Av-Alert: Avalanche Risk Analysis System
Client: Steep Mountaineering

Requirements Specification Document 4.0

Snowlutions

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Revision History

Name	Date	Reason for Changes	Version
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1 Introduction

1.1 Purpose

This document outlines the requirements specifications necessary for Av-Alert version 1.0, a new Avalanche Risk Analysis System for the client Steep Mountaineering. Steep Mountaineering's current system relies on manual collection and analysis of snow pit data, which makes real-time risk analysis impossible. Av-Alert's objectives are to make avalanche risk analysis available to each Administrator and Public User in real-time, and to replace manual data collection and analysis with an automated system.

1.2 Project Scope

There are three major objectives for Av-Alert. Av-Alert's first objective is to automate the collection of Avalanche Risk Analysis Data required to track and analyze potential avalanche conditions. Steep Mountaineering's current system requires multiple snow pits to be dug and data to be manually recorded for later analysis. Av-Alert will remove the need for manual data collection, reduce cost and time spent doing so, and improve Resort Staff safety. Av-Alert's second objective is to provide frequent updates and Alerts about the risk factor of an avalanche occurring. Av-Alert will eliminate manual analysis and will update the calculated risk factor when new Avalanche Risk Analysis Data becomes available, increasing safety by allowing Public Users to make informed decisions. Av-Alert's third objective is to create an interface for viewing the Avalanche Forecasts. By creating an interface that can display current Avalanche Forecasts, Steep Mountaineering will be able to reach a wider user base with a product that requires no specialized knowledge for analyzing Avalanche Risk Analysis Data.

1.3 Glossary of Terms

API	Abbreviation for Application Programming Interface. An API specifies how software components will interact.
Administrative Portal	A website that is designed for Administrators to complete tasks and functions related to Av-Alert.
Administrator	System Administrator or Resort Administrator.
Advisory	An Advisory is authorized when a Slope is forecasted as having a medium risk of avalanches. By default it is made up of 2 components: 1. An indication in Av-Alert to each Public User whose Specified Resort is within 50km of the at-risk Slope. 2. A radio broadcast covering 50km from the Resort closest to the at-risk Slope. These conditions can be modified by a Resort Administrator.

Alert	An Alert is authorized when a Slope is forecasted as having a high risk of avalanches. By default it is made up of 3 components: 1. An indication in Av-Alert to each Public User whose Specified Resort is within 50km of the at-risk Slope. 2. A notification sent out to each Public User whose Specified Resort is within 50km of the at-risk Slope. 3. A radio broadcast covering 50km from the Resort closest to the at-risk Slope. These conditions can be modified by a Resort Administrator.
Avalanche Forecast	Risks calculated for Slopes within 50km of a Resort using Av-Alert. The risks are summarized as a Low, Medium, or High Risk of an avalanche for each Slope. Risks are calculated for the next three days.
Avalanche Risk Analysis Data	The correlated and analyzed data from Topological Maps, Remote Sensing Instruments, and Meteorological Data [A-1.6].
Avalanche Risk Analysis Data Set	A collection of Avalanche Risk Analysis Data for a specific date, time and Resort.
Client	Steep Mountaineering commissioned Av-Alert.
Cloud Storage	Service in which data is maintained, managed, and backed up remotely and available to users over a network(typically the Internet).
Consumer Environment	The public, front facing interface of Av-Alert.
Data Sources	The sources from which data is collected to form the Raw Avalanche Data, these sources are specified for each Resort.
Educational Material	A detailed description of avalanche Educational Material learning objectives to allow all users to learn through videos and text articles.
Emergency Services	Organizations that provide safety and rescue services, such as Search and Rescue. They may be specifically associated with a Resort.
Forecasting Agencies	Weather stations providing data on weather conditions at a location.
High Risk	Equivalent to a considerable danger warning level or higher on the European avalanche danger scale. “A considerable, high, or extreme danger warning level is risk factor 8, 16, or 32 respectively. An avalanche can already be triggered with low additional load (one person), especially on indicated steep slopes. Sometimes and spontaneously, some medium, occasionally also large avalanches are possible.” [9]

Historical Data	Data taken from past events over a long period of time. This data can be used to inform predictive modelling.
Low Risk	Equivalent to a low danger warning level on the European avalanche danger scale. “A low danger warning level is assigned a risk factor of 2. An avalanche can generally only be triggered with high additional loads (groups of people, snow groomer, avalanche dispersion) at isolated points on extremely steep terrain. Spontaneously, only slides and small avalanches are possible. Generally safe conditions.” [9]
Medium Risk	Equivalent to a moderate danger warning level on the European avalanche danger scale. “A moderate danger warning level is risk factor 4 (twice as much as a low danger). An avalanche can be triggered particularly with high additional loads (a group of people, snow groomer, avalanche dispersion), especially on indicated steep slopes. Large spontaneous avalanches are not expected. Mostly favourable conditions. Careful route selection, especially on steep slopes of indicated exposure and altitude.” [9]
Meteorological Data	Information about wind, temperature, air density and humidity.
Mobile Interface	A touch sensitive display for Av-Alert on mobile devices.
Predictive Models	Statistics are used to predict outcomes. Training data is modelled and adjusted to output the best prediction. The predictive models become more accurate as more training data is run through.
Public Users	Users who use Av-Alert but are not employed by Steep Mountaineering or a Resort utilizing Av-Alert.
Push Notification	A notification that appears at the system level of a mobile device, often accompanied with a sound or other notification method.
Radio Broadcasting Equipment	The hardware required to transmit a radio signal. Minimally consisting of: a transmitter, an antenna, and an audio processor.
Radio Equipment	Electronics and software capable of receiving and decoding radio frequencies. Consisting of handheld radios as well as larger units.
Raw Avalanche Data	The uncorrelated and unanalyzed data collected by Avalanche Risk Analysis Data sources for a Resort.

Remote Sensing Instruments	Devices installed into multiple Snow Pit locations at individual Resorts. Data about the Snow Pit is sent to that Resort's Av-Alert system.
Resort	A commercial establishment created for skiing, snowboarding and other winter activities.
Resort Administrator	A subset of Resort staff with privileged access to Av-Alert for administrative tasks related specifically to their Specified Resort.
Resort Profile	A Resort Profile is made up of a collection of Resort specific information such as name, location, Resort Administrators and data sources.
Resort Staff	Individuals employed at a specific Resort.
Risk Analysis Update Intervals	Updates will take place at the following times daily: 6am, 12pm and 6pm [A-1.5].
Risk Factor	Low, Medium, or High Risk
Slope	A surface or area within 50km [A-1.2] of a Resort which can be skied or snowboarded upon.
Snow Pit	A snow pit is a trench exposing a flat, vertical snow face from the snow surface to the ground. It allows people to study the characteristics of the different layers of the snowpack that have developed as the snow has changed due to compaction and weather changes [1].
Specified Resort	The Resort chosen by a Public User for which they want Avalanche Forecasts.
System Administrators	People who are responsible for managing, maintaining, and configuring the reliability of multiple systems.
Topological Maps	A detailed description of the natural and artificial features of an area.
User	One of System Administrator, Resort Administrator, or Public User.
Verified Data Source	A data source that has been approved for use in Av-Alert by a System Administrator.
Web Browser Interface	A method of interacting with Av-Alert through a web browser.
Client	The Client organization for this project, Steep Mountaineering

1.4 References

[1] "Avalanche.org Snowpit", Avalanche.org, 2019. [Online]. Available: https://avalanche.org/avalanche-encyclopedia/snowpit/. [Accessed: 26- Sep- 2019].

[2] D. MacDonald, C. Liu, N. Schaufele, J. Sandberg, V. Potrykus, G. Conell and Z. Chen, "Requirements Elicitation", UVic, Engineering Lab Wing, B215, 2019.

[3] M. of Environment, “Automated Snow Weather Station Data,” Province of British Columbia, 23-Nov-2018. [Online]. Available: https://www2.gov.bc.ca/gov/content/environment/air-land-water/water/water-science-data/water-data-tools/snow-survey-data/automated-snow-weather-station-data. [Accessed: 26- Sep- 2019].

[4] N. Assaraf, “5 Safety Concerns with Cloud Data Storage, Answered.,” *cloudHQ* Blog, 22-Jan-2015. [Online]. Available: https://blog.cloudhq.net/5-safety-concerns-with-cloud-data-storage-answered/. [Accessed: 26-Nov-2019].

[5] R. A. Fernandes, F. Canisius, S. G. Leblanc, M. Maloley, S. Oakes, C. Prévost, and C. Schmidt, “Assessment of UAV-based photogrammetry for snow-depth mapping: data collection and processing,” 2017.

[6] Steep Mountaineering, "Avalanche Prediction System - Request for Proposal", Victoria, 2019.

[7] US Department of Commerce and Noaa, NOAA Weather Radio. [Online]. Available: https://www.nws.noaa.gov/nwr/. [Accessed: 30-Oct-2019].

[8] “Werner Munter's Avalanche Reduction Method " Online Calculator,” *Werner Munter's Avalanche Reduction Method* " Online Calculator. [Online]. Available: https://www.bergfreunde.eu/munter-reduction-method-calculator/. [Accessed: 30-Oct-2019].

[9] “What are Terms and Conditions and Why it is Important to Have it,” *WebsitePolicies.com*, 10-Mar-2017. [Online]. Available: https://www.websitepolicies.com/blog/what-are-terms-and-conditions. [Accessed: 25-Nov-2019].

1.5 Overview

This document contains eight sections plus an appendix. The second section describes Av-Alert, including an overview of current systems, major features, user classes, operating environment, as well as constraints to design and implementation. Following that, the third section provides in-depth descriptions of the major system features required by Steep Mountaineering. Next, the fourth section outlines the interfaces required by Steep Mountaineering for user interaction with Av-Alert. The fifth section outlines any non-functional requirements that Av-Alert must meet. The sixth section specifies any additional requirements necessary for Av-Alert. In sections three, four, five, and six the requirements for Av-Alert are stated with rationale for backwards traceability and test cases for forwards traceability. In the seventh section, each of the Use Cases are outlined, and summarized in a Use Case and System Sequence diagram. The Use Cases which are related to high priority system features include a UI flow mock-up. Additionally, Use Cases which are important to client group required features include a UI flow mock-up. The eighth section offers further analysis of Av-Alert, including an Entity-Relationship Diagram, Data

Dictionary, and Data Flow Diagrams. The appendix contains a list of clarifications made with the client group, as well as meeting notes from the first and second client elicitations.

2 Overall Description

2.1 Product Perspective

Av-Alert is a replacement for Steep Mountaineering's current system of manual data collection for avalanche risk analysis. Manual data collection techniques for avalanche risk analysis are subjective, time-intensive, can put data collectors at risk, and are not able to provide real-time data [2][6]. Av-Alert will replace manual data collection with Remote Sensing Instruments on Slopes within 50km [A-1.2] of a Resort using Av-Alert. These Remote Sensing Instruments will provide objective, safe, and up-to-date Avalanche Risk Analysis Data. Figure 1 represents Steep Mountaineering's current system.

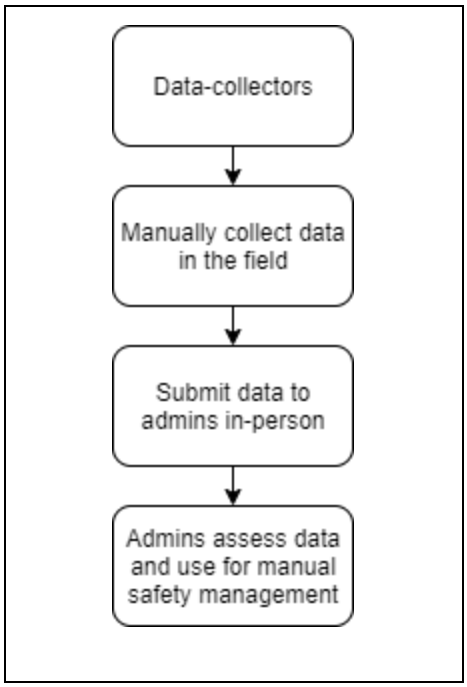


Figure 1: Steep Mountaineering's current system.

2.2 Product Features

Av-Alert consists of six main features. First, the Av-Alert Data Collection feature collects information from Remote Sensing Instruments, weather institutions, and topological maps, to create Avalanche Risk Analysis Data which Av-Alert will use to base its Avalanche Forecast on. Second, the Avalanche Risk Analysis feature uses Predictive Models to create Avalanche Forecasts on Slopes within a 50 km radius of each Resort using Av-Alert. Third, the Alert and Advisory feature delivers Resort specific Alerts and Advisories based on the Avalanche Forecasts to Resort Staff, Emergency Services and Public Users.

Alerts and Advisories are delivered through Push Notifications in Av-Alerts Mobile Interface and through radio broadcasts. Fourth, the Topological Avalanche Map feature displays the terrain around a Public User's location with its current Avalanche Forecast. The Topological Avalanche Map and the current Avalanche Forecast is also downloadable by each Public User. Fifth, the Avalanche Training feature provides Educational Material regarding avalanche safety, and what to do if caught in one. Finally, Av-Alert provides an Administrative Portal feature which allows each Administrator to manage Av-Alert and each Resort on a system wide and Resort level.

2.3 User Classes and Characteristics

Av-Alert has three user classes: System Administrators, Resort Administrators, and Public Users.

2.3.1 Administrators

2.3.1.1 System Administrators

System Administrators have high privilege access on Av-Alert. With high privilege access, System Administrators have full access across Av-Alert and are able to create, delete, or edit Resorts and Resort Administrators, as well as manage Educational Material. Additionally, they are able to edit the Avalanche Risk Analysis Data Sources used at a Resort. The primary tasks of each System Administrator is to ensure the availability of Av-Alert to Public Users. Each System Administrator manages and maintains each Resort Administrator, each Resort Profile, and each Data Source that contributes to Avalanche Risk Analysis Data. In order for System Administrators to access Av-Alert, they must be authenticated through the Administrative Portal.

2.3.1.2 Resort Administrators

Each Resort Administrator is experienced in analyzing Avalanche Risk Analysis Data. Each Resort Administrator has medium privilege access to Av-Alert and these privileges are limited to their assigned Resort. In order for each Resort Administrator to access Av-Alert, they must be authenticated through the Administrative Portal. Within their assigned Resort, each Resort Administrator is able to add other Resort Administrators, monitor mountain conditions, alert Resort Staff and Resort guests of potential avalanches, and manage Educational Material. Each Resort Administrator may update Av-Alert with an Alert or Advisory based off of an Avalanche Forecast and may also update Av-Alert with an Alert or Advisory if they receive information through pre-existing local communication channels outside of Av-Alert, such as Resort Staff communicating an observed change in avalanche conditions over radio.

2.3.2 Public Users

Each Public User does not require any technical knowledge and have low privilege access on Av-Alert. With low privilege access, each Public User does not need to be authenticated and is able to view a Topological Map interface showing Avalanche Forecasts, Alerts, Advisories,

Avalanche Risk Analysis Data [A-1.3] and Educational Material. The only thing that a Public User is able to enter is the location of the Resort which they would like to view Forecasts for.

2.4 Operating Environment

Av-Alert will receive information from Topological Maps, Remote Sensing Instruments, and Meteorological Data. Meteorological Data will be retrieved through APIs provided by Forecasting Agencies. Avalanche Risk Analysis Data is stored on Av-Alert's cloud storage. Av-Alert will analyze, correlate, and map the Avalanche Risk Analysis Data to produce a Topological Map interface displaying the Avalanche Forecast. Av-Alert will receive an updated Avalanche Risk Analysis Data Set during the Risk Analysis Update Intervals. The updated Avalanche Risk Analysis Data Set will be analyzed, correlated, and mapped to update the existing Topological Map interface displaying the Avalanche Forecast for the corresponding region.

Av-Alert contains two separate user interfaces, a Mobile Interface and a Web Browser Interface. The Mobile Interface of Av-Alert must support iOS 12.4.3 (last supported version for iOS) on the Apple iOS platform and support Android 7.1.1(last supported version of Android) on the Android platform.

Public Users will be accessing Av-Alert through the Mobile Interface. The Mobile Interface is not required to authenticate Public Users. Administrators must access Av-Alert through the Web Browser Interface. Administrators will be prompted to authenticate with their credentials.

Av-Alert will allow Administrators to broadcast Alerts and Advisories in audio format via Radio Broadcasting Equipment. The audio format Alerts and Advisories will be transmitted through a line out audio port to the Radio Broadcasting Equipment. The audio format Alerts and Advisories will be kept up to date and broadcast on a repeating loop.

2.5 Design and Implementation Constraints

There are four major design and implementation constraints on Av-Alert:

Due to the nature of the environment that Av-Alert will be deployed in, it is required that Av-Alert be able to provide Avalanche Risk Analysis Data for a minimum of 72 hours without primary power.
C-1: Remote Sensing Instruments must be able to maintain full functionality for 72 hours without access to their primary battery power source [A-1.7].

C-2: Av-Alert must stay within the implementation budget of four million CAD [A-1.1].

C-3: Each Administrator must be able to access the Administrative Portal through a Web Browser Interface.

C-4: Each Public User must be able to access public system features through a mobile application.

2.6 Assumptions and Dependencies

The following sections, 2.6.1-2.6.2, outline the assumptions and dependencies of Av-Alert.

2.6.1 Assumptions

Steep Mountaineering will be receiving and collecting Avalanche Risk Analysis Data from weather forecasters, government agencies, and research groups regarding avalanche reports and historical data. If Avalanche Risk Analysis Data received from a source external to Av-Alert contains inconsistencies or is erroneous, such as contrasting data types, measurement units, or values outside of a reasonable range, incorrect analysis of the current conditions may occur. All values will be checked to see if they are metric, and if not, they will be converted into metric.

A-1: Avalanche Risk Analysis Data is standardized and is free of inconsistencies and errors.
A-2: The Avalanche Risk Analysis Data is not required to be stored in a single physical location.
A-3: The Meteorological Data received from the Forecast Agencies API is compatible with Av-Alert.

2.6.2 Dependencies

The alert and Avalanche Risk Analysis Data transmission of Av-Alert is dependent on a multimodal data transmission model. The transmission model attempts to send alerts and Avalanche Risk Analysis Data through cellular towers and radio transmissions.
D-1: Av-Alert must have a data transmission model available at all times.

Remote sensors must have at least two power supplies as a precaution. When a power outage occurs, remote sensors must be powered by a secondary power supply.
D-2: Remote sensors must have a secondary battery power supply [A-1.7].

3 System Features

The following section outlines the core features of Av-Alert with a description of each feature and the feature's functional requirements. Each System Feature description includes a priority ranking the importance of that feature to the core functionality of Av-Alert.

3.1 System Feature 1 - Data Collection

3.1.1 Description and Priority

The Data Collection feature collects Raw Avalanche Data from multiple Data Sources, such as Remote Sensing Instruments, Topological Maps, and weather stations. After collection, this feature turns the Raw Avalanche Data into Avalanche Risk Analysis Data. The Data Collection feature is of high priority as the Raw Avalanche Data collected by the Data Collection Feature provides the basis for Av-Alert's Avalanche Risk Analysis feature.

3.1.2 Functional Requirements

As Data Sources become available or obsolete for a particular Resort, the System Administrator must be able to modify the sources which make up the Raw Avalanche Data for that Resort.

DC-1: Each System Administrator must be able to modify each Data Source for each Resort.

Rationale(Backwards Traceability): The Client's RFP stated that a proposed Avalanche Prediction System must "provide consolidated information from various authorities for predictive modelling" [6]. Av-Alert provides the option to modify each Data Source for each Resort, and therefore ensure that the Raw Avalanche Data provided by each Data Source is correctly curated before Avalanche Risk Analysis occurs.

Test Scenarios (Forward Traceability):

- **TC-DC-1a**: Verify that each System Administrator is able to modify each Data Source for a Resort.
- Verify that each modification to each Data Source for each Resort is reflected in the next generated Avalanche Forecast.
- **TC-DC-1b**: Verify that each Public User is not able to modify any Data Source for each Resort.

Traceability Matrix - Data Collection

System Feature	Functional Requirement ID	Associated Use Case	Priority	Test Case ID No.
Data Collection	DC-1	13	High	TC-DC-1a TC-DC-1b

3.2 System Feature 2 - Avalanche Risk Analysis

3.2.1 Description and Priority

The Avalanche Risk Analysis feature is passed the Raw Avalanche Data for each Resort collected by the Data Collection feature mentioned previously. The Avalanche Risk Analysis feature then uses predictive modelling to create Avalanche Risk Analysis Data and the corresponding Avalanche Forecasts. The Avalanche Risk Analysis feature does this for each individual Slope within the 50km range from a Resort which Av-Alert is deployed at. This feature is of high priority as it is imperative that Avalanche Forecasts are accurate, as an inaccurate Avalanche Forecast could result in the injury or death of misinformed Public Users who may be relying on the Avalanche Forecast.

3.2.2 Functional Requirements

In order to allow for further analysis and observations based on more than just the most recently available Avalanche Risk Analysis Data, Av-Alert will provide the option to view each set of previously available Avalanche Risk Analysis Data for each Resort.

ARA-1: Each System Administrator must be able to download each previously stored Avalanche Risk Analysis Data Set.

Rationale: The Client stated in the first elicitation meeting that each System Administrator must be able to download each set of Avalanche Risk Analysis Data [A-2]. Then the Avalanche Risk Analysis can be checked to ensure it is syntactically correct and up to date.

Test Scenarios :

- **TC-ARA-1a**: Verify that each System Administrator can successfully download some subset of Avalanche Risk Analysis Data.
- **TC-ARA-1b**: Verify that each downloaded set of Avalanche Risk Analysis Data is syntactically correct.

ARA-2: Each Resort Administrator must be able to download each previously stored Avalanche Risk Analysis Data Set.

Rationale: The Client stated in the first elicitation meeting that each Resort Administrator must be able to download each set of the Avalanche Risk Analysis Data for the Resort they administer in order to analyze the Avalanche Risk Analysis Data and make an informed decision to authorize an Alert or Advisory [A-2].

Test Scenarios :

- **TC-ARA-2**: Verify that each Resort Administrator can successfully download some subset of Avalanche Risk Analysis Data.

ARA-3: Each Public User must be able to download each previously stored Avalanche Risk Analysis Data Set.

Rationale: The Client clarified over Slack that each Public User should be able to access each previously recorded Avalanche Risk Analysis Data Set [A-1.3].

Test Scenarios :

- **TC-ARA-3**: Verify that each Public User can successfully download some subset of Avalanche Risk Analysis Data.

Traceability Matrix - Avalanche Risk Analysis

System Feature	**Functional Requirement ID**	**Associated Use Case**	**Priority**	**Test Case ID No.**
Avalanche Risk Analysis	ARA-1	9.1	High	TC-ARA-1a TC-ARA-1b
Avalanche Risk Analysis	ARA-2	9.1	High	TC-ARA-2
Avalanche Risk Analysis	ARA-3	9.1	High	TC-ARA-3

3.3 System Feature 3 - Alert and Advisory

3.3.1 Description and Priority

The Alerts and Advisory (AA) feature delivers Alerts and Advisories based on current Avalanche Forecasts to Resort Staff, Emergency Services, and Public Users with access to the Av-Alert app or Radio Equipment. The AA feature has two main methods of transmitting Alerts and Advisories: Push Notifications and Radio Alerts. Alerts and Advisories for a Resort are authorized manually by a Resort Administrator. The AA feature is high priority as it provides actionable information to each Public User, and without it, their lives may be at risk.

3.3.2 Functional Requirements

AA-1: Each Public User must be able to check for each Alert at their Specified Resort.

Rationale: The Client stated in the first elicitation meeting that a major goal of Av-Alert was “Predictive and real time models to alert resorts and individuals” [A-2], to meet their further objective to “Improve safety for employees and resort customers" [6]. The Alert and Advisory feature provides each Public User with information from the current Avalanche Forecast for their Specified Resort, which identifies any major risks.

Test Scenarios :

- **TC-AA-1:** Verify that each Public User can check for each Alert at their Specified Resort.

AA-2: Each Public User must be able to check for each Advisory at their Specified Resort.

Rationale: The Client stated in the first elicitation meeting that a major goal of Av-Alert was “Predictive and real time models to alert resorts and individuals” [A-2], to meet their further objective to “Improve safety for employees and resort customers" [6]. The Alert and Advisory feature provides each Public User with information from the current Avalanche Forecast for their Specified Resort, which identifies any major risks.

Test Scenarios :

- **TC-AA-2:** Verify that each Public User can check for each Advisory at their Specified Resort.

AA-3: Each Resort Administrator must be able to authorize each Alert for the Resort they administer.

Rationale: The Client’s RFP states that the Alerts and Advisory interface “must be updated in real-time as new information about any avalanches is discovered or any threatening changes in weather happen” [6]. Therefore, each Resort Administrator must be able to authorize each Alert for the Resort they administer, for the safety of each Public User.

Test Scenarios :

- **TC-AA-3a:** Verify that Each Resort Administrator can authorize each Alert for the Resort they administer.
- **TC-AA-3b:** Verify that Each Public User can receive each Alert authorized for their specified Resort.

AA-4: Each Resort Administrator must be able to authorize each Advisory for the Resort they administer.

Rationale: The Client's RFP states that the Alerts and Advisory interface "must be updated in real-time as new information about any avalanches is discovered or any threatening changes in weather happen" [6]. Therefore, each Resort Administrator must be able to authorize each Advisory for the Resort they administer, for the safety of each Public User.

Test Scenarios :

- **TC-AA-4a:** Verify that each Resort Administrator can authorize each Advisory for the Resort they administer.
- **TC-AA-4b:** Verify that each Public User can receive each Advisory authorized for their specified Resort.

Traceability Matrix - Alert and Advisory

System Feature	Functional Requirement ID	Associated Use Case	Priority	Test Case ID No.
Alert and Advisory	AA-1	3	High	TC-AA-1
Alert and Advisory	AA-2	3	High	TC-AA-2
Alert and Advisory	AA-3	7	High	TC-AA-3a TC-AA-3b
Alert and Advisory	AA-4	7	High	TC-AA-4a TC-AA

3.4 System Feature 4 - Topological Avalanche Map

3.4.1 Description and Priority

The Topological Avalanche Map feature visualizes the Avalanche Forecast [A-1.4] made by the Avalanche Risk Analysis feature. The Topological Avalanche Map feature overlays the Avalanche Forecast onto a topological map of the selected area, colour coding the Slopes with the computed Risk Factor of an avalanche occurring, from green (Low Risk) to red (High Risk). The Topological Avalanche Map feature is of high priority as it is one of Av-Alert's main components.

3.4.2 Functional Requirements

TAM-1: Each Public User must be able to search for each Resort location.

Rationale: The Client stated in the first elicitation meeting that "the need is large across many ski resorts" [A-2] in relation to Av-Alert. As it is expected that Av-Alert will be in use at several Resorts, Av-Alert must provide each Public User the option to specify a Resort.

Test Scenarios :

- **TC-TAM-1a**: Verify that each Public User is able to search for each Resort location.

- **TC-TAM-1b**: Verify that when each Public User enters an invalid Resort, no Resorts are returned in the search.

TAM-2: Each Public User must be able to view the current Avalanche Forecast for their Specified Resort.

Rationale: The Client's RFP describes a map interface which meets their objectives, it "should have information about the approximate topographic information and an estimation of how likely an avalanche is to occur." [6]. The Topological Avalanche Map feature makes each Avalanche Forecast available.

Test Scenarios :

- **TC-TAM-2**: Verify that each Public User can view the current Avalanche Forecast for their Specified Resort.

TAM-3: Each Public User must be able to update to the most recent Avalanche Forecast for their Specified Resort.

Rationale: The Client stated in the first elicitation meeting that that Av-Alert must improve on the safety of the current system by providing "almost real time data" [A-2]. The Client clarified in the second elicitation meeting that "real time data" could be understood as updates to each Avalanche Forecast at "3-4 intervals per day" [A-3]. Av-alert provides each Public User with the option to update to the most recent Avalanche Forecast for their Specified Resort if it is available.

Test Scenarios :

- **TC-TAM-3**: Verify that each Public User can refresh the Avalanche Forecast to fetch the most up-to-date Avalanche Forecast.

TAM-4: Each Public User must be able to download the current Topological Avalanche Map with the associated Avalanche Risk Analysis Data Set used to create its Avalanche Forecast.

