Requirements Specification Document
Snow Plow Route Optimization

Donny Brook Software

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Revision History

Name	Date	Reason for Changes	Version
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1 Introduction

1.1 Purpose

This is a Requirements Specification Document (RSD) 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

[5] "10 Codes Communication Guide," *Quality Two-Way Radios* [Online], 2020
https://quality2wayradios.com/store/Radio-Ten-Codes

1.5 Overview

This RSD 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 RSD 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. This document also details all use cases associated with each system feature. The RSD 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. There are often delays in the current system, leading to many hazards not being dealt with for long periods of time.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, one full day 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. One full day training session 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. These run Android 8.0 operating system.

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 web 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 French, 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. We aim to respond to any reported issues within the hour during working hours. At that time, Donny Brook will be able to provide an estimated completion time to the city Letterkenny. 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. The public interface should support the following operating systems: Windows 10, macOS 10.14+, Android 6.0+, and iOS9+. Additionally, it should support use on Google Chrome, Safari, and 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 overlaid on the city map.

REQ-1-2: The driver should receive turn-by-turn navigation from the interface on the tablet screen.

REQ-1-3: The driver can optionally receive turn-by-turn navigation in voice form (toggleable from the tablet interface).

REQ-1-4: The displayed route should update automatically when a change is made by dispatch, and notify the driver of the change.

REQ-1-5: The interface should display non-critical notifications such as the current weather.

REQ-1-6: The interface should continue providing turn-by-turn navigation even if the tablet is temporarily disconnected from the internet.

REQ-1-7: The interface should warn the driver when connection to dispatch is lost.

REQ-1-8: The tablet should report its GPS location and systems status to dispatch.

REQ-1-9: The driver can choose whether their GPS location is visible on the public interface.

REQ-1-10: 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.

REQ-1-11: The interface items are large enough to be viewed at a glance. The driver should not have to look at the display for more than 1-2 seconds to gain the information they need.

REQ-1-12: The tablet app will collect map and navigation data from Google Maps.

REQ-1-13: The tablet app will collect GPS position data from the tablet's GPS module.

3.1.3 Use Cases

Table 1. UC-1-1

Use Case: DisplayRoute
ID: UC-1-1
Brief Description: The driver's current route will be displayed on a virtual map on the screen. The driver can interact with the map to reveal more information.
Actor(s): 1. Driver
Preconditions: 1. The driver interface has received the driver's route from dispatch. 2. The driver interface is open to the navigation page. 3. The driver has logged in to the driver interface. 4. The driver's tablet is connected to the internet.
Main Flow: 1. As the Driver is driving and following the assigned route, audio directions are spoken, and turn-by-turn navigation steps are shown visually. 2. The Driver presses the "Zoom Out" button, revealing the whole route overlaid on the map of Letterkenny. 3. The Driver presses the "Recentre" button, again showing the Driver's location as they drive and follow their route. 4. include(DriverReceivesNotification) 4.1. The Driver receives a notification from Dispatch, shown as a banner across the top of the screen. It disappears after 5 seconds. 4.2. If Dispatch modifies route, Driver's navigation directions are updated 5. The Driver finishes their route. 5.1. If there is a new route assigned: 5.1.1. Show the new route on the same navigation page. 5.2. Else: 5.2.1. Indicate that there is no route assigned. Navigation will not display driving directions.
Postconditions: None.
Alternative Flow(s): a. OffRoute b. LostInternetConnection c. LostGPSConnection

Table 2. UC-1-2

Use Case: ToggleDriverLocationOnPublicInterface
ID: UC-1-2
Brief Description: The driver toggles their snow plow location visibility on the public interface.
Actor(s): 1. Driver
Preconditions: 1. The driver interface has received the driver's route from dispatch. 2. The driver interface is open to the navigation page. 3. The driver has logged in to the driver interface. 4. The driver's tablet is connected to the internet. 5. The driver is pulled over or parked.
Main Flow: 1. The Driver presses the *Share Location with Public Interface* toggle. 1.1. If *Share Location with Public Interface* == ON: 1.1.1.*Share Location with Public Interface* = OFF 1.2. Else: 1.2.1.*Share Location with Public Interface* = ON
Postconditions: 1. The snow plow location is visible on the public interface if the *Share Location with Public Interface* toggle is on. 2. The snow plow location is not visible on the public interface if the *Share Location with Public Interface* toggle is off.
Alternative Flow(s): a. LostInternetConnection b. LostGPSConnection c. OffRoute

