Requirements Document
Snow Plow Route Optimization

Donny Brook Software

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Contents

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1 Introduction

1.1 Purpose

This is a Requirements Document for the Snow Plow Route Optimization (SPRO) system requested by the city of Letterkenny's Snow and Ice Control Team (SICT). SICT facilitates the plowing and maintenance of Letterkenny's roads during the winter season (November - April), in addition to informing the public on road conditions. The current system in place is inefficient, leading to numerous hazards and unplowed roads reducing Letterkenny residents' safety and mobility. The SPRO will improve SICT's communication within the organization and with the residents of Letterkenny. The SPRO will overall advance SICT's encouragement of public safety and mobility.

1.2 Project Scope

This document specifies the requirements for the initial version of the SPRO system. The SPRO software provides a centralized system for the SICT to efficiently carry out plowing and maintenance of Letterkenny's roads during winter. The SPRO consists of three platforms to benefit each of its primary users: snow plow drivers, SICT dispatch, and residents of Letterkenny.

The SPRO is managed by the dispatch, who develop and send out routes to snow plow drivers, and inform Letterkenny residents on the status of road safety. The SPRO utilizes traffic and weather data to estimate their impact on road conditions, and to assist with planning snow plow routes. Additionally, the SPRO will provide Letterkenny residents a system to report road hazards to the SICT and, the ability to track real-time snow plow locations to accurately view maintenance progress. Above all, the SPRO will assist the city of Letterkenny with maintaining function during winter conditions.

1.3 Glossary of Terms

Term	**Definition**
SICT	Snow and Ice Control Team, department of the city of Letterkenny responsible for managing roads during winter conditions
SPRO	Snow Plow Route Optimization, proposed software to be used by SICT
Environment Canada	Department of the Government of Canada responsible for forecasting daily weather conditions and warnings
API	Application programming interface, a set of tools used to specify the interaction of software components.

1.4 References

[1] "Traffic Safety Act," *Province of Alberta,* Dec. 2018
http://www.qp.alberta.ca/documents/Acts/t06.pdf

[2] "Web Content Accessibility Guidelines," *World Wide Web Consortium*, Jun. 2018
https://www.w3.org/WAI/standards-guidelines/wcag/

[3] "Google Maps Platform Documentation," *Google Developers* [Online], 2020
https://developers.google.com/maps/documentation

[4] "Weather data, research and learning", *Environment Canada* [Online], May 2018
https://www.canada.ca/en/environment-climate-change/services/weather-general-tools-resources/weather-tools-specialized-data/free-service.html

1.5 Overview

This requirements document provides an overall description which consists of the Product Perspective, Product Features, User Classes and Characteristics, Operating Environment, Design and Implementation Constraints, and Assumptions and Dependencies. The requirements document then discusses the System Features, which analyzes the functional requirements of the three main user-interfaces (Driver, Dispatch, Public), and processes including Route Tracking and Management, and Submitting Reports on snowfall and hazards. The requirements document then outlines the External Requirements for User Interfaces, Hardware Interfaces, Software Interfaces, and Communication Interfaces. The requirements document then discusses other Non-Functional Requirements such as Performance, Safety, Security, and Software Quality requirements. Finally, the requirements document contains an Appendix list noting issues to be further analyzed.

2 Overall Description

2.1 Product Perspective

The SPRO will replace the current paper and radio-based snow plow organization system that SICT currently uses. Currently, dispatchers choose routes (pre-existing or new), and assign these routes to drivers via a paper map. The SPRO would digitize this system, in addition to providing a variety of other functions to dispatch, drivers and Letterkenny residents. The SPRO will provide drivers with directions and route maps. Currently, in order to report road conditions to SICT, Letterkenny residents must phone a dispatcher on duty, then the dispatcher will inform the nearest driver to handle the hazard accordingly. The SPRO streamlines the process by providing an interface for citizens to report hazards and for dispatch to efficiently communicate such hazards to drivers.