Rationale: The Client requested in the first elicitation meeting an "offline mode to save current state of avalanche map to view when in backcountry" [A-2]. Av-Alert provides to each Public User the option to download Topological Avalanche Map data.

Test Scenarios :

- **TC-TAM-4a**: Verify that each Public User can download the Topographical Avalanche Map for their Specified Resort.
- **TC-TAM-4b**: Verify that each Topographical Avalanche Map download is associated with the correct Avalanche Risk Analysis Data Set download.

Traceability Matrix - Topological Avalanche Map

System Feature	**Functional Requirement ID**	**Associated Use Case**	**Priority**	**Test Case ID No.**
Topological Avalanche Map	TAM-1	1	High	TC-TAM-1a TC-TAM-1b
Topological Avalanche Map	TAM-2	1	High	TC-TAM-2
Topological Avalanche Map	TAM-3	1.1	High	TC-TAM-3
Topological Avalanche Map	TAM-4	2	High	TC-TAM-4a TC-TAM-4b

3.5 System Feature 5 - Avalanche Training

3.5.1 Description and Priority

The Avalanche Training feature provides each Public User with Educational Material such as how to identify Slopes at High Risk of avalanches and what to do during an avalanche. Each Public User is able to access and download Educational Material to their mobile device. The Avalanche Training feature is of medium priority as it is not essential to core functionality of Av-Alert, however, it is still important as it provides possibly life-saving information for each Public User.

3.5.2 Functional Requirements

AT-1: Each Administrator must be able to create new Educational Material.

Rationale: The Client's RFP states that a "Safety and Training Page" [6] would be required to satisfy their objectives. The Avalanche Training feature provides each Administrator with the option to create new Educational Material.

Test Scenarios :

- **TC-AT-1**: Verify that each System Administrator and each Resort Administrator can create new Educational Material.

AT-2: Each Administrator must be able to edit each Educational Material.

Rationale: The Client's RFP states that a "Safety and Training Page" [6] would be required to satisfy their objectives. The Avalanche Training feature provides each Administrator with the option to edit Educational Material.

Test Scenarios :

- **TC-AT-2**: Verify that each System Administrator and each Resort Administrator can edit Education Material.

AT-3: Each Administrator must be able to delete each Educational Material.

Rationale: The Client's RFP states that a "Safety and Training Page" [6] would be required to satisfy their objectives. The Avalanche Training feature provides each Administrator with the option to delete Educational Material.

Test Scenarios :

- **TC-AT-3**: Verify that each System Administrator and each Resort Administrator can delete Educational Material.

AT-4: Each Public User must be able to access each Educational Material.

Rationale: The Client's RFP states that "The safety and training page must be able to display videos and articles relating to avalanche safety and training to the users" [6]. The Avalanche Training feature provides safety and training content.

Test Scenarios :

- **TC-AT-4a**: Verify that each Public User can view Educational Material.
- **TC-AT-4b**: Verify that each Public User cannot edit or delete Educational Material.

AT-5: Each Public User must be able to download each Educational Material for offline usage.

Rationale: The Client states in the first elicitation meeting that the "safety and training information interface" would be included in the "offline mode" [A-2]. The Avalanche

Training feature provides each Public User with the option to download Educational Material.

Test Scenarios :

- **TC-AT-5**: Verify that each Public User can download Educational Material and view it offline.

Traceability Matrix - Avalanche Training

System Feature	Functional Requirement ID	Associated Use Case	Priority	Test Case ID No.
Avalanche Training	AT-1	8	Medium	TC-AT-1
Avalanche Training	AT-2	8.1	Medium	TC-AT-2
Avalanche Training	AT-3	8.1	Medium	TC-AT-3
Avalanche Training	AT-4	4	Medium	TC-AT-4a TC-AT-4b
Avalanche Training	AT-5	5	Medium	TC-AT-5

3.6 System Feature 6 - Administrative Portal

3.6.1 Description and Priority

The Administrative Portal feature provides an interface for Administrators to manage Av-Alert on a system wide and Resort level. The Administrative Portal is of high priority as it is essential in the management of Av-Alert, its Resorts and Administrators by providing an interface for activities such as creating, editing or deleting a Resort or Resort Administrator, as well as changing the information found in a Resort Profile.

3.6.2 Functional Requirements

AP-1: Each System Administrator must be able to create a new Resort Profile.

Rationale: The Client states in the first elicitation meeting that “the need is large across many ski resorts” in relation to Av-Alert [A-2]. By allowing each System Administrator to create new Resort Profiles, Av-Alert can be expanded to accommodate as many Resorts as needed.

Test Scenarios :

- **TC-AP-1:** Verify that each System Administrator can create a Resort Profile

AP-2: Each System Administrator must be able to edit each pre-existing Resort Profile.

Rationale: The Client states in the first elicitation meeting that “the need is large across many ski resorts” in relation to Av-Alert [A-2]. By allowing each System Administrator to edit each Resort Profile, Av-Alert can accommodate maintaining as many Resorts as needed.

Test Scenarios :

- **TC-AP-2:** Verify that each System Administrator can edit each pre-existing Resort Profile.

AP-3: Each System Administrator must be able to delete each pre-existing Resort Profile.

Rationale: The Client states in the first elicitation meeting that "the need is large across many ski resorts" in relation to Av-Alert [A-2]. By allowing each System Administrator to delete each Resort Profile, Av-Alert can accommodate removing Resorts as needed.

Test Scenarios :

- **TC-AP-3:** Verify that each System Administrator can delete each pre-existing Resort Profile.

AP-4: Each System Administrator must be able to create a new Resort Administrator for any Resort.

Rationale: The Client states in the first elicitation meeting that "the need is large across many ski resorts" in relation to Av-Alert [A-2]. By allowing each System Administrator to create new Resort Administrators at each Resort, Av-Alert will be able to accommodate Administrators with privileges restricted to a specific Resort.

Test Scenarios :

- **TC-AP-4:** Verify each System Administrator can create a new Resort Administrator for any Resort.

AP-5: Each Resort Administrator must be able to create a new Resort Administrator for their specified Resort.

Rationale: The Client states in the first elicitation meeting that "the need is large across many ski resorts" in relation to Av-Alert [A-2]. By allowing each Resort Administrator to create new Resort Administrators at each Resort, Av-Alert will be able to accommodate Administrators with privileges restricted to a specific Resort.

Test Scenarios :

- **TC-AP-5:** Verify each Resort Administrator can create a new Resort Administrator for the Resort they administer.

AP-6: Each System Administrator must be able to edit each Resort Administrator's first name, last name, and the assigned Resort.

Rationale: The Client states in the first elicitation meeting that "the need is large across many ski resorts" in relation to Av-Alert [A-2]. By allowing each System Administrator to edit each Resort Administrator at each Resort, Av-Alert will allow for updates to be made to each Resort Administrator as needed.

Test Scenarios :

- **TC-AP-6:** Verify each System Administrator can edit each Resort Administrator's first name, last name, and their assigned Resort.

AP-7: Each Administrator must be able to sign in to the Administrative Portal.

Rationale: The Client states in the first elicitation meeting that "staff need login" to Av-Alert [A-2]. Av-Alert requires each Administrator to sign in.

Test Scenarios :

- **TC-AP-7:** Verify each Administrator can sign in to the Administrative Portal.

Traceability Matrix - Administrative Portal

System Feature	Functional Requirement ID	Associated Use Case	Priority	Test Case ID No.
Administrative Portal	AP-1	10	High	TC-AP-1
Administrative Portal	AP-2	11	High	TC-AP-2
Administrative Portal	AP-3	12	High	TC-AP-3
Administrative Portal	AP-4	14	High	TC-AP-4
Administrative Portal	AP-5	14	High	TC-AP-5
Administrative Portal	AP-6	14	High	TC-AP-6
Administrative Portal	AP-7	6	High	TC-AP-7

4 External Interface Requirements

4.1 User Interfaces

The following sections describe the user interfaces which Av-Alert will interact with and the requirements for those interactions.

4.1.1 Public Interface

The public interface is accessed by Public Users and is used to access the front-facing features of Av-Alert, such as the Topological Avalanche Map and Educational Material. Additionally, through the public interface Public Users will receive Alerts and Advisories.

PI-1: Av-Alert must present each Avalanche Forecast as a Topological Map.

Rationale: The Client's RFP states that "The map interface should have information about the approximate topographic information and an estimation of how likely an avalanche is to occur" [6]. Av-Alert present Avalanche Forecasts as a Topological Map.

Test Scenarios :

- **TC-PI-1:** Verify that the user interface displays the Avalanche Forecast when a Slope is selected on the Topographical Map.

PI-2: Each Avalanche Forecast on the Topological Map must be colour coded.

Rationale: The Client states in the first elicitation meeting that the UI should include a "topological map of area with color coding of how likely an avalanche is to occur" [A-2]. Av-Alert colour codes the Topological map to match Avalanche Forecasts.

Test Scenarios :

- **TC-PI-2:** Verify that the user interface displays a colour coded Avalanche Forecast on the Topographical Map.

4.2 Hardware Interfaces

The following sections describe the hardware interfaces which Av-Alert will interact with and the requirements for those interactions.

4.2.1 Weather Collection Stations

Av-Alert will collect Meteorological Data from the BC Ministry of Environment Meteorological Data collection stations. The BC Ministry of Environment Meteorological Data collection stations remotely sense snow and provide Meteorological Data that is uploaded in near real-time [3]. The Meteorological Data is uploaded hourly and transmitted through a geostationary satellite network. The Meteorological Data is freely available to download in csv format.

WCS-1: Av-Alert must collect data from the BC Ministry of Environment Meteorological Data collection stations.

Rationale: The Client states in the second elicitation meeting that each Data Source would include “topological, remote sensing and weather data” [A-3]. Av-Alert collects data from the BC Ministry of Environment Meteorological Data collection stations.

Test Scenarios :

- **TC-WCS-1:** Verify that the data coming from BC Ministry of Environment Meteorological Data collection stations is contained in the Raw Avalanche Data.

4.2.2 Remote Sensing Instruments

Remote Sensing Instruments are capable of acquiring snow depth data over large spatially continuous areas. Land-based laser scanning has already proven its ability to monitor the spatial distribution of snow depth in subsets of single alpine catchments [5]. Air-borne or spaceborne sensors, cover several hundreds of square kilometers in one data acquisition.

RSI-1: Av-Alert must collect data from Remote Sensing Instruments

Rationale: The Client’s RFP states that a solution Avalanche Prediction system must “Reduce time and cost of manual data collection" [6], and the Client clarifies in the first elicitation meeting that Av-Alert must perform “automated collection and distribution of data” [A-2]. Av-Alert will be collecting data from Remote Sensing Instruments automatically, and the need for manual data collection will be eliminated.

Test Scenarios :

- **TC-RSI-1:** Verify that the Remote Sensing Instruments are sending data to be processed by the Avalanche Risk Analysis process.

4.3 Software Interfaces

The following sections describe the software interfaces which Av-Alert will interact with and the requirements for those interactions.

SI-1: Each Public User must be able to access and view the Av-Alert mobile application on their mobile device.

Rationale: The Client states in the first elicitation meeting that "users need map and general interface" without specifying a platform for implementation [A-2]. The Client approved the user interface created for the Use Case Storyboards [A-1.9]. As the mobile application is how each Public User will communicate with Av-Alert, it is required that they can access and view the mobile application.

Test Scenarios :

- **TC-SI-1a:** Verify each Public User can open and view the Av-Alert mobile application on supported Apple iOS.
- **TC-SI-1b:** Verify each Public User can open and view the Av-Alert mobile application on supported Android Operating System.

SI-2: Each Public User must be able to see the most up-to-date Avalanche Forecasts at all times.

Rationale: The Client clarifies in the second elicitation meeting that the Avalanche Forecast should be "not fully real time but 3-4 intervals per day" [A-3]. Av-Alert ensures that the most recently available Avalanche Forecast is visible to each Public User.

Test Scenarios :

- **TC-SI-2:** Verify that each Public User's timestamp is the most up to date according to the Risk Analysis Update Intervals.

SI-3: Each Administrator must be able to see the most up-to-date Avalanche Forecasts at all times.

Rationale: The Client clarifies in the second elicitation meeting that the Avalanche Forecast should be "not fully real time but 3-4 intervals per day" [A-3]. Av-Alert ensures that the most recently available Avalanche Forecast is visible to each Administrator.

Test Scenarios :

- **TC-SI-3:** Verify that each Administrator's timestamp is the most up to date according to the Risk Analysis Update Intervals.

As the Data Collection feature fetches information from its Data Sources, the information will naturally come in different forms. To prevent errors during the creation of Avalanche Forecasts, data types and measurement units should be standardized to metric.

SI-4: The Data Collection feature must standardize each data type and measurement unit it collects from varying information sources.

Rationale: The Client clarified that the required standardized unit of measurement for Av-Alert will be metric. [A-1.8]

Test Scenarios :

- **TC-SI-4:** Verify the collected data from the varying information sources is standardized through a generic data type process.

Av-Alert's data must be stored remotely and accessible via the internet to ensure data reliability and security.

SI-5: All Resort data must be stored in cloud storage.

Rationale: Cloud storage has become one of the safest ways to store information securely and reliably on a large scale. The Client recognized the value in using cloud storage and approved its use for Av-Alert Resort data.

Test Scenarios :

- **TC-SI-5:** Verify that data has been uploaded to the cloud storage.

SI-6: All Administrator data must be stored in cloud storage.

Rationale: Cloud storage has become one of the safest ways to store information securely and reliably on a large scale [4]. The Client recognized the value in using cloud storage and approved its use for Av-Alert Administrator data.

Test Scenarios :

- **TC-SI-6:** Verify all administrator data is stored on the cloud storage.

SI-7: All Alerts and Advisories data must be stored in cloud storage.

Rationale: Cloud storage has become one of the safest ways to store information securely and reliably on a large scale [4]. The Client recognized the value in using cloud storage and approved its use for Av-Alert Alerts and Advisories data.

Test Scenarios :

- **TC-SI-7:** Verify all Alerts and Advisories are stored on the cloud storage.

SI-8: All Educational Material must be stored in cloud storage.

Rationale: Cloud storage has become one of the safest ways to store information securely and reliably on a large scale [4]. The Client recognized the value in using cloud storage and approved its use for Av-Alert Educational Material.

Test Scenarios :

- **TC-SI-8:** Verify all Educational Material are stored on the cloud storage.

4.4 Communications Interfaces

For radio communications, Av-Alert is to convert Alerts and Advisories to an audio format, similar to NOAA's Weather Radio [7]. Audio format Alerts and Advisories will then be transmitted by a Resort Administrator using the Administrative Portal through the line out audio port to their Resort's Radio Broadcasting Equipment. Transmission of the audio format Alerts and Advisories is the responsibility of each Resort Administrator.

CI-1: Av-Alert must convert Alerts and Advisories to a standard audio format.

Rationale: In the first elicitation meeting the Client described a "radio communication system if really bad weather is coming in" [A-2]. In order for the Alerts and Advisories to be properly distributed over the Resort's Radio Broadcasting Equipment, they must first be converted into an audio format.

Test Scenarios :

- **TC-CI-1:** Verify Av-Alert converts Alerts and Advisories to a standard audio format.

CI-2: Audio format Alerts and Advisories must be transmitted via radio to at least 50km around the Resort to which they pertain.

Rationale: The Client describes in the first elicitation meeting that a "radio communication system if really bad weather is coming in"[A-2] and the Client later approved a 50km operational radius for Av-Alert from each Resort [A-1.2]. Av-Alert will ensure that the audio format Alerts and Advisories will be transmitted via radio at least 50km from each Resort.

Test Scenarios :

- **TC-CI-2:** Verify Audio format Alerts and Advisories are transmitted via radio to at least 50km around each Resort.

Traceability Matrix - External Interface Requirements

System Feature	Functional Requirement ID	Associated Use Case	Priority	Test Case ID No.
Public Interface	PI-1	1	High	TC-PI-1
Public Interface	PI-2	1	High	TC-PI-2
Hardware Interface	WCS-1	13	High	TC-WCS-1
Hardware Interface	RSI-1	13	High	TC-RSI-1
Software Interface	SI-1	1	Medium	TC-SI-1a TC-SI-1b
Software Interface	SI-2	1	Medium	TC-SI-2
Software Interface	SI-3	1	Medium	TC-SI-3
Software Interface	SI-4	13	Medium	TC-SI-4
Software Interface	SI-5	10	Medium	TC-SI-5
Software Interface	SI-6	14, 15, 16	Medium	TC-SI-6
Software Interface	SI-7	3	Medium	TC-SI-7
Software Interface	SI-8	4, 5, 8	Medium	TC-SI-8
Communication Interface	CI-1	3	High	TC-CI-1
Communication Interface	CI-2	3	High	TC-CI-2

5 Other Non-Functional Requirements

5.1 Safety Requirements

If misinformation is spread to Resort staff, misunderstanding will occur. Misunderstandings can result in unsatisfactory safety precautions taking place such as not closing off a high-risk Slope, and can result in Public User injury or death.

SAR-1: Av-Alert must notify Resort staff of each potential avalanche.

Rationale: The Client's RFP states that an objective is to "improve safety for employees and resort customers" [6]. Av-Alert will provide information to each Resort Administrator so they can inform staff.

Test Scenarios :

- **TC-SAR-1:** Verify that the Avalanche Risk Analysis will alert each Resort Administrator if there is a potential avalanche.

Av-Alert's Public Users require Avalanche Forecasts to be regularly updated at precise times each day so that they may make educated decisions about their present and future activities at their Specified Resort.
SAR-2: Av-Alert must update the Avalanche Forecast for each Resort at precise intervals: 6:00am, 12:00pm, and 6:00pm [A-1.5].

Rationale: The Client clarified in the second elicitation meeting that the Avalanche Forecast was "not fully real time but 3-4 intervals per day" [A-3], and later approved the three intervals 6:00am, 12:00pm, and 6:00pm [A-1.5]. Each Avalanche Forecast is updated at those same set intervals.

Test Scenarios :

- **TC-SAR-2:** Verify that Av-Alert sends out updated Avalanche Forecasts at 6:00am, 12:00om, and 6:00pm.

5.2 Security Requirements

Integrity of Avalanche Risk Analysis Data is important. If Avalanche Risk Analysis Data is tampered with, it could result in misinformation or false Avalanche Forecasts leading to user injury and loss of life.
SER-1: Incoming Raw Avalanche Data must be encrypted after entering Av-Alert.

Rationale: If Avalanche Risk Analysis Data is tampered with, it could result in misinformation or false Avalanche Forecasts leading to user injury and loss of life. Encryption will protect Avalanche Risk Analysis Data from tampering [6].

Test Scenarios:

- **TC-SER-1:** Verify that the Raw Avalanche Data stored in Av-Alert is encrypted.

SER-2: Each System Administrator must have high privilege access in order to manage and maintain Av-Alert, each Resort, each Data source, and each other Administrator.

Rationale: The Client stated in the first elicitation meeting [A-2] that "the need is large across many ski resorts" for Av-Alert. By giving System Administrators high privileged access, they will be able to oversee the management of the various Resorts which the Client expects to use Av-Alert.

Test Scenarios :

- **TC-SER-2:** Verify that each System Administrator has high privilege access in Av-Alert.

SER-3: Each Administrator must be authenticated to use Av-Alert.

Rationale: The Client stated in the first elicitation meeting [A-2] that staff need a login system. Av-Alert requires that only the intended Administrators can be authenticated.

Test Scenarios :

- **TC-SER-3a:** Verify that each System Administrator and each Resort Administrator must be authenticated before accessing Av-Alert.
- **TC-SER-3b:** Verify that each System Administrator and each Resort Administrator cannot access Av-Alert if they fail authentication.

SER-4: Each Public User must not be able to gain privileged access to Av-Alert.

Rationale: The Client stated in the first elicitation meeting [A-2] that staff need a login system in. Av-Alert requires that only the intended Administrators can be authenticated, and thus that Public Users cannot be authenticated .

Test Scenarios :

- **TC-SER-4:** Verify that each Public User cannot gain privileged access to Av-Alert.

5.3 Reliability Requirements

Due to the extreme cold, heavy snow and freeze-thaw cycles found in the problem domain and importance that Av-Alert must be reliable, the hardware must be able to function in any weather condition.

RR-1: Av-Alert's hardware, such as Remote Sensing Instruments, must work in all weather conditions.

Rationale: The Client's RFP state that Remote Sensing Instruments will operate in "cold environment and changing weather conditions" [5]. Av-Alert can function in those conditions.

Test Scenarios :

- **TC-RR-1:** Verify that Av-Alert's hardware is functional in all weather conditions.

As aspects of any system can temporarily go down, it is important to ensure that in such an event the Data Collection feature continues to function as normal.

RR-2: The Data Collection feature must not halt if one of the Data Sources is unreachable.

Rationale: The Client stated in the second elicitation meeting that each Data Source should have "many channels open" for the purposes of gathering Raw Avalanche Data [A-3]. The Data Collection feature must continue to gather from available sources if one becomes unreachable in order to meet the Client expectations for consistent Avalanche Forecasts.

Test Scenarios :

- **TC-RR-2:** Verify that if a Data Source cannot be reached, other data collection features will still function.

5.4 Software Quality Attributes

SQR-1: Av-Alert must be developed as a series of independent subsystems.

Rationale: The Client stated in the first elicitation meeting that that Av-Alert should aim for "less hands on work from system admins" [6]. The terrain of the problem domain could prevent ease of access to both Resort Staff and Resort Administrators, making maintenance tasks more complex. Therefore it is important to maximize maintainability.

Test Scenarios :

- **TC-SQR-1:** Verify that when subsystems fail, other subsystems that are dependent on the failed subsystems should continue working, or fail elegantly.

SQR-2: Av-Alert must be capable of receiving and processing Avalanche Risk Analysis Data inflows from in-field sensors.

Rationale: In the Client's RFP it was one of their stated objectives to "automate the collection of data using the latest technologies and industry standards" [6]. Av-Alert has the capability to receive and process data from a variety of sensors.

Test Scenarios :

- **TC-SQR-2:** Verify that the Avalanche Risk Analysis Data from in-field sensors have been received and processed.

Traceability Matrix - Non-Functional Requirements

System Feature	Functional Requirement ID	Associated Use Case	Priority	Test Case ID No.
Safety Requirements	SAR-1	7	Medium	TC-SAR-1
Safety Requirements	SAR-2	7	Medium	TC-SAR-2
Security Requirements	SER-1	9	Medium	TC-SER-1
Security Requirements	SER-2	6	Medium	TC-SER-2
Security Requirements	SER-3	6	Medium	TC-SER-3a TC-SER-3b
Security Requirements	SER-4	1	High	TC-SER4
Reliability Requirements	RR-1	9	High	TC-RR-1
Reliability Requirements	RR-2	9	High	TC-RR-2
Software Quality Attributes	SQR-1	6	High	TC-SQR-1
Software Quality Attributes	SQR-2	9	High	TC-SQR-2

6 Other Requirements

In the unfortunate event of an avalanche, it is important that no liability is held by Snowlutions or the Resort using Av-Alert. Av-Alert only provides the risk analysis of an avalanche based on the available Avalanche Risk Analysis Data. It serves only as an approximation of the risk Public Users are exposed to as they make choices for themselves.

OR-1: All Public Users must agree to the Terms and Conditions of using Av-Alert.

Rationale: The Client specified in the first elicitation meeting that "the need is large across many ski resorts" in relation to Av-Alert. As it is expected that Av-Alert will be available to users who may access Av-Alert independently, it is important to offer Terms and Conditions to each user as it forms the initial legal basis between Av-Alert' and each user [9].

Test Scenarios :

- **TC-OR-1a:** Verify that the Public User must agree to the Terms and Conditions before using Av-Alert.
- **TC-OR-1b**: Verify that the Public User cannot access Av-Alert if they do not accept the Terms and Conditions.

OR-2: Av-Alert's Terms and Conditions must include that Av-Alert is not held liable in the event of injury or loss of life due to an avalanche.

Rationale: In the Client's RFP it was one of their stated objectives to "Improve safety for employees and resort customers" [6], but not to prevent or claim responsibility for the safety of each Public User. Av-Alert must Limit Liability in the case that a Public User is harmed while using Av-Alert [9].

Test Scenarios :

- **TC-OR-2:** Verify that the Terms and Conditions includes a clause that states in the event of injury or loss of life due to an avalanche, Av-Alert will not be held liable.

OR-3: Av-Alert's Terms and Conditions must include that Av-Alert is not held liable in the event of misinformation stemming from Avalanche Risk Analysis Data.

Rationale: In the Client's RFP it was one of their stated objectives to "Improve safety for employees and resort customers" [6], but not to prevent or claim responsibility for the safety of each Public User. Av-Alert must Limit Liability in the case that a Public User is harmed while using the Avalanche Forecasts to make decisions concerning their safety [9].

Test Scenarios :

- **TC-OR-3:** Verify that the Terms and Conditions includes a clause that states in the event of misinformation stemming from Avalanche Risk Analysis Data that Av-Alert will not be held liable.

Traceability Matrix - Other Requirements

System Feature	**Functional Requirement ID**	**Associated Use Case**	**Priority**	**Test Case ID No.**
Other Requirements	OR-1	N/A	Medium	TC-OR-1a TC-OR-1b
Other Requirements	OR-2	N/A	Medium	TC-OR-2
Other Requirements	OR-3	N/A	Medium	TC-OR-3

7 Use Case Diagram

Below, through a Use Case Diagram, is displayed how users will interact with Av-Alert.

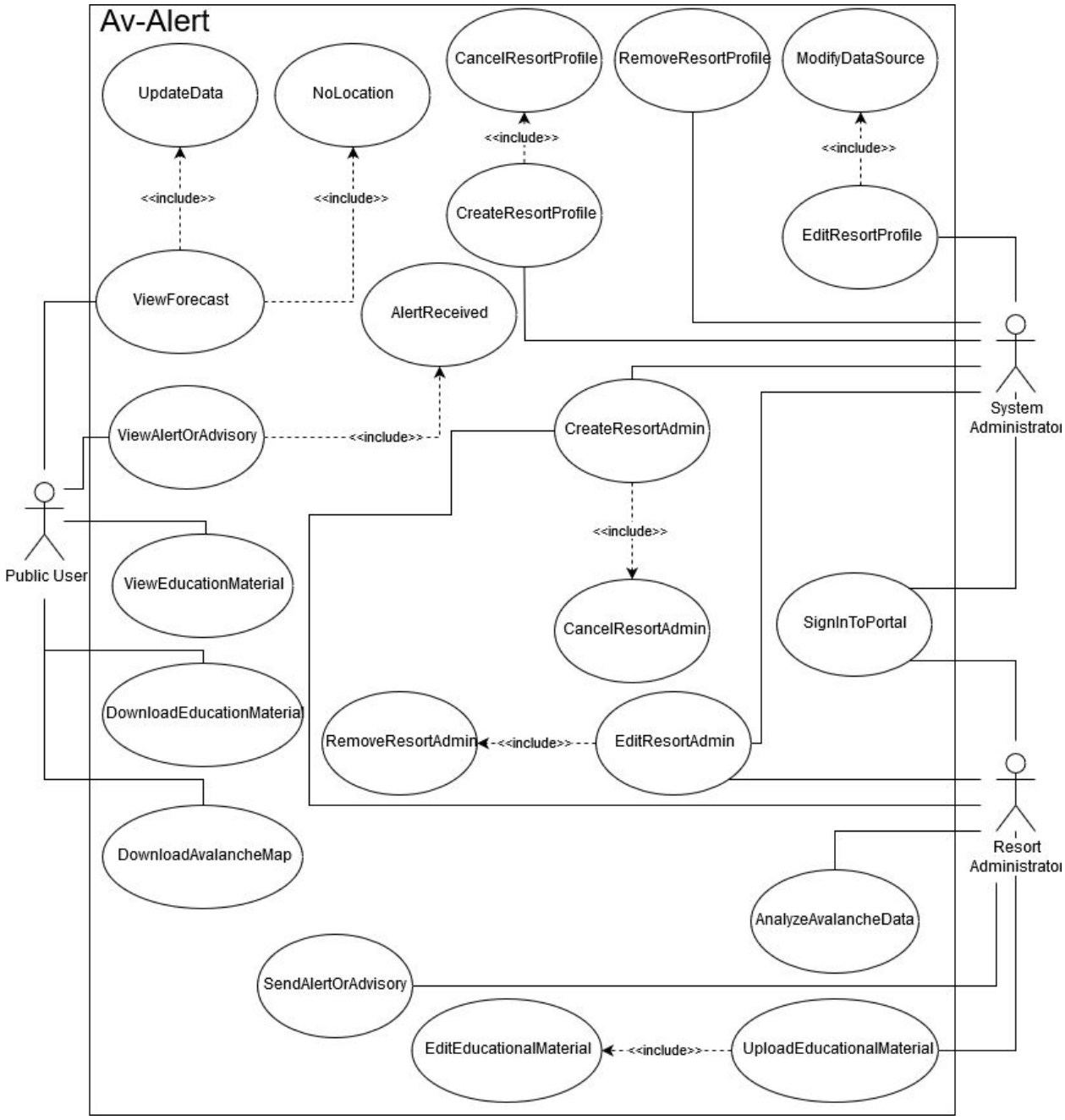


Figure 2: Av-Alert's Use Case Diagram.

