# Letter of Transmittal (could be text of an email)

* Addressed to sponsor, interested parties
* Says “here’s an (interim, final) report on the XYZ project”
* Provide appropriate acknowledge for sponsor support

# Cover Page

CS 481

Park-IT-CdA Design Report

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# Executive Summary

Too much time and effort are spent by those looking for a place to park in one or more garages in downtown Coeur d’ Alene. Commuters would benefit greatly from a system that indicates whether there are spaces available for parking within a parking garage. The Garage Sensor System (GSS) will allow people to find open parking spaces, and hopefully provide this information before they enter the garage. The Garage Sensor Units (GSU) will be placed above parking stalls to indicate the status via LEDs; a green light means there is an open stall, where a red means the stall is currently occupied by another  
vehicle. This is not the complete functionality of the system, but rather a level of abstraction for the consumer; the data that is measured/collected, will be distributed from device to device via a mesh network, then sent through a gateway where it will be received at The Den as a means of data collection for possible further research.

A short, powerful synopsis

* Intro sentence: what you are designing
* Needs -> Features of solution -> Benefits
* Pivotal technical and business merits
* Summary of quantitative test results

# Background

* Describe sponsor motivation for the work
* Identify the need/opportunity associated with this project
* Summarize benefits to different stakeholders

# Problem Definition

Park-IT-CdA is a parking garage monitoring system located in Coeur d’Alene, Idaho at the parking garage between 3rd and 4th Avenue and along Coeur d’Alene Avenue. It is capable of detecting when a car is parked in a stall and will relay this information to a server which will monitor the parking garage’s statistics such as: time from entering the garage to finding a stall, average time a stall is occupied, average number of stalls used and the current state of all stalls.

The GSS is comprised of 5 Garage Sensor Units (GSU). The GSUs will decide among themselves which is to be the Garage Sensor Master (GSM).

The deliverables are to be the following:

* 5 GSU’s which includes the enclosure, computer hardware – sensors, LEDs, embedded system.
* 1 Garage Sensor Gateway (GSG) to be installed on the roof of the Innovation Den.
* An archive of the software to run the GSS – Arduino sketches, simulation.
* User manual on how to operate the GSUs and simulation
* The portfolio including all documentation of the requirements, design process, project learning, communications, design solution and references.
* All other documents produced throughout the two semesters.

Constraints:

* $1500 budget
* The GSU must be battery powered and last at least a year without recharging
* The communication between GSUs must be wireless
* Communication must be capable of penetrating concrete and brick walls
* The GSU must be within 4”x4”x4”

# Project Plan

## Team Members

Nikolai Tiong

Roles

* Team Leader
* Mesh network design
* Mesh network testing
* Documentation

Zane Goodrich

Roles

* Sensors for the GSUs
* Hardware design – sensors, power
* Hardware testing
* Documentation

Tyrel Parker

Roles

* Processing received data from GSS
* Simulation Software
* Hardware purchasing
* Documentation

Joel Berain

Joined Spring 2020

Roles

* Organizing the Wiki page
* Getting caught up on the project
* Documentation
* Encryption of messages

# Concepts Considered

## Wireless Transmission

The distance between the garage and the Innovation Den is approximately 400 ft. There is Line of Sight between the second and third floors of the garage to the Den’s rooftop where the GSG will be mounted. The garage is constructed out of concrete which greatly reduces the signal strength of wireless signals. The Den is constructed of out brick which does the same. There is also the power requirement which means the wireless technology used must use low power while still covering the distance required.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Range - Urban | Power Usage (Transmitting) | Frequency | Notes |
| WiFi | 50 m | 2-20 W | 2.4 GHz |  |
| Sigfox | 3-10 Km | 158 mW | 900 MHz | Requires SIM card  Service fee |
| Zigbee | 100 m | 100 mW | 868, 915 MHz, 2.4 GHz | Capable of forming mesh network |
| LoRa | 2-3 Km | 100 mW | 433, 868 – 915 MHz | Capable of forming mesh network |

WiFi has too short of a range and too much power usage.

Sigfox requiring a subscription fee ruled that out.

Zigbee has too short of a range.

