

Airport Safety Management System



Design Challenge II - Runway Safety/Runway Incursions

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1. Executive Summary

Hazards at airports are identified and reported in a haphazard way. Each organization tends to handle only those hazards that directly affect them. The effect is the creation of “silos” of information and control that inhibit information flow and the proper handling, in turn obviously affecting runway safety. There have been many instances in which latent hazards have contributed to accidents and incidents just as FOD or poor runway lighting have. In 1991, Air Ontario was operating in a time recently following deregulation, which led to heavy economic pressures by company management. On May 10th Air Ontario Flight 1363 crashed after only 15 seconds of taking off, causing the death of 21 of 65 passengers and 3 of 4 crew members. But, the underlying cause was the silos of values that diluted the safety judgment of the captain, in which the pilots were expected to know everything. There was also a culture among flight crews that flight attendants were not expected to speak to the pilots about safety items. The pilots were expected to know everything. Each of these silos of values diluted the safety judgment of the captain and first officer. Therefore, the motivation behind our proposed solution is to reduce severity, number and rate of runway incursions through infrastructure development, using our proposed Safety Management System.

Our Safety Management System will bridge the gap between those different “silos” through a website based content management system that centralizes all hazards. The system will provide an interface for operators to log new hazards that are reported to them from anyone at the airport. Operators will have the option of viewing active hazards to address them in real-time, through which they will be shown a history of past occurrences and deployed mitigations of similar hazards. Operators can also filter all hazards in order to create reports and logs. In addition, other users will have access to collaborative elements such as a forum, a news and alerts section which for example, can track top reporters, etc., to encourage involvement.

We were fortunate to have as our industry advisor, Mr. Thomas Anthony who has served as a consultant for the International Civil Aviation Organization and as Regional Division Manager for Civil Aviation Security in the Western Pacific Region for the FAA. We hope our solution will be considered for further development.

2. Problem Statement & Background

Safety is the most important concern at any airport, and indeed, the health of the entire aviation industry can be damaged by even a few accidents. While large, high profile accidents may seem rare yet inexorable, they often have their genesis in a single careless mistake on the ground. Why these preventable mistakes go unreported can be linked to the disorganization present in the hazard reporting system itself. Currently, the responsibility of reporting potentially unsafe situations in most airports is split between many different agencies, including the owners of the airport, the FAA, the ground control agency, and other entities. This split leads to the creation of several distinct “silos” present in many airports. Spreading the responsibility & management of hazards which arise around this many organizations leads to distressing lapses in safety when a miscommunication arises due to a difference in policy between distinct silos. This issue is the one that we hope to alleviate with a silo-unifying Safety Management System, which will be universally adopted across all silos. Additionally, many airports have an extremely rudimentary system currently in place for performing this reporting. A high-profile airport like LAX, until recently was still using a system as primitive as submitting slips of paper to a box. These two factors contribute to a safety management system in place at most airports that is lacking in efficiency, technology, and accountability.

3. Summary of Literature Review

Designing a safety management system requires understanding interactions between the various components and parties involved. Our research process had two distinct phases. The first was the

literature studying process, which enabled us to gain a complete understanding of the domain, while the latter was field research through interactions with key personnel.

Annex 14 International Civil Aviation Organization (ICAO) gave us the specific definitions for the terms used in the domain, and allowed us to pinpoint appropriate definitions we would use for key terms. It also provided us with aerodrome specifics, and details about the physical characteristics of the airport and supporting structures. The Los Angeles Tower Standard Operating Procedures (SOP) and the FAA regulations (Air Traffic Control) gave us understanding on how our system would be affected by these regulations. The FAA supports harmonization of international standards, and has worked to make U.S. aviation safety regulations consistent with ICAO standards and recommended practices. The Advisory Circular (AC No: AC 150/5200-37) published by the FAA was our primary source to come up with requirements for the system. It introduced the concept of a safety management system for airport operators. We utilized some more important definitions from this document, including hazard, risk, and an SMS. It also detailed the elements of the SMS, safety policy, safety objectives, and distinct five phases that is required by a risk management system.

4. Team's Problem Solving Approach

Our design challenge reflects to develop a technological solution that can help enhance airport safety as a whole, specifically runway safety. When actually tasked with this challenge, our team decided to take an iterative design process, which meant primarily to clearly define the problem, then iteratively perform research to better define the requirements. Next, analyze and understand the environment in which the system would be deployed, designing and modeling the system, investigating current or proposed alternatives, designing a functioning prototype and all the while receiving user feedback to verify every part of our system lends to solving the proposed problem. Our team decided that in order to more efficiently conduct this iterative process, we should split our seven member group into the teams of Research, Requirements, Design and Prototyping. While initially the research and

requirements teams were pulling the majority of the weight, once they had presentable information this allowed for several teams to be working in parallel, making the iterative process more efficient. We came together approximately one to two times per week in team design meetings, where the individual team information was shared and new tasks were doled out. Each of the tasks met by these four teams largely describes the manner in which we actually solved our problem, and thus is presented here.

