how we presented it. Not having clear guidelines, we had to make sure to include everything that was needed in the final presentation, as the judges are not lenient on what they require, and this also prepares us for the capstone expo, so we can prepare the best we can to market our product in front of multiple judges. By keeping these lessons in mind, we can ensure the success of the ePlate at the capstone expo and aim to win.

Another lesson we learned is to always order spare parts for the projects as we ran into some hiccups during the testing phase and some cables were not able to function accordingly. It is crucial to carefully examine which components are essential to the project's success and, thus, require redundancy when acquiring backup parts for it. These comprise parts that are prone to breaking down, need a significant lead time to replace, or are essential to the operation of the project. Also, it is vital to make sure that the backup components have been verified, configured correctly, and are compatible with the current components before using them. To reduce downtime and avoid project delays, it is also a good idea to keep an adequate supply of replacement parts on hand and to have a plan in place for promptly replacing malfunctioning parts. By taking these steps, we can ensure that we are well-prepared to handle any unexpected failures and can ensure the project’s overall success.

# 5 Conclusion & Final Thoughts

Overall, the connection between the display screen and Raspberry Pi is successfully established via a power bank and will be used to demonstrate our license plate. Moreover, the base template of the license plate has been created for the province of Ontario and will be displayed on our prototype.

The digital license plate was a complex and challenging process that required a great deal of planning, research, and development, all while making sure everything is going smoothly and accordingly. There were many surprises that came throughout the process such as the integration of the cloud to make it real-time and provide notifications for a user, along with the programming languages used to build the functional prototype. We also went through many unexpected challenges during our time working on this project such as managing external IPs, ensuring the real-time event processing, and protecting the sensitive data of a user with the security measures in place. Even with all these obstacles, we were able to successfully develop a working prototype that met the requirements we set in place and given to us, while demonstrating the potential of this product to our advisor and coordinator. There are still many opportunities to improve on this prototype to better the functionality, scalability, and adding more features to this idea. Our capstone project has given us the opportunity to apply our engineering knowledge and fundamentals to use and learn more about innovation and technological advancements. This project has been tremendously exciting to work on and we would like to thank our peers, advisors, and coordinator for helping make this project successful.