Table 3. UC-1-1-a

Alternative Flow: LostInternetConnection
ID: UC-1-1-a
Brief Description: Driver interface loses internet connection and Dispatch is notified
Actors: 1. Driver 2. Dispatch
Preconditions: 1. Driver loses internet connection.
Alternative Flow: 1. Driver interface displays 'Lost Internet Connection' on top of interface 1.1. Driver still receives navigation with GPS connection 2. Pop-up appears on Dispatch Interface indicating information on disconnected plow and Driver 2.1. Includes last known location, assigned route, Driver name 3. Snow plow location displayed on dispatch interface map with a badge indicating duration of lost connection
Postconditions: 1. Dispatch is notified that driver cannot communicate through interface 2. Dispatch and Driver use 2-way radio communication

Table 4. UC-1-1-b

Alternative Flow: LostGPSConnection
ID: UC-1-1-b
Brief Description: Dispatch is notified of Driver interface's loss to GPS connection.
Actors: 1. Driver 2. Dispatch
Preconditions: None.
Alternative Flow: 1. While Driver does not have GPS connection 2. Full screen overview of uncompleted route and directions displayed on Driver interface 3. If no internet connection: 3.1. Driver interface speaks "Lost GPS and Internet connection: Please use radios for communication" 4. Dispatch interface notified of snow plow's information with a popup 4.1. Last location, driver information, remaining route directions
Postconditions: 1. Driver follows list of navigation instructions until reconnected

Table 5. UC-1-1-c

Alternative Flow: OffRoute
ID: UC-1-1-c
Brief Description: The Driver deviates from the planned route and is automatically navigated back to the original route.
Actor(s): 1. Dispatch 2. Driver
Preconditions: 1. Driver has gone off route.
Alternative Flow: 1. Dispatch is notified with Driver's information 2. Dispatch may modify route 3. The system automatically calculates a route to efficiently direct the driver to the location where the Driver deviated from the original route. 4. System plays an audio sound indicating to the Driver the route has changed. 5. Driver receives directions and the visual route on the system to navigate to the previous location.
Postconditions: 1. The Driver is navigated to the last position on the original route, where the driver continues to follow the route.

3.2 Public Interface

3.2.1 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.

3.2.2 Functional Requirements

REQ-2-1: 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-2-2: The website should provide a way to submit reports about road hazards such as fallen trees or car accidents.

REQ-2-3: The website should provide a way to request that a specific road or set of roads be plowed.

REQ-2-4: The website should provide a way to view other approved reports in an area (to help prevent duplicate reports).

3.2.3 Use Cases

Table 6. UC-2-1

Use Case: UserChecksRoadConditions
ID: UC-2-1
Brief Description: Member of the public views road conditions of a particular road in Letterkenny.
Actor(s): 1. Member of the public (user)
Preconditions: 1. User has the SPRO website open. 2. User's device is connected to the internet.
Main Flow: 1. User navigates the map, using 'Zoom In' and 'Zoom Out' buttons, to a particular road. 2. User clicks on the particular road. 3. A small pop-up appears over the selected road displaying: 3.1. the time it was last plowed 3.2. the estimated time of the next plow 3.3. current status of the road (clear, drive with caution or unsafe) 4. User clicks anywhere else on screen. 5. Pop-up closes.
Post Conditions: None.
Alternative Flows: None.

Table 7. UC-2-2

Use Case: UserChecksHazardReports
ID: UC-2-2
Brief Description: Member of the public views a particular road hazard in Letterkenny.
Actor(s): 1. Member of the public (user)
Preconditions: 1. User has the SPRO website open. 2. User is connected to the internet. 3. There are current active hazards.
Main Flow: 1. Hazards are identified by a red arrow pointing to the hazard location. 2. User navigates to a particular hazard, using ‘Zoom In’ and ‘Zoom Out’ buttons on the map. 3. User clicks on the red arrow. 4. A small hazard window pops up right above the hazard location giving: 4.1. the hazard description 4.2. the rated severity 4.3. an estimated time it will be dealt with 5. User clicks anywhere else on the map. 6. Hazard pop-up closes.
Post Conditions: None.
Alternative Flows: None.