4.1 Research: Defining the Problem and Investigating the Proposed Environment

Discussions with Thomas Anthony allowed us to get a better understanding of the problem of airport safety in general, as well as focus in on specific documents to do further research. Our team was then able to research the actual requirements for an airport Safety Management System by examining the regulations clarified in the FAA's Advisory Circular, as well as the standards presented in ICAO's Safety Management Manual: Annex 14. This research led us to a better understanding of the concept of a SMS, however we felt we lacked the motivation behind development of such a system that seeing its uses and location in the field might give. This led us to take several visits to airports, also outlined in our Industry Experts section. These visits narrowed our interest into deploying such a system in the Operations Department of an airport. We were able to get a clear understanding of industry expert's views on what causes runway incursions and airport hazards in general, as well as a desire to breach the barriers sequestering the many silos of organization in an airport. As we went through an iterative process, we also came back to research as questions came up regarding additional features that could be available to our system, as well as what features already are available. This led us to research such ideas as voice recognition reporting service, the building block of a Content Management System, etc. Furthermore, on approach to our last iterative cycle, we were able to take our initial prototypes to some experts in the field and acquire specific feedback on their interaction with our system.

4.2 Requirements: Narrowing the scope and need for our System

After initial discussions with Mr. Anthony and in-depth research of the documents mentioned above,

our team was able to narrow the scope of the requirements for our system. Next, our team collectively decided which parts of the ideas generated from our research could feasibly make it to our system. We narrowed our requirements to the following:

- The system’s hazard reporting capabilities must be accessible to all personnel on site.
- Our system must be optimized for rapid data entry, accessibility, stability, and performance.
- Our system must promote cooperation and interactivity between the different “silos” present in all airports.
- The amount of additional personnel required to implement the system, as well as the amount of training required for each additional personnel, must be minimized.

4.3 Design:

Once our team had the first iteration in defining our requirements, we were able to begin our design of the system. This included creating clear use cases for every major transaction a user would have with the system. We were then able to turn these use cases into more clear interaction diagrams.

Finally, we decided to implement our system on top of a Content Management System (CMS), using HTML, XML, AJAX, and PHP as the primary technologies powering the system. Our system will serve as a plug-in to this CMS. This fulfilled our requirements, as the web interface provides a lightweight, easy to use, browser-integrated solution. Hybridizing our system with a CMS also enabled our system to be infinitely customizable to promote interaction and cooperation within the silos. For more information, including interaction diagrams and screenshots consult our “Description of Technical Aspects” section.

4.4 Prototyping: Modeling the System

Upon achieving an idea of the design for our system, as well as using the general use cases already developed, our prototyping team was able to begin putting together some initial mockups of what the

system would look like. This includes the various screens a user would need to navigate through a system in carry out a use case as outlined previously. We were truly able to get a small use of the iterative design process in that our team was able to take these initial prototypes of the system and get industry feedback as to the usability and functionality of our system, such that we may modify the current prototype to reflect their valued opinions. Furthermore, the portions of our system that received industry approval began to coalesce into a usable system, so as to better ascertain how effective our system would be.

5. Safety Risk Assessment

5.1 Risk Assessment as part of the safety management system

As instructed in FAA Safety Management System Guidance, our system uses risk assessment as part of the risk management process to analyze hazards and assign a potential risk related to the hazards. When our system is deployed to an airport, all recorded and acknowledged hazards will undergo a rigorous risk assessment process. New hazards will be analyzed and characterized as they are identified during day-to-day operation. We applied a centralized approach for the system that enables the hazards data to be retrieved from all organizations operating at an airport such as vendor, oversight or enforcement agencies. Our Safety Management System will analyze reported hazards and determine associated risk(s) associated with each hazard. As previously introduced have developed a Safety Management System. Deploying and implementing a new system in itself is considered as hazards. According to the FAA advisory circular: A **hazard** is a condition, object or activity with the potential for causing damage, loss, or injury. A **risk** is the chance of loss or injury measured in terms of severity and probability. It is important to indentify that transitioning to a new system will have potential risk. The table below show some of the potential risk related to new system transition.

Hazard	Server failure
Description	Server fails due to hardware failure
Severity	Hazardous: the system will be inaccessible during the time the server is down
Likelihood	Extremely Remote
Assessment	Medium Risk
Mitigation	Transition in backup system and inform IT team

Hazard	Communication device failure
Description	Communication devices such as cell phone, remote desktops or internet connection is down
Severity	Major: failure to report serious hazards could lead to potential incidents or accidents
Likelihood	Probable
Assessment	High Risk
Mitigation	Provide alternative ways/channels for information to mitigate

Hazard	Inappropriate training
Description	SMS operators and other potential users will undergo a rigorous training to prepare them for SMS daily operation. If such training is inappropriate or insufficient it can lead to a potential hazard
Severity	Hazardous: human error is the leading cause of runway incursions
Likelihood	Extremely improbable
Assessment	Low risk
Mitigation	Retraining or reassignment on the position

5.2 Tangible Hazards

Tangible Hazards are hazards that can be easily identified and classified. Tangible hazards are recognizable by any employee or vendor working in the airport environment. Foreign object debris, lack of or inadequate lighting, malfunctioning devices, etc.

As recommended in the FAA Advisory Circular 150/5200-37, after reporting, each hazard goes through a rigorous risk analysis process through these stages:

- Identification of the severity and probability of the possible risk related to the hazard.
- Suggestion of mitigation strategies, through previous data, analysis tools and human intervention.
- Continues monitoring of mitigation strategy and generates feedback to the reporter to encourage future reporting and reward good conduct.
- Modification and improvement of the strategies as necessary.

