# “Unstable Bluff” Detection System Requirement Specification

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# 1 Introduction and Overview

The “Unstable Bluff” Detection System is designed to address the growing concerns about the bluff instability in the Del Mar, California area. The bluffs in this area pose a significant risk to the train tracks situated atop the cliffs as well as a hazard to public safety. The primary goal of the detection system is to monitor these bluffs and provide timely alerts to relevant authorities when instability is detected along the Del Mar bluffs. This detection system serves as a proactive solution to safeguard the transportation system and the public by monitoring any bluff changes.

The initial system will be a prototype monitoring a 300-foot section of the Del Mar bluffs using 6 high resolution, wifi-enabled cameras. The cameras capture and transmit images of the bluffs hourly for further analysis. The system will evaluate any changes in the bluffs and alert authorities if any hazardous shifts are detected based on a 0-5 ranking system. This enables quick action to take place in order to mitigate potential risks due to bluff changes.

This document serves as the Software System Requirement Specification for the “Unstable Bluff” Detection System. It provides a comprehensive overview of the system's functions, features, and operational goals. The document is organized as follow:

1.Introduction and Overview: an outline of the systems intended purpose

2.User requirement: an expansion of the systems functionality

3.System requirement: Introduce all of the functions the system will include, the users, and how the users will interact with different functions

4.Other: future additions and software enhancements

This specification document provides a clear roadmap for evaluating and developing the “Unstable Bluff” Detection System, ensuring a shared understanding of the system's purpose and technical requirements for all stakeholders.

# 2 User Requirements

## 2.1 Monitoring and Alert System

The “Unstable Bluff” Detection System will continuously monitor a 300-foot stretch of bluffs in the Del Mar area using 6 fixed cameras. The system's primary function is to capture images and transmit images up to 300 feet in order to detect any changes in the bluff stability. Users, authorities and rail operators, receive real-time alerts if any changes in the bluffs stability is detected by the system.

## 2.2 Image Capture and Analysis System

The system will capture and process high-resolution images of the bluff every hour using the six wifi enabled,10-megapixel, cameras. These images will be periodically transmitted to a local test facility, the users, for further processing and analysis to detect bluff changes. The cameras are capable of withstanding environmental conditions such as strong winds and fluctuating temperatures, thus, they are  suited for this software.

## 2.3 Constraints

**Power and Network constraints:** the cameras rely on a stable internet connection and a continuous power supply. Wireless routers, repeaters, and access points will be used to ensure reliable transmission between the cameras and a local test facility (central site). Amtrak has also agreed to provide direct access from cellular-enabled cameras to cellular service for the future for the interest of railway companies.