Table 8. UC-2-3

Use Case: UserChecksSnowplowLocations
ID: UC-2-3
Brief Description: Member of the public views snowplow locations
Actor(s): 1. Member of the public (user)
Preconditions: 1. User has the SPRO website open. 2. User is connected to the internet. 3. There are current active snowplows.
Main Flow: 1. Snow Plows are indicated by moving blue snow plow icons on the map. 2. These snow plow icons update using the snow plow's GPS coordinates. 3. User navigates the map to click on an individual snow plow icon. 4. Route that the snowplow has covered in the last 2 hours turns blue and the route that the snowplow will cover in the next 2 hours turns white. 5. User clicks anywhere else on the map. 6. The white and blue overlay disappears.
Post Conditions: None.
Alternative Flows: None.

3.2.4 Use Case Diagram

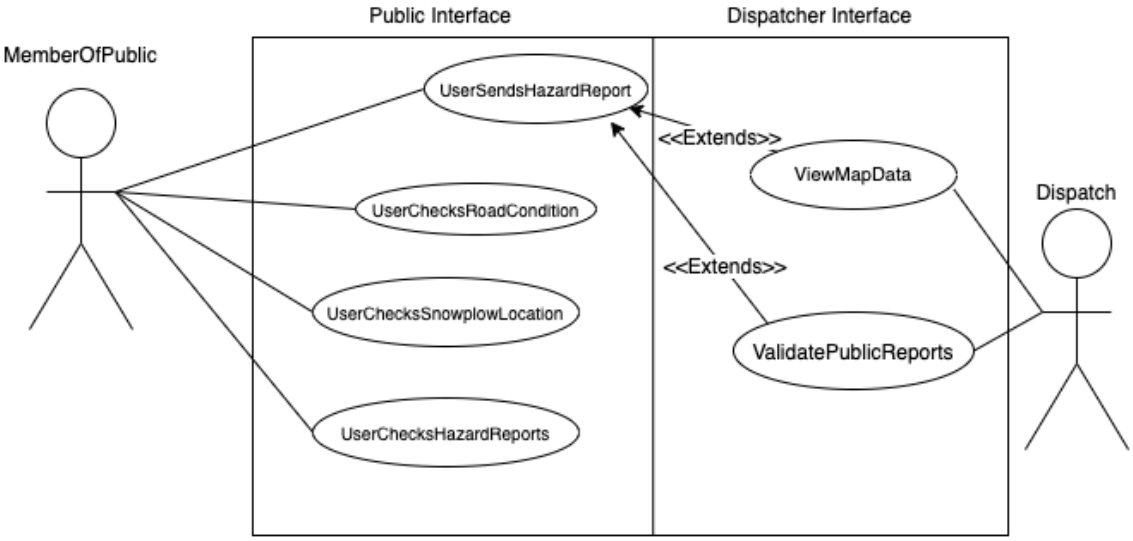

Figure 1. Use case diagram for the public and dispatcher interface.

3.3 Submitting Reports

3.3.1 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.

3.3.2 Functional Requirements

REQ-3-1: Members of the public should be able to submit reports by the web interface.

REQ-3-2: All types of reports should be collected into a report list to be analyzed by dispatch.

REQ-3-3: Submitted reports should automatically include GPS data of submitters location, option to include additional location information.

REQ-3-3: If location data attached, submitted reports should be processed to display on a map.

REQ-3-4: Detecting spam (multiple requests from one source).

REQ-3-5: The system will group reports by location, with reports from the same area (from different users) increasing the priority of the area.

REQ-3-6: The public interface is not available 5 months of the year (May - October).