5.3 Non-Tangible Hazards

Not all hazards are tangible and easily recognizable. These we classify as non-tangible hazards. Our SMS system is designed to handle non-tangible hazards through management involvement. Our SMS does more than identification and mitigation strategies, however. An important part of the SMS is management. The system is a reliable tool but at the same time it requires human intervention and management decisions. Many hazards develop due to inappropriate organization of labor, poor communication, inadequate training etc. Such hazards can lead to a high likelihood of high severity situations. In the ValueJet crash of 1996, the management culture put an extremely high value on low ticket prices and cost cutting, by hiring a contractor to load the jet. This led to a low bid but no supervision by the air carrier. The contractor hired low bid personnel with poor to no training on hazmat so they loaded the hazmat oxygen generators next to tires in the hold of their aircraft and a great fire and crash ensued. Management is the only one that can look across all organizational silos

and make an appropriately balanced decision in the interest of the whole organization. For many hazards the mitigation process is very expensive and it will be impossible to mitigate without the management approval.

Our system employs the classic five phases approach for the analysis process. Figure [needed] below is an illustration from FAA Safety Management System Manual.

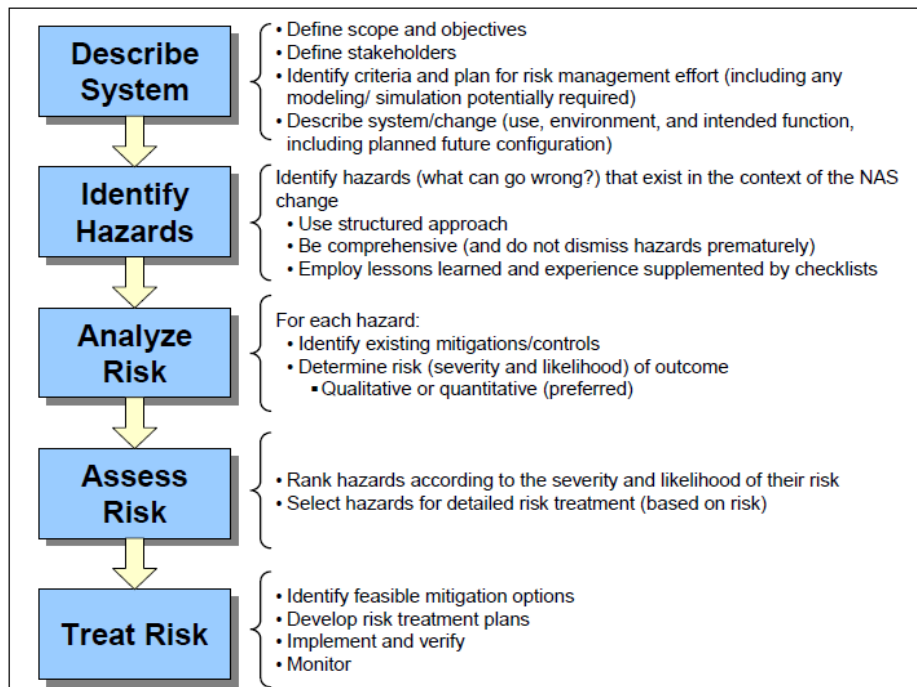


Figure 5.1, Safety Analysis Phases

5.4 Risk Assessment Factors

Our system utilizes two important factors to categorize hazards and predict the related risk. The assessment algorithm takes into account the likelihood and the severity of a risk to result into an accident.

Likelihood is the probability that the identified hazard will resolve into an incident. Severity is the factor determined in material, monetary or any other form of loss determined quantitatively, if the hazard resolves into an accident. For more information on how our system derives this risk, consult Description of Technical Aspects.

The predictive Risk Matrix introduced in the FAA Advisory Circular 150/5200-37 and illustrated below is a useful tool in categorizing and associating hazards and their probable risk. Matrix shows that certain hazards though less likely to happen can have a high severity, though they should be given particular attention. Similarly frequently occurring hazards with major impact should also given a high consideration.

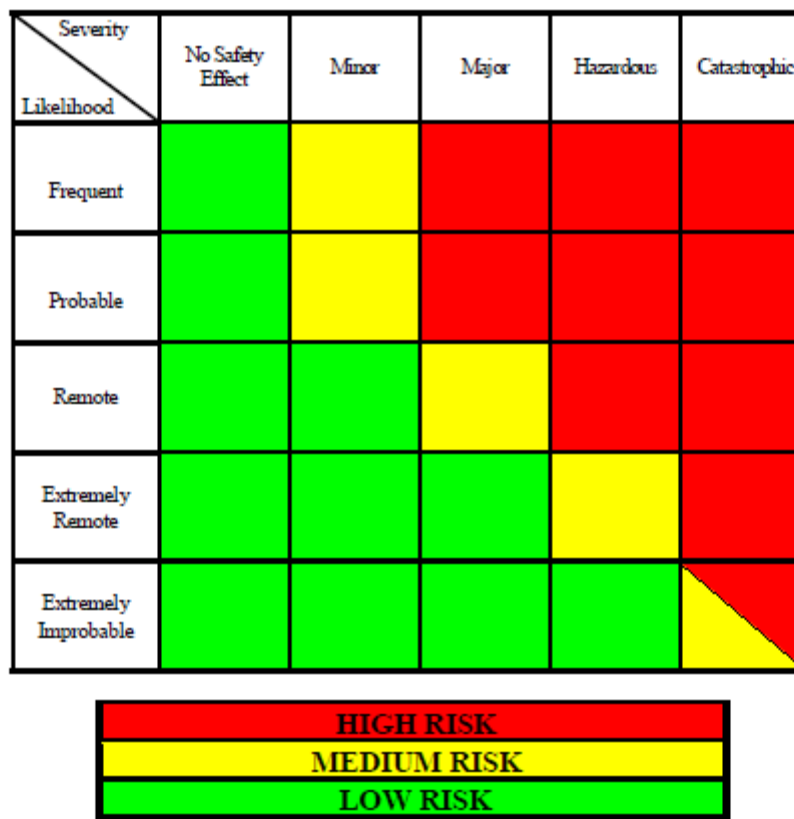


Fig 5.2 – Predictive Risk Matrix (from Advisory Circular)

5.5 Examples of Hazards

Since our system tries to take into account all possible hazards, we will demonstrate some hazards and what possible outcome (risk level, possibly mitigation strategy) our system will produce.