7.1 Use Cases

The following section outlines the different use cases that a Public User or Administrator may follow. Use Cases regarding high priority system features are followed by a System Sequence Diagram. Use Cases regarding high priority system features and Use Cases which are important to client specified system features are followed by a User Interface Storyboard. System Sequence Diagrams and User Interface Storyboards are not included for the high priority Use Cases: CreateResortProfile, EditResortProfile, and RemoveResortProfile. This exclusion is due to their close similarity with the Use Cases: CreateResortAdmin, EditResortAdmin, and RemoveResortAdmin.

Use Case: ViewForecast	
ID:	1
Brief description:	The Public User views Avalanche Forecast through the Topological Map.
Actor(s):	Public User.
Preconditions:	1. The Public User has GPS location provided to Av-Alert.
Main flow:	1. The Public User selects the Topological Map. 2. If the Public User has not provided a location to Av-Alert then: 2.1. The Public User manually selects a Resort as their Specified Resort. 3. If the Public User adjusts the view of the Topological Map then: 3.1. Public User sees an updated view of the Topological Map. 4. The Public User selects a Slope of the Topological Map. 5. The Public User sees the Avalanche Forecast for that area.
Postconditions:	1. If the Public User selected a Specified Resort then: 1.1. Av-Alert has cached the Resort on the Public User's mobile device.
Alternative flow(s):	UpdateData

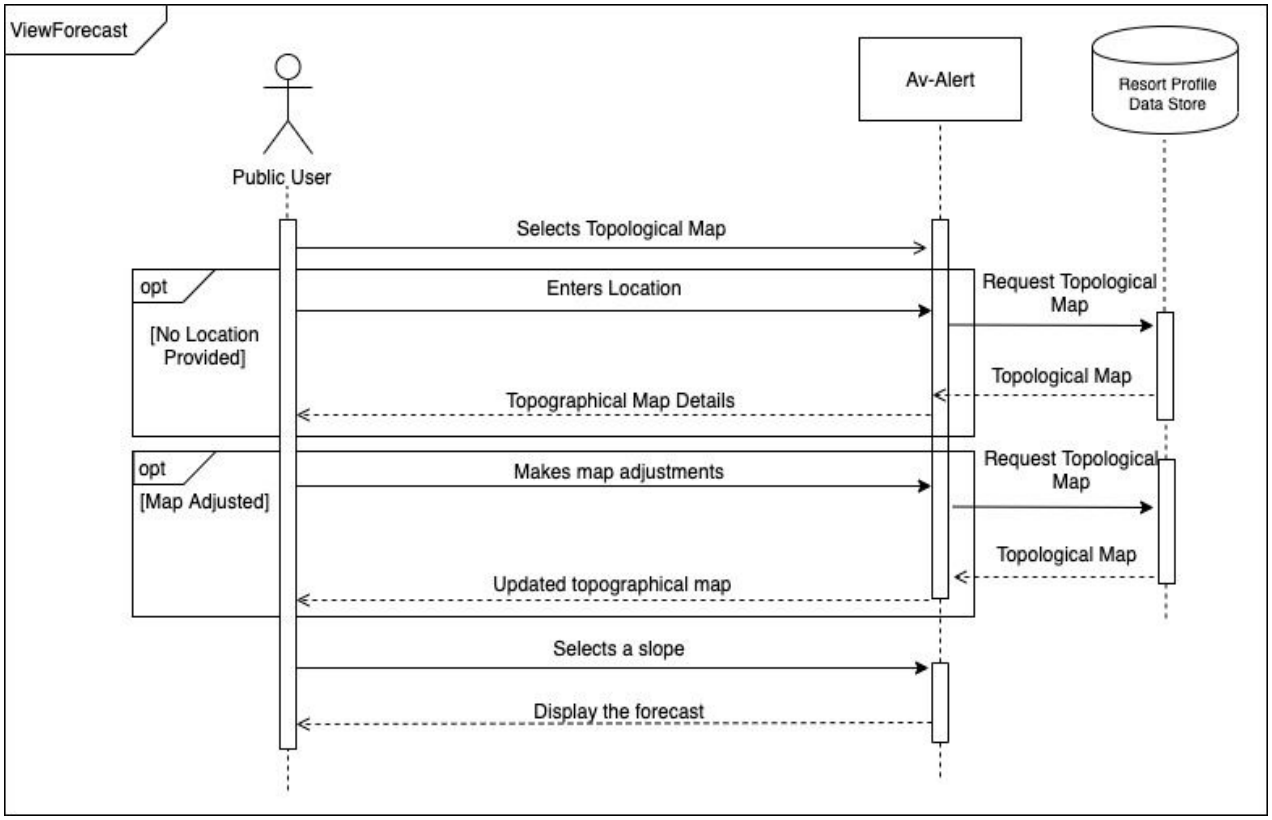
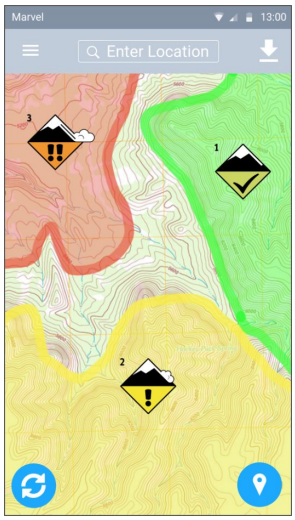
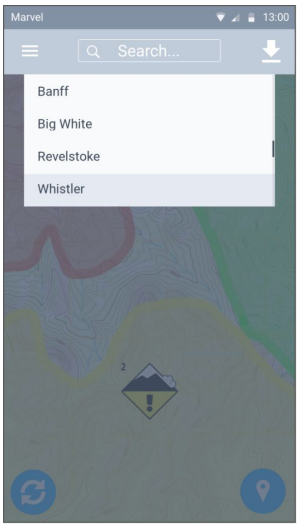
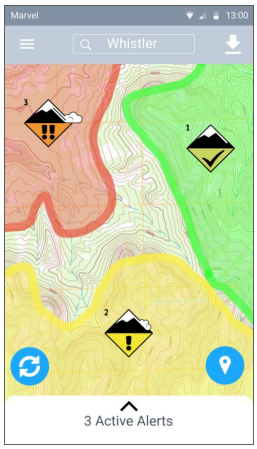
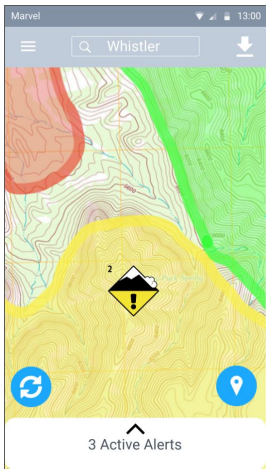


Figure 3: System Sequence Diagram - Use Case 1.

<table>
<tr><td colspan="3">Storyboard: The Public User Without a Specified Resort Views Avalanche Forecast</td></tr>
<tr><td>1. The Public User is viewing the Topological Map.</td><td colspan="2">2. After selecting “Enter Location”.</td></tr>
<tr><td> 
</td><td colspan="2"> 
</td></tr>
<tr><td>3. After selecting a Resort from the list of Resorts.</td><td>4. After adjusting the map by zooming map into a Medium Risk Slope.</td><td>5. After selecting the Medium Risk Slope.</td></tr>
<tr><td> 
</td><td> 
</td><td> 
</td></tr>
</table>

Alternative Flow: ViewForecast: UpdateData	
ID:	1.1
Brief description:	The Public User updates the Avalanche Risk Analysis Data on the Topological Map.
Actor(s):	Public User.
Preconditions:	None.
Alternate flow:	The alternate flow begins at any time. 1. The Public User updates the information on the map by selecting the refresh option. 2. If Av-Alert is able to retrieve Avalanche Risk Analysis Data on the Topological Map which is newer than the current Avalanche Forecast loaded on Av-Alert then: 2.1. The Public User's view of the Topological Map is updated with the new Avalanche Risk Analysis Data. 3. Else the Public User sees that no new Avalanche Risk Analysis Data is available.
Postconditions:	None.

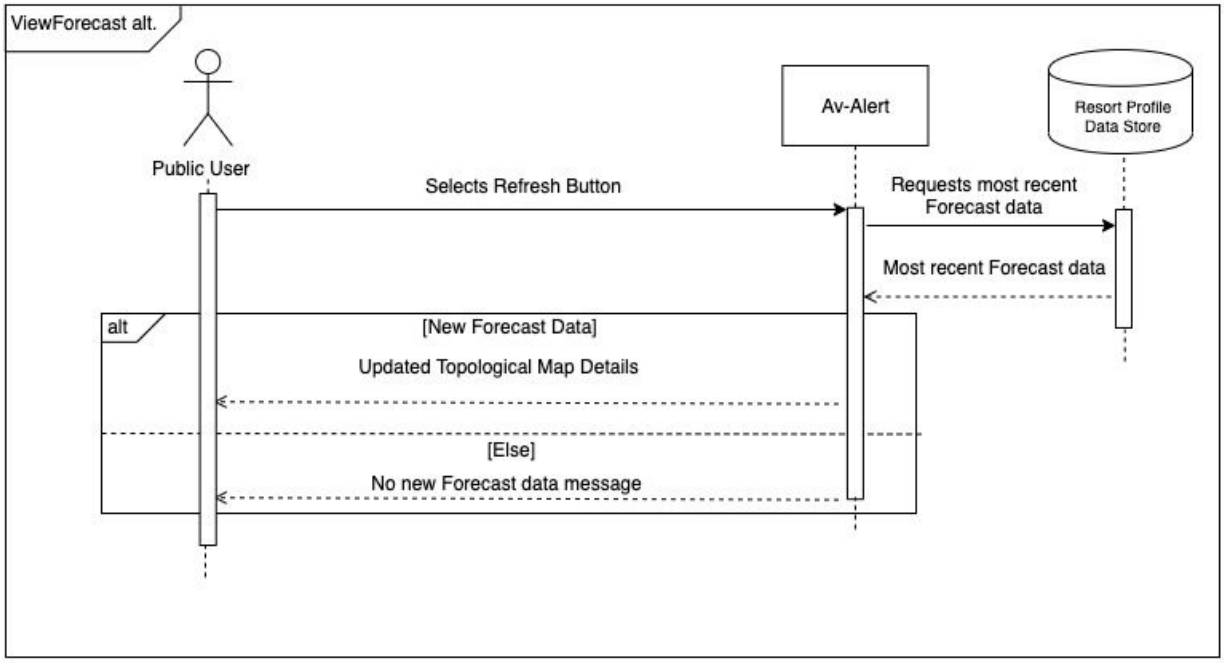
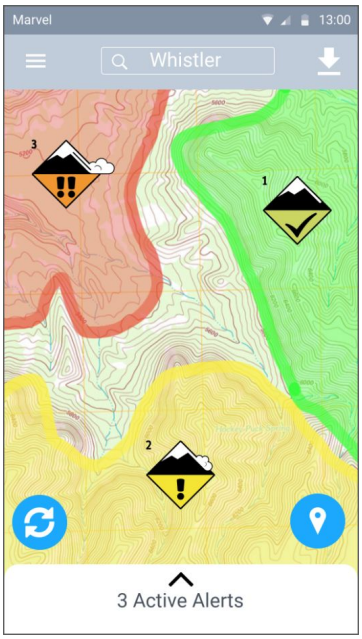
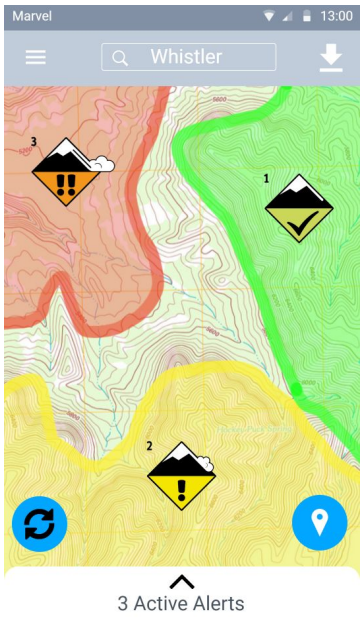


Figure 4: System Sequence Diagram - Use Case 1.1.

<table>
<tr><td colspan="2">Storyboard: The Public User Updates Map Data</td></tr>
<tr><td>1. The Public User has previously selected “Whistler” as their Specified Resort.</td><td>2. After selecting update button in the bottom left corner.</td></tr>
<tr><td> 
</td><td> 
</td></tr>
<tr><td colspan="2">3. After the Public User is notified that the Topological Map has been updated.</td></tr>
<tr><td colspan="2"> 
</td></tr>
</table>

Use Case: DownloadAvalancheMap	
ID:	2
Brief description:	The Public User downloads the Topological Map for offline use.
Actor(s):	Public User.
Preconditions:	1. The Public User has GPS location provided to Av-Alert. 2. The Public User has cell service or Wi-Fi connection. 3. The Public User has selected their Specified Resort.
Main flow:	1. The Public User selects the Topological Map. 2. The Public User selects the option to download the map.
Postconditions:	1. The map is downloaded to the Public User's mobile device and stored in the application memory.
Alternate flow:	None.

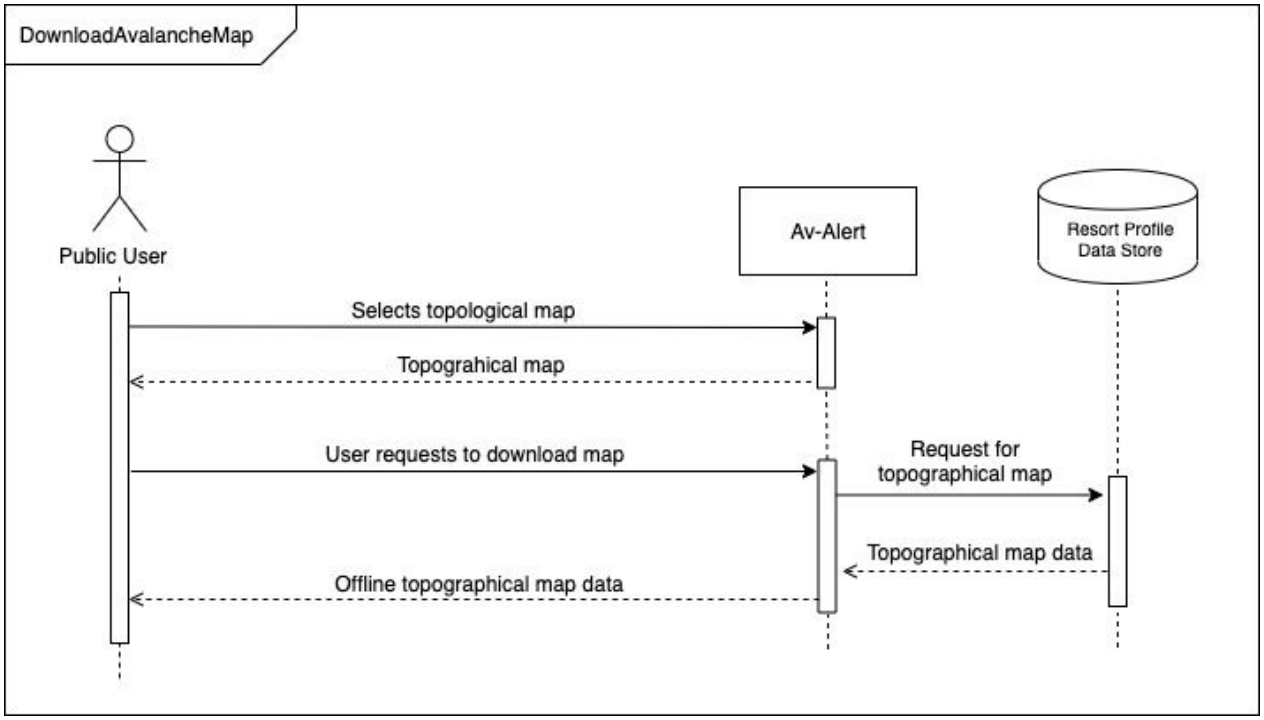
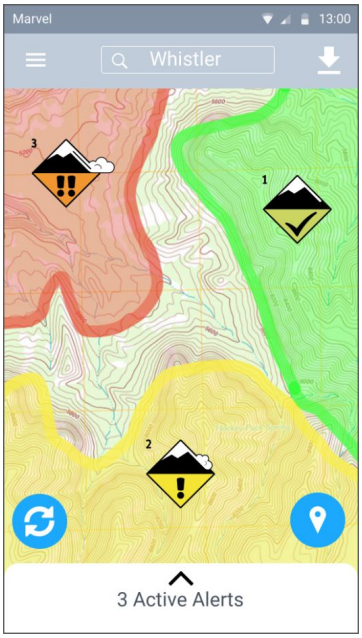
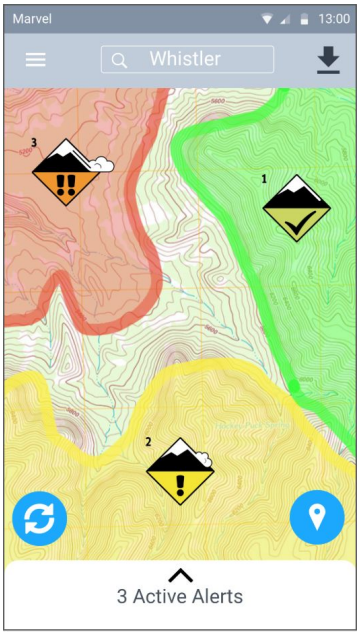
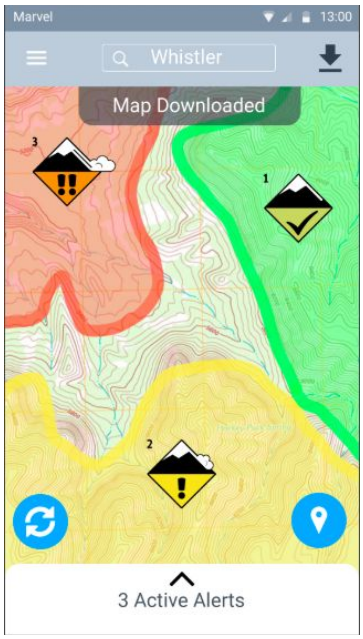


Figure 5: System Sequence Diagram - Use Case 2.

<table>
<tr><td colspan="2">Storyboard: The Public User Downloads Map to their Device</td></tr>
<tr><td>1. The Public User is at the Topological Map screen.</td><td>2. After selecting the download button in the top right corner.</td></tr>
<tr><td> 
</td><td> 
</td></tr>
<tr><td colspan="2">3. After the Public User is notified that the Topological Map has been downloaded.</td></tr>
<tr><td colspan="2"> 
</td></tr>
</table>

Use Case: ViewAlertOrAdvisory	
ID:	3
Brief description:	The Public User views an Alert or Advisory pertaining to an Avalanche Forecast.
Actor(s):	Public User.
Preconditions:	1. The Public User has GPS location provided to Av-Alert.
Main flow:	1. The Public User navigates to the list of Alerts and Advisories. 2. The Public User sees the list of Alerts and Advisories, sorted in order of most recently received. 3. The Public User selects an item from the list of Alert and Advisories 4. The Public User sees the expanded view of the selected Alert or Advisory.
Postconditions:	None.
Alternative flow(s):	AlertReceived.

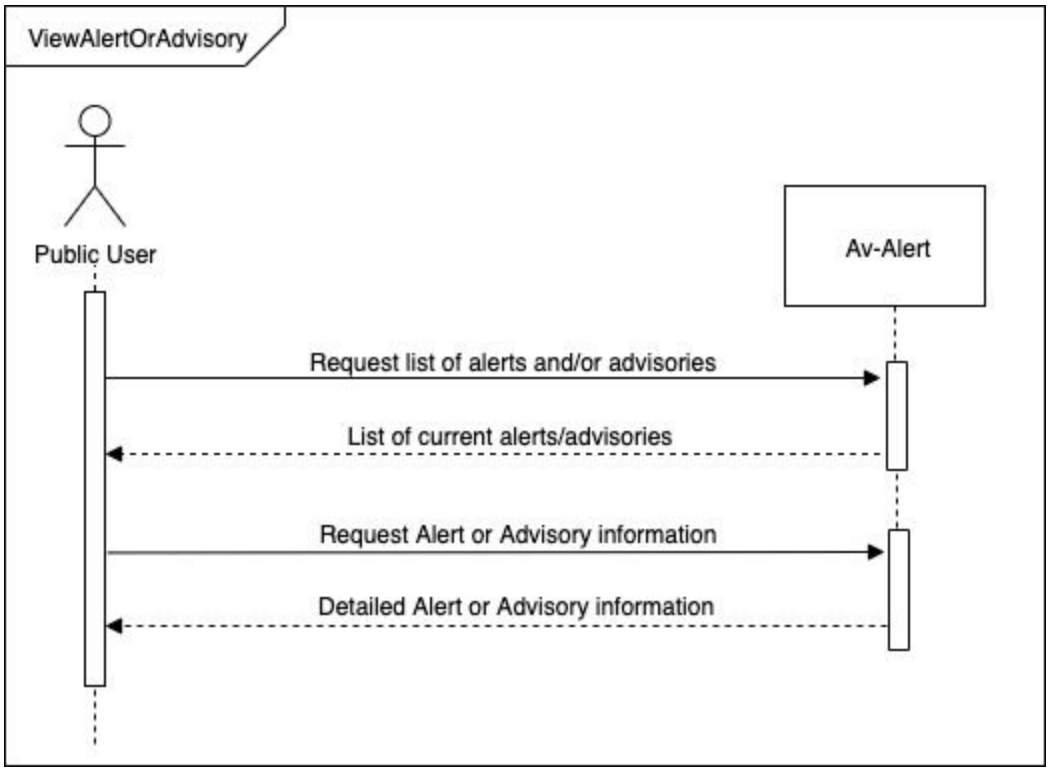
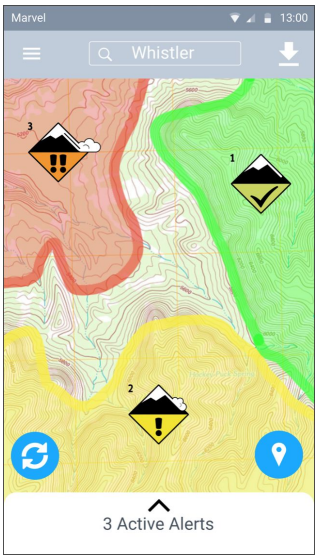
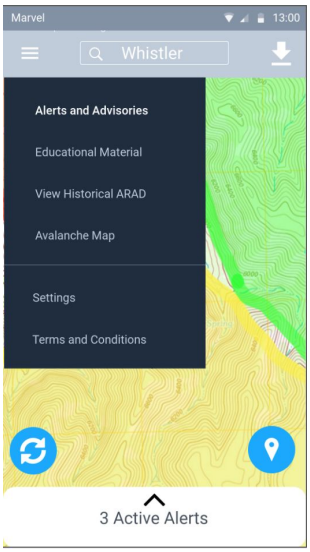
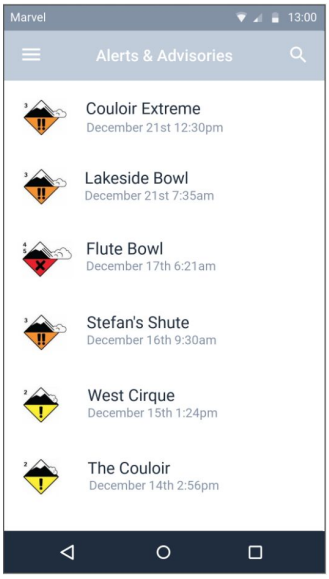
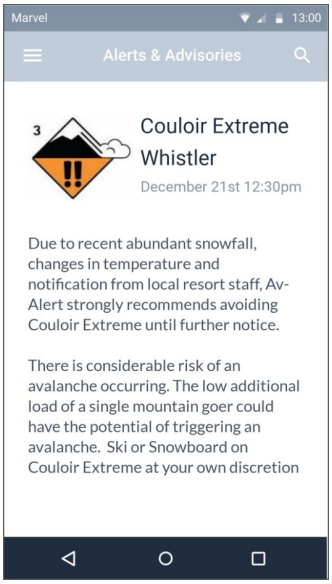


Figure 6: System Sequence Diagram - Use Case 3.

Storyboard: The Public User Views a Specific Slope Alert	
1. The Public User is at the Topological Map screen.	2. After selecting the hamburger button in the top left corner.
	
3. After selecting "Alerts and Advisories" from the list of options.	4. After selecting the first Alert in the list of Alerts and Advisories.
	

Alternative Flow: ViewAlertOrAdvisory: AlertReceived	
ID:	3.1
Brief description:	The Public User opens a received Alert.
Actor(s):	Public User.
Preconditions:	1. The Public User has GPS location provided to Av-Alert. 2. An Alert has been sent out to the Resort which matches the Specified Resort of the Public User.
Alternate flow:	1. The Public User has received a push notification on their mobile device notifying them of an Alert. 2. The Public User selects the notification. 3. The Public User is directed by Av-Alert to the received Alert. Main flow is entered at step 4.
Postconditions:	1. Alert is now marked as read but remains available for viewing.

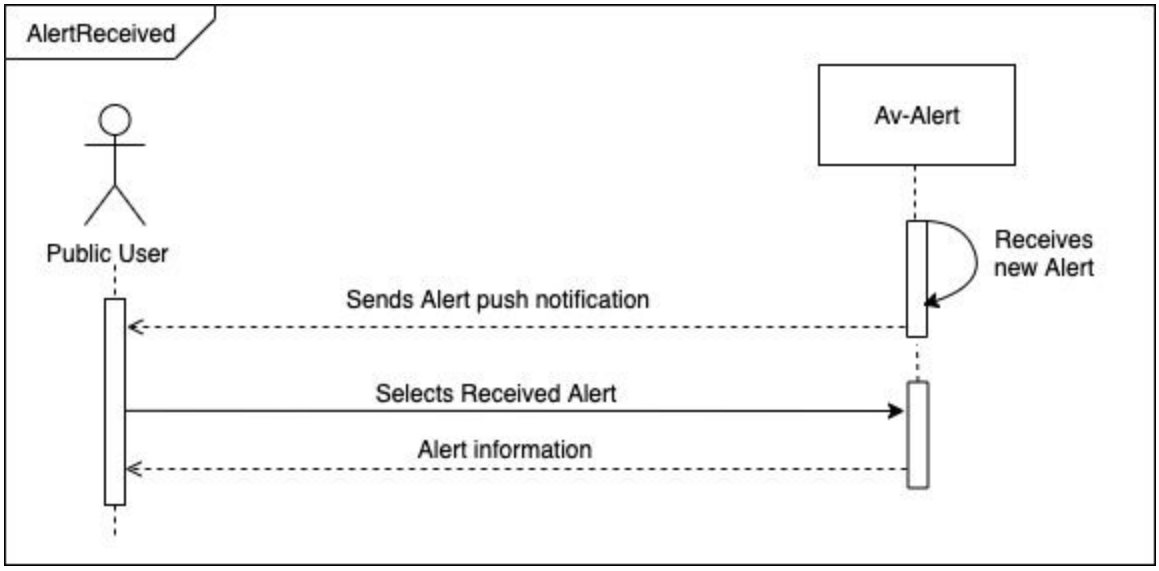
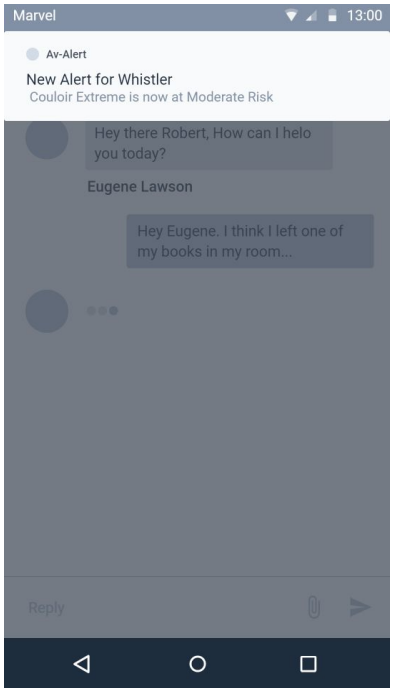
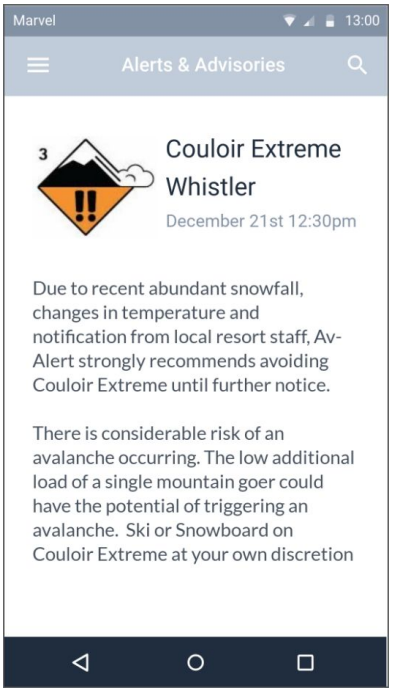


Figure 7: System Sequence Diagram - Use Case 3.1

Storyboard: The Public User Receives an Alert While Outside of Av-Alert App	
1. The Public User is notified of an Alert using a Push Notification.	2. After selecting the Push Notification the Av-Alert application is opened directly to the Alert.
	

