Requirements Document 1.0
Client: Steep Mountaineering
Project: Av-Alert

September 30th, 2019

Contents

Revision History

Name	Date	Reason for Changes	Version
First Draft	Sept 25, 2019	Initial Draft. Interpreting elicitation notes and creating outlines of each section.	0.7
Rough Draft	Sept 26, 2019	Filled out each section from initial outline.	0.8
Complete Draft	Sept 30, 2019	Sections commented and ready for review by team members.	0.9
Final Version	Sept 30, 2019	Complete and reviewed document, ready for review by Steep Mountaineering.	1.0

1 Introduction

1.1 Purpose

This document outlines the requirements necessary for version 1.0 of Av-Alert, a new Avalanche Prediction System for the client Steep Mountaineering. Steep Mountaineering's current system relies on manual collection and manual analysis of data, resulting in real time data and analysis not being currently possible for Steep Mountaineering. The objective of Av-Alert is to automate the collection of data for avalanche risk analysis to eliminate manual collection and analysis and provide readily accessible information.

1.2 Project Scope

There are three major objectives for the Avalanche Prediction System. Av-Alert's first objective is to automate the collection of data required to track and analyze potential avalanche conditions. Steep Mountaineering's current system requires an employee to dig multiple snow pits and manually record the data for later analysis. Av-Alert will remove the need for manual data collection, reduce cost and time spent doing so, and improve employee safety. Av-Alert's second objective is to provide real time updates and alerts about the probability of an avalanche occurring. Av-Alert would eliminate manual analysis and manual updating when new data becomes available and will increase safety and marketability by allowing for informed decisions by users through up to date avalanche risk information. Av-Alert's third objective is to create an interface for the Avalanche Prediction System. By creating an interface that can convey current avalanche risk information, Steep Mountaineering will be able to reach a wider user base with a product that requires no specialized knowledge for analyzing avalanche risk data.

1.3 Glossary of Terms

Administrative Portal	A website that is designed for administrative users to conveniently access important and useful information of a system.
APRS	Automatic Packet Reporting System, a system of encoding data for transmission over standard radio systems.
Big Data Analytics	A process of examining large volumes of data to identify correlations between data sets
Docker Container	A software container that packages up code and all its dependencies so applications can run quickly and reliably from one computing environment to another.
Hadoop	A collection of open source software utilities that manage a network of computers to solve problems involving massive amounts of data and computation.
Message Bus	A messaging infrastructure to allow one or more computers to communicate through a shared set of interfaces.
Multi-Factor Authentication	An authentication method that requires more than one method of authentication that satisfies two of the following: Something the user has, Something the user knows, and Something the user is.
Public users	Users who use Av-Alert but are not employed by Steep Mountaineering or the resort utilizing the software

Resort Administrator	A subset of resort staff with privileged access to Av-Alert to perform applicational tasks
Resort staff	Employees who work at the mountain resort where Av-Alert is utilized
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.[3]
System Administrators	People who are responsible for managing, maintaining, and configuring the reliability of multiple systems.

1.4 References

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

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

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

[4] F. Sabatini, “Setting up and Managing Automatic Weather Stations for Remote Sites Monitoring: From Niger to Nepal,” Renewing Local Planning to Face Climate Change in the Tropics Green Energy and Technology, pp. 21–39, Jul. 2017.

[5] 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.

[6]A. Widforss, “Avalanche Visualisation Using Satellite Radar,” p. 54, 2019.

1.5 Overview

This document contains six sections plus an appendix. The second section describes Av-Alert and includes an overview of current systems, major features, user classes, the operating environment, and constraints related to the options available for development. The third section provides in-depth descriptions of the major system features required by Steep Mountaineering. 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. The appendix contains a list of yet to be resolved requirements issues.

2 Overall Description

2.1 Product Perspective

Av-Alert is a replacement for a current system of manual data-collection for avalanche risk monitoring. Manual data-collection techniques for avalanche risk assessment are subjective, time-intensive, can put data collectors at risk, and are not able to provide real-time data[1][2]. Av-Alert will allow for the manual data-collection to be replaced with remote sensing, thus providing more objective, safer, and closer to real-time data.