2.2 Product Features

The SPRO contains three interfaces: dispatch, driver and Letterkenny residents (public). The driver interface runs on a mounted tablet in the snowplow. It provides mapping and directions to the driver, in addition to allowing dispatch to update the routes. Within the driver interface, a route tracking system guides drivers along their route. The public interface provides residents with the status of road conditions

and allows users to submit hazards and requests for service. The hazard reports that are submitted are then analyzed by dispatch, who make necessary changes to routes. The dispatch interface is run on desktop computers, it provides dispatchers with all reported hazards, weather reports, and current routes. The dispatch interface includes route organization which lets dispatchers create and modify routes and then assign them to drivers.

2.3 User Classes and Characteristics

SPRO has three classes of intended users: Letterkenny residents (public), drivers, and dispatchers. Dispatchers and drivers should be the most important to satisfy as this is primarily a work organization system. The SPRO will satisfy Letterkenny residents by providing the snowplows' real-time locations and routes, in addition to improving the hazard reporting system. For the majority of use, all users are expected to have access to the internet when using the system.

2.3.1 Dispatchers

Dispatchers are responsible for coordinating SICT's snow plow drivers and communicating with the public. In Letterkenny, there is a dispatcher on duty 24/7 during the winter months (November - April). Dispatchers work on desktop computers in the city of Letterkenny municipal office. All dispatchers have at least a high school education and are familiar working with computers. When implementing the new system, training will be provided to the dispatchers. Dispatchers will use the SPRO daily to complete the majority of their work duties. Each dispatcher is assigned individual login credentials. Dispatchers primarily use the dispatcher interface, however they would be able to access the public interface on personal devices.

2.3.2 Drivers

Drivers would interact with the SPRO daily via the in-plow computer. Like dispatchers, all drivers have high school education but they do not use computers in their current duties. Training would be provided to familiarize drivers with using the SPRO. Drivers access the interface using their individual login credentials. Drivers will only have access to the driver system on the in-plow computers. Drivers would be able to use the public interface on their personal devices.

2.3.3 Public

The public - namely Letterkenny residents - will use the SPRO via their personal computer or mobile device. Most users would use the SPRO in the winter, mostly aligning with heavy snowfalls. Residents will use the public interface to receive information on road conditions and report road hazards. It should be assumed that most citizens have minimal expertise in technology so the public interface must be user friendly and easy to understand. Citizens should not have access to either the dispatch or driver interface.

2.4 Operating Environment

The SPRO requires an internet connection for all platforms to ensure all information is effectively communicated between users. However, the driver platform should still provide turn-by-turn navigation if temporarily disconnected from internet connection.

In the SICT headquarters, dispatchers use iMacs with 2.3Ghz Dual Core Intel i5 processors, 8GB of RAM, and 1TB Fusion Drives. These iMacs currently have macOS Catalina 10.15.2 installed. The dispatcher interface would run on the latest version of Safari on these machines. In each snow plow there are Qualcomm Snapdragon 850 mobile computer platforms that the SPRO would run on. They have built-in LTE connectivity, 4GB of RAM, a 128GB SSD and a touchscreen.

Letterkenny residents use mostly Windows and Macintosh computers and can access the new interface on a variety of internet browsers including Google Chrome, Safari and Firefox. Citizens can also use the public interface application on their mobile phones. Android and iOS phones are most popular in Letterkenny. It can be assumed that citizens have internet access when accessing SPRO.

2.5 Design and Implementation Constraints

The SPRO must run on the computers and operating systems outlined in section 2.4. The new system must source weather data from Environment Canada for predicting weather conditions. Map visuals and navigations will use Google Maps' API. The driver platform must conform to the policies outlined in the Alberta Traffic Safety Act [1]. In accordance with this legislation, the nature of the driver interface must require minimal input while the snow plow is in motion.

The SPRO must operate in English and employ a user-friendly interface to be accessible by persons of all abilities. The public platform must conform to Level A of the Web Content Accessibility Guide (WCAG) to ensure usability for all citizens of Letterkenny [2].