3.3.3 Use Cases

Table 9. UC-3-1

Use Case: UserSendsHazardReport
ID: UC-3-1
Brief Description: Member of the public creates a hazard report.
Actor(s): 1. Member of the public (user)
Preconditions: 1. User sees a hazard within the city of Letterkenny. 2. User has the SPRO website open. 3. User is connected to the internet.
Main Flow: 1. User selects ‘Add Hazard Report’ button. 2. A new pop-up overlay within the website opens. 3. User inputs location data (either using the device’s current location or via a text field). 4. User inputs hazard description (400 characters maximum). 5. User presses the ‘Submit’ button. 6. The screen changes to say ‘Submitted! Thank you for keeping Letterkenny safe and sound.’. 7. The pop-up disappears returning back to the SPRO website main page.
Post Conditions: 1. The hazard report is sent to dispatch.
Alternative Flows: UC-3-1-a UserCancelsHazardReport UC-3-1-b UserSendsHazardReportContactInfo

Table 10. UC-3-1-a

Alternative Flow: UserCancelsHazardReport
ID: UC-3-1-a
Brief Description: The user cancels the Hazard Report form.
Actor(s): 1. Member of the public (the user)
Preconditions: None.
Alternative flow: 1. The User can cancel a hazard report at any time. 2. The User selects the 'Cancel Report' button. 3. Screen displays 'Hazard Report Canceled'. 4. User is returned to the SPRO website main page.
Postconditions: 1. The hazard report is *not* sent to Dispatch.

Table 11. UC-3-1-b

Alternative Flow: UserSendsHazardReportContactInfo
ID: UC-3-1-b
Brief Description: Members of the public can create hazard reports and input contact information for follow up.
Actor(s): 1. Member of the public (the user)
Preconditions: 1. User starts filling out the contact information section of the 'Add Hazard Report' section.
Alternative Flow: 1. The alternate flow begins when the user fills out either 1.1. Their phone number (must be 10 characters) 1.2. Their email address 2. When either field is filled out, the field value is automatically checked for validity. Only one field may be filled out. Once a phone number is filled out, the email address field is grayed out. When the email address field is filled out, the phone number field is grayed out. 3. The 'Submit' button is pressed.
Post Conditions: 1. The hazard report is sent to dispatch. 2. Dispatch then sends an automated email or phone call based on the user's preferred contact information, updating the user that the report was either validated or invalidated. If the report was validated it also provides an estimated time that the hazard will be dealt with.

3.4 Dispatch Interface

3.4.1 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.

3.4.2 Functional Requirements

REQ-4-1: Snow plow information should be streamed into view in real time.

REQ-4-2: Weather reports should be routinely gathered and streamed into view in real time.

REQ-4-3: User reports should be pinned to a map according to reported location.

REQ-4-4: User reports should be viewable in a list format from newest to oldest.

REQ-4-5: Dispatch should be able to draw route plans.

REQ-4-6: Able to edit generated snow plow routes and publish in real time.

REQ-4-7: Interface displays how long ago a street was plowed.

3.4.3 Use Cases

Table 12. UC-4-1

Use Case: ValidatePublicReports
ID: UC-4-1
Brief Description: The dispatcher can view and validate public reports. Validated reports will be added to the system.
Actor(s): 1. Dispatcher
Preconditions: 1. There is at least one submitted report in the queue which has not yet been approved
Main Flow: 1. The dispatcher sees the user-submitted report in the queue. 2. The dispatcher clicks on the report, showing a detailed version as a popup. 3. The dispatcher can choose to either reject or accept the submitted report. 4. If the report was accepted: 4.1. The information from the report will be used to auto-fill the “new report” form (on the dispatcher side, separate from the user reports). 4.2. The dispatcher can modify the information in the form. 4.3. Once the dispatcher is satisfied with the form, they can submit it. 5. If the user who submitted the report provided contact information: 5.1. The user will be notified of whether their report was accepted or rejected.
Postconditions: 1. A new internal report is created in the system. 2. The report icon appears in the appropriate location on the dispatcher’s map. 3. The report appears in the public interface.
Alternative Flow(s): None.

Table 13. UC-4-2

Use Case: CreateReportFromScratch
ID: UC-4-2
Brief Description: The dispatcher can create a report from scratch if they have information which was not provided through the user reporting system.
Actor(s): 1. Dispatcher
Preconditions: 1. The dispatcher has information for a report that they would like to submit to the system.
Main Flow: 1. The dispatcher receives information from an external source that they would like to enter into the system (for example: via radio from a driver). 2. The dispatcher opens the “new report” form manually. 3. The dispatcher fills in the fields required to add a report. 4. Once the dispatcher is satisfied with the information they submit the report.
Postconditions: 1. A new internal report is created in the system. 2. The report icon appears in the appropriate location on the dispatcher’s map. 3. The report appears in the public interface.
Alternative Flow(s): None.