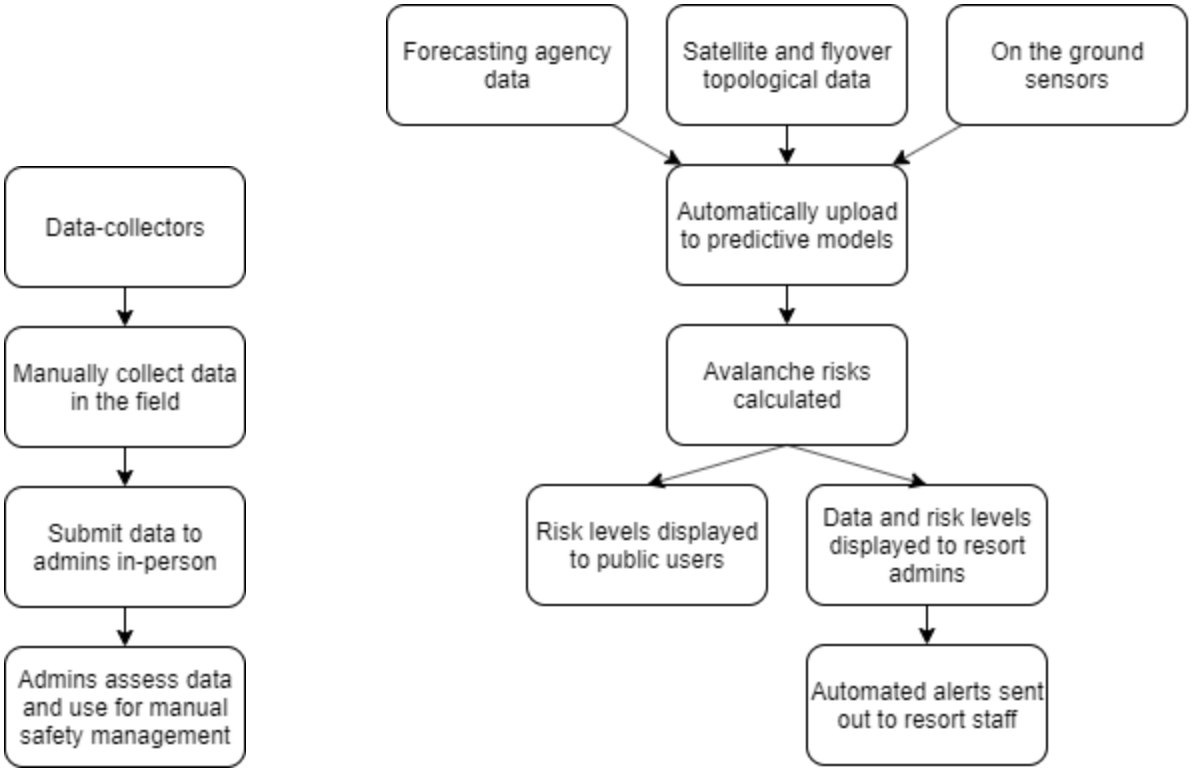

Figure 2.1.1: Component diagram of the current system

Figure 2.1.2: Component diagram of Av-Alert

2.2 Product Features

Av-Alert consists of five main features. First, our data collection system scrapes information from a large array of sources to create a robust data set which we can base our predictions on. Second, the avalanche prediction feature uses predictive models to create risk analysis predictions on slopes in the given area. Third, radio alerts are used for high priority information such as rapid changes to condition or updates on high risk area. Fourth, an interactive topological map displays the current status of conditions for the given area which users can then explore and download for offline use. Fifth, Av-Alert provides informational material regarding avalanche safety, and what to do if you are caught in one.

2.3 User Classes and Characteristics

There are three user classes for the new system: System Administrators, Resort Administrators, and Public Users.

2.3.1 System Administrators

System Administrators are users with a high level of expertise and with privileged access on Av-Alert. In order for System Administrators to access Av-Alert, they must be authenticated using Multi-Factor Authentication. The primary tasks of the System Administrator are to manage and maintain Av-Alert and ensure that it is available.

2.3.2 Resort Administrators

Resort Administrators are users who are experts in identifying stable snow packs with medium privileged access on Av-Alert. Resort Administrators must be authenticated through an administrative website in order to access Av-Alert. The Resort Administrators will be able to monitor mountain conditions, alert staff and resort guests of potential avalanches, upload additional news and information feeds, and manage safety and training artifacts.