When a user submits a hazard request, their personal information (name and contact information) is private, unless dispatch deems it necessary to follow up. Only dispatch should be able to access the user's name and contact information. User's personal information is removed five days after submitting a report.

The current snow plow routes will be inputted by dispatch into the SPRO. SICT employees must have login credentials to access their platforms. Drivers may only access their platform through the in-plow computer. Drivers and citizens should not be able to access the dispatch system. The public interface does not employ user accounts.

Donny Brook Software is responsible for any technical issues with the SPRO. However, Letterkenny's own Information Technology team is responsible for network maintenance.

2.6 Assumptions and dependencies

The SPRO's navigation will rely on the Google Maps API to plan routes based on real-time traffic data [3]. Dispatchers will develop routes to prioritize highly-trafficked roads. The driver interface additionally uses the API for directing drivers along their routes.

Weather data will be sourced from Environment Canada's weather server [4]. This weather data includes average, predicted, and actual snowfall, current and predicted temperature, and any current or predicted weather warnings.

It was assumed that all dispatchers and drivers have at least a high school education. Dispatchers are computer-literate, as they use computers in their current duties. Drivers are assumed to have low familiarity, as they have not been trained to use computers. Users are also assumed to have low familiarity to ensure ease of use. The SPRO is assumed to be compatible with all hardware used by SICT. It was assumed that Mac and Windows operating systems are the most popular in Letterkenny along with popular internet browsers to be Google Chrome, Safari, Firefox.

3 System Features

3.1 Driver Interface

3.1.1 Description and Priority

The driver interface is the primary method used by drivers to interact with dispatch. The interface is displayed to the driver on a dash-mounted tablet. This feature is high priority as there would be no way for drivers to see their route without it.

3.1.2 Functional Requirements

REQ-1-1: The driver should be able to see their current route (in map form).

REQ-1-2: The driver should receive turn-by-turn navigation from the interface (both on the screen and audio form).

REQ-1-3: The displayed route should update automatically when a change is made by dispatch.

REQ-1-4: The interface should display non-critical notifications such as the current weather.

REQ-1-5: The interface should continue providing turn-by-turn navigation even if the tablet is temporarily disconnected from the internet.

REQ-1-6: The interface should warn the driver when connection to dispatch is lost.

REQ-1-7: The tablet should report its GPS location and systems status to dispatch.

REQ-1-8: The interface should receive a new route from dispatch when the current one is finished, or request a new one if there is not one in the queue.

3.2 Route Tracking

3.2.1 Description and Priority

Route tracking is a feature offered in the driver interface. It shows the driver their current route & position, and provides turn-by-turn navigation to guide them through the route. This feature is high priority because it provides drivers with their routes.

3.2.2 Functional Requirements

REQ-2-1: A map of the city and the route should be displayed on the interface.

REQ-2-2: The driver's next turn should be displayed on the interface.

REQ-2-3: The tablet app will collect map and navigation data from Google Maps.

REQ-2-4: The tablet app will collect GPS position data from the tablet's GPS module.

3.3 Public Interface

3.3.1 Description and Priority

The public interface is a website which provides citizens with information about the status of roads in the city. It also offers users a way to submit reports about road status or request that a specific road be serviced.

3.3.2 Functional Requirements

REQ-3-1: The website should display a map of the city that shows which roads have been plowed, which roads will be plowed in the future, and which roads are not planned to be plowed.

REQ-3-2: The website should provide a way to submit reports about road hazards such as fallen trees or car accidents.

REQ-3-3: The website should provide a way to request that a specific road or set of roads be plowed

REQ-3-4: The website should provide a way to view other approved user reports in an area (to help prevent duplicate reports)

3.4 Submitting Reports

3.4.1 Description and Priority

Snowfall and hazard reporting is the main way users interact with the system besides viewing snow plow routes. Reports will have an impact on the way dispatch designs routes. This feature would be medium priority, as dispatch would still be able to formulate routes without user reports but the accuracy and priority of these routes might not be mapped as well as they could be.

3.4.2 Functional Requirements

REQ-4-1: Users should be able to submit reports by phone call.