Use Case: ViewEducationalMaterial	
ID:	4
Brief description:	The Public User views Educational Material information relevant to avalanche risk.
Actor(s):	Public User.
Preconditions:	1. The Public User
Main flow:	1. The Public User navigates to the Educational Material section. 2. The Public User sees a list of Educational Material materials sorted in order of most recently published. 3. The Public User selects a piece of content. 4. The Public User sees the expanded view of the selected safety or training content. 5. If the selected content contains video content then: 5.1. The Public User presses the play button to start the video content. 5.2. The Public User views the video content.
Postconditions:	None.
Alternative flow(s):	None.

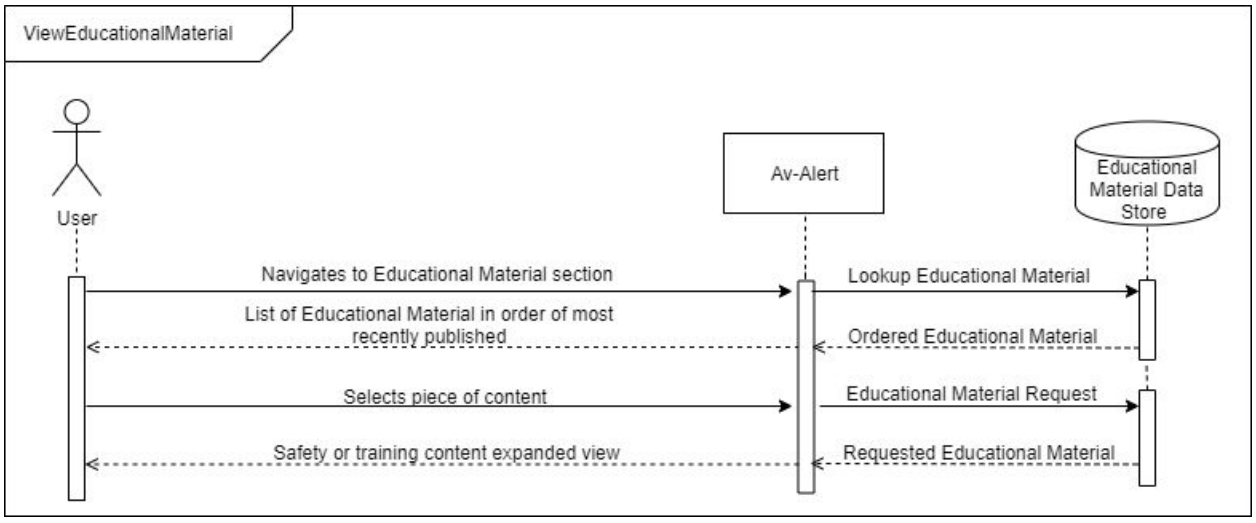
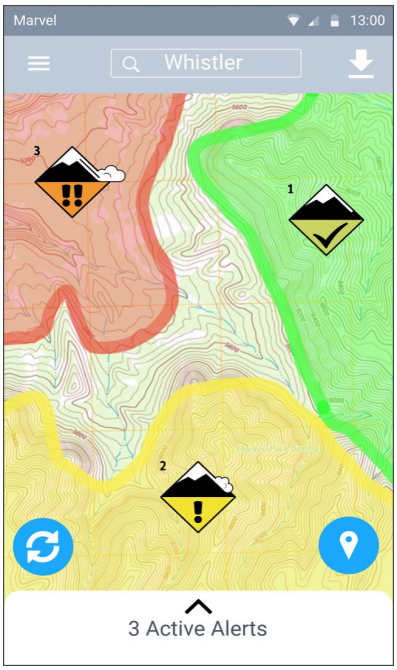
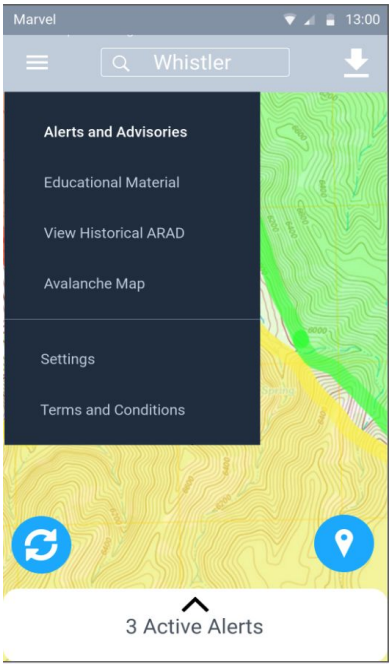
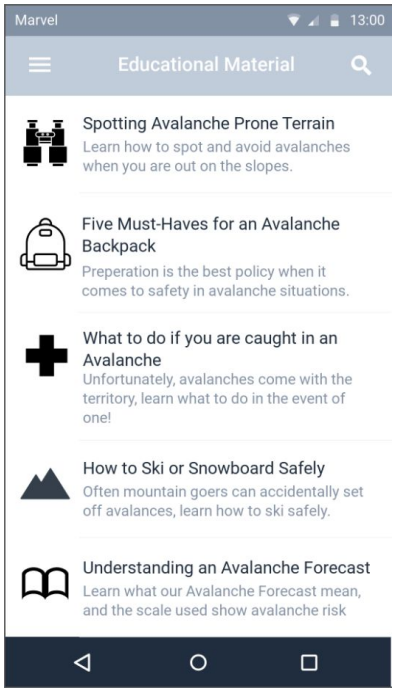
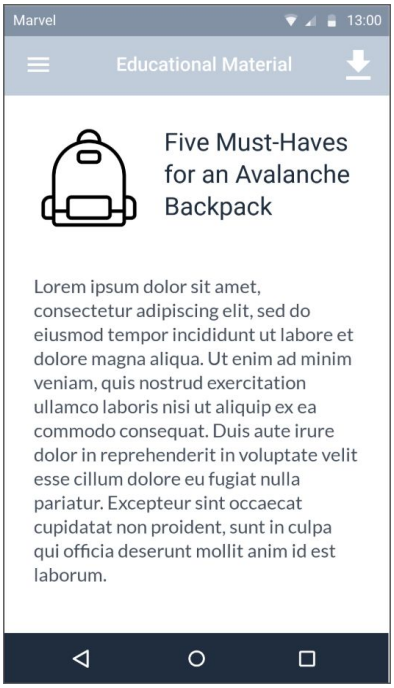


Figure 8: System Sequence Diagram - Use Case 4

Storyboard: Public User Views a Specific Piece of Educational Material	
1. The Public User is at the Topological Map screen.	2. After selecting the hamburger button in the top left corner.
	
3. After selecting “Educational Material” from the list of options.	4. After selecting the second piece of content from the list of Educational Materials.
	

Use Case: DownloadEducationalMaterial	
ID:	5
Brief description:	The Public User downloads a piece of Educational Material information.
Actor(s):	Public User.
Preconditions:	1. The Public User has GPS location provided to Av-Alert. 2. The Public User has cell service or Wi-Fi connection.
Main flow:	1. The Public User navigates to the Educational Material section. 2. The Public User sees a list of Educational Material materials sorted in order of most recently published. 3. The Public User selects a piece of content. 4. The Public User sees the expanded view of the selected safety or training content. 5. The Public User selects the download option for that piece of content.
Postconditions:	1. The selected content is downloaded to the Public Users mobile device and stored in the application memory.
Alternative flow(s):	None.

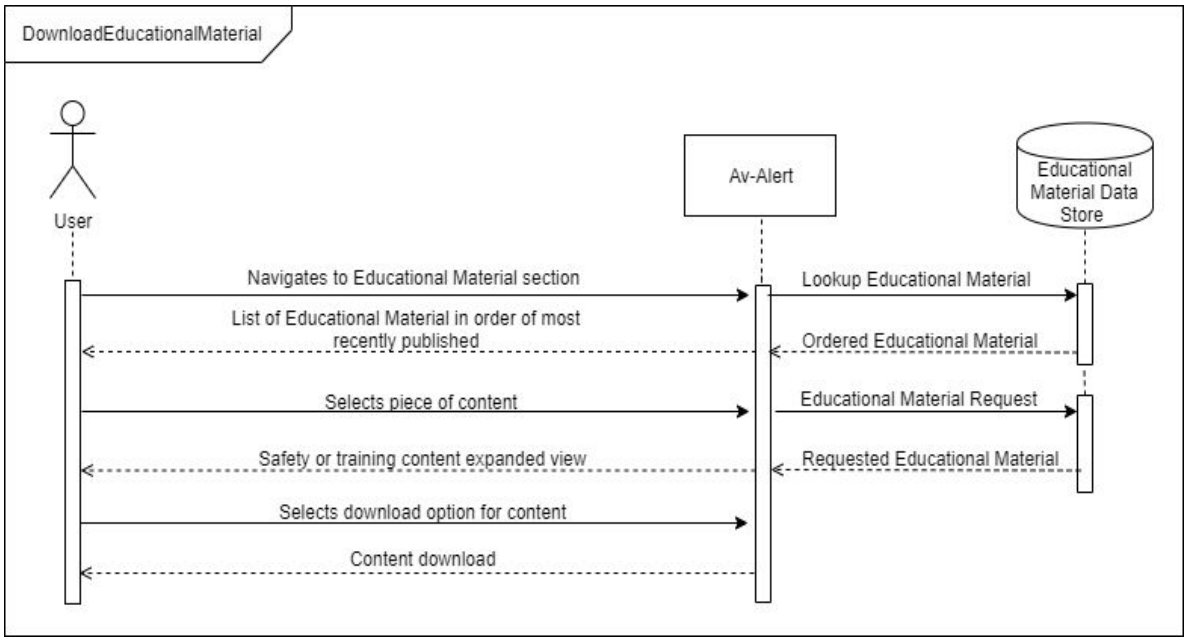
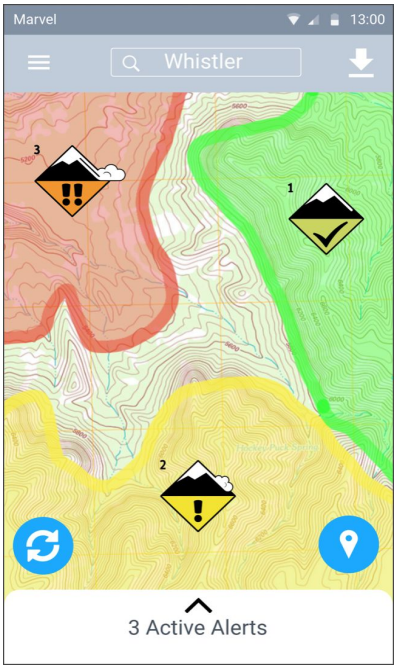
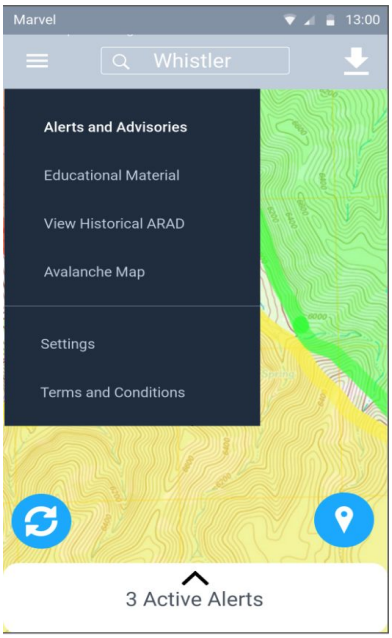
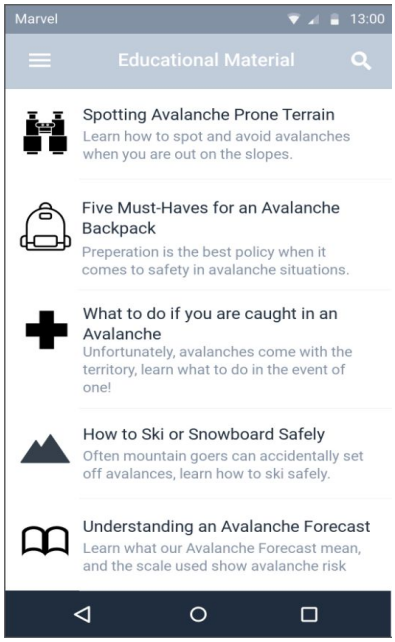
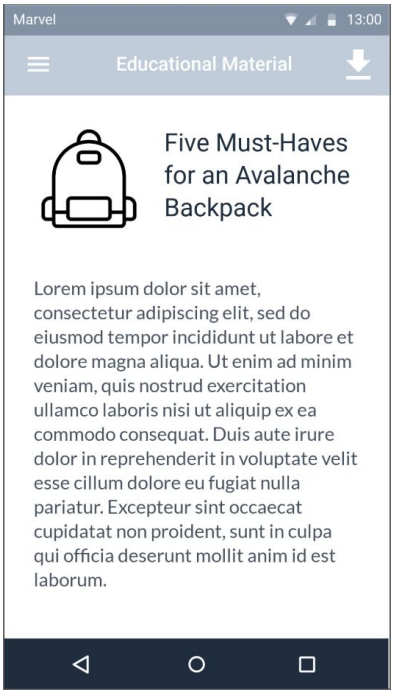
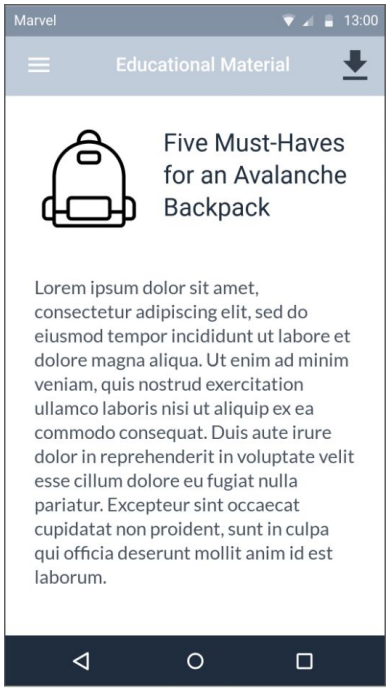


Figure 9: System Sequence Diagram - Use Case 5

Storyboard: The Public User Downloads a Specific Piece of Educational Material	
1. The Public User is at the Topological Map screen.	2. After the Public User has opened the option menu
	
2. After selecting “Educational Material” from the list of options.	3. After selecting the second piece of content from the list of Educational Materials.
	

4. After selecting the download button in the top right corner.	5. After the Public Users is notified that the Educational Material has been downloaded.
	

Use Case: SignInToPortal	
ID:	6
Brief description:	The Administrator wants to sign in to the Administrative Portal.
Actor(s):	System Administrator or Resort Administrator.
Preconditions:	1. The Administrator has previously created an account.
Main flow:	1. The Administrator opens the Administrative Portal 2. The Administrator enters their username and password. 3. While the username and password are incorrect then: 3.1. The Administrator is prompted to enter their credentials again. 4. The Administrator is verified and signed into their account.
Postconditions:	1. The Administrator is now signed into the Administrative Portal.
Alternative flow(s):	3.1 b) Username not recognized. 3.1 c) Password incorrect.

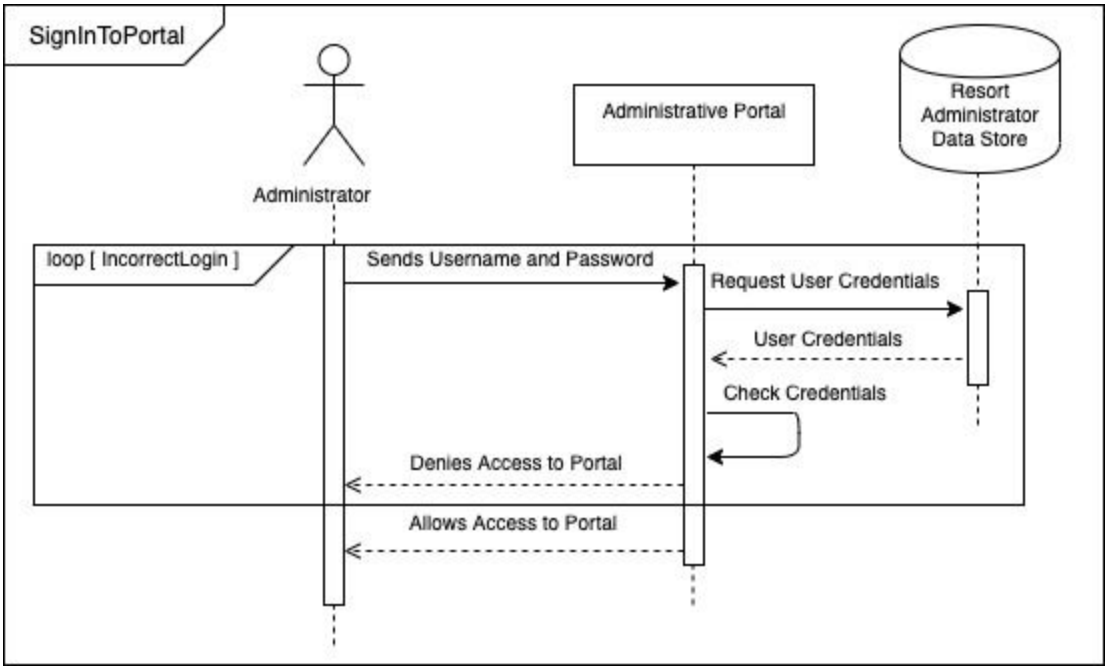
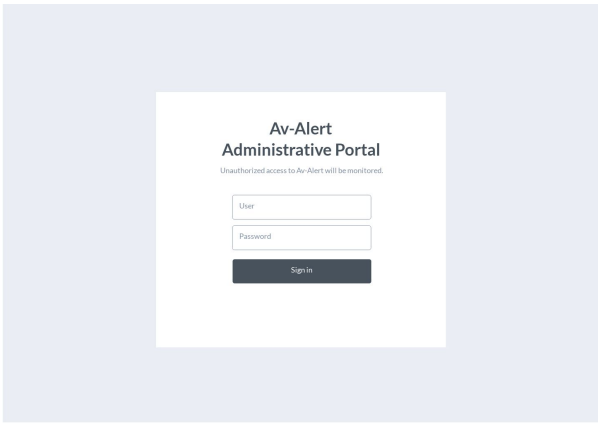
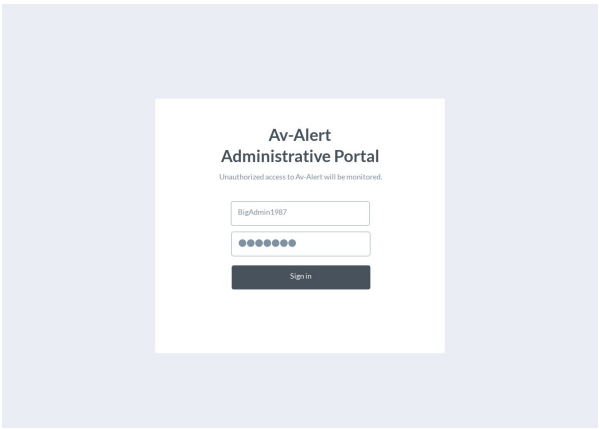
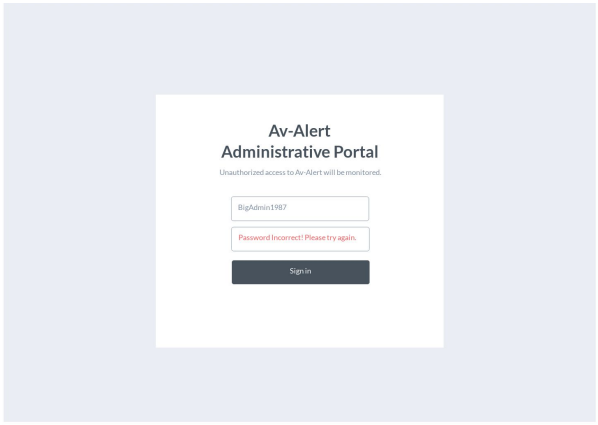
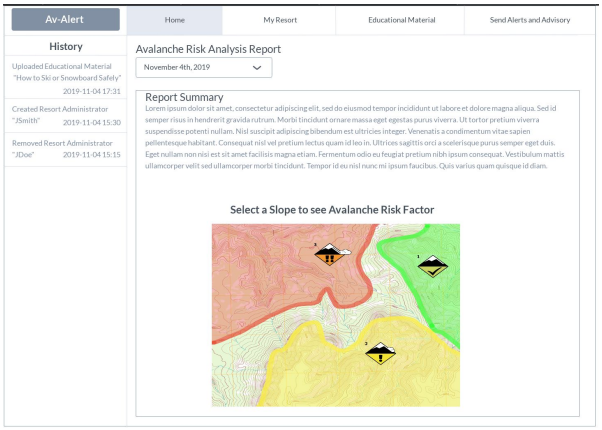


Figure 10: System Sequence Diagram - Use Case 6.

Storyboard: The Administrator Signs in to the Administrative Portal	
1. The Administrator is at the sign in screen of the Administrative Portal.	2. The Administrator enters their username and password into the appropriate fields.
	
3. a) After clicking the “Sign in” button with incorrect username or password.	3. b) After clicking the “Sign in” button with the correct username and password.
	

Use Case: SendAlertOrAdvisory	
ID:	7
Brief description:	The Resort Administrator decides the need for an Alert or an Advisory for a Slope.
Actor(s):	Resort Administrator.
Preconditions:	1. The Resort Administrator has processed the latest Avalanche Risk Analysis Data and identified a medium or greater Risk Factor for a Slope within the 50km radius of the Resort. 2. The Resort Administrator is signed into the Administrative Portal.
Main flow:	1. The Resort Administrator sees the latest colour-coded Avalanche Forecast for the surrounding Slopes on the Topological Map. 2. The Resort Administrator selects a Slope of the Topological Map for detailed information on Avalanche Risk Factor. 3. If the Resort Administrator decides the Risk Factor is great enough to warrant an Alert to be sent out then: 3.1. The Resort Administrator authorizes an Alert for that Slope. 3.2. The Resort Administrator sees that Av-Alert has sent the Alert to each Public User who has set their specified Resort to the Resort Administrator's Resort. 3.3. The Resort Administrator sees that Av-Alert has begun broadcasting the authorized Alert over the local radio channel reserved for Alert and Advisory information. 4. Else if the Resort Administrator decides the Risk Factor is enough to warrant an Advisory then: 4.1. The Resort Administrator authorizes an Advisory for their Resort. 4.2. The Resort Administrator sees that Av-Alert has set an Advisory for the specified Slope. 4.3. The Resort Administrator sees that Av-Alert has begun broadcasting the authorized Advisory over the local radio channel reserved for Alert and Advisory information.
Postconditions:	1. If an Alert has been sent out for a Slope then: 1.1. The Alert has been recorded in Av-Alert. 1.2. Each Public User with their Specified Resort set to a Resort within 50km of the Slope will receive an Av-Alert notification. 2. Else if an Advisory has been sent out for a Slope then: 2.1. The Advisory has been recorded in Av-Alert. 2.2. Each Public User with their Specified Resort set to a Resort within 50km of the Slope will see the Advisory if they select that area of the Topological Map.
Alternative flow(s):	None.