The characteristics of each hazard for different airports vary greatly due to weather conditions, airport

layout, airport location, airport size, etc. That is why our system is easily configurable. It has to adjust to different airports so it calculates risk levels more accurately and works more effectively. However, there are probably some hazards that are universal in their characteristics.

1. *hazard*: small foreign object debris (FOD) on runway

effect: FOD can interfere with normal airport operation

severity: minor (depends on the size and material of FOD)

likelihood: frequent (several times per week)

risk: medium

mitigations: send someone to pick up the FOD

2. *hazard*: jet blast

effect: damage to other vehicles, blows off various debris to runways and taxiways

severity: major

likelihood: probable (once per month)

risk: high

mitigations: move parking spots of planes further from busy roads so that planes can be placed on a safe distance from taxiways, runways, and roads used by other vehicles; clear territory and warn everybody in the nearby area before a plane starts engines

3. *hazard*: power loss

effect: system is down, lights are off, only visual approach is used in assessment of situation on the airfield

severity: hazardous

likelihood: extremely remote (once every 10-15 years)

risk: medium

mitigations: have a reserve source of power not dependent on the main source; mobilize all human resources to fix the problem as soon as possible and help in dealing with planes still operating in the air and on the airfield

4. *hazard*: wildfire

effect: if it occurs in nearby area, smoke and heat from wildfire can interrupt the normal operation of an airport. However, if it occurs in the immediate region of an airport, it will cause a greater damage

severity: major (in the first case), catastrophic (in the second case)

likelihood: extremely remote (once every 10-15 years)

risk: low (first case), high (second case)

mitigations: have a firefighting team ready to fight a wildfire; get rid of any flammable plants and buildings around the airport

5. *hazard*: unauthorized vehicle on the airfield

effect: creates potential danger of runway incursion

severity: catastrophic

likelihood: extremely remote (once every 10-15 years)

risk: high

mitigations: require clearance before any vehicle can enter the airfield; get the vehicle out of the airfield as soon as possible

6. Description of Technical Aspects

6.1 Overview

Once our team had the first iteration in defining our requirements, we were able to begin our design of the system. We began by designing preliminary use cases for the system's Safety Operators and developed interaction diagrams its organizational side.

6.2 Use Cases

The following use cases describe the different users and interactions between when operating the Safety Management System. A use case is a powerful engineering tool which links the requirements generated by the users with a design crafted by the engineering team. It is also serves as a guideline and a focus for prototyping. A set of use cases imports a sense of what the system does without becoming too bogged down with technical details.

Users (UC-U)

This will help define the users of our system, any acronyms for reference, as well as whom is in general user categories labeled "personnel"

(UC-U1) Airport Safety Personnel (ASP)

ASP are the personnel that work directly for the Airport in the Airport Safety Office.

4. Airport Safety Manager (ASM) - Manager in charge of Airport Safety Office, can handle ALL types/levels of hazards, but is responsible for directly handling new hazards or hazards with high risk level, see (UC-HR1).
5. Airport Safety Operator (ASO) - Operators working at terminals in Airport Safety Office, under the ASM. They are responsible for directly handling non runway incursion hazards of lower risk levels. See (UC-HR2)

6. Airport Cross Trained (Air Traffic Controller/Safety) Operator (ACTO) - Operators working in the Airport Safety Office, cross trained as Air Traffic Controllers. They are specifically able to handle, and responsible for hazards relating to runway incursions of all risk levels. See (UC-HR3).

(UC-U2) General Personnel

General Personnel is any personnel working for any third party vendor on the Airport, as well as any personnel working for the Airport directly, not in the Safety Office.

General Employees - General employees at any location on the airport (Any person ranging from: Airline Employees, Contractor Employees, Emergency Services personnel, and other individuals with a requirement for airport access). They are responsible for reporting any hazards through their chain of command. See (UC-HI1)

General Safety Liaisons (GSL) - One or Two employees at the head of each general employee chain of command, trained to input hazards into system. They are responsible for ensuring hazards reported by general employees are accurately entered into the system in a timely manner. See (UC-HI2).

(UC-U3) Mitigation Team Personnel

This is any personnel working for the mitigation team that enacts mitigations decided upon by the ASP in (UC-HR3)

1. Mitigation team Liaison - they are the contact to the ASP in the Airport Safety Office, taking action requests and returning reports.
2. Mitigation Resolving Teams - they are the various teams that actually enact the mitigations

Connecting to the System (UC-CS)

These use cases are identified but not described. We will import the best available technology to make

sure registration and login are secure, as well as cut costs.