REQ-4-2: Users should be able to submit reports by e-mail.

REQ-4-3: Members of the public should be able to submit reports by web interface.

REQ-4-4: All types of reports should be collected into lists to be analyzed by dispatch.

REQ-4-5: When possible, submitted reports should be formatted to display on a map.

REQ-4-6: Detecting spam (multiple requests from one source).

REQ-4-7: Group reports by location, modifying priority.

REQ-4-8: The public interface is not available 5 months of the year (May - October).

3.5 Dispatch Interface

3.5.1 Description and Priority

The dispatch interface is the primary means of how dispatch interacts with the system. The interface will be used on computer monitors in headquarters. This feature is high priority as routes will never be mapped without input from dispatch.

3.5.2 Functional Requirements

REQ-5-1: Dispatch should be able to view and interact with lists of reports; play audio if submitted by phone call, read if e-mail or web interface.

REQ-5-2: Snow plow information should be streamed into view in real time.

REQ-5-3: Weather reports should be streamed into view in real time.

REQ-5-4: User reports should be pinned to a map according to reported location.

REQ-5-5: Dispatch should be able to draw route plans.

REQ-5-6: Able to edit generated snow plow routes.

REQ-5-7: Able to adjust individual snow plow routes in real time.

3.6 Route Management (auto generation)

3.6.1 Description and Priority

Dispatch will have a variety of tools and options to form snow plow routes and publish them to drivers. The system should also be able to auto correct mistakes and update routes to drivers when they complete a route or unexpected rerouting occurs. This feature is high priority as routes will not be published without the route management system.

3.6.2 Functional Requirements

REQ-6-1: Update route plan to safely adjust back to original if a driver takes unexpected actions.

REQ-6-2: Generate a route plan based on compiled data which is able to be edited before publishing.

REQ-6-3: Gather weather data at the time to accurately predict problematic areas.

REQ-6-4: Gather road and traffic data to decide priority of roads in a route.

REQ-6-5: Generate summary report of where snow plows covered during the day.

REQ-6-6: If a snowplow becomes inactive for any reason, notifies dispatch and gives a suggested route, dispatch confirms, and adjusts other snow plows to cover.

4 External Interface Requirements

4.1 User Interfaces

4.1.1 Dispatch

The dispatch interface begins with a log-in page in order to securely access the dispatch information. The main component will be a map of Letterkenny with an overlay of snow plow routes, driver locations, snowfall levels [4], and pinpoints locations. In this component, additional weather information [4], traffic

data [3], and unlocated user reports will be displayed alongside the map to keep dispatchers informed. The snow plow routes will be broken into categories consisting of current roads being plowed, roads that have already been plowed, roads that have been planned, and roads that have not been assigned to be plowed. The user reports will be categorized based on priority level. All overlay objects on the map will have a legend on the page that allows for the objects to be toggled on and off.

Within this component, two buttons will be implemented to create and modify snow plow routes. The “create” button will produce a new pop-up menu that gives dispatchers the ability to draw snow plow routes directly on the map or select from a list of predetermined routes. When the route is complete, the dispatcher will be provided driver information on a list to use to assign the route appropriately. The “modify" button allows the dispatcher to select a route on the map and modify it using the same drawing tool or list of predetermined routes. Once a route has been created or modified, it will be sent to the assigned driver and the map will be updated to reflect the change.

The SPRO requires a component for dispatchers to interact with public reports. This component will be a list of public generated reports that can be filtered based on priority and location. Dispatchers can select a report to create a pop-up that displays the entire contents of the form along with a “delete” button to remove the report if they believe it to be spam. When a user calls or emails a report, the component contains a “generate report” button that produces the report form used by public users that dispatchers manually fill in. If any required information is missing, an error message will appear and redirect them to the form and highlight the input field with missing information.