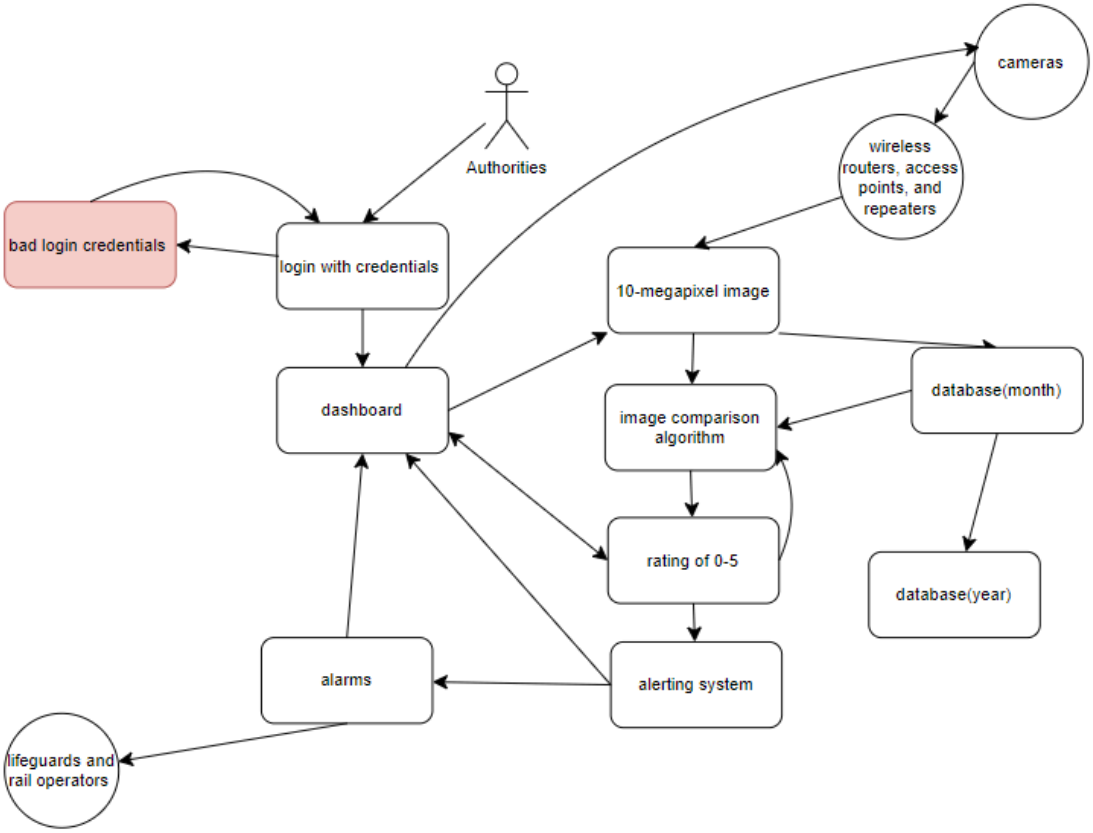
**Data storage:** The system has an image comparison algorithm and it has a database that stores  one month's worth of hourly data and it can archive one image per day for up to a year. Due to the high resolution(10-megapixels) of each image, the system requires significant storage capacity and optimized data handling procedures to avoid any issues during retrieval and image comparison.

# 3 System Requirements

## 3.1 Functional Requirements

The "Unstable Bluff" Detection System is designed to monitor bluff stability in the Del Mar, California area by utilizing 6 cameras and a central processing system that analyzes the images and detects any changes. The system will automatically capture images, analyze changes over time using an image comparison algorithm, and send alerts to relevant authorities based on the severity of the detected changes. Users will be able to interact with the system through a central dashboard, which will allow them to monitor bluff status, review historical data, and send control commands to the cameras.

## Normal flow

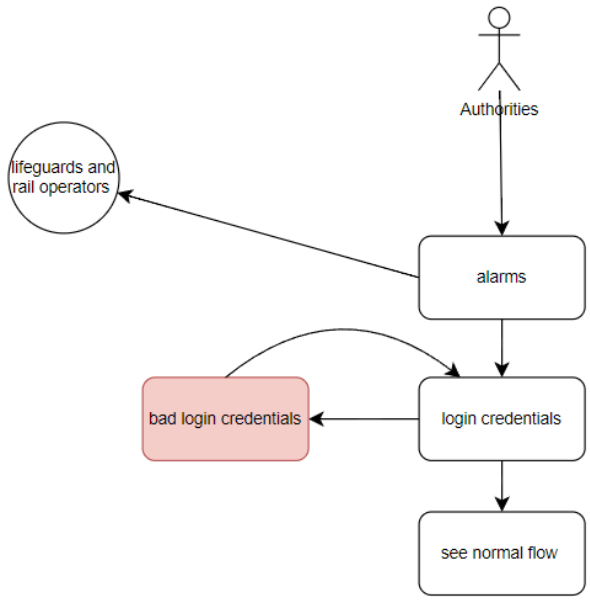



The authorities have access to a central dashboard in order to access the following: captured images, alerts, alarms, ratings, and the option to change rating levels. The dashboard will be simple and intuitive to ensure usability for users without technical expertise and it will present real-time updates. The authorities will be able to login to the system using their credentials. After logging in they will see the main dashboard that gives them access to the images transmitted by the camera using wireless routers, access points, and repeaters. The system uses an image comparison algorithm that will compare the 10-megapixel image, which includes a 32-bit timestamp and 32-bit geolocation, with previous hourly images from the database(month). The database(month) stores hourly images for up to a month and transfers one image per day to be stored for up to a year in the database(year).