2.3.3 Public Users

Public Users are users who may possess varying levels of technical knowledge with low privileged access on Av-Alert. Public users have read-only access to generic information on Av-Alert. Public Users are only able to view a geographical map interface of potential avalanches, news and information feeds, and safety and training artifacts.

2.4 Operating Environment

Steep Mountaineering's current system is not required to interact with Av-Alert. However, Av-Alert must receive data from different data sources. To accommodate for geographical information sources, Av-Alert can receive the collected data through land-based, airborne and spaceborne sensors. Additional data sources from forecasting agencies, government agencies, news outlets and research groups will have the option to contribute data through the multiple message busses of Av-Alert. Data that is manually collected by all Resort Administrators can be manually imported into Av-Alert. Data collected is analyzed, correlated and mapped by the system to produce a geographical map interface of potential avalanches.

The Resort Administrators must be authenticated to an administrative website interface to monitor mountain conditions, alert Public Users of potential avalanche, upload additional news and information feeds on the Public User environment, and manage safety and training artifacts.

The Public Users will access the Av-Alert interface through a mobile application or website interface on their personal devices. Av-Alert must be operational on all devices of various operating systems and versions. Public User access to Av-Alert is limited to a geographical map interface of potential avalanches, news and information feeds, and safety and training artifacts [1].

The System Administrators will be responsible for managing and maintaining Av-Alert. In order to access Av-Alert, the System Administrators must be authenticated to the system using multi-factor authentication.

The hardware components of Av-Alert relies on two Dell servers, PowerEdge R430 and PowerEdge R730xd, running CentOS version 8 as the operating system. The software components that operate Av-Alert consists of the Hadoop ecosystem and Docker containers for the web application services and mobile application services.

2.5 Design and Implementation Constraints

Steep Mountaineering indicated flexibility regarding the design of Av-Alert. The ideal goal of Av-Alert is to replace Steep Mountaineering's current system and does not require any integration with Steep Mountaineering's current system.

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

C-1: Changes in mountain conditions must be updated as soon as a change in conditions is identified by the data collection system.

C-2: Any data gathered must not be available to public users. Only the conclusion gathered from the data should be released to the public users

C-3: Data collection systems must be able to maintain full functionality for 72 hours without access to its primary power source

2.6 Assumptions and dependencies

The following outlines the assumptions and dependencies of the system:

2.6.1 Assumptions

Steep Mountaineering is receiving and collecting data from news outlets, government agencies, and research groups regarding avalanche reports and historical data. If the data received from an outside source contains inconsistencies or is erroneous, the result may be incorrect reporting of current conditions by the system.

A-1: The data collected is normalized and is free of inconsistencies and errors.

Data is not required to only reside on premise. If the data is not required to only reside on premise, Av-Alert could be modeled as a hybrid system residing on-premise and on the cloud. This will ensure full availability of Av-Alert in the event of an outage on-premise or in the cloud.

A-2: The data collected is not required to reside in a single physical location.

2.6.2 Dependencies

The data transmission of Av-Alert is dependent on a hierarchical data transmission model. The transmission model attempts to send data through the following data transmission channel: cellular towers, satellite and radio transmissions.

D-1: Av-Alert depends on having a data transmission model available always.

The system must have at least two power supplies for redundancy. When a power outage occurs, the system must be powered by the redundant power supply, as well as stored battery power.

D-2: Av-Alert must have a secondary power supply.

3 System Features

3.1 System Feature 1 - Data Collection

3.1.1 Description and Priority

The Data Collection system feature collects data from an array of different sources, and turns it into a homogenous data set. This data is then further used by the Avalanche Prediction feature. This feature is of high priority as the rest of Av-Alert relies on it and its collected data must be robust and accurate.

3.1.2 Functional Requirements

REQ-1: Data Collection must not halt or fail if one of the sources is unreachable. Things can temporarily go down, so it is important to make sure that in such an event event, the Data Collection system continues to function as normal.

REQ-2: The Data Collection System must be able to homogenize all data types it collects from varying information sources. As the Data Collection system fetches information from its sources, the information will come in different forms. To prevent errors during avalanche risk prediction, data types and measurement units must be standardized.

REQ-3: The Data Collection System must be able to handle large inflows of data from scheduled or unscheduled updates from in-field sensors.