(UC-CS1) Vendor Safety Liaison, Airport Safety Manager, Airport Safety Operator Registration

(UC-CS2) Vendor Safety Liaison, Airport Safety Manager, Airport Safety Operator

Logon/Validation

(UC-CS3) Vendor Safety Liaison, Airport Safety Manager, Airport Safety Operator Logoff

Hazard Input (UC-HI)

The following use cases describe how all hazards are added to the system.

(UC-HI1) General Employee Reports Hazard

Once a general employee observes a hazard, they must report it through their chain of command.

1. General employee observes a hazard.
2. General employee contacts the General Safety Liaison in their chain of command.
 1. They relay the hazard location.
 2. They relay the hazard category and detailed description.
 3. They receive a verbal confirmation from the VSL.
3. General employee continues working.

(UC-HI2) General Safety Liaison Inputs Hazard to System

Once a General Employee reports a hazard, the GSL must input it into the system.

1. [The GSL must logon to system. See UC-CS2]
2. On the beginning screen, the GSL has options to choose to input a newly reported hazard, or view messages
3. If they Choose to report a new hazard, they:
 1. Then they must enter the hazard location,
 2. They must enter the time of the original report
 3. They must enter the general employee that originally reported it.
 4. Then they must choose the hazard category
 5. Then they choose the specific hazard from the list of hazards in this category. If one does not exist, they choose to input new hazard.
 6. Then they must enter a specific description of this hazard.
 7. The GSL submits the report to the server. [This data is then updated to the Hazard Database, where Automated Risk Assessment can be done for hazards with database history (Hazards with no history are displayed directly to the ASM, see (UC-HR1). It will then be displayed to the relevant Airport Safety Personnel, see the use cases starting at (UC-HR1).]

Hazard Resolution (UC-HR)

Once a hazard has been inputted to the system, it is ran through the database and can be displayed to all Airport Safety Personnel. This Use Case is our main use case, as it discusses how the ASP view the system and interact with it to monitor and resolve reported hazards.

(UC-HR1) Viewing All Relevant Hazards in the System

This is the use case that describes how the ASP views their system.

1. Once the system is started, the ASP must log on, as discussed in UC-CS2.

2. [Once logged in, the system will consistently pull input from its databases and data sources]
3. As continuously refreshed hazards reported are input to the system, they are sent to the logic analysis to determine the severity of risk autonomously based on past hazard history.
 1. Hazards for which no history is available are sent directly to the ASM's for risk analysis.
 2. Hazards with history of all types and risk severities are available to the ASM
 3. Hazards with history of non-runway incursion relation and lower risk severities are available to the ASO's
 4. Hazards with history of runway-incursion relation, all risk severities, are available to the ACTO's.
4. All ASP can view a list of their relevant hazards.
 1. The ASO's and ACTO's screens have the hazards ranked by risk severity, with the option of choosing one to view more specifically.
 2. The ASM's has a view of all hazards, ranked with those needing risk analysis on top, and following that, all other hazards ranked by risk severity.
 1. The ASM then may also select a hazard to view more specifically.

(UC-HR2) Selecting a Specific Hazard that Has No History and needs Risk Analysis/Resolving

This describes how a ASM can select a specific Hazard to perform risk analysis.

1. From the list of All Relevant Hazards (see (UC-HR1.3)), the ASM may choose one from the top, that requires risk analysis
 1. This will show them all data inputted for the hazard, including location, category and complete description.
 2. Using previous training and reference material, they must assign a severity to the risk, as well as determine an appropriate mitigation.
 1. This may be done using both training and reference material from similar risks

and successful mitigations.

2. Once a risk severity and approved mitigation is decided upon, the ASM must Call the mitigation team to enact the mitigation.
3. Then the ASM must log the action, see (UC-HR5)

(UC-HR3) Selecting a Specific Hazard with History for Resolving

This describes how ASP may select a specific Hazard to view its relevant data and resolve the hazard.

1. From the list of All Relevant Hazards (see UC-HR1.3)), the ASP may choose any hazard from the list [preferably one with higher severity].
 1. This will show them all data pulled from the database on the history of this hazard. This includes:
 1. Number of previous occurrences
 2. Severity of possible incidents
 3. All suggested mitigations, including previously taken and logged mitigations, and successes/failures.
 2. The ASP may then choose an approved [knowledge from training] mitigation, and enact it. See (UC-HR4).
 1. Once the mitigation team has confirmed the outcome of action, the ASP must log the action taken, see (UC-HR5)
 3. While waiting for mitigation team confirmation, the ASP may select that mitigation is pending, and exit to the main screen.
 1. If this is done, the Hazard will be placed on the bottom of the list, to be selected for logging.
 4. If the ASP decides not to select a mitigation, but select a new hazard to view, they may simply return to the original screen, and start over as in (UC-HR3.1).

(UC-HR4) Enacting the Mitigation

This use case describes how the various Airport Safety Personnel may enact the mitigation they choose from (UC-HR3)

1. The ASP must contact the Mitigation Team directly, and relay the hazard/mitigation information, including:
 1. Hazard location on the airport
 2. Time reported
 3. Hazard category and description
 4. Hazard's risk severity
 5. Mitigation to be taken.

(UC-HR5) Logging Action taken as Mitigation to a Hazard

This describes how ASP must log a hazard once mitigation has been taken, either from the hazard's screen, or from the beginning.