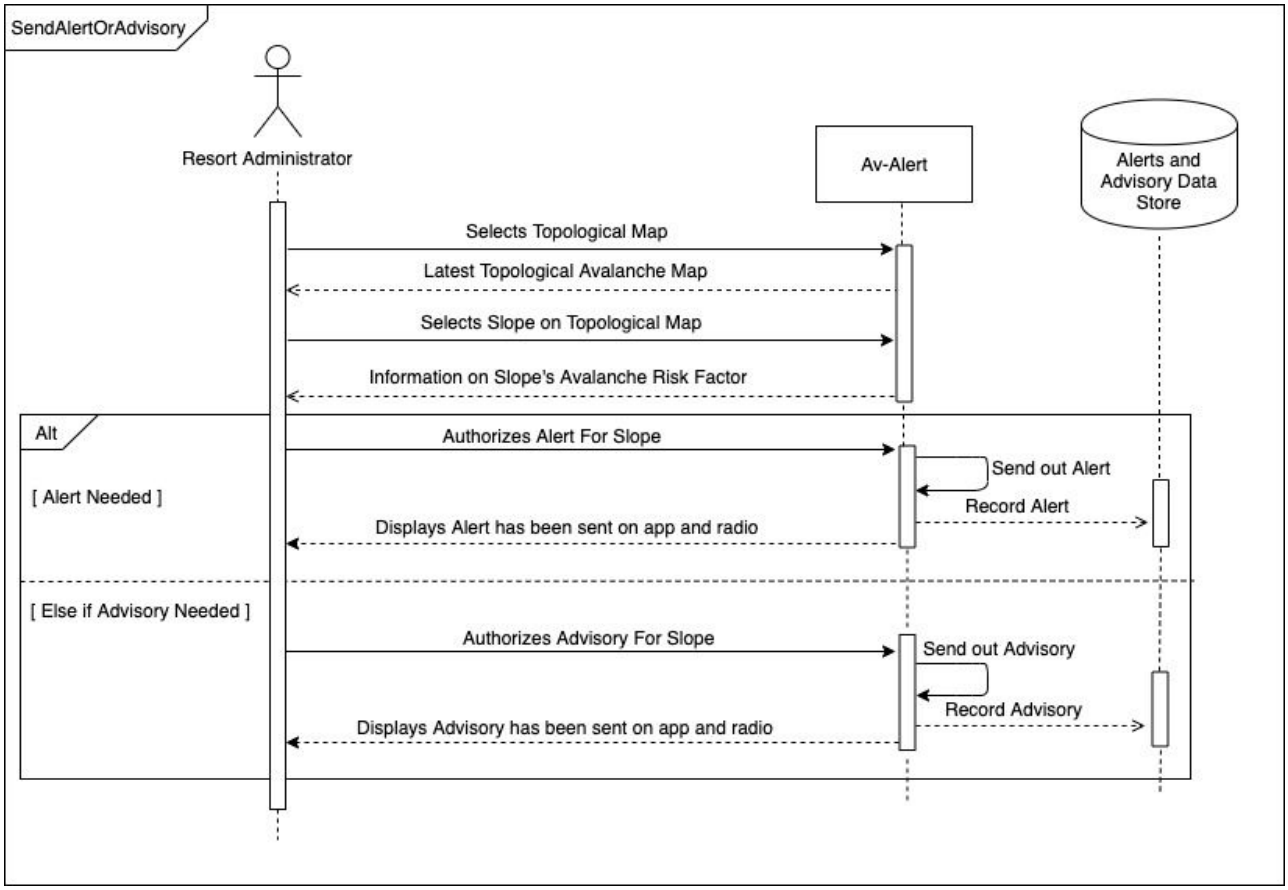
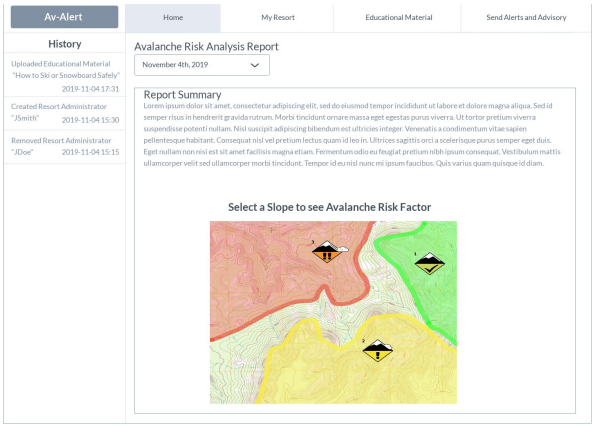
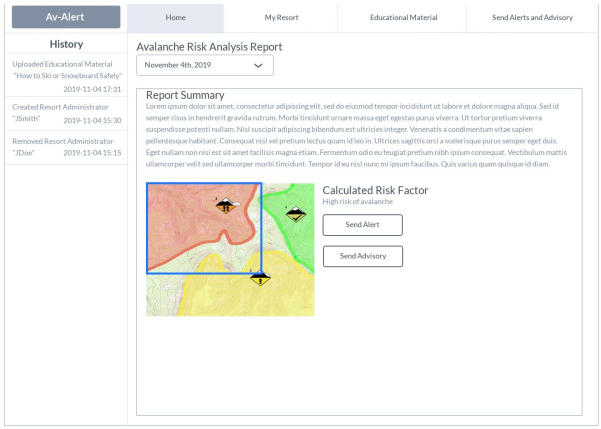
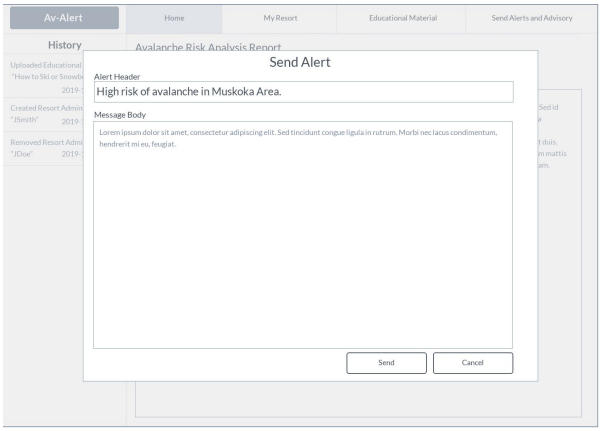
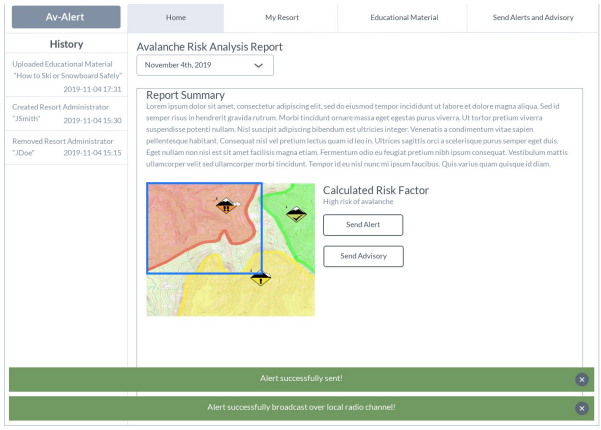
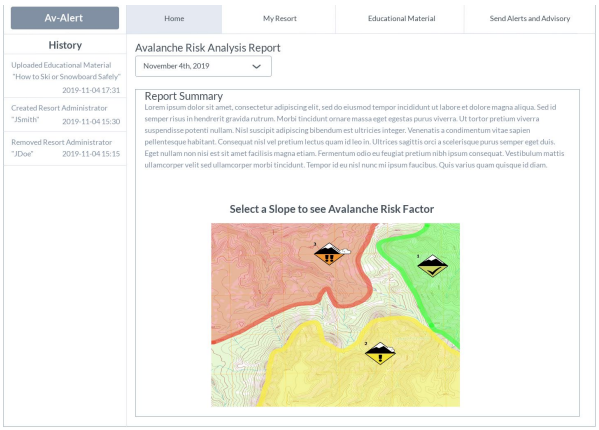
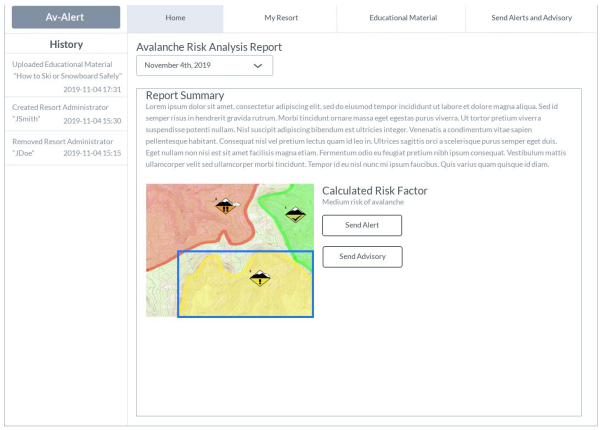
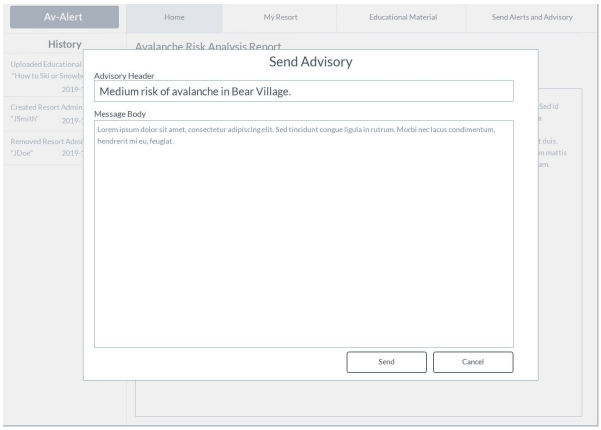
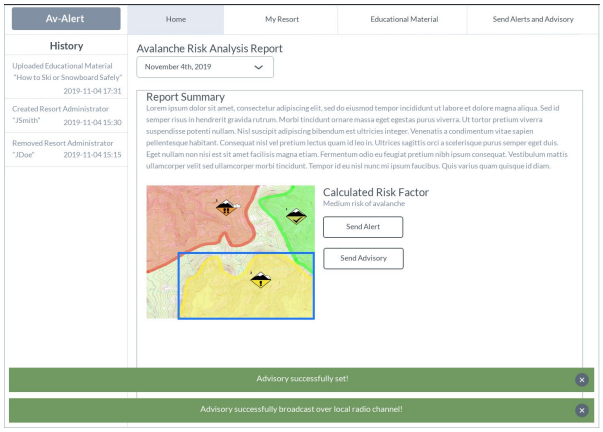


Figure 11: System Sequence Diagram - Use Case 7.

Storyboard: The Resort Administrator Sends Alert	
1. The Resort Administrator is viewing the latest Avalanche Forecast.	2. The High Risk Slope is selected.
	
3. After selecting “Send Alert”, the Alert is ready to be authorized.	4. After selecting “Send” on the Alert
	

Storyboard: The Resort Administrator Sends Advisory	
1. The Resort Administrator is viewing the latest Avalanche Forecast.	2. The Medium Risk Slope is selected.
	
3. After selecting “Send Advisory”, the Advisory is ready to be authorized.	4. After selecting “Send” on the Advisory.
	

Use Case: UploadEducationalMaterial	
ID:	8
Brief description:	The Administrator wants to upload or edit Educational Material content.
Actor(s):	System Administrator or Resort Administrator.
Preconditions:	1. The Administrator is signed into the Administrative Portal.
Main flow:	1. The Administrator selects the Educational Material page.. 2. The Administrator sees a list of any previously uploaded Educational Material. 3. The Administrator selects add new Educational Material. 4. The Administrator uploads new Educational Material to Av-Alert.
Postconditions:	1. The Educational Material has been uploaded to Av-Alert.
Alternative flow(s):	EditMaterial.

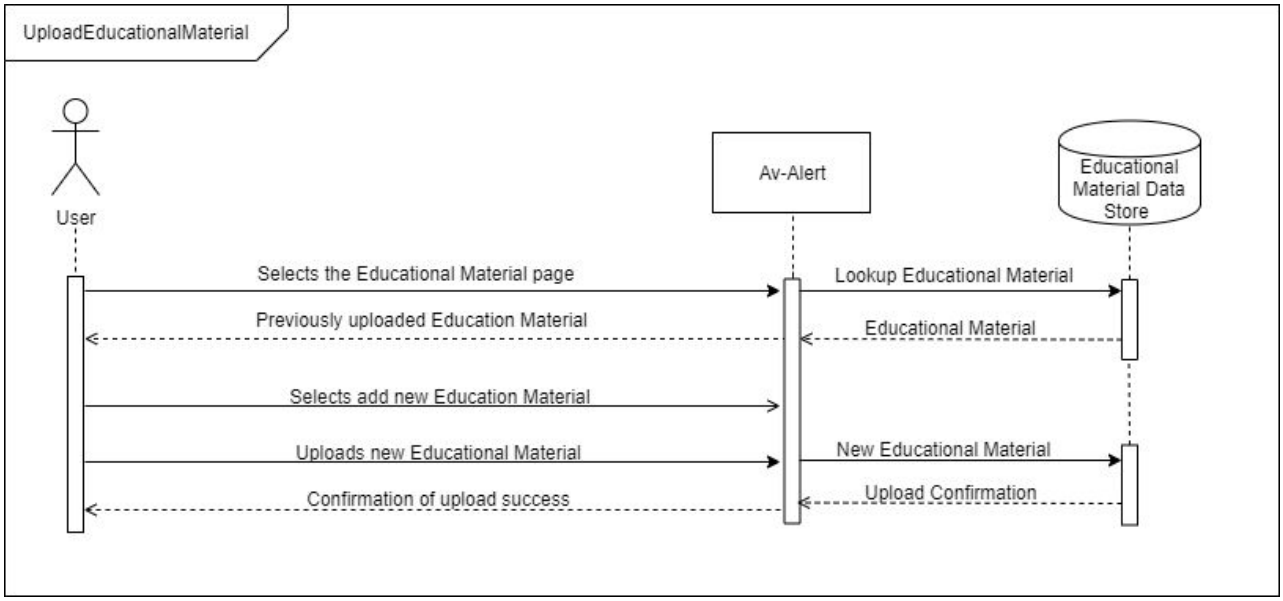


Figure 12: System Sequence Diagram - Use Case 8.

Alternative Flow: UploadEducationalMaterial: EditEducationalMaterial	
ID:	8.1
Brief description:	The Administrator wants to edit pre-existing Educational Material.
Actor(s):	System Administrator or Resort Administrator.
Preconditions:	1. Educational Material has been previously uploaded to Av-Alert. 2. The Administrator is signed into the Administrative Portal.
Main flow:	1. The Administrator selects the Educational Material page. 2. The Administrator sees a list of any previously uploaded Educational Material. 3. The Administrator selects an item from the list of Educational Material. 4. The Administrator selects edit Educational Material. 5. The Administrator makes modification to the selected Educational Material. 6. The Administrator selects save changes.
Postconditions:	1. The edits made to the selected Educational Material has been recorded.
Alternative flow(s):	None.

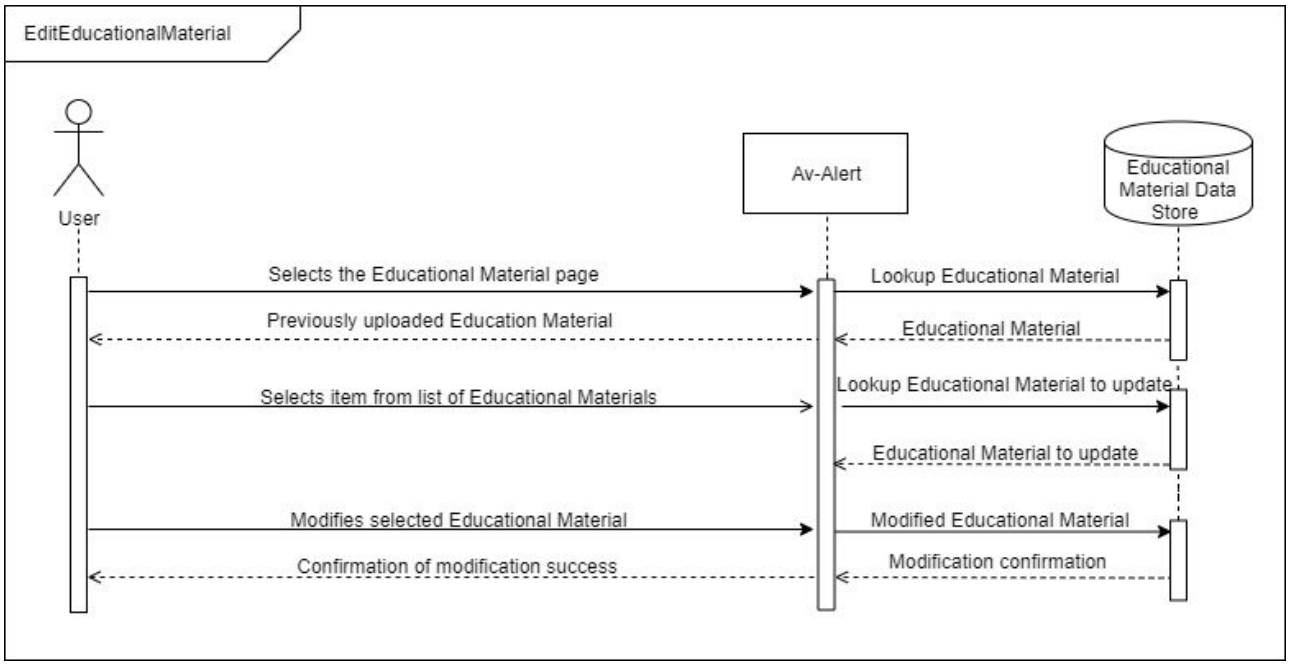


Figure 13: System Sequence Diagram - Use Case 8.1.

Use Case: AnalyzeAvalancheData	
ID:	9
Brief description:	The Actor downloads and analyzes the trend in Avalanche Risk Analysis Data that were collected over a period of time.
Actor(s):	Resort Administrator, System Administrator, or Public User.
Preconditions:	1. If the Actor is an Administrator then: 1.1. The Actor is signed into the Administrative Portal
Main flow:	1. The Actor selects the list view of Avalanche Risk Analysis Data. 2. The Actor sees each Avalanche Risk Analysis Data Set, which is sorted by most recently recorded. 3. The Actor selects an Avalanche Risk Analysis Data Set from the list to download. 4. The Actor sees a confirmation that the Avalanche Risk Analysis Data Set has been downloaded successfully. 5. The Actor sees a detailed view of the Avalanche Risk Analysis Data for the selected time period.
Postconditions:	None.
Alternative flow(s):	None.

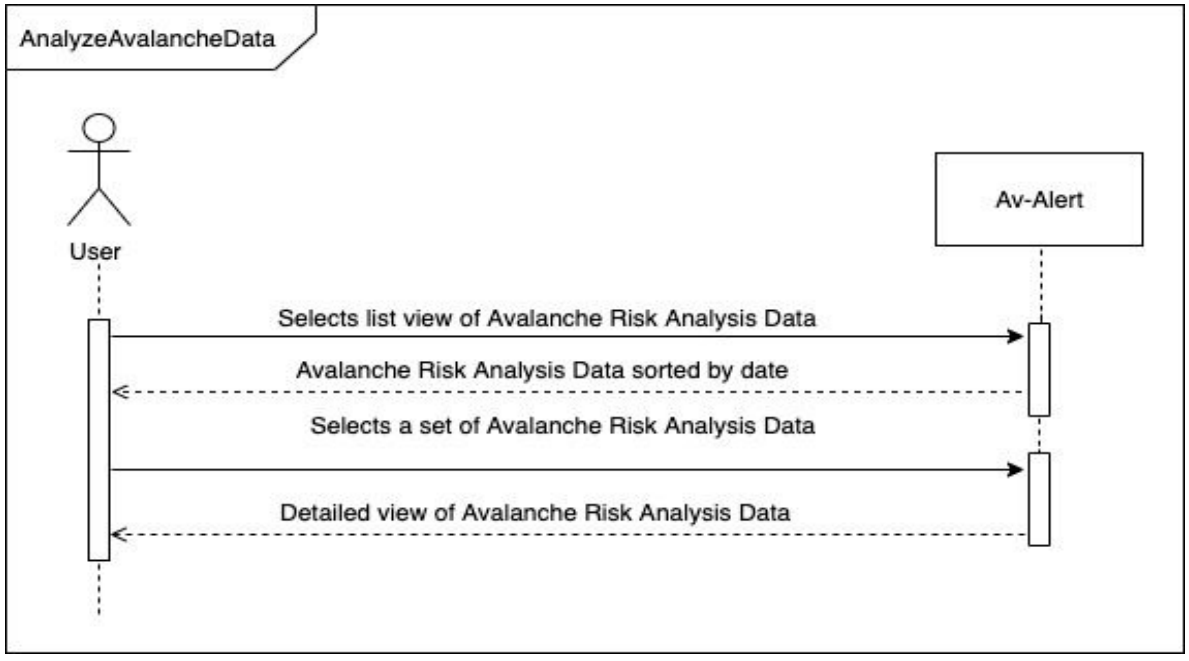
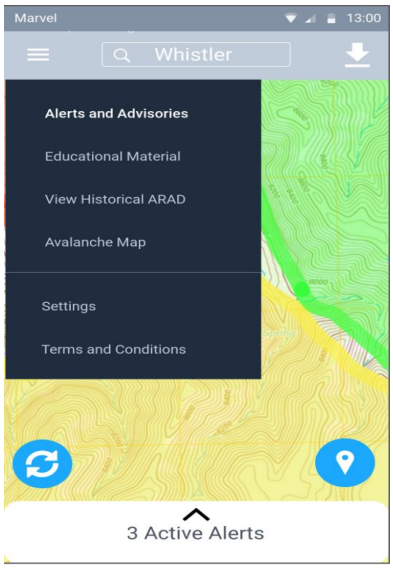
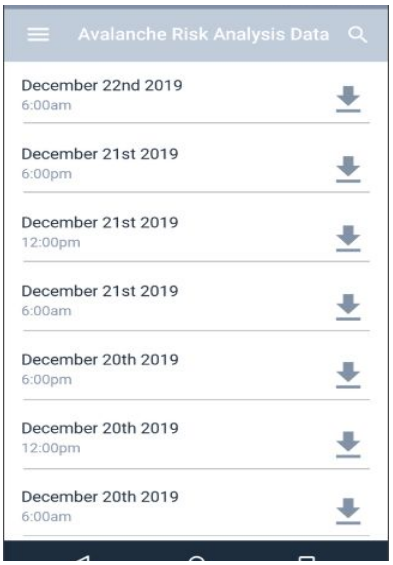
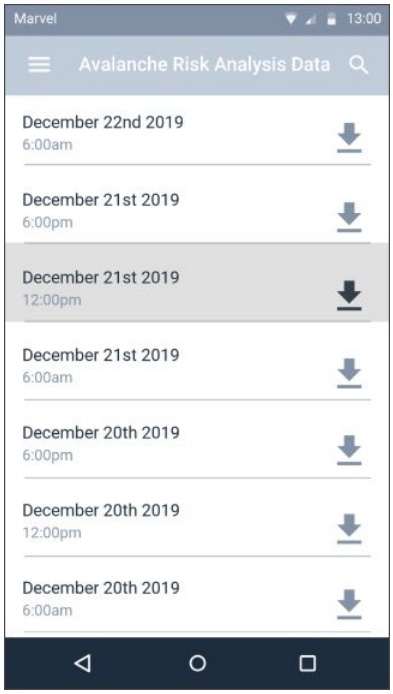
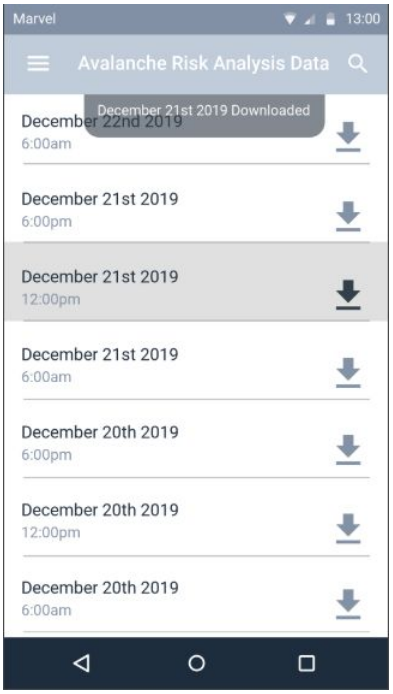


Figure 14: System Sequence Diagram - Use Case 9.

Storyboard: The Public User views Avalanche Risk Analysis Data	
1. After the Public User opens the options menu.	2. After the Public User navigates to the list of sorted Historical Avalanche Risk Analysis Data.
	
3. After the Public User selects a set of Avalanche Risk Analysis Data to download.	4. After the Avalanche Risk Analysis Data Set has been downloaded to the Public User's device.
	

Use Case: CreateResortProfile	
ID:	10
Brief description:	The System Administrator wants to create a new Resort Profile instance.
Actor(s):	System Administrator.
Preconditions:	1. The System Administrator is signed into the Administrative Portal. 2. The System Administrator has the information to fill out the Resort Profile.
Main flow:	1. The System Administrator selects the option to create a Resort Profile. 2. The System Administrator sees a prompt to input Resort information. 3. The System Administrator inputs the Resort information into the respective fields. 4. The System Administrator submits the Resort information. 5. The System Administrator sees that the Resort Profile was successfully created.
Postconditions:	1. A Resort Profile has been created.
Alternative flow(s):	CancelResortProfile.

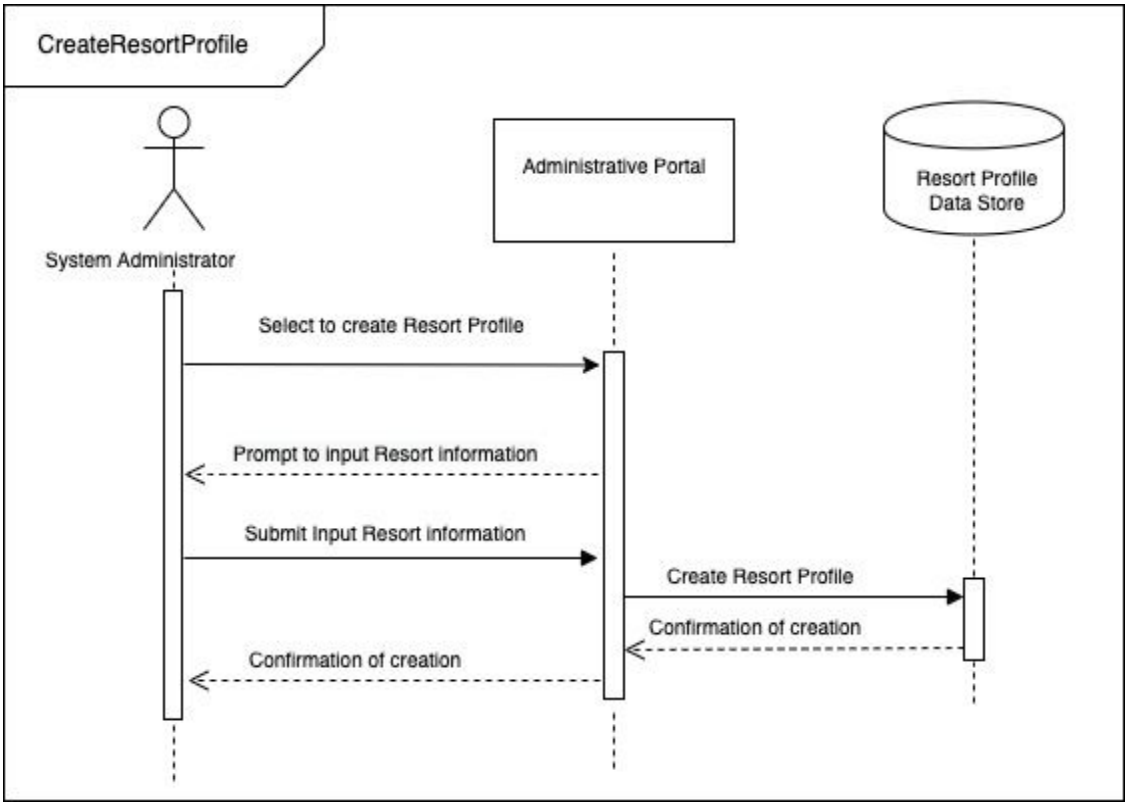


Figure 15: System Sequence Diagram - Use Case 10.

Alternative Flow: CreateResortProfile: CancelResortProfile	
ID:	10.1
Brief description:	The System Administrator cancels the creation of a Resort Profile.
Actor(s):	System Administrator.
Preconditions:	None.
Alternate flow:	The alternate flow begins at any time. 1. The System Administrator cancels the creation of a new Resort Profile.
Postconditions:	1. A new Resort Profile is not created.

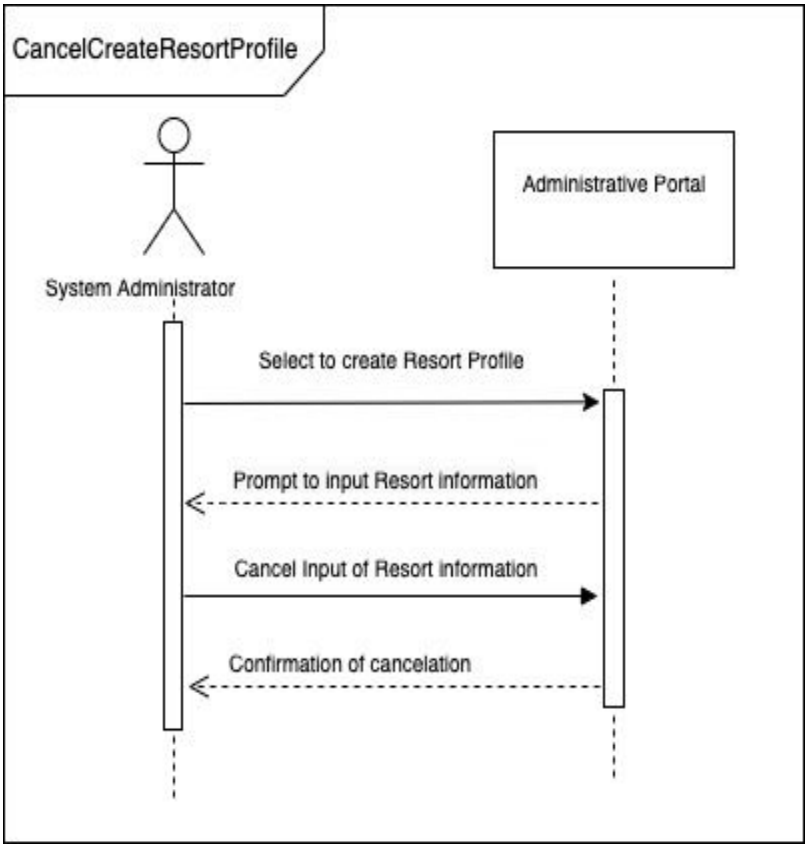


Figure 16: System Sequence Diagram - Use Case 10.1

Use Case: EditResortProfile	
ID:	11
Brief description:	The System Administrator wants to edit a pre-existing Resort Profile.
Actor(s):	System Administrator.
Preconditions:	1. A Resort Profile has been previously created. 2. The System Administrator is signed into the Administrative Portal. 3. The System Administrator has the information to fill out the Resort Profile.
Main flow:	1. The System Administrator selects a specific Resort Profile from a list of Resorts. 2. The System Administrator selects the option to edit the Resort Profile. 3. The System Administrator sees a prompt to edit the fields for the Resort Profile. 4. The System Administrator makes modifications to the Resort Profile information. 5. The System Administrator submits the modified Resort information. 6. The System Administrator sees that the Resort Profile was successfully modified.
Postconditions:	1. The modified Resort Profile has been updated.
Alternate flow(s):	None.