The image comparison algorithm will rate the bluff changes based on a rating of zero(no change) to five (major change). A rating of zero indicates no identifiable change in the bluffs. Ratings between one and three are considered predictive of a significant slide, indicating that monitoring should be in place. A rating of four indicates significant change

and further evaluation is required to determine whether rail traffic should be stopped, and if people need to be evacuated. A rating of five indicates major change has been detected and rail traffic should be stopped immediately and people should be evacuated. Additionally, the image that indicates a major change should be compared to the last image at that location to determine if trains or people were in the area right before, and if rescue operations are needed. Ratings at levels four and five will trigger alarms to go off and messages are sent to lifeguards and rail operators in order to take immediate action. These actions include but are not limited to stopping rail traffic and evacuating people from the area to avoid possible injury or the risk of death. The amount of change for each level is user-defined so as to allow authorities to set the amount of change using the dashboard as well as view the ratings throughout the day.

## Alternate Flow




In the alternative flow, if the rating detected by the image algorithm system is a 4 or 5, the alarms will be visible on the system prior to the login of authorities so the necessary personnel are aware and informed. This is to allow a proper and timely response in the case that authorities are not already logged in. This way authorities will still be notified of major changes in the bluffs without proper login. No changes or access to the dashboard will be given, just the alarm will be visible. To continue to the dashboard, authorities will log in using their given credentials and follow the normal flow.

### Exceptional flow

If the login credentials are incorrect/not accepted the authorities will be prompted to re-enter their credentials, username, and password. The system will have multi-factor authentication for user access and maintain an audit log of all actions taken by users, including changes to interval time between images and image specifications. This is part of both the normal flow and alternate flow diagrams. After credentials are accepted, they can access the dashboard and follow the normal flow.

## 3.2 Nonfunctional Requirements

The “Unstable Bluff” Detection System must be highly reliable, as it is responsible for monitoring critical infrastructure and public safety. Any downtime or missed detection could lead to damages and even loss of life.

The system must maintain at least 99.9% uptime, ensuring continuous monitoring of the bluff. To ensure continuous monitoring the cameras will have night vision capability. The 6 cameras should be able to capture images in both color and grayscale. The cameras will need backup power supplies and redundant network connections should be in place to prevent any image transferring issues.

The software system must support real-time detection and alerting, especially when bluff changes are detected and immediate action is necessary. Alerts and alarms should be presented clearly with actionable steps for users to follow. They should also be delivered to backup contacts if it is perceived that primarily users do not systematically acknowledge the alerts. The cameras should be able to transmit images to the central site reliably every hour. If there are transmission errors, the system must retry within 5 minutes and log any transmission failures.Additionally, the UI must be simple and require minimal training for the users.

Since the “Unstable Bluff” Detection System is a prototype being deployed first to the  Del Mar area to evaluate the feasibility of the system for further use on other bluffs with similar concerns on the California coastline, the system should be built using modular, well documented code to allow for future software updates and hardware replacements. It should also be able to accommodate environmental changes without significant changes to the infrastructure.

# 4 Other

## 4.1 Future Additions and System Enhancements

After the initial prototype and testing phase, the “Unstable Bluff” Detection System will evolve and expand both in functionality and coverage area. Below are potential enhancements for post-prototype phase:

**Expansion of Geographic coverage:** The system could be scaled to monitor a larger range of bluffs in the Del Mar area well beyond the 300-foot stretch and throughout the California coastline. The camera and processing infrastructure will be replicated to additional high risk areas along the coast.

**Real-time Video feed Integration:** A future version of the system could introduce real-time video streaming from the cameras. This will enable authorities to monitor the bluff activity in real-time rather than relying solely on hourly image captures. This can also help improve the comparison algorithm.

**Environmental sensors**: The system could further integrate sensors to measure rainfall and seismic activity to enhance the accuracy of the bluff monitoring system by correlating these facts with observed changes in the bluffs.

## 4.2 General Timeline

**Phase 1:** Prototype (6 months): Completion of the initial prototype to monitor the 300-foot stretch of bluffs in the Del Mar area.
**Phase 2:** Testing and Expansion (6-12 months): Scaling the system to cover additional bluffs along the California coastline and enhancing the system based on early user feedback and data collected from the prototype.
**Phase 3:** Full Rollout and Additions (1-2 years): Deploying the system along the entire California coastline, integrating new features such as real-time video capturing and environmental sensors.