4.1.2 Drivers

The drivers will have a touch-screen interface that is simple and intuitive to use based on their limited computer experience. The main component on the screen will display the driver’s current location and snow plow route on the map. Pin-pointed user reports and current weather conditions will also appear on the map as small icons. The screen uses touch input to transverse the map and interact with user and weather reports. Touching a user or weather report icon will provide a pop-up box with detailed information. These can be dismissed easily by touching outside the box.

The driver will have voice and on-screen navigation for their current route. The voice will also provide alerts alongside a small notification pop-up when situations outlined in section 3.1.2 occur. The voice will notify the user when a current route is complete and directly upload the new route for navigating.

4.1.3 Public

The main public interface will be a map of Letterkenny with an overlay of snow plow route. There will be a legend indicating current roads being plowed, roads that have been plowed, roads that have been planned, and roads that have not been assigned to be plowed. The user will have the ability to toggle the different types of routes on and off.

On this main interface, there will be a button to report any hazardous conditions. Pressing this “report” button will produce a form of questions that help the user describe the issue. When the form is complete, a user will have the option to include contact information in an input field in order to be notified by clicking a “notify me” button. Clicking the “submit” button will send the report to dispatch. If any required information is missing, an error will pop up indicating missing information and redirect the user to the form with the highlighted input field with missing input.

On both the map and report interfaces, there will be a “help” function that explains the features of the site.

4.2 Hardware Interfaces

4.2.1 Dispatch

The dispatch SPRO interface will be run on iMacs, with 2.3Ghz Dual Core Intel i5 processors, 8GB of RAM, and 1TB Fusion Drives. The iMacs communicate with other interfaces using the office’s wifi. Data from user reports and drivers will be transmitted through the internet via TCP. To communicate directly with the drivers, an existing two-way radio system is used. In addition, dispatch will have a landline to communicate with public users who phone-in to submit a report. The radio and landline are already in place and are not considered part of the SPRO.

4.2.2 Drivers

Drivers use a two-way radio to communicate directly with the dispatcher. In the vehicle, there is a built-in computer, with a Qualcomm Snapdragon 850 processor with built-in LTE connectivity, 4GB of RAM, 128GB SSD, and a touchscreen. The LTE network will be used to receive and transmit data between the drivers and dispatch as well as send the driver’s location via TCP.

4.2.3 Public

The public facing web application must be supported on iOS and Android phones and tablets in addition to personal computers. The public user must have access to the internet in order to use the view the map and submit reports. When submitting reports, there is an option of sharing their location, which would require either a user to have GPS capabilities on their device. If the public users do not want to use the web application to submit a form, there is still an option to phone dispatch.

4.3 Software Interfaces

4.3.1 Dispatch

The dispatch interface will be implemented as a web application accessed by the dispatch computers. The web application includes a GUI that is designed to be easy to learn and to use by dispatchers without a technical or software background. The application includes the use of a NoSQL database, which can be easily scalable for future projects and provide sufficient latency for communication within the system. The database stores snow plow route information, user reported hazards, and dispatch hazard reports. The dispatch interface transfers snow plow route information to the driver interface. The dispatch interface additionally transfers snow plow route information, snow plow location, and road clearing status to the public interface. The dispatch interface communicates with the other interfaces over the office’s WiFi network.

4.3.2 Driver

The driver interface imports the snow plow route assigned by dispatch with the Google Maps API. The driver interface then shows the driver’s route on the app, displayed by Google Maps SDK API for Android. The driver interface keeps track of the road clearing history (the actual route that the driver has plowed, regardless if it is the same as the route given). The driver interface sends location and road clearing history to both the dispatch and public interfaces periodically (at least every 30 seconds and 5

minutes, respectively). The driver interface communicates over an LTE network.

4.3.3 Public

The public interface is a web application that supports all modern browsers (Chrome, Firefox, Edge, Safari). The web app uses the Google Maps Javascript API to display the map of Letterkenny overlaid with data from the system's NoSQL database and the real-time information from the driver interface. This overlaid data includes snow plow location and information, road clearing status, and routes to be plowed. The public interface does not collect any data except for user reports.

4.4 Communications Interfaces

All communication to/from external terminals as well as between interfaces is done over TCP. Further information on all communication is described here.