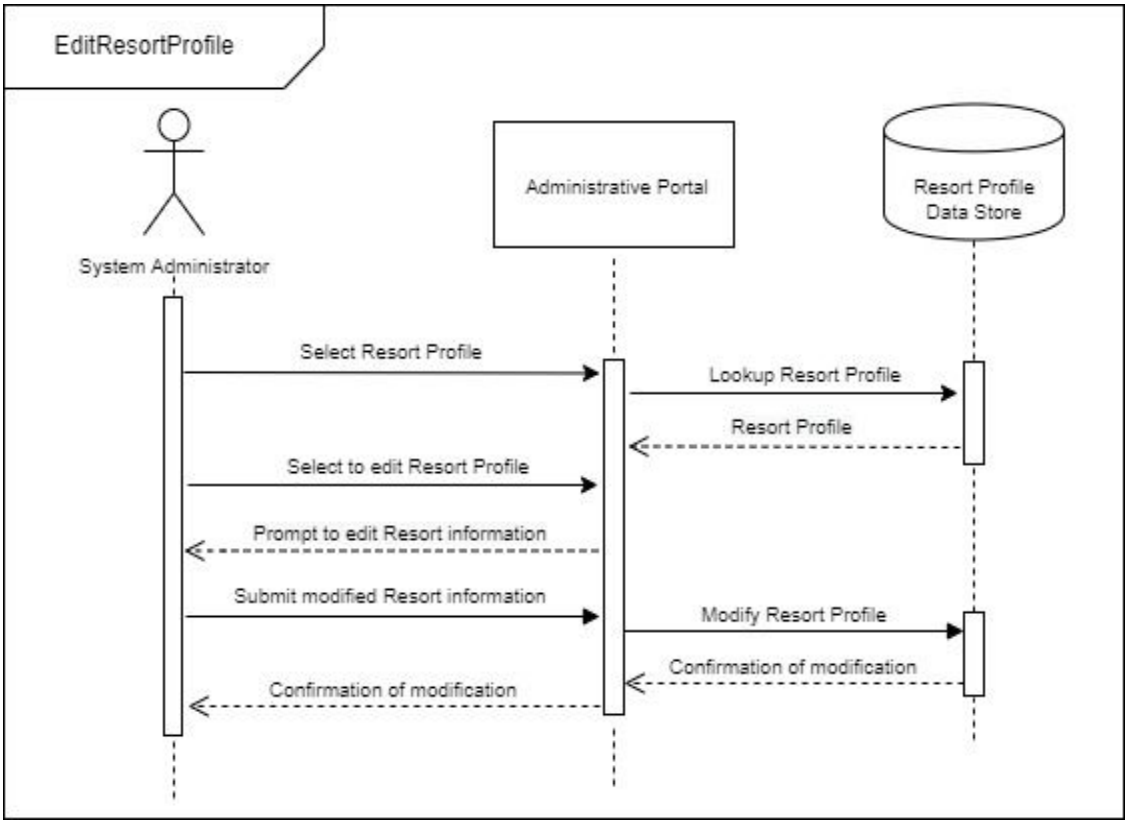


Figure 17: System Sequence Diagram - Use Case 11.

Use Case: RemoveResortProfile	
ID:	12
Brief description:	The System Administrator wants to remove a pre-existing Resort Profile.
Actor(s):	System Administrator.
Preconditions:	1. The System Administrator is signed into the Administrative Portal. 2. A Resort Profile has been previously created.
Main flow:	1. The System Administrator selects a specific Resort Profile from a list of Resorts. 2. The System Administrator selects the option to edit the Resort Profile. 3. The System Administrator selects the option to delete the Resort Profile. 4. The System Administrator selects the option to confirm the deletion of the Resort Profile
Postconditions:	1. The modified Resort Profile has been deleted.
Alternative flow(s):	None.

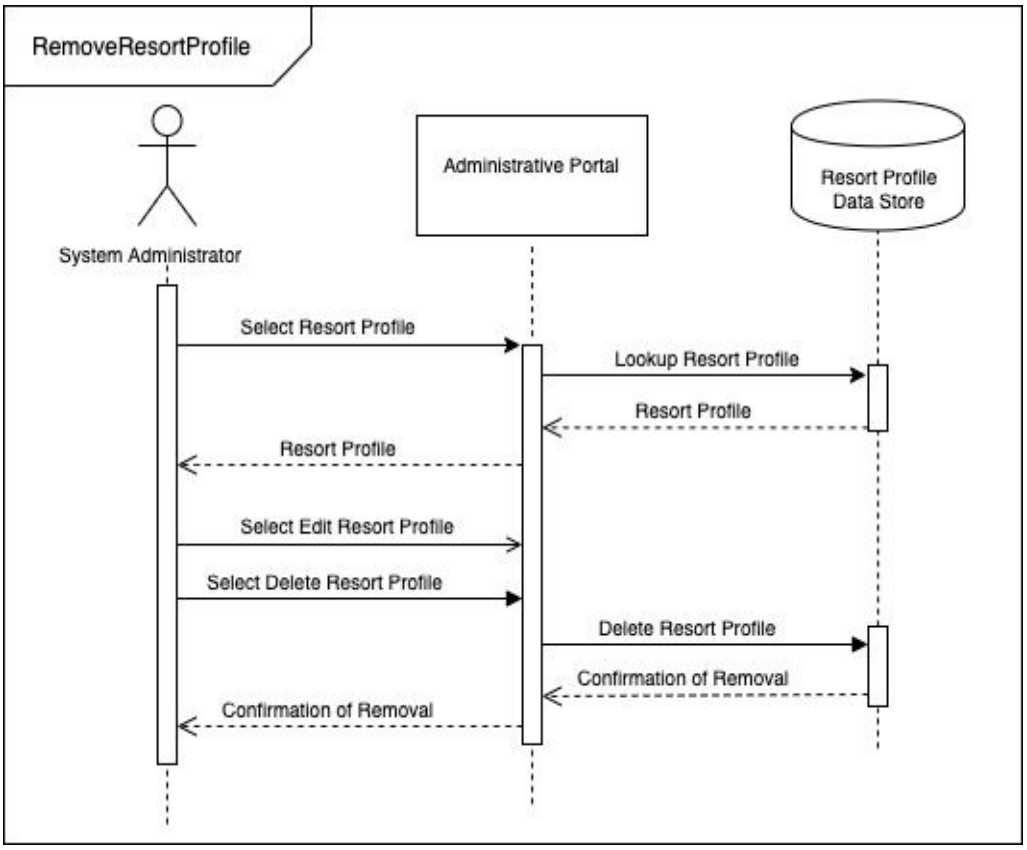


Figure 18: System Sequence Diagram - Use Case 12.

Use Case: ModifyDataSource	
ID:	13
Brief description:	The Administrator wants to modify the Data Sources which contribute to the Avalanche Risk Analysis Data for a Resort.
Actor(s):	System Administrator or Resort Administrator.
Preconditions:	1. The Administrator is signed into the Administrative Portal.
Main flow:	1. If the Administrator is a System Administrator then: 1.1. The Administrator selects a specific Resort Profile from a list of Resorts. 2. The Administrator selects a Resort Profile. 3. The Administrator selects the option to view Data Sources. 4. The Administrator sees the Data Sources available to use at the selected Resort. 5. The Administrator selects a Data Source. 6. If the Data Source is not being used at the selected Resort then: 6.1. The Administrator selects the option to add the specific Data Source to the Resort Profile. 7. Else the Data Source is being used at the selected Resort then: 7.1. The Administrator selects the option to remove the specific Data Source to the Resort Profile. 8. The Administrator sees the the updated set of Data Sources in use at the selected Resort.
Postconditions:	1. The Data Sources for the selected Resort has been updated. 2. If a Data Source has been added to a Resort Profile: 2.1. The Avalanche Risk Analysis now includes the Data Source. 3. Else a Data Source has been Removed from a Resort Profile: 3.1. The Avalanche Risk Analysis no longer includes the Data Source.
Alternative flow(s):	None.

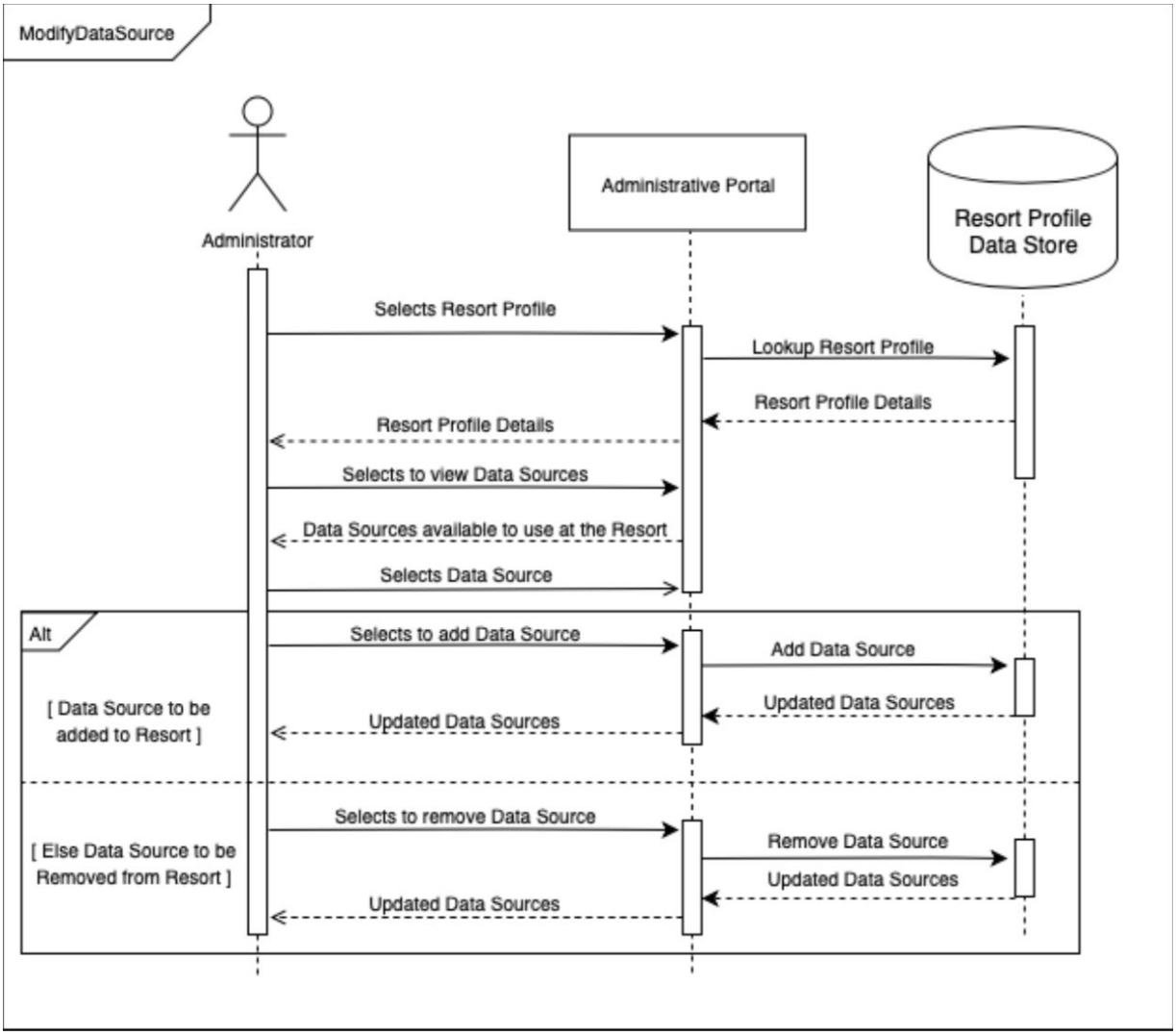
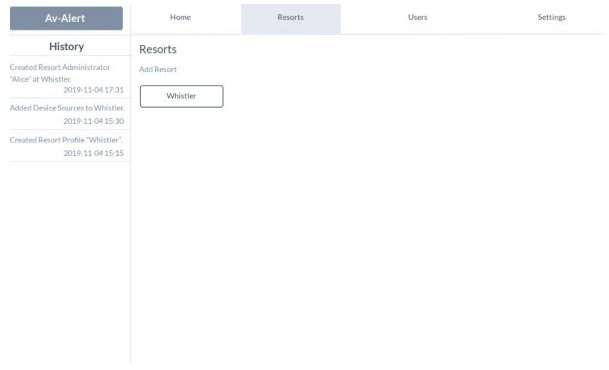


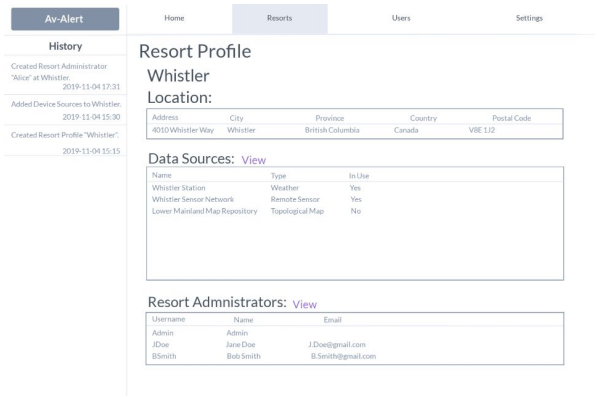
Figure 19: System Sequence Diagram - Use Case 13.

Storyboard: The System Administrator adds a Resort Data Source

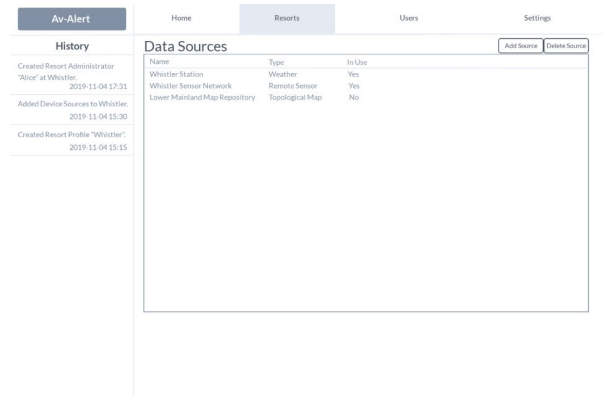
1. The System Administrator sees each Resort under the “Resorts” tab.



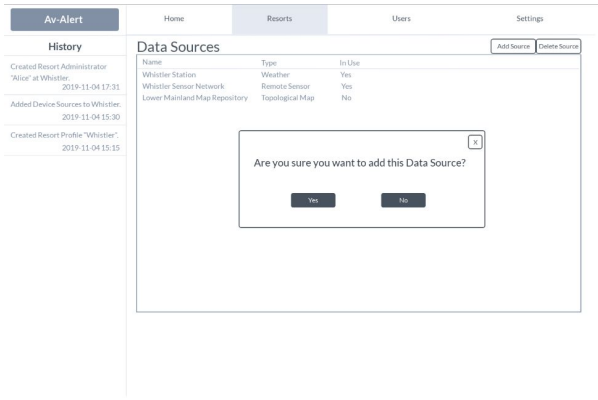
2. After selecting a Resort from the list of Resorts to see the Resort Profile.



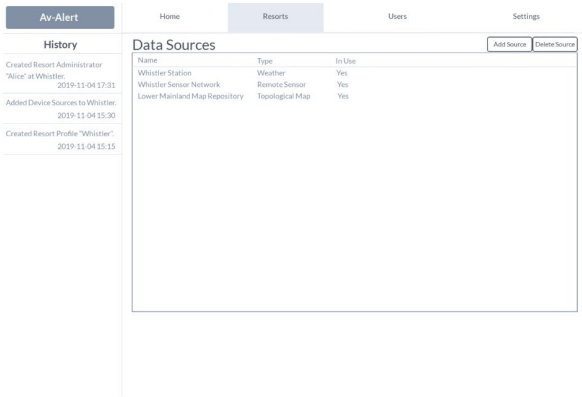
3. After selecting to view Data Sources.

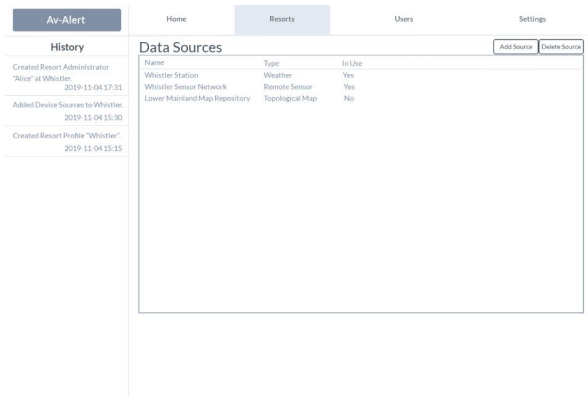
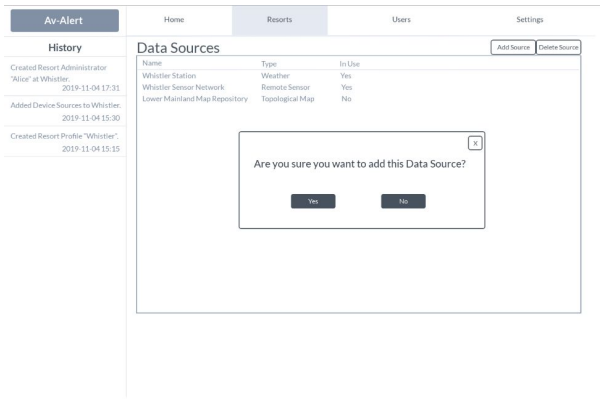
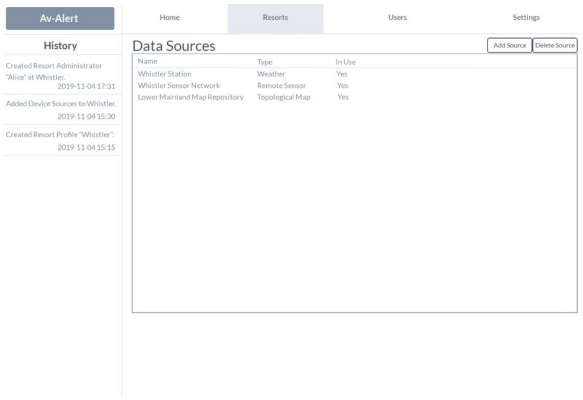


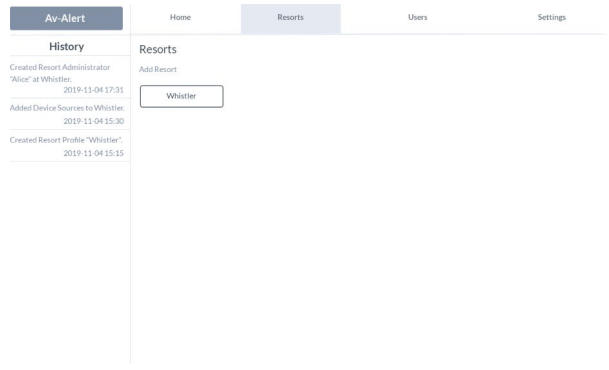
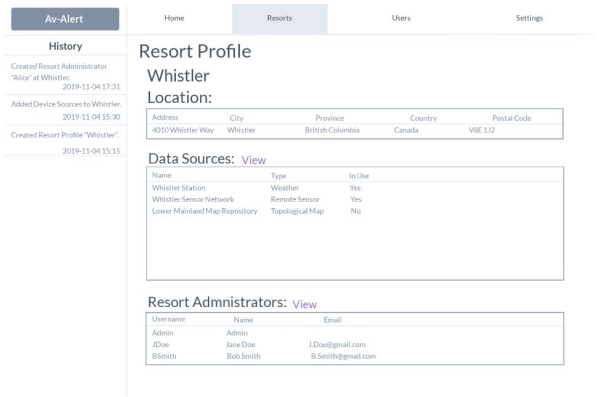
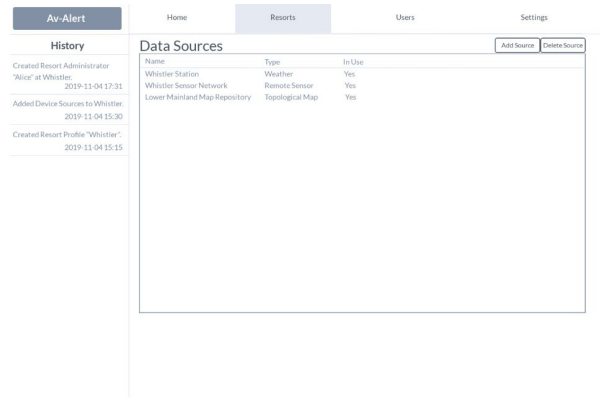
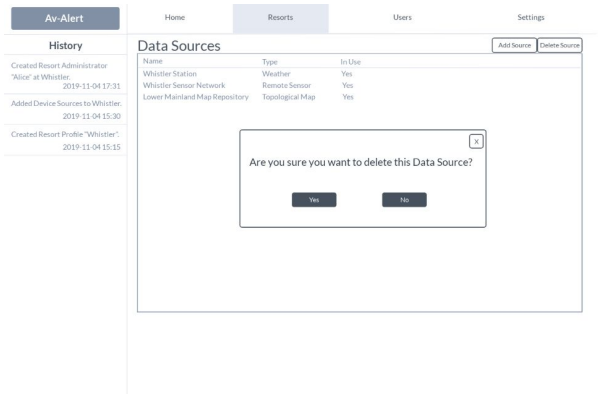
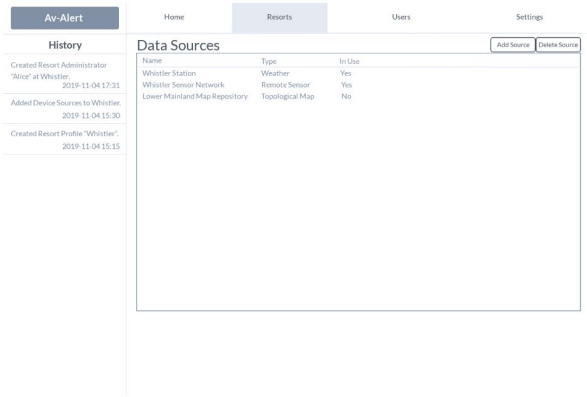
4. After selecting a Data Source and selecting the “Add Source” option, a window will pop up to confirm their selection.

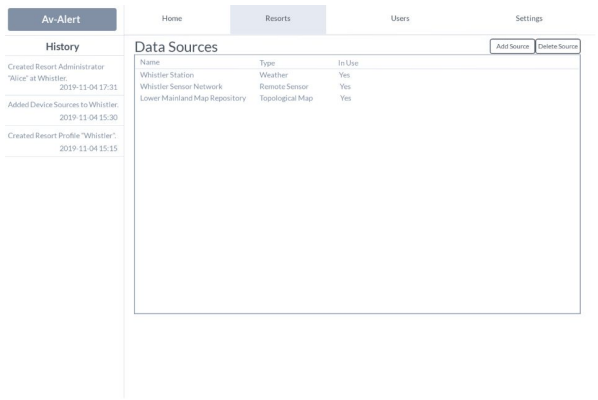
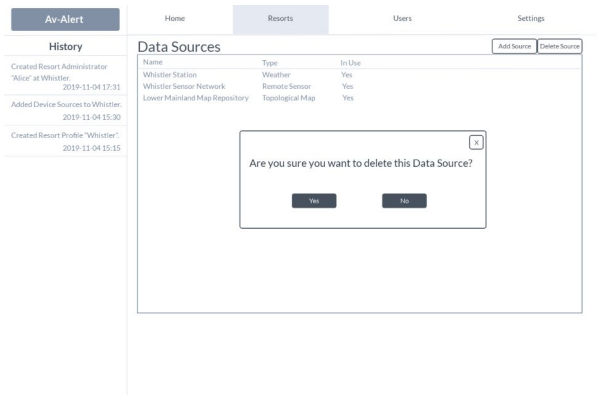
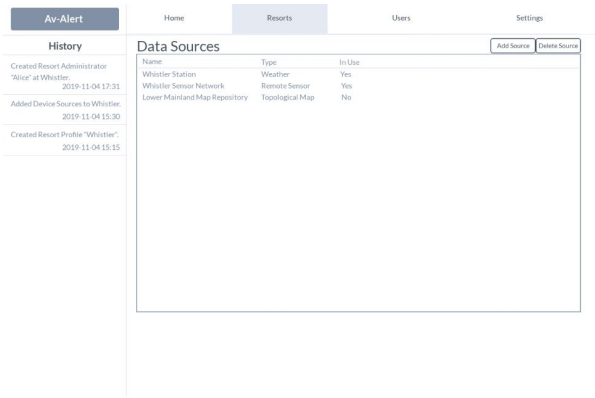


5. After confirming their selection, updated Data Sources will be displayed.



Storyboard:The Resort Administrator adds a Resort Data Source	
1. After selecting to view Data Sources.	2. After selecting a Data Source and selecting the “Add Source” option, a window will pop up to confirm their selection.
	
3. After confirming their selection, updated Data Sources will be displayed.	
	

Storyboard: The System Administrator removes a Resort Data Source	
1. The System Administrator sees each Resort under the “Resorts” tab.	2. After selecting a Resort from the list of Resorts to see the Resort Profile.
	
3. After selecting to view Data Sources.	4. After selecting a Data Source and selecting the “Delete Source” option, a window will pop up to confirm their selection.
	
5. After confirming their selection, updated Data Sources will be displayed	
	

Storyboard: The Resort Administrator removes a Resort Data Source	
1. After selecting to view Data Sources.	2. After selecting a Data Source and selecting the “Delete Source” option, a window will pop up to confirm their selection.
	
3. After confirming their selection, updated Data Sources will be displayed.	
	

Use Case: CreateResortAdmin	
ID:	14
Brief description:	The Administrator wants to create a new Resort Administrator for a Resort.
Actor(s):	System Administrator or Resort Administrator.
Preconditions:	1. The Administrator is signed into the Administrative Portal.
Main flow:	1. If the Administrator is a System Administrator then: 1.1. The Administrator selects a specific Resort Profile from a list of Resorts. 2. The Administrator sees each Resort Administrator for that Resort. 3. The Administrator selects the option to create a new Resort Administrator. 4. The Administrator is prompted to enter the Resort Administrator details. 5. The Administrator inputs the Resort Administrator details into the respective fields. 6. The Administrator submits the Resort Administrator. 7. The Administrator sees that the Resort Administrator has been created.
Postconditions:	1. A new Resort Administrator has been created.
Alternative flow(s):	CancelResortAdmin.