Table 14. UC-4-3

Use Case: NotifyDrivers
ID: UC-4-3
Brief Description: If routes need to be changed, or hazards appear that drivers should look out for, dispatch should be able to notify drivers on their interfaces.
Actor(s): 1. Dispatcher
Preconditions: 1. The dispatcher has changed/updated a route based on user reports and needs to alert drivers. 2. The driver wants to send an alert to all drivers to relay crucial information.
Main Flow: 1. Dispatch clicks the "notify" button, which brings up a form to be filled out. 2. Dispatch has the option of selecting type of notification: 2.1. Route. Can select from a list of previously changed routes to notify drivers about. Formats message based on route selected. 2.2. Hazard. Select a location and type of hazard to warn drivers about. Formats message based on what was selected. 2.3. Emergency. Complete custom message for urgent, unforeseen situations. 3. Dispatch hits the send button, sending the message to specific drivers, which will be displayed in the driver interface.
Postconditions: 1. Report of notification is stored in notification history.
Alternative Flow(s): None.

Table 15. UC-4-4

Use Case: ViewMapData
ID: UC-4-4
Brief Description: To gain better insights in creating snow plow routes, dispatchers should be able to view weather and traffic data from the interface.
Actor(s): 1. Dispatcher
Preconditions: 1. Weather data and forecasts must be gathered and accessible to the interface. 2. Historic traffic data must be gathered and accessible to the interface.
Main Flow: 1. Dispatch navigates to data overlay dropdown, opens and clicks one of two options: 1.1. Show Weather Data 1.2. Show traffic Data. 2. Upon clicking an option, the interface generates overlays which dispatch can discern information for creating routes. 2.1. Weather data displayed as colored polygons over different regions. 2.2. Traffic data is displayed as colored highlights over roads. 3. Hovering or clicking a data display opens a view of details for that region. 3.1. Details for weather data include type of weather, duration of weather, and intensity of weather (expected snowfall or rainfall). 3.2. Details for traffic data include intensity at different times, average road flow over a period of time, and important amenities that are linked to this road. 4. Dispatch clicks “Hide Data” from data overlay dropdown, and map returns to normal.
Postconditions: 1. Dispatch improves snow plow route plans based on the information that they have studied.
Alternative Flow(s): 1. Dispatch clicks on a road to open the data view of the road. 2. Clicks a toggle in data view to enable intensity highlighting.

3.5 Route Management (Auto Generation)

3.5.1 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.

3.5.2 Functional Requirements

REQ-5-1: Update route plan to safely adjust back to original if a driver takes unexpected actions.

REQ-5-2: Generate a route plan based on compiled data which is able to be edited before publishing.

REQ-5-3: Gather weather data every 5 min to accurately predict problematic areas.

REQ-5-4: Gather historical road and traffic data to decide priority of roads in a route.

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

REQ-5-6: If a snowplow becomes inactive for any reason, notifies dispatch and gives a suggested route, dispatch confirms, and adjusts other snow plows to cover.

3.5.3 Use Cases

Table 16. UC-5-1

Use Case: CreateRoute
ID: UC-5-1
Brief Description: Dispatch generates a new route to give to a driver.
Actor(s): 1. Dispatch 2. Driver
Preconditions: 1. Dispatch must be logged into the dispatch interface. 2. Dispatch's iMac must be connected to the internet. 3. Driver information and availability must be up to date and accessible in the SPRO system.
Main Flow: 1. Dispatch chooses to create a new route. 2. Dispatch selects the date of route. 3. If Dispatch selects to draw the route then 3.1. The system displays the map. 3.2. Dispatch uses their mouse to draw a route on the map. 3.3. System generates an estimated time to complete the route. 3.4. Dispatch can further edit the route if needed. 4. Else dispatch selects to use predetermined route 4.1. The system showcases predetermined routes on the map. 4.2. Dispatch selects predetermined route. 5. Dispatch assigns a driver to the route.
Postconditions: 1. Driver has a new route assigned to them.
Alternative Flow(s): None.