3.2 System Feature 2 - Avalanche Prediction

3.2.1 Description and Priority

The Avalanche Prediction system feature takes data collected by the Data Collection system and uses predictive modelling to create risk analysis probability for avalanches happening within the specified domain. This feature is of high priority as it is imperative that predictions are accurate as inaccurate predictions could result in the injury of users.

3.2.2 Functional Requirements

REQ-4: Calculations are stored as historical data for future reference. As information is being gathered and computed, it must be preserved as it will hold future value. Through its analysis, it can be used to improve the predictive models.

REQ-5: Predictions can still be made to account for a minor degree of missing data. As data is collected from a large number of sources, there is a chance a source could suffer an outage. It is important to make sure that predictions can still be made in such a scenario.

3.3 System Feature 3 - Radio Alerts

3.3.1 Description and Priority

The Radio Alert system feature delivers alerts and updates to resort staff and associated emergency services. A radio update would contain the current status of avalanche prone areas in the vicinity, and a radio alert would identify fast changing conditions or hazardous areas..The Radio Alert system does so over radio, as radio is the most easily accessible method of communication for users requiring avalanche information, and is available where cell service may not be. Usage of radio also has the benefit of a lower

power draw [4]. The Radio Alert system is of high priority due to the information being of high importance, time sensitive, and could lead to injury if ignored.

3.3.2 Functional Requirements

REQ-6: Readily decodable data packets and/or vocal warnings and updates to radio users both within the organization and the general public.

REQ-7: Radio signal should have the same coverage as measured area, either through direct transmission, or via repeaters. The information transmitted can be quite important to resort staff and emergency services, thus it is important that anyone in the measured area can hear these alerts.

3.4 System Feature 4 - Topological Avalanche Map

3.4.1 Description and Priority

The Topological Avalanche Map system feature visualizes the predictions made by our Avalanche Prediction system feature. The Topological Avalanche Map feature overlays the predictions onto a topological map of the given area, colour coding the areas with the predicted risk of an avalanche occurring, from green (low risk) to red (high risk). The Topological Avalanche Map feature is of high priority as it is the front facing component of the main functionality of Av-Alert.

3.4.2 Functional Requirements

REQ-8: The Topological Map must be downloadable to allow public users to use the map when they don't have cell service or wifi. This is a common scenario due to the nature of the problem domain, but the use of the map is an essential feature of Av-Alert.

REQ-9: Users can search for different regions. The coverage of the data collection is a large area, so it is important that public users are able to search for the specific area they are interested in.

REQ-10: Status of avalanche probability is updated in real time. Due to the importance of the predictions, the data must be real time so that public users can make educated choices in the event of noticeable changes in their vicinity.

3.5 System Feature 5 - Avalanche Training

3.5.1 Description and Priority

The Avalanche Training system feature serves to provide public users with educational material regarding issues such as how to spot high risk avalanche areas and what to do in the occurrence of an avalanche. The Avalanche Training feature is of medium priority since it is not essential to the core functionality of Av-Alert.

3.5.2 Functional Requirements

REQ-11: Video playback available for public users to view training and safety videos.

REQ-12: Content can be downloaded for offline use. Many regions that Av-Alert cover have limited access to cell service and wifi, and it is important that public users have access to this material while in areas at a high-risk of an avalanche.

4 External Interface Requirements

4.1 User Interfaces

4.1.1 Public Interface

The public interface is accessed by public users. The public interface only allows for public users to read the curated data provided by Av-Alert. The public interface should not display any raw data or allow for public users to contribute any data to Av-Alert.

4.1.2 Resort Interface

The resort interface is accessed by resort administrators. The resort interface requires resort administrators to be authenticated and resembles the public interface but with additional permissions. Authenticated resort administrators will be able to affect the system by sending alerts and news to the public interface.

4.2 Hardware Interfaces

The following sections describe the hardware interfaces which Av-Alert will interact with.

4.2.1 Weather Collection Stations

Av-Alert will interact with weather data collection stations to collect meteorological data. The BC government has automated weather data collection stations which remotely sense snow and provide meteorological data that is uploaded in near real time [5]. The snow and meteorological data is uploaded hourly and transmitted through a geostationary satellite network. The data is freely available to download in csv format.