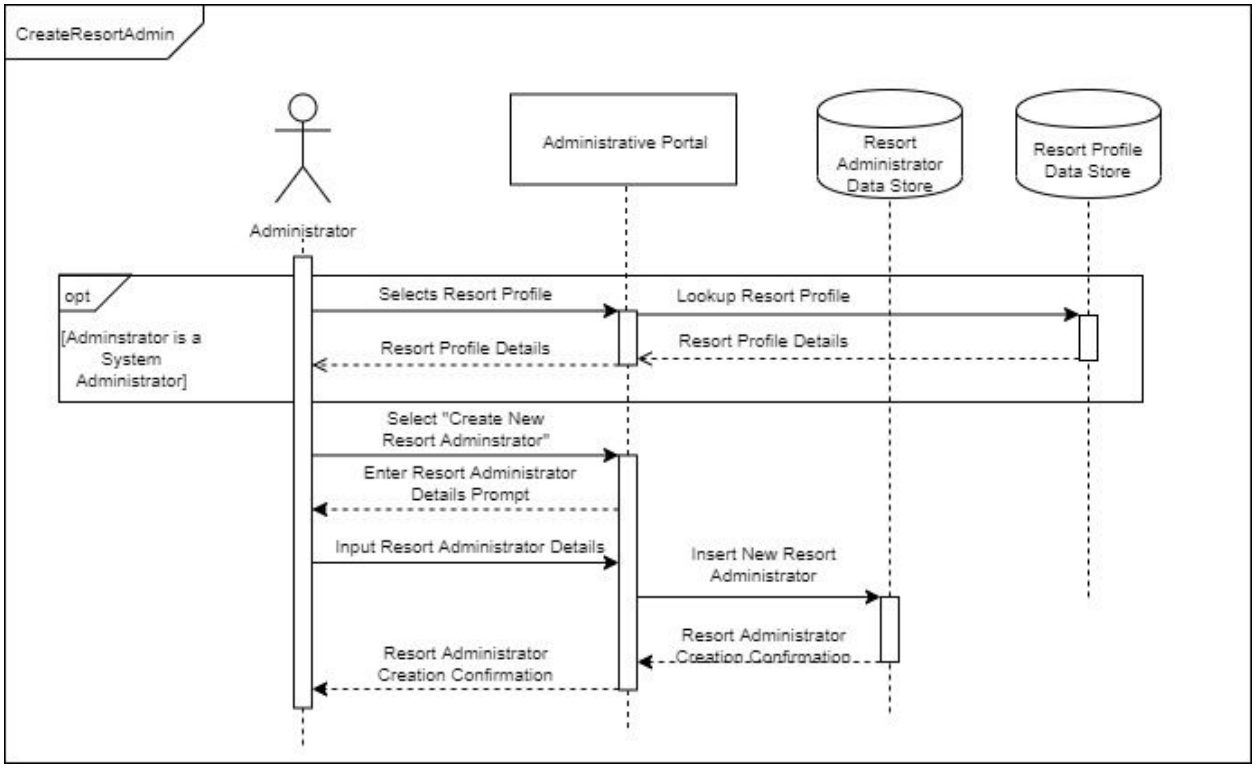
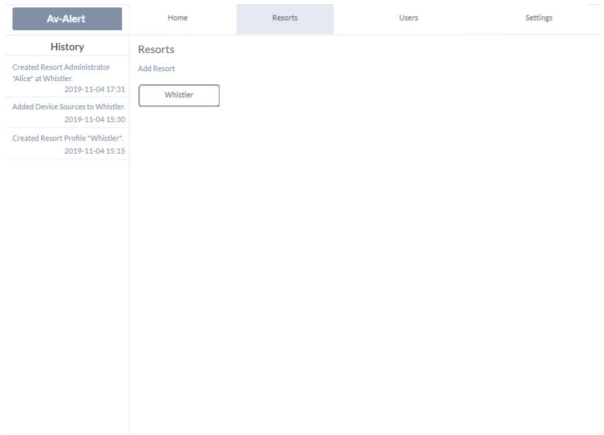
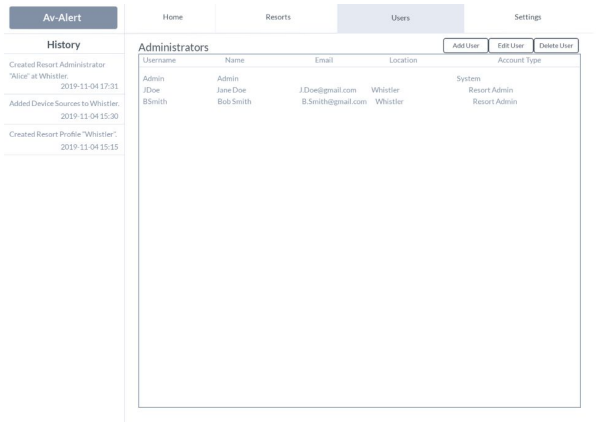
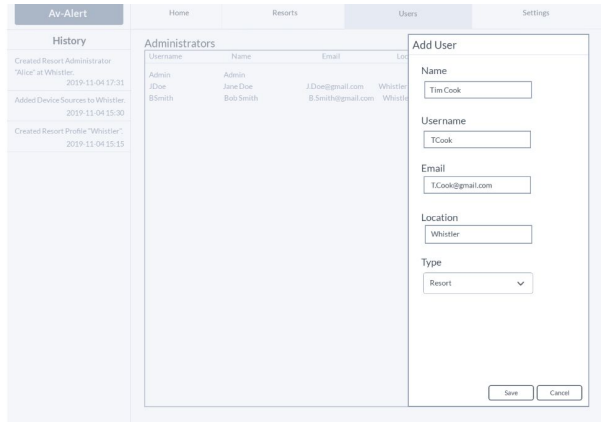
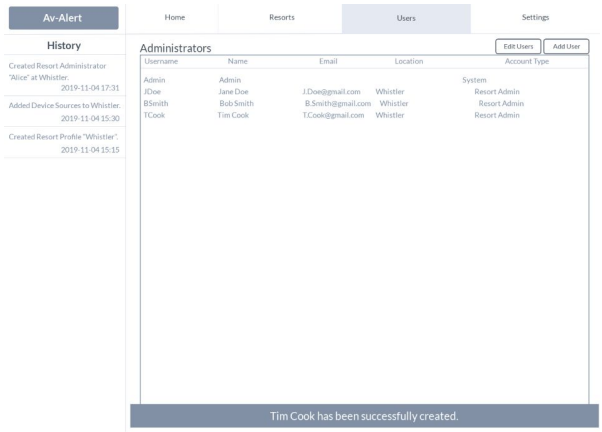
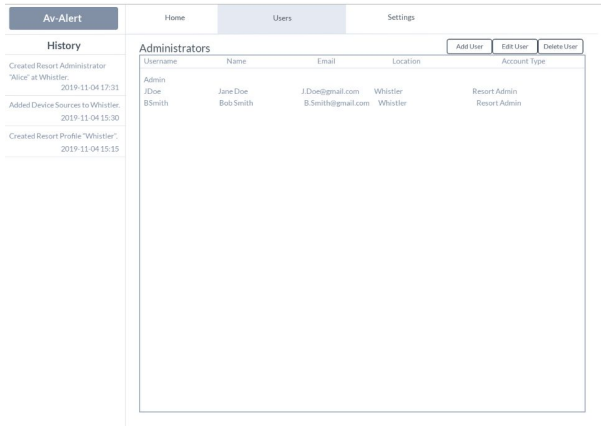
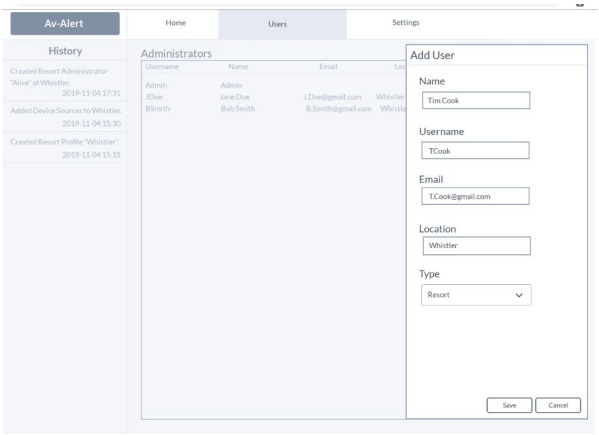
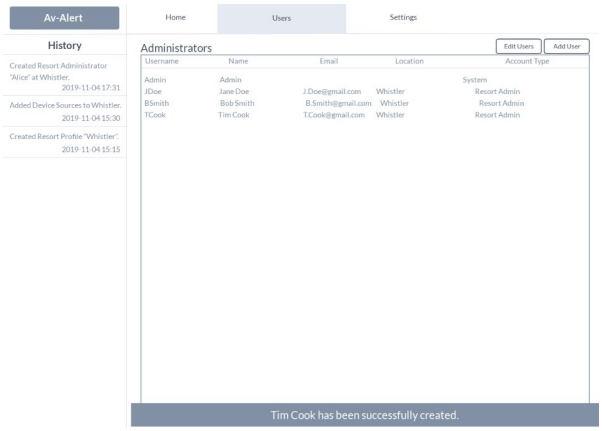


Figure 20: System Sequence Diagram - Use Case 14.

Storyboard: The System Administrator Creates a Resort Admin	
1. The System Administrator sees each Resort under the “Resorts” tab.	2. After selecting a Resort from the list of Resorts and selecting the “Users” tab.
	
3. After selecting “Add User”, a window will pop up providing user information fields to be filled.	4. After entering the Resort Administrator’s details and selecting “Save”.
	

Storyboard: The Resort Administrator Creates a Resort Admin	
1. After the Resort Administrator selects the “Users” tab.	2. After selecting “Add User”, a window will pop up providing user information fields to be filled.
	
3. After entering the Resort Administrator’s details and selecting “Save”.	
	

Alternative Flow: CreateResortAdmin: CancelResortAdmin	
ID:	14.1
Brief description:	The Administrator cancels the creation of a Resort Administrator.
Actor(s):	System Administrator or Resort Administrator.
Preconditions:	None.
Alternate flow:	The alternate flow begins at any time. 1. The Administrator cancels the creation of a new Resort Administrator.
Postconditions:	1. A new Resort Administrator is not created.

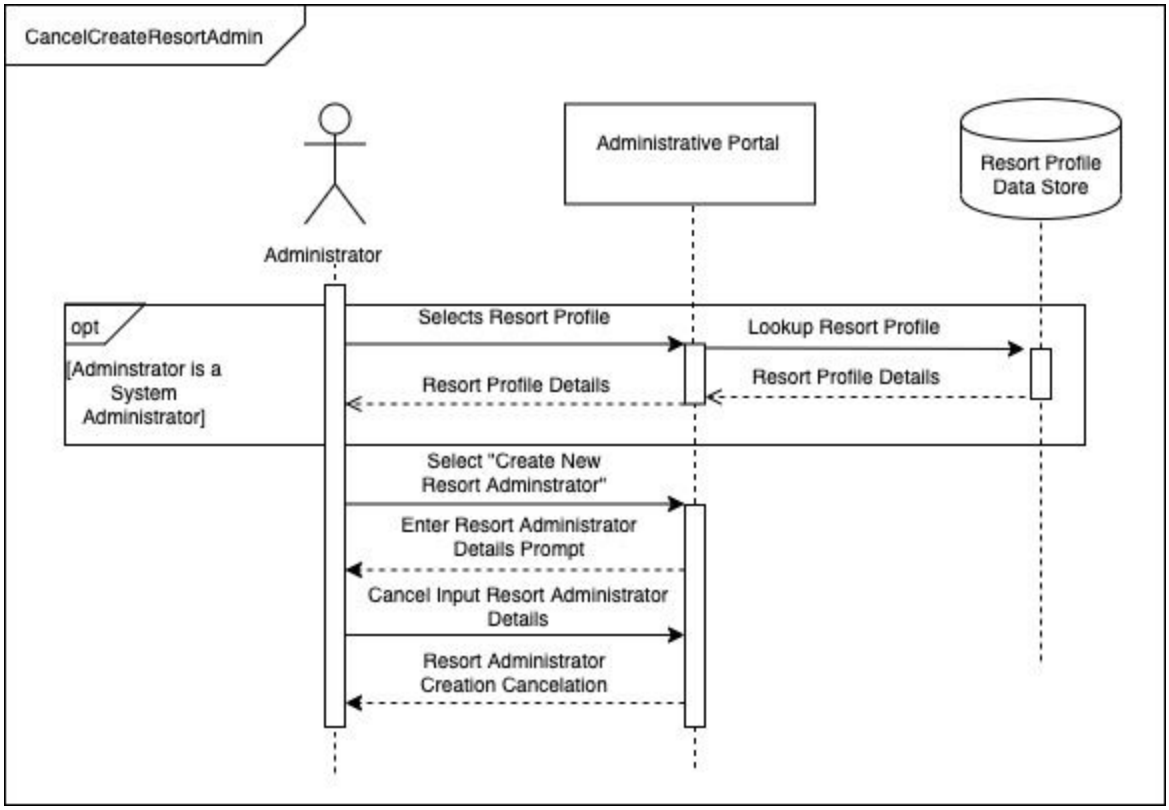


Figure 21: System Sequence Diagram - Use Case 14.1

Use Case: EditResortAdmin	
ID:	15
Brief description:	The Administrator wants to edit a pre-existing Resort Administrator's details.
Actor(s):	System Administrator or Resort Administrator.
Preconditions:	1. A Resort Administrator has been previously created. 2. The Administrator is signed into the Administrative Portal.
Alternate flow:	1. If the Administrator is a System Administrator then: 1.1. The System Administrator selects a specific Resort Profile from a list of Resorts. 2. The Administrator sees each Resort Administrator for that Resort. 3. The Administrator selects a Resort Administrator. 4. The Administrator is prompted to edit the selected Resort Administrators details. 5. The Administrator edits the Resort Administrators details. 6. The Administrator sees that the Resort Administrator has been updated.
Postconditions:	1. The Resort Administrator has been updated.

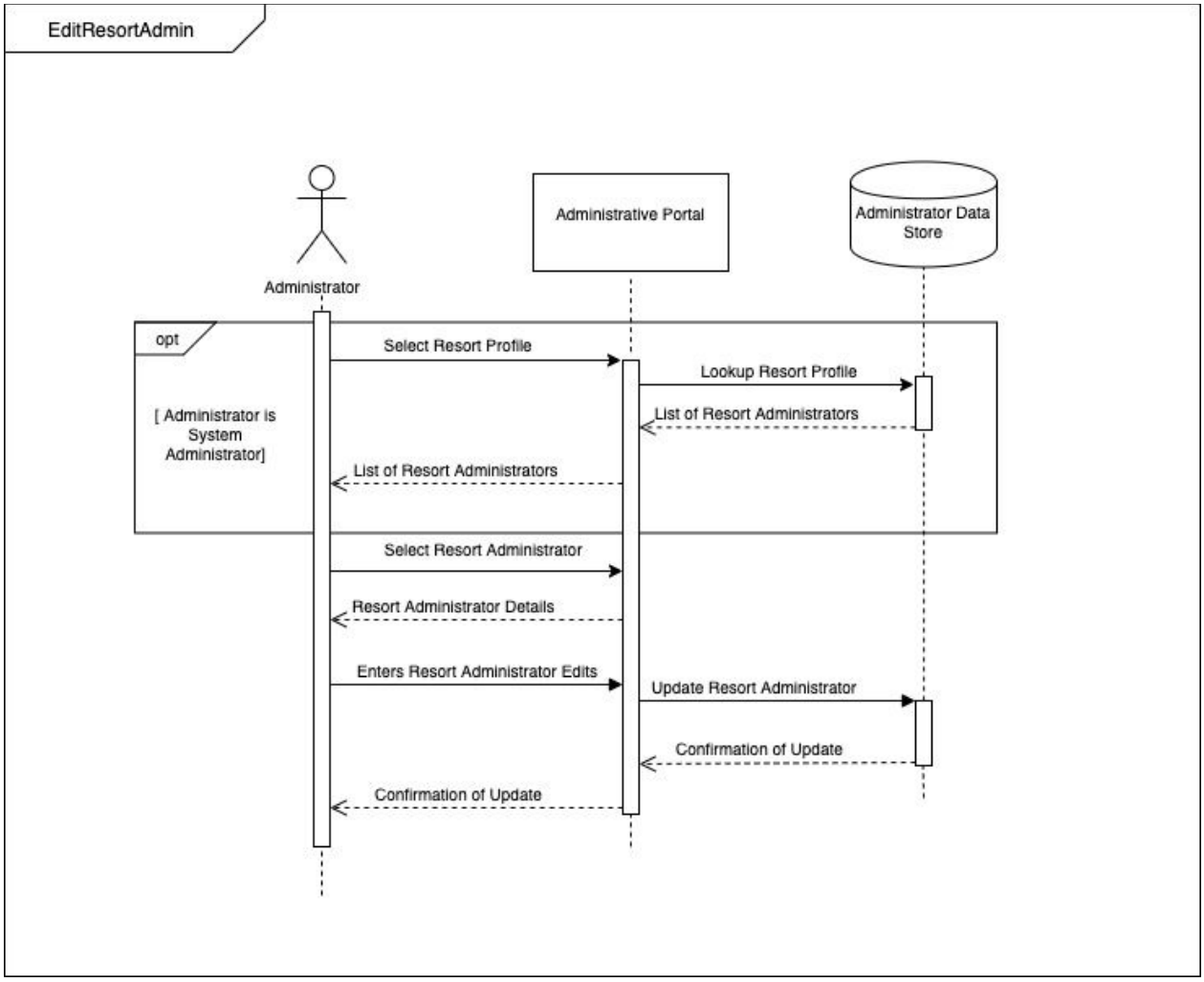
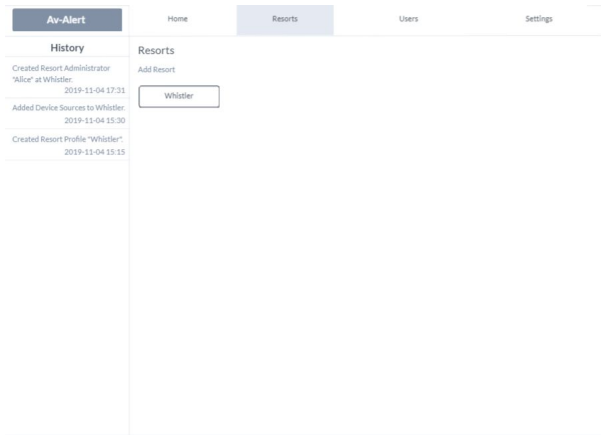
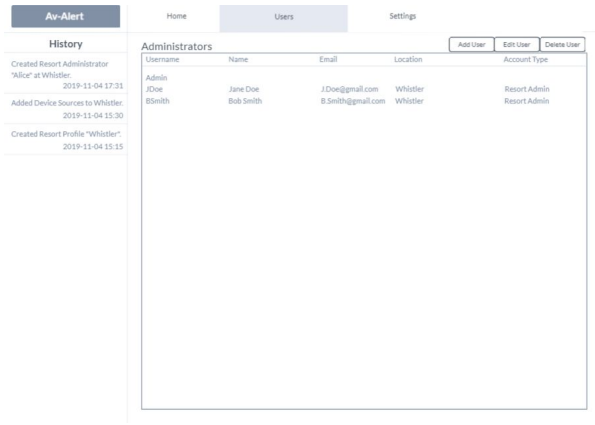
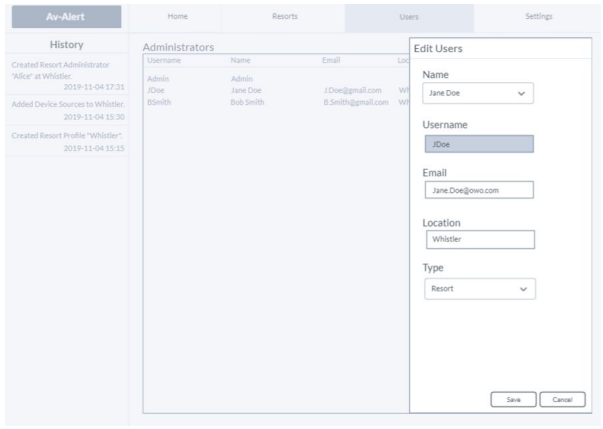
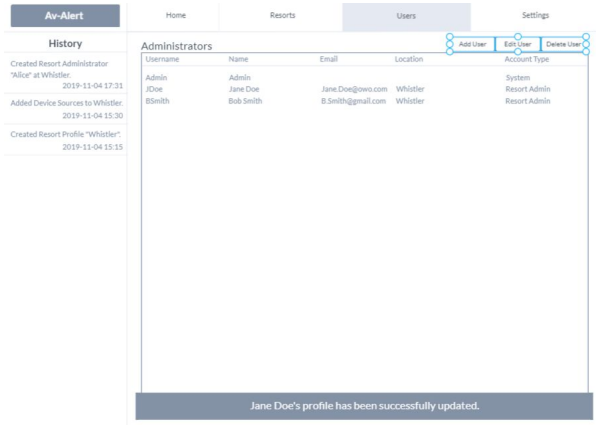
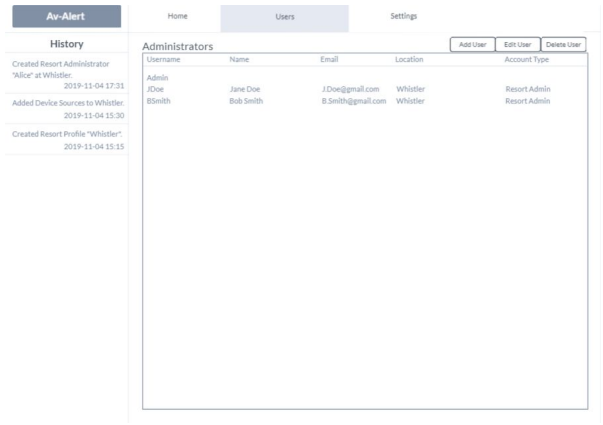
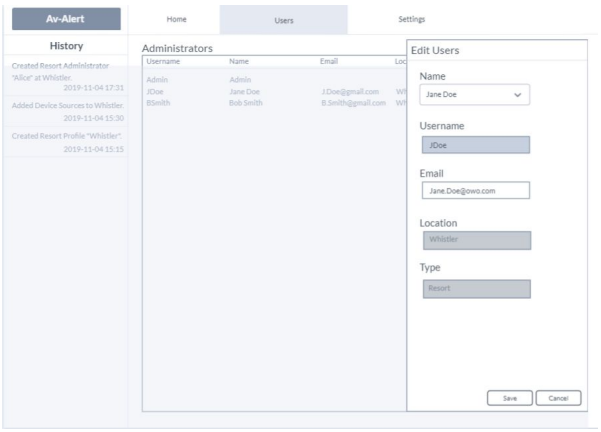
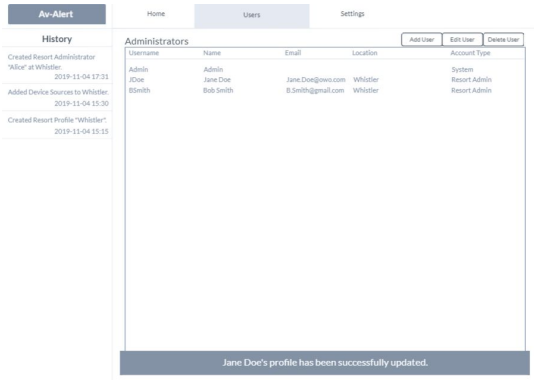


Figure 22: System Sequence Diagram - Use Case 15.

Storyboard: The System Administrator Edits the Details of a Resort Administrator	
1. The System Administrator sees each Resort under the “Resorts” tab.	2. After selecting a Resort from the list of Resorts and selecting the “Users” tab.
	
3. After selecting a Resort Administrator, a window will pop up providing options for what can be edited.	4. After editing the Resort Administrator’s details and selecting “Save”.
	

Storyboard: The Resort Administrator Edits the Details of a Resort Administrator	
1. Each Resort Administrator will see each current Resort Administrator for their Resort under the “Users” tab.	2. After selecting a Resort Administrator, a window will pop up with values that can be edited.
	
3. After editing the Resort Administrator’s details and selecting “Save”.	
	

UseCaseName: RemoveResortAdmin	
ID:	16
Brief description:	The Administrator wants to remove a pre-existing Resort Administrator from a Resort Profile.
Actor(s):	System Administrator or Resort Administrator.
Preconditions:	1. A Resort Administrator has been previously created. 2. A Resort Administrator has been previously assigned to a Resort.
Alternate flow:	1. If the Administrator is a System Administrator then: 1.1. The Administrator selects a specific Resort Profile from a list of Resorts. 2. The Administrator sees each Resort Administrator for that Resort. 3. The Administrator selects a Resort Administrator. 4. The Administrator removes that Resort Administrator's details.
Postconditions:	1. The Resort Administrator has been removed from the Resort.

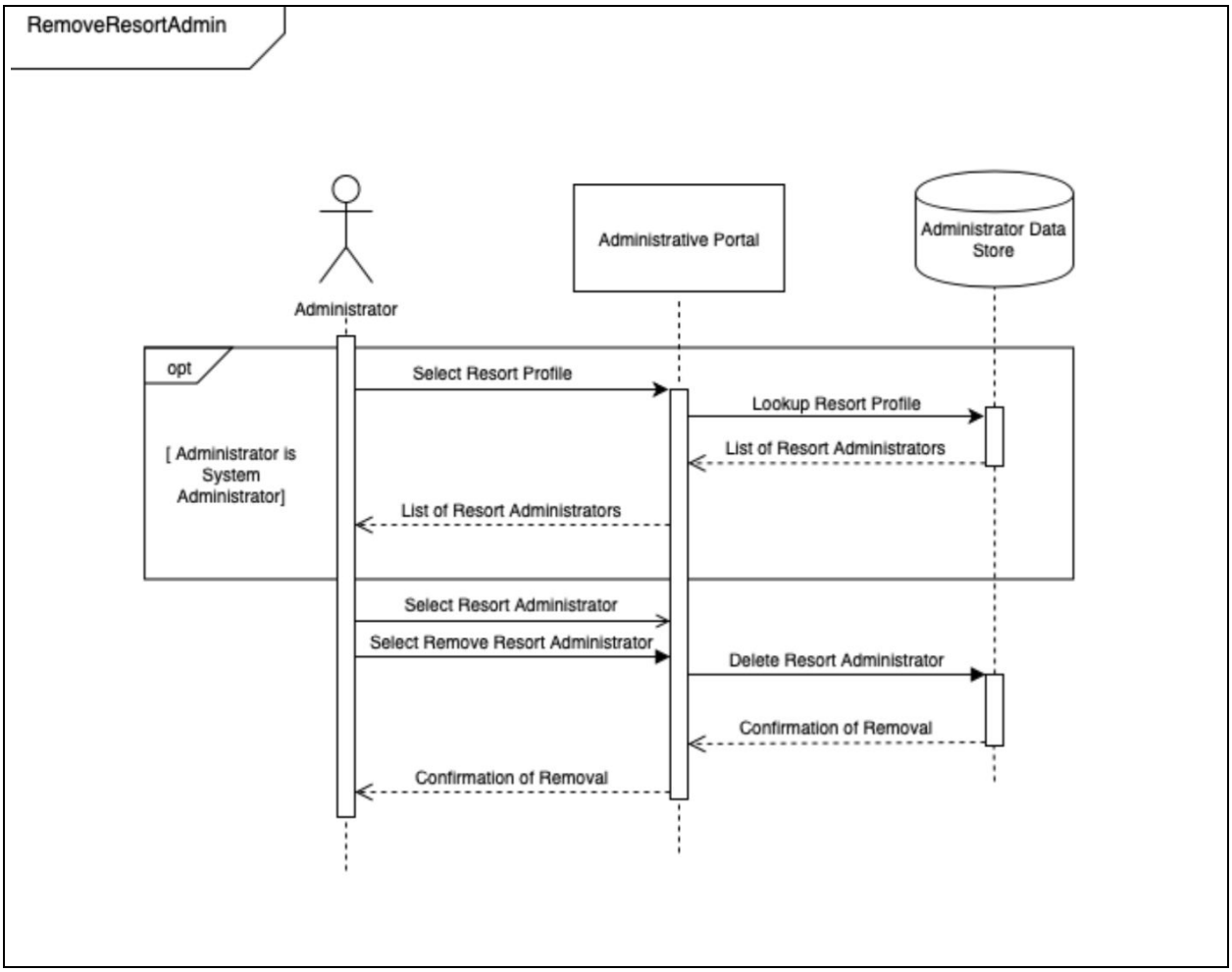
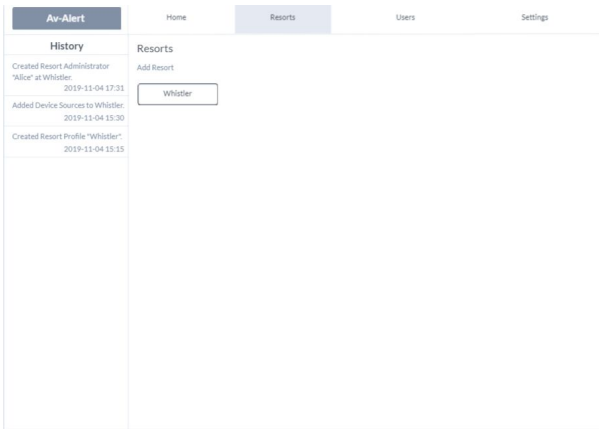
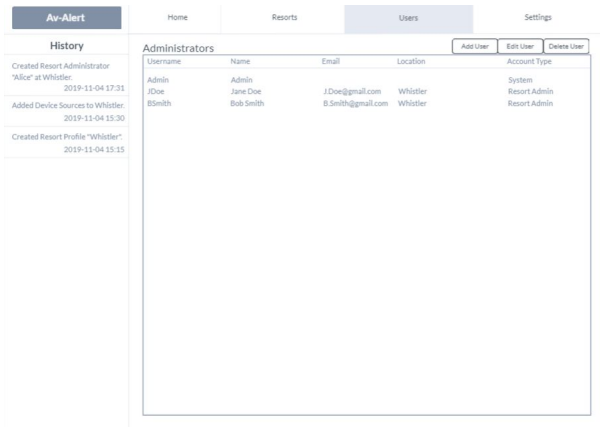
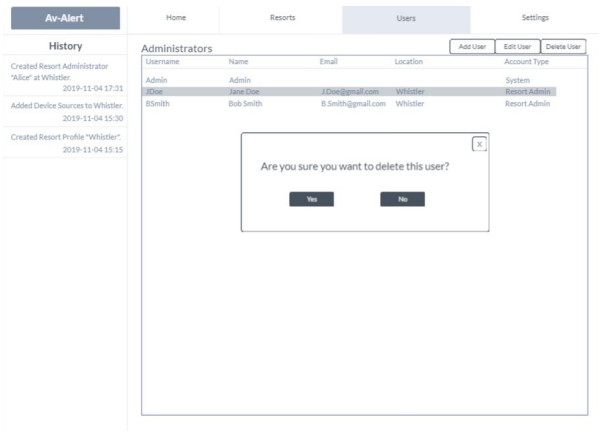
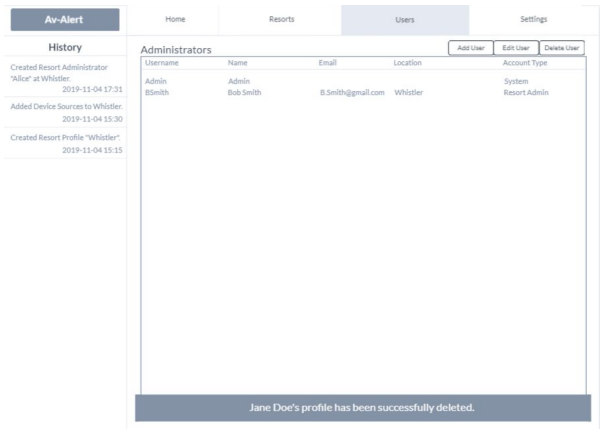
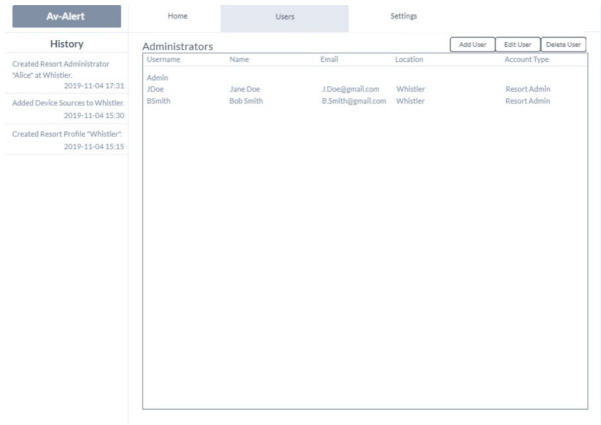
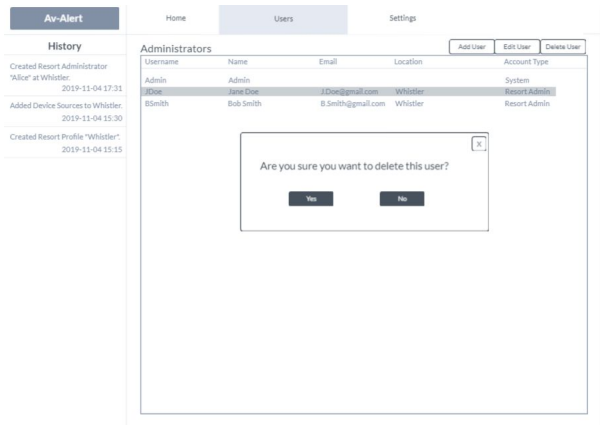
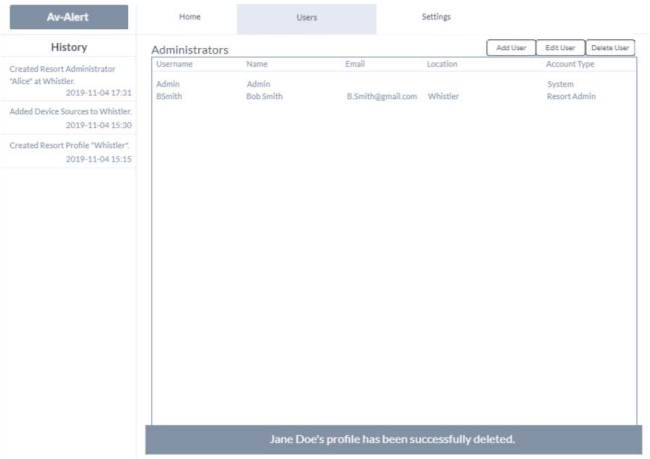