Table 17. UC-5-2

Use Case: ModifyRoute
ID: UC-5-2
Brief Description: Dispatch modifies a route currently assigned to a driver.
Actor(s): 1. Dispatch 2. Driver
Preconditions: 1. Dispatch must be logged into the dispatch interface. 2. Dispatch's iMac must be connected to the internet. 3. Driver information and availability must be up to date and accessible in the SPRO system. 4. All route information must be up to date and accessible in the SPRO system. 5. Route must be already inputted into the system.
Main Flow: 1. Dispatch selects to modify a route. 2. If a driver is on the selected route 2.1. The system selects the route from the point of not yet completed. 2.2. If dispatch selects to their mouse to draw new route on map 2.2.1.The system displays the map. 2.2.2.Dispatch uses their mouse to draw a route on the map. 2.2.3.System generates estimated time to complete the route. 2.2.4.Dispatch can further edit the route if needed. 2.3. Else if dispatch selects a predetermined route 2.3.1.System updates route to follow predetermined route from last point of completion. 2.4. System sends the updated route to the driver. 2.5. System sends notification to the driver. 3. If route is planned for the future 3.1. If dispatch uses their mouse to draw new route on map 3.1.1.System generates estimated time to complete the route. 3.1.2.Dispatch can further edit the route if needed. 3.2. Else dispatch selects a predetermined route. 3.3. Dispatch re-assigns a driver for the route.
Postconditions: 1. The driver's route has been modified.
Alternative Flow(s): None.

Table 18. UC-5-3

Use Case: ConfirmAutogeneratedRoute
ID: UC-5-3
Brief Description: Dispatch confirms an auto-generated route when a driver goes off their scheduled route.
Actor(s): 1. Dispatch 2. Driver
Preconditions: 1. Dispatch must be logged into the dispatch interface. 2. Dispatch's iMac must be connected to the internet. 3. Driver information and availability must be up to date and accessible in the SPRO system. 4. All route information must be up to date and accessible in the SPRO system. 5. Driver goes off track of their scheduled route. 6. System has autogenerated route to get driver back on track.
Main Flow: 1. System notifies dispatch that the driver has gone off route. 2. System displays autogenerated route to get driver back on their scheduled route. 3. If dispatch wants to change the autogenerated route 3.1. include(ModifyRoute[2]) 4. Else dispatch confirms autogenerated route. 5. System updates route for driver. 6. Driver is notified of the new route.
Postconditions: 1. The driver receives autogenerated route.
Alternative Flow(s): None.

3.5.4 Use Case Diagram

Figure 2. Use case diagram for the driver and dispatch interfaces.

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.

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. A concise hazard report from dispatch 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 routes. 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.

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. The iMacs communicate with other interfaces using the office’s wifi router. To communicate directly with the drivers, an existing two-way radio system is used. The radio is already in place and is 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 LTE connectivity.

4.3 Software Interfaces

4.3.1 Dispatch

The dispatch interface will be implemented as a web application accessed by the dispatch computers. 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 if available, else all other cellular networks.

4.3.3 Public

The public interface is a web application that uses the Google Maps Javascript API to display the map of Letterkenny. This map is 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 using TCP. TCP will ensure data is transferred successfully, and the system is not large enough and does not require minimal transmission speed to warrant UDP. 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. GPS will be used to locate and navigate drivers.

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. This communication is done over the internet.

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. In these reports, the public can share their GPS location when submitting user reports.

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

After receiving the RD 1.1 and following up with a second elicitation meeting, we have resolved this issue in RSD 1.0.

Issue 2 - Verification of Employee Status Through Radio

A client requirement discussed during the RD 1.1 meeting was verifying employees when they communicate through the two-way radio. The validation would be done when dispatch wants to communicate with drivers by having dispatch send a code to the driver's interface that drivers would have to read over the radio. The validation would also be done when drivers communicate to dispatch, by having drivers pull over to send a code to dispatch that dispatch would have to read back.

However, a decision was made to exclude this requirement based on it violating Alberta's Traffic Safety Act [1]. Making the driver read the code from the built-in computer while driving would constitute as distracted driving, in addition, it would be inefficient for drivers to pull over everytime they need to communicate. Therefore, we recommend dispatch and drivers enact a radio communication protocol such as 10-Code [5] to confirm their employee status.