1. If the ASP is already viewing the actual hazard, they must simply choose to log mitigation taken. See (UC-HR4.2.2)
2. If the ASP needs to start the system, they log on as in (UC-CS2), then view the main screen as in (UC-HR1).
 1. Then they may select the hazard from the bottom of the hazard list, where the hazards needing logged are.
 2. Then they choose to log the mitigation taken
 1. This will give them the option of selecting from a mitigation suggested (if any), or inputting a new mitigation.
 2. Either way, it will also require they input the outcome of the event, the severity

caused/avoided, as well as the success/failure of the mitigation taken. (and perhaps more statistics???)

3. Then, once logged correctly, it will return them to their main view, as in (UC-HR1)

Mitigation Handling (UC-MH)

This use case describes how the Mitigation Team must handle and take action on mitigations.

(UC-MH1) Receive Hazard/Mitigation information

1. The Mitigation Handling Team Liaison is contacted by an ASP.
2. They must log all relevant data, if any is not provided, must make sure to request it from ASP
 1. Hazard location on the airport
 2. Time reported
 3. Hazard category and complete description
 4. Hazard's risk severity
 5. Mitigation to be taken.

(UC-MH2) Sending Mitigation Personnel to enact Mitigation

1. The Mitigation Team Liaison that took the report must determine correct Resolving Team to enact mitigation (using trained protocol).
2. They must relay the information to the Resolving Team, and ensure confirmation is received from the same team.
3. Once the Mitigation has been complete and the Liaison has received confirmation, they must report it to the ASP.

Hazard Outcome Reporting (UC-HOR)

This use case describes how a hazard that has been resolved must be reported through the chain to encourage continuing general employee participation.

(UC-HOR1) The General Safety Liaison reports to the General Employees

1. [Once a mitigation is successfully logged, that data is sent to the GSL system as a message.
2. [The GSL must logon to system. See UC-CS2]
3. On the beginning screen, the GSL has options to choose to input a newly reported hazard, or view messages
4. If they Choose to view their messages:
 1. It will bring up a screen that displays messages sent by the system when mitigations have been logged by ASP.
 2. The GSL may choose to view a message.
 1. This will show a message including:
 1. Original Date of Report, including reporting General Employee
 2. Location and description of hazard.
 3. Mitigation taken to avert hazard
 4. Success/Failure of hazard.
 2. The GSL is responsible for reporting this data to the General employee responsible for reporting the hazard, as a means of employees viewing their impact on airport safety.

6.3 Designed Interactions

Once the use cases were clearly defined, the different interactions between users became clear. We developed the following system overview:

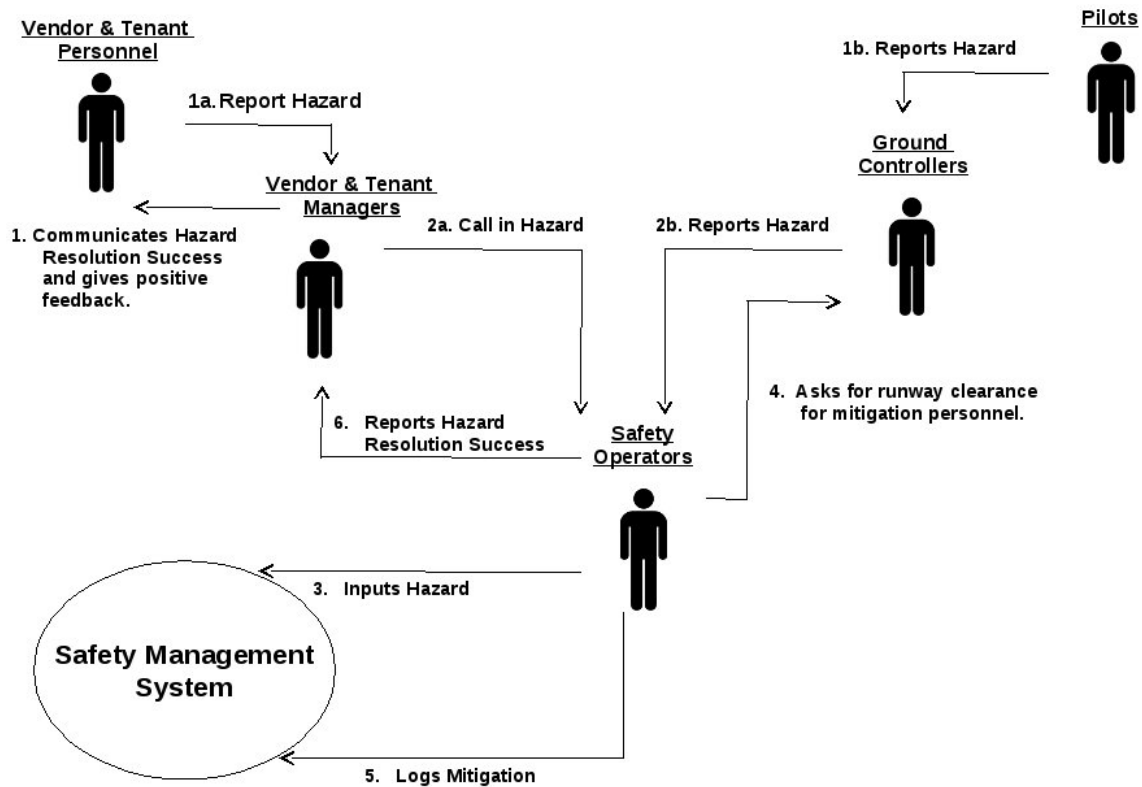


Fig 6.1 – Interaction Diagram

We decided that our system would be accessed not only by the Airport's Safety Operator but also by all other employees, creating a focal point for hazards, incidents and resolutions. This would potentially allow all the workers at the airport to come together and contribute to a safer working environment. To achieve this, we decided to use a web based implementation for our “Safety Management System” shown in the above diagram. We decided that the two main categories of users for our system were employees of the airport (public users) and safety operators working on current hazards at the airport. Following this distinction, we ran through the different interactions each user group would have with the website.