Figure 23: System Sequence Diagram - Use Case 16.

Storyboard: The System Administrator removes a Resort Administrator	
1. The System Administrator sees each Resort under the “Resorts” tab.	2. After selecting a Resort from the list of Resorts and selecting the “Users” tab.
	
3. After selecting a Resort Administrator and selecting the “Delete User” option, a window will pop up to confirm their selection.	4. After selecting “Yes” to delete the Resort Administrator.
	

Storyboard: The Resort Administrator removes a Resort Administrator	
1. Resort Administrators will see each Resort Administrator for their Resort under the “Users” tab.	2. After selecting a Resort Administrator and selecting the “Delete User” option, a window will pop up to confirm their selection.
	
3. After selecting “Yes” to delete the Resort Administrator.	
	

8 Analysis Model

This section displays a deeper analysis of Av-Alert, including an Entity-Relationship Diagram, Data Dictionary, and Data Flow Diagrams.

8.1 Entity Relation Diagram

Below is an entity-relation diagram, which displays how the various components of Av-Alert will interact with each other.

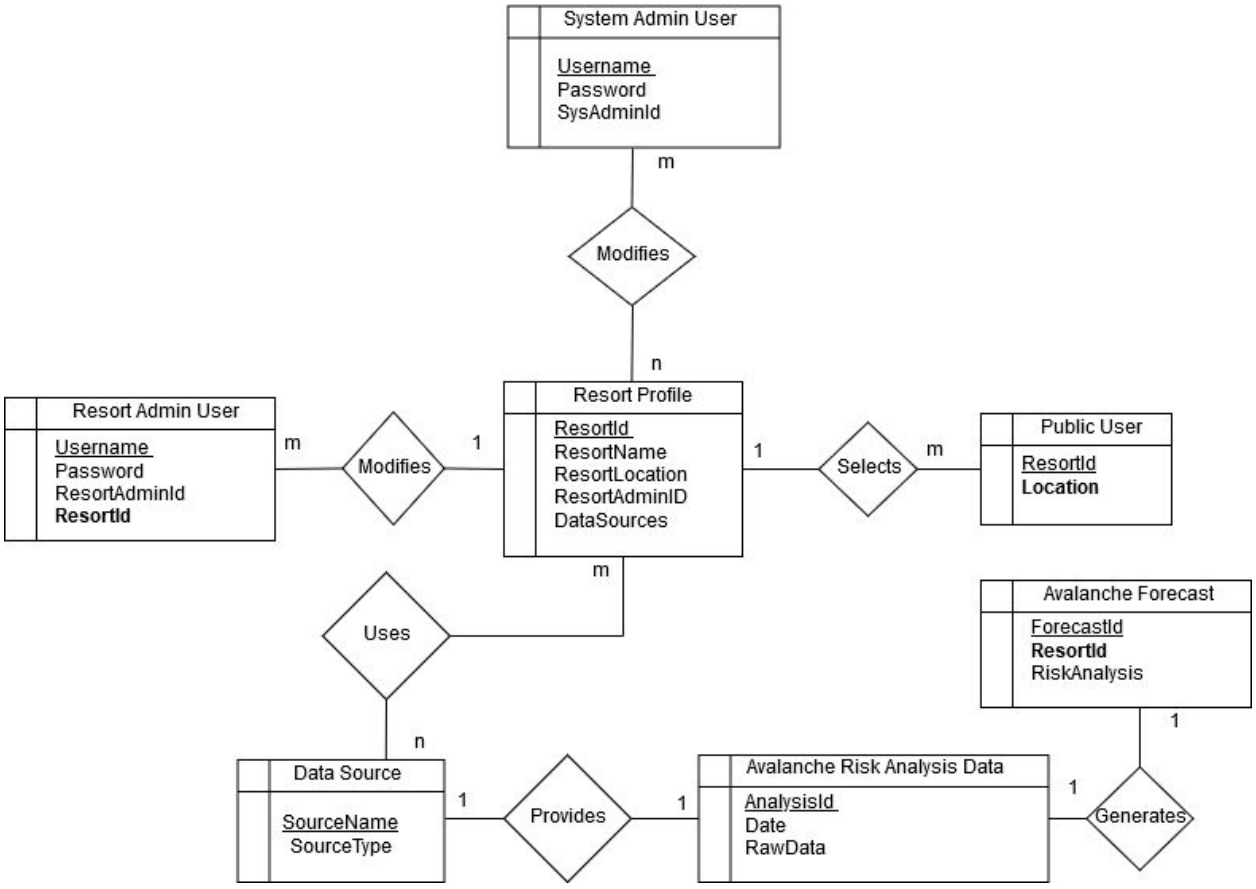


Figure 24: Entity Model Diagram.

8.2 Data Dictionary

The primary keys are denoted by underline and the **foreign keys** are denoted by bold text.

8.2.1 Resort Admin User

Field Name	Data Type	Data Format	Field Size	Description
ResortId	Integer	NNNN	4	A unique identifier for each Resort.
Username	Varchar	N^{16}	16	A unique string of letters and/or numbers. Used during the sign in flow.
Password	Varchar	N^{16}	16	A string of characters and/or numbers. Used during the sign in flow.
ResortAdminId	Integer	NNNN	4	A unique identifier for each Resort Administrator.

8.2.2 System Admin User

Field Name	Data Type	Data Format	Field Size	Description
Username	Varchar	N^{16}	16	A unique string of letters and/or numbers. Used during sign in flow.
Password	Varchar	N^{16}	16	A string of characters and/or numbers. Used during the sign in flow.
SystemAdminId	Integer	NNNN	4	A unique identifier for each System Administrator.

8.2.3 Public User

Field Name	Data Type	Data Format	Field Size	Description
Location	String	N^{17}	17	Latitude and longitude values.
ResortId	Integer	NNNN	4	A unique identifier for their Specified Resort.

8.2.4 Avalanche Risk Analysis Data

Field Name	Data Type	Data Format	Field Size	Description
AnalysisId	Integer	N^{6}	6	A unique identifier for an Avalanche Risk Analysis Data Set.
Date	Varchar	N^{19}	19	A string of letters and numbers that indicates when the report was generated. Format is ISO 8601: "YYYY-MM-DDThh:mm:ss".
RawData	Integer	$(NNNN)^{50}$	4^{50}	A unique list of integers.

8.2.5 Avalanche Forecast

Field Name	Data Type	Data Format	Field Size	Description
ResortId	Integer	NNNN	4	A unique identifier for each Resort.
ForecastId	Integer	N^{6}	6	A unique identifier for an Avalanche Forecast.
RiskAnalysis	Integer	NN,NN,NN	8	A unique list of integers indicating Low, Medium or High risk.

8.2.6 Resort Profile

Field Name	Data Type	Data Format	Field Size	Description
ResortId	Integer	NNNN	4	A unique identifier for each Resort.
ResortName	String	N^{16}	16	The public name for the Resort.
ResortLocation	Varchar	N^{17}	17	Latitude and longitude values.
ResortAdminId	Integer	NNNN	4	A unique identifier for an associated Resort Administrator.
DataSources	String	$(N^{30})^{3}$	30^{3}	A list of Data Sources.

8.2.7 Data Source

Field Name	Data Type	Data Format	Field Size	Description
SourceName	Varchar	N^{16}	16	A unique identifier for the data source name.
SourceType	String	N^{16}	16	The type of the Data Source.

8.3 Data Flow Diagram Level 0

Below, DFD 0 displays how users interact with Av-Alert, and how it interacts with Data Sources.

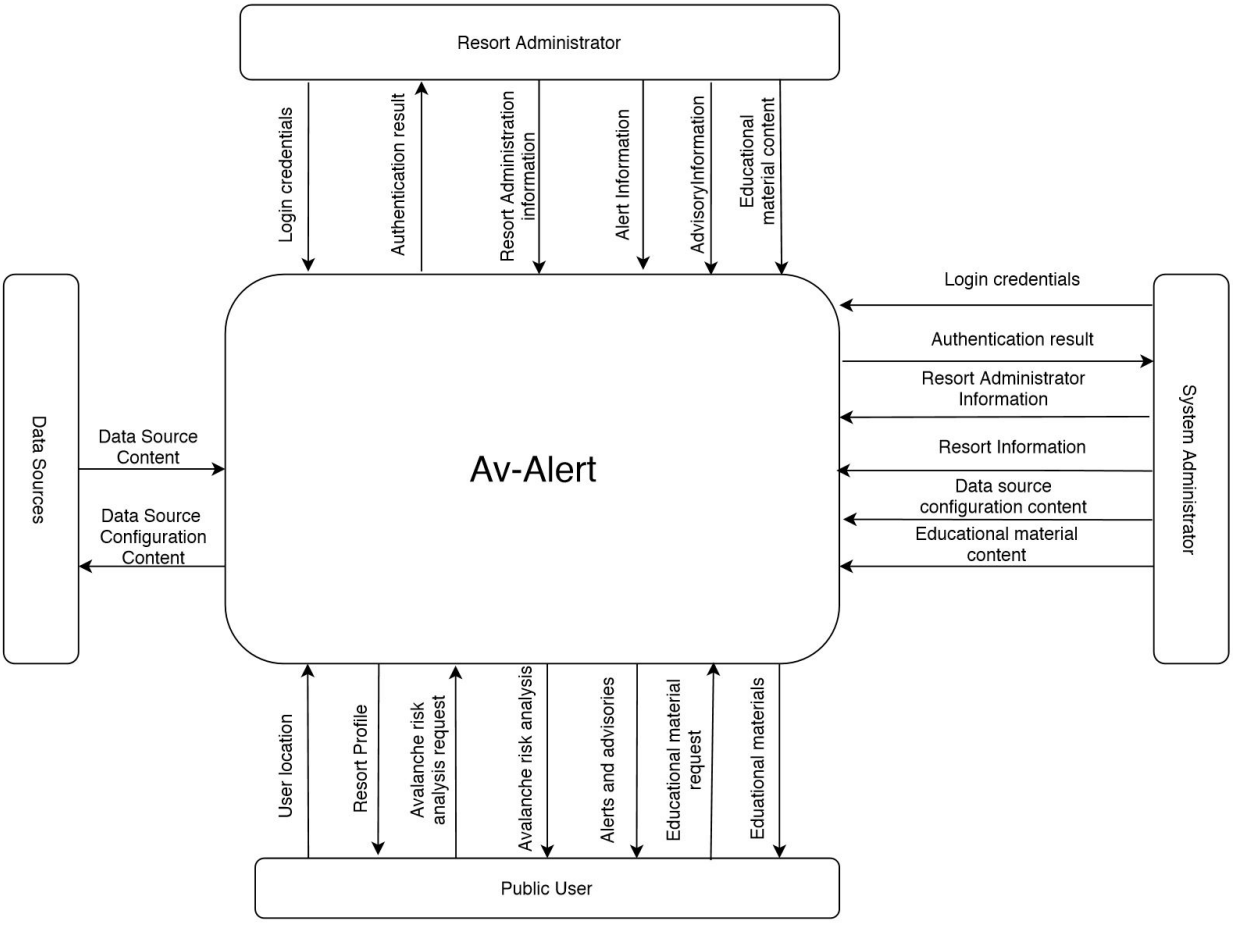


Figure 25: Data Flow Diagram Level 0.

8.4 Data Flow Diagram Level 1

Below, DFD 1 shows a more in-depth view of how users interact with the various processes of Av-Alert.

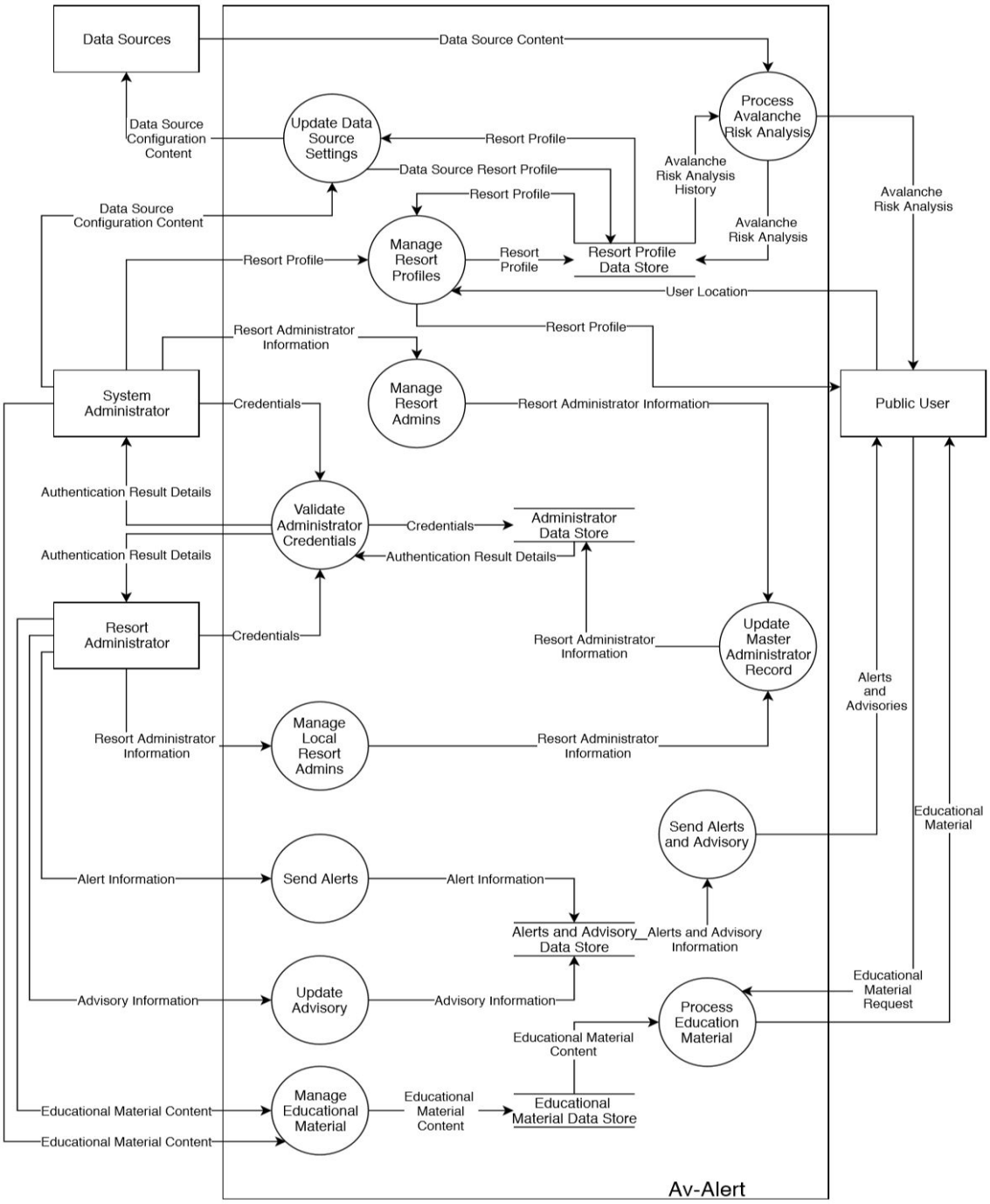


Figure 26: Data Flow Diagram Level 1.

8.4.1 Data Dictionary Data: Flow Diagram Level 1

Data	Information encapsulated in the data.
Advisory Information	Identifying info (geographic location, name, etc.) for a Slope at Medium Risk of avalanches.
Alert Information	Identifying info (geographic location, name, etc.) for a Slope at High Risk of avalanches.
Authentication Result Details	A true or false value showing if a sign in attempt was successful.
Credentials	Sign in credentials of the administrator, comprising of username and password.
Data Source Configuration Content	Information used by a Data Source to set the format of future information passed from itself.
Data Source Resort Information	A list of Data Sources connected to a Specified Reps.
Educational Material Content	A text or video file that allow a user to gain knowledge towards the Educational Material learning objectives .
Educational Material Request	An Administrator query for a text or video file within the Educational Material Data Store.
Resort Administrator Information	Information such as ResortId, Username, ResortAdminId about a given Resort Administrator.

8.5 Data Flow Diagram Level 2

Process: Manage Resort Profile.

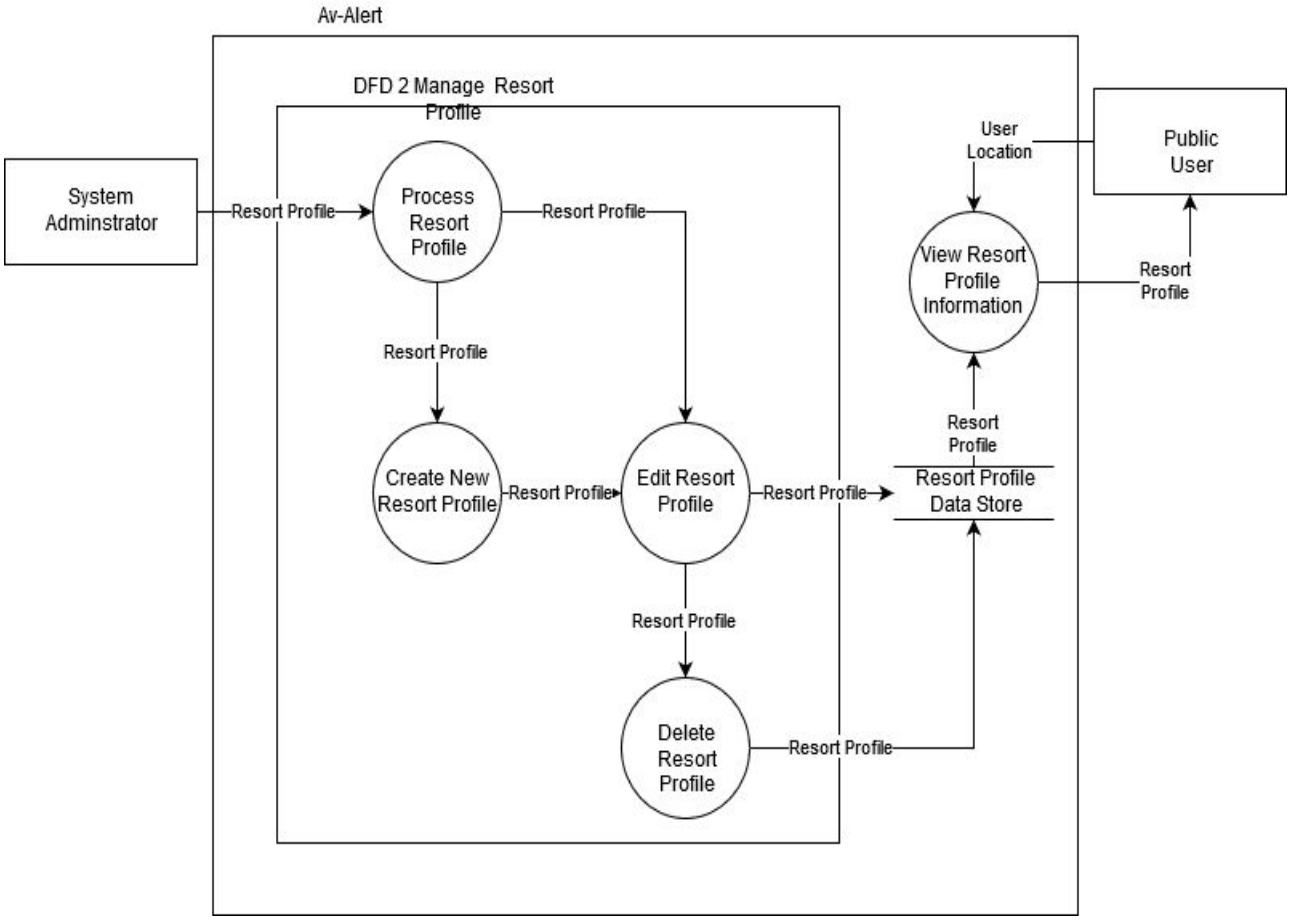


Figure 27: Data Flow Diagram Level 2.

Appendix: Issues List

A-1: Client Clarifications

A-1.1: The budget set by the client for Av-Alert is four million CAD, this was clarified during further elicitation with Steep Mountaineering during the lab.

A-1.2: The radius around each Resort needing to be covered by Av-Alert is 50 km, this was clarified during further elicitation with Steep Mountaineering during the SENG 321 lab session in ELW B215.

A-1.3: Public Users will have access to Avalanche Risk Analysis Data. This was clarified with Steep Mountaineering over Slack.

The following clarifications were made with Steep Mountaineering after receiving feedback that the problem that Av-Alert was attempting to solve was a wicked problem.

A-1.4: Av-Alert will produce avalanche risk analysis in the form of an Avalanche Forecast, not a prediction.

A-1.5: Av-Alert will produce Avalanche Risk Analysis Data to create Avalanche Forecasts three times a day, at 6:00am, 12:00pm and 6:00pm instead of being real time as previously specified.

A-1.6: Av-Alert will only use three main data sources to create Avalanche Risk Analysis Data, they are as follows: Topological Maps, Remote Sensing Instruments, and Meteorological Data.

The following clarification was made in response to questions about primary and secondary battery power.

A-1.7: Remote Sensing Instruments are powered by battery, and can have a secondary battery unit to extend their running time in case of a failure of the first.

A-1.8: The required standardized unit of measurement for Av-Alert will be metric, this was clarified during further elicitation with Steep Mountaineering during the SENG 321 lab session in ELW B215.

A-1.9: Av-Alerts UI demo and prototype were approved on November 5th 2019 during the SENG 321 lab session in EWL B215 dedicated to UI and prototype demonstration.

A-2: First Client Elicitation, September 24th 2019

Location:

- General Whistler area

Current Systems:

- Currently, snow pit records data in a spreadsheet, crunching numbers, and then transferring to website
- Spreadsheet with website holding information
    - All manual collection, no remote sensing
- Users include:
    - Administrators (running the organization and staff)
    - Data collectors
    - General public (accessing information)
- Data is collected in a 50KM radius around Whistler
    - Data is recorded in the field with pen and paper
- Data is updated in intervals by administration talking to data collectors
    - Occurs twice a week
- Current staff alert system uses walkie-talkies

Client Needs:

- Automated collection and distribution of data
- Less hands on work from system administrators
- No OS constraints
    - Current administrators use windows
- Administrators need an editing interface
- Users need a map and general interface
    - Website is needed for front-facing content
    - Including safety training and information interface
- Formal staff alert system
- Radio communication system if really bad weather is coming in or if things change quickly
- Staff log-ins

New System:

- Will be marketed to people and resorts, as the need is large across many ski resorts
- Must meet current industry standards
    - Some resorts have minor avalanche prediction services based on basic probability, combined with weather data and topological maps
- Hardware may already exist to help with collection
- Budget of $4 million

Vision:

- Predictive and real-time models to alert resorts and individuals through the use of a webpage/website/general interface and a radio communication
    - Topological map of the area with colour-coding of how likely an avalanche is to occur in an area
        - Must be dynamic, allowing users to change their view

    - Include safety training and information interface
    - Offline mode to save current state of avalanche map to view when in backcountry

A-3: Second Client Elicitation, October 3rd 2019

Clarification on Users never being able to access raw data:

- Users can look at the raw data but only after the system has created the Avalanche Forecast
- Av-Alert will no longer be fully real time but 3-4 intervals per day, new Avalanche Risk Analysis Data will be released

Confirmation:

- Project scope, purpose, direction and product perspective approved by clients

User Classes:

- Medium privilege for Resort Administrators means that they can view all system information but require System Administrators for higher privileged actions

Operating Environment:

- We require clarity on operating systems which are supported on our system
    - browser versions, OS versions

Cloud Storage:

- Clients approved the usage of cloud storage

Assumptions and Dependencies:

- 72 hours of backup power is needed for Av-Alert in the occasion of long power outage