4.2.2 Satellite Data

Av-Alert has the potential to interact with other forms of data such as remote satellite data. Satellite radar from space can detect snow depth by correlating the brightness of the snow and the snow depth[6].

4.2.3 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.
- Restricted to single catchments within a range of 5 km in the line of sight of the sensor

Air-borne or spaceborne sensors, on the other hand can cover several hundreds of square kilome-ters in one data acquisition. Airborne and land-based laser scanning and field measurements as reference data. Preliminary results indicate that snow depth measurements with a precision of 20cm can be obtained, which are confirmed with hand measurement.

4.3 Software Interfaces

The public user will be able to access and view this software user interface but will not be able to delete or modify the data. The public user and the resort administrator user will see the latest updated predictions at any given time. The public user and the resort administrator user should have the option to refresh the interface. This will force the system to check for new data and update the predictions accordingly.

4.4 Communications Interfaces

For radio communication, Av-Alertis to be easily accessible by staff and the public, so it will use a standard format for radio communication, such as APRS. This requires encoding of snowpack info before broadcasting it via Narrow Band FM. Post transmission, depending on the area covered by a data station, radio signals may be interrupted, so Av-Alert will be designed to either have a large initial broadcast range from the data station, or have the signal be repeated over the range.

5 Other Non-Functional Requirements

5.1 Performance Requirements

REQ-13: Hardware must work in all weather conditions. Due to the harsh nature of the problem domain and importance that the system must be reliable, the hardware must be able to function in any weather condition.

REQ-14: Avalanche predictions must be realtime. As conditions in the systems coverage can change quickly, it is important for public users to have the current status of the terrain, since real time choices are made by the specified users.

REQ-15: Av-Alert in-field systems must be able to function without main power source. Due to the nature of the environment that the system will be deployed in, it is required that Av-Alert be able to provide data for a minimum of 72 hours without primary power.

5.2 Safety Requirements

REQ-16: Av-Alert must accurately alert resort staff on potential avalanches. If misinformation is spread to resort staff, misunderstanding will occur. Misunderstandings can result in unsatisfactory safety precautions taking place, and can result in public user injury or death.

REQ-17: Av-Alert's Radio Alert systems must be tested regularly to ensure it stays operational. If critical information is not broadcasted effectively, user injury can occur.

5.3 Security Requirements

REQ-18: Incoming data should only come from verified data collection sources and be secured after entering Av-Alert. Data integrity is important, and data must not be tampered with, as it can result in misinformation or false predictions.

REQ-19: System Administrators must have sufficient access to maintain, troubleshoot, and resolve abnormalities within Av-Alert. Sufficient access must be given to the system administrators, as it is important that they be able to conduct their job efficiently and effectively.

REQ-20: Systems administrators must be able to log into the system securely with user authentication, and others must not be able to gain access to the system. It is integral that only authorized users can gain access to the system.

REQ-21: Resort staff must be able to analyze and upload content to the consumer environment. As resort staff act as people on the ground in our problem domain, it is important that they have the ability to contribute back to the system via interactions with their consumer environment.

REQ-22: Public users only see the results of the data analysis with no access to the database. This is to prevent misunderstandings to public users who might attempt to interpret the data themselves.

REQ-23: Av-Alert must only allow System Administrators access to the data that is collected by the terrestrial laser sensors, air-borne and spaceborne sensors, and forecast agency data. Furthermore, the System Administrators and resort staff must be able to access Av-Alert through a secure authentication method.

5.4 Software Quality Attributes

REQ-24: Avalanche predictions must be presented with readability and clarity in mind. Due to the nature of the predictions it is very important that the public user can understand the prediction presented..

REQ-25: The system must be easily maintainable. The terrain of the problem domain could prevent ease of access to both resort crews and system administrators, making maintenance tasks more complex, thus it is important to maximize maintainability.

6 Other Requirements

REQ-26: In the unfortunate event of an avalanche, no liability is held by Snowlutions or the resort using the system. The system only provides the probability of an avalanche based on the available data. It serves only as an approximation of the risk users are exposed to as they make choices for themselves.

REQ-27: Data must have acknowledgement of delay/staleness if necessary, to ensure absolvence of liability in case of misinformation stemming from this data.

Appendix: Issues List

I-1: No user interface guidelines provided by the client.