The following diagram illustrates the online implementation of the Safety Management System:

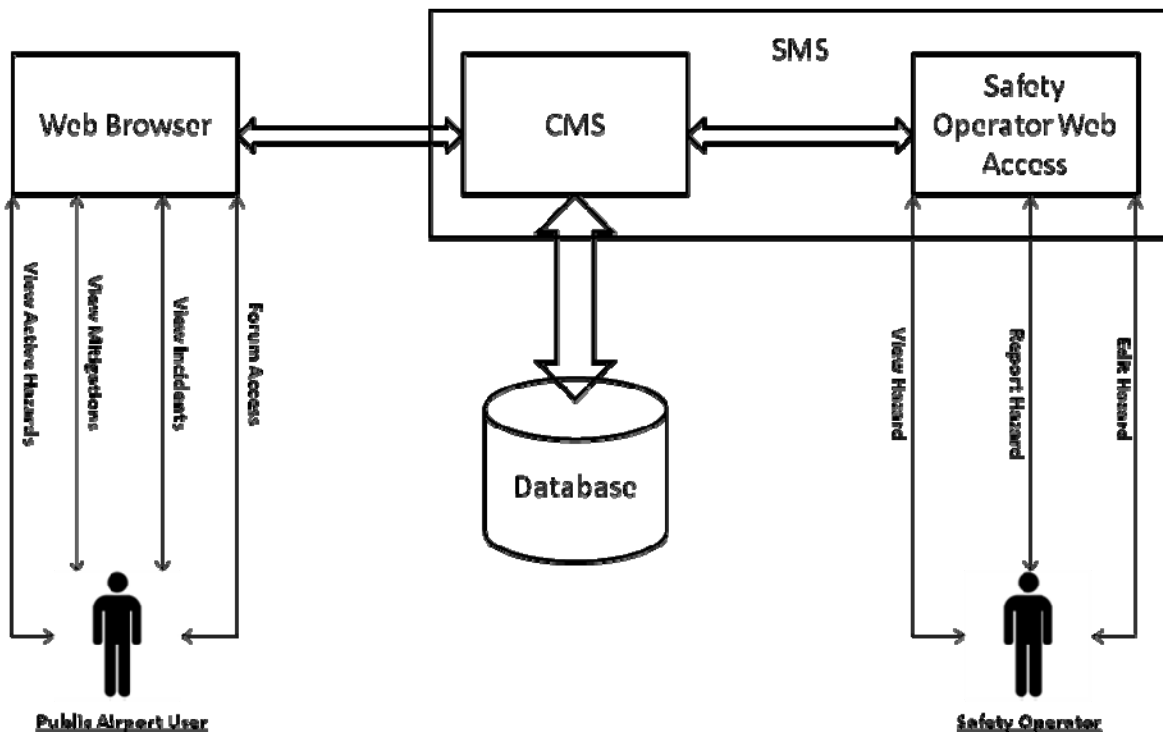


Fig 6.2 – Diagram of System Layout

Finally, we decided to embed our hazard design in a CMS in order to take advantage of the community features built into the design of every CMS. That gives our hazard system a natural place to express problems, patterns, and the other things we hope to communicate to all stakeholders in a way that cuts through the silos). We used HTML, XML, AJAX, and PHP as the primary technologies to power the system. This fulfilled our requirements, as the web interface provides a lightweight, easy to use, browser-integrated solution. Hybridizing our system with a CMS also enabled our system to be infinitely customizable to promote interaction and cooperation within the silos. The CMS also provides a simple method of editing the data on a website and adding additional information. This will allow individual airports to customize their website for their own needs through a web browser, without the need for additional software. As well being able to import static files into the CMS, the administrators of the system can add new content to the site while browsing. This allows for easy addition of information, such as recent incidents and resolutions taken to eliminate hazards.

6.4 User Interface

From the design decisions taken, we began designing the user interface for the website and producing a workable prototype. This site will be available on the Intranet of the airport, a private computer network that only airport based computers can access.

Below is a combination of the design decisions for the interface as well as screenshots of important implementations:

Home

The home screen displays the phone number that employees should call in order to report a hazard and a short description of what the site offers. It also acts as a portal to other parts of the system. From this page one can navigate to the Safety Center and Safety Operator sites by clicking on the links at the top of the page. Additionally, there are links to search the site and view the employee directory

Safety Center

This part of the system is accessible by all airport employees. While only authorized users can add and edit hazards, all personnel can view current alerts and resolutions. After clicking the Safety Center link, the start page is shown. This page describes how to use the Safety Center features. On the left side of the screen, links to view hazards or see resolutions and incidents are available.

The hazards section shows a list of current hazards at the airport. Each hazard can be clicked for more information. This section is important because it allows personnel to stay informed and allows them to double check if a hazard they have noticed has already been reported.

The resolutions and incidents page educates all of the resolution successes and unfortunate incidents that happened recently at the airport. Each headline can be clicked to show more information on the issue. There are also links to view resolved hazards and incidents separately.