## Microcontroller

A microcontroller will be needed as the base hardware due to their low power consumption, low cost and small size.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | Current Usage (Sleep) | Processor | RAM | Storage | I/O Pins | Wireless Module |
| Arduino Uno | 30 mA | AVR 16 MHz | 2 KB | 32 KB | 20 | Separate |
| Arduino Pro Mini | 4.2 uA | AVR 16 MHz | 2 KB | 32 KB | 20 | Separate |
| Arduino MKR WAN 1310 | 104 uA | SAMD21 48 MHz | 32 KB | 256 KB | 20 | LoRa |
| ESP8266 | 20 uA | L106 80 MHz | 32 KB | 512 KB | 16 | WiFi |
| Raspberry Pi | 100 mA | ARM 1.5 GHz | 4 GB | Variable >1 GB | 40 | WiFi |
| Adafruit Feather M0 | 300 uA | SAMD21 48 MHz | 32 KB | 256 KB | 20 | LoRa |

The Raspberry PI and Arduino Uno use too much power to be usable.

Everyone in the group has taken CS443 and is familiar with using the Arduino Uno. We purchased some Arduino Pro Minis first and tested them out. We had mixed results with them with being unable to power them on and upload sketches.

The next board tested was the MKR WAN 1310 which had a built in LoRa board. At this point we had decided on using LoRa with the Radiohead Library. However, upon testing it, it was revealed that the LoRa radio on this board does not support Radiohead.

## Battery

## Enclosure

## Simulation

## Encryption

# Concept Selection

## Wireless Transmission

Of the 4 options considered, LoRa fit the requirements the best. It was capable of the range we needed and used low power. It also made use of the Radiohead library that Dr Shovic suggested that we consider using. We purchased some Adafruit LoRa radio modules and tested them out on Arduino Unos and Megas. This was successful when taken out on a field test between the garage and the Innovation Den, as well as within the garage. Nikolai also found a mesh network implementation that could be used as a base to build upon.

## Microcontroller

The Adafruit Feather M0 was selected as the microcontroller after the plan to use the MKR WAN 1310 fell through. However, this didn’t happen until January 2020 which left little time to obtain and test another board.

## Battery

Due to the difficulty in sourcing a large enough battery, the battery decided upon was a 2500 mAh capacity one. The uptime of the GSU would be timed and then extrapolated to determine how large a battery would be needed to last a year.

## Enclosure

## Simulation

## Encryption

# System Architecture – 2+ pages

Base Unit

Adafruit Feather M0 with RFM95 LoRa Radio – 900 MHz

Features from Adafruit Site: <https://www.adafruit.com/product/3178>

The Adafruit Feather comes with a built in LoRa module capable of running the Radiohead library.

* Describe the conceptual design – justify continued development
* Describe the components and how they are integrated
* Highlight novel features – your “value added”
* Explain how does each major component satisfy requirements

# Design Evaluation – 2 pages

* Analyze DFMEA against project specifications (1-2 page Excel document included in Appendix)

(define scoring rubrics, assess design risks, and summarize key ideas for remediation)

* Explain product testing procedures
* Sustainability assessment
* Provide results from product performance testing

# Future Work

Due to COVID-19, the original design was not implemented. Many features were missing from the final test used for the Expo presentation.

Features Implemented

* Sensing a vehicle using ultrasonic and PIR sensors
* LED indication of parking stall status
* Point-to-point communication over LoRa – 2x GSU to GSG
* Addressing scheme over LoRa
* LoRa message format
* GSG to MQTT communication over internet
* Simulation
* Real Time Clock for timestamps

Features Not Implemented

* Battery requirement was removed and never tested
* Sleep and power usage reduction
* Solar panel and charger were not purchased
* Encryption
* Mesh network – changed at start of Spring 2020 to a star topology network
* Star network – long range communication of 1.25 miles was inconsistent and point-to-point was used

A future group project should start work in the following order:

* Build the star network with multiple GSUs communicating with the GSM
* Synchronize the GSUs so that there isn’t more than one transmitting to the GSM at a time
* Implement the sleep and waking up from an interrupt from the DS3231 RTC
* Implement the encryption module
* Reduce power usage
* Revamp the GSU enclosure and add the solar panel

# Appendices

Supporting documents to long or detailed for main body

* Calculations, drawings
* Large tables, figures
* Computer programs
* Vendor data sheets
* 1-page Project Schedule in Excel (as originally planned at start of project)
* 1-page Project Schedule in Excel (as executed at end of project)
* DFMEA worksheet
* Overview of folder/file organization on shared drive