4.4.1 External Terminals

All three interfaces use data from Google Maps. This communication is done through the respective Google Maps APIs, described in section 4.3. The dispatch and driver interfaces also use weather information from Environment Canada, described in section 2.6.

4.4.2 Dispatch and Drivers

Currently, dispatch and drivers communicate only via two-way radio, which will remain in place as is. The SPRO will add communication from dispatch to either specific or all drivers. As mentioned in section 3.4, the messages will be inputted through an electronic form on the dispatch interface, and shown as notifications on the driver interface.

4.4.3 Dispatch and Public

The public interface and dispatch interface access the same database. Both interfaces use the following data from the database: road clearing status, and routes to be plowed. The dispatch also uses more information: staff information, snow plow information, and user reports. Public users can submit these user reports through an electronic form, which is written into the database.

The public interface must be lightweight enough to run with the existing hardware in the office (see section 2.4). Since the public interface requires slower update time, the server will poll from the Google Maps API, and update the map on the web page every five minutes.

5 Other Non-Functional Requirements

5.1 Performance Requirements

The dispatch system receives data from Google Maps every 30 seconds. This is done over the office's WiFi network. The dispatch system is not expected to handle heavy load, but should be able to receive 500 user reports daily and manage all snow plows without noticeable delay to the user.

The driver interface communicates more frequently over LTE, less than every 5 seconds as part of its navigation feature. The navigation feature must be close to "real-time" as it should direct drivers along

their route as they are driving.

The public interface receives data every five minutes. From the elicitation, since the likelihood of drivers following their routes is high, seeing the routes of the snow plow should be sufficient and should overshadow the slower update time of the snow plow location. Up to 10,000 users must be able to access the website at the same time without noticeable delay to the user.

5.2 Safety Requirements

Alberta's Traffic Safety Act [1] outlines that individuals cannot hold, view, or manipulate any electrical communication device while driving. Individuals can only use the device when safely pulled off at the road and at a complete stop or in hands-free mode. To ensure this act is upheld, users must confirm that they are not driving before submitting a report. Snowplow drivers' computers are secured to the vehicle allowing hands-free use of the device. The exception to this regulation is the use of 2-way radio devices for the purpose of maintaining communication of a driver who requires the communication to perform their job duties. This allows for the snow plow drivers to use their radio to communicate with dispatch.

5.3 Security Requirements

Each driver has their own secure login (company assigned username and password) which they use to login to the snow plow computer before they start driving. Dispatch workers have their own secure login (company assigned username and password) to login on the dispatch computers. There is no authentication from public users, and the public interface does not take any personal data. As per the client meeting, the SICT has their own security system that holds wage, schedule, personal information, which we can use for employee login information. The SICT security system is external to the SPRO; the SPRO only provides authentication for the driver and dispatch interface.

5.4 Software Quality Attributes

Being a government project, the public facing web pages must be in accordance with Alberta's government websites accessibility guidelines. The guidelines used are the Web Content Accessibility Guidelines of the Worldwide Web Consortium [2], which outline that the website must be accessible to visually impaired users using a screen reading software and navigate without a mouse.

In terms of availability, the public interface must be closed during the summer or non-snowfall time to prevent unrelated user reports being generated.

Due to lack of software knowledge within the City of Letterkenny's staff, the system must require little or no maintenance. Any network issues can be fixed by their information technology department, but bugs within the software will be reported to Donny Brook's development team.

Appendix: Issues List

Issue 1 - State Diagram For Route Assignment

Before the design stage, it will be important to receive and discuss a state diagram regarding the automation of route assignment, which will include all states the driver and dispatch could be in with regards to route assignment, and the transitions between states. An example of what could be described by

the state diagram is:

- What does the driver interface show when the driver goes off route? And is any change to the route in this scenario automated or must it be approved by dispatch?

This was discussed briefly in the elicitation meeting, and we have a good idea of what the transitions and states are. However, we consider this a significant area to clear up before we can design the system.