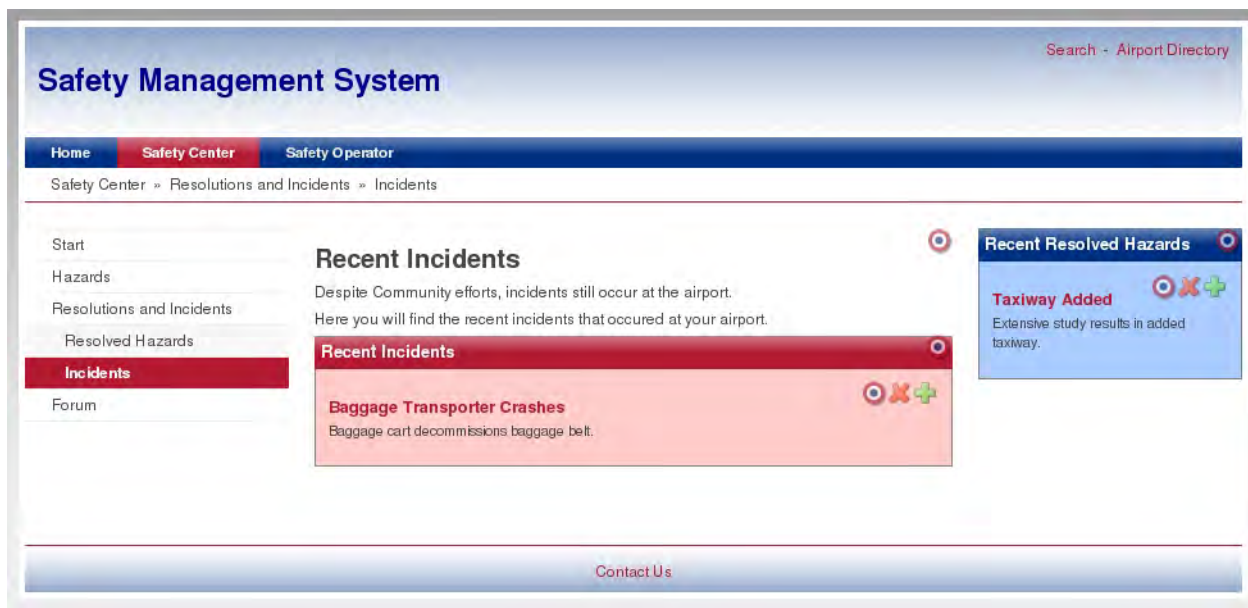


Figure 6.3 – Page with Recent Incidents.

Safety Operator

The Safety Operator button takes the user to the secure login site. This is the entryway to the parts of the system only available to authorized safety personnel. All airport employees will have access to the Intranet; however, depending on the level of clearance the user has, they employee may or may not be issued login information to the reporting system. On this page, the user will be prompted for login information. Once verified, the user will see the hazard reporting site. If the user remains idle for over fifteen minutes, they will be logged out of the system for security purposes.

Safety Management System

After login, the home screen of the SMS site is displayed. This site has links to report a hazard, view current hazards, and view hazard logs. On the home screen there is a box of important messages that notify personnel of urgent information. Additionally, there is an option to log out of the system.

Report a Hazard

When the user wants to input a hazard into the system, the first step is to click “add a hazard” on the SMS home screen. This link will navigate the employee to the hazard reporting form. The information that must be filled in includes the field reporter, location of the hazard, date and time the hazard

occurred, category of the hazard, risk level, and comments.

Home

View Current Hazards

Search Hazards

Report A Hazard

Statistics

Report A Hazard

Reporter:

Type:

Date Occured:

Time Occured:

Location

Lincoln Blvd

World Way

Los Angeles Int'l Airport

W Century Blvd

W Imperial Hwy

University of West Los Angeles

Avion Dr

Pacific Coast Hwy

Severely

Comments and Useful Additions:

Submit Hazard

Figure 6.4 – The Report a Hazard screen

The following steps describe how to input a hazard into the Report Hazard form shown above.

1. Type the name or ID number of the field reporter.
 - a. The field reporter is the employee who called in the hazard. After typing either the name or ID number, the system will look in the employee directory to automatically fill in the employee's information.
2. Select a hazard category

- a. A drop down list displays all the possible hazard categories, including the option to select “other.”
3. Enter the date and time the hazard occurred.
 - a. The current date is already chosen, but this can be edited if the event was on a previous day. The time of the occurrence should be written in military standard time.
 4. Select the hazard location.
 - a. In order to select the hazard location, the user must click the view map button. When the map of the airport appears, the user can click on the desired location. The system will update the form with the coordinate location of the hazard and the name of the area it represents. The user also has the opportunity to elaborate by clicking the “add location details” button.
 5. Adjust the hazard's severity level.
 - a. This option appears after the category has been chosen. Depending on the category selected, dotted lines on the risk meter will indicate the boundaries in which the user can slide the bar to adjust the risk level. If there is a need to exceed these boundaries one can click the supervisor overload button. This button pops up a login screen in which an authorized supervisor must give permission, by providing a username and password, to override this rule. Also, if the “other” category is selected no boundaries appear.
 6. Add a description
 - a. This optional box allows the user to provide any additional information about the hazard.

7. Click “Submit Hazard”

- a. This will save the information and return the user to the SMS home screen.

View Current Hazards and Adding Resolution Details

When the “View Current Hazards” link is clicked from the SMS home screen a page appears with a map of the airport and a list of the hazards that are currently *unresolved* or *in progress*. On the map different colored pins will indicate the location of said hazards. The color of the pins gives an estimate of the hazard's previously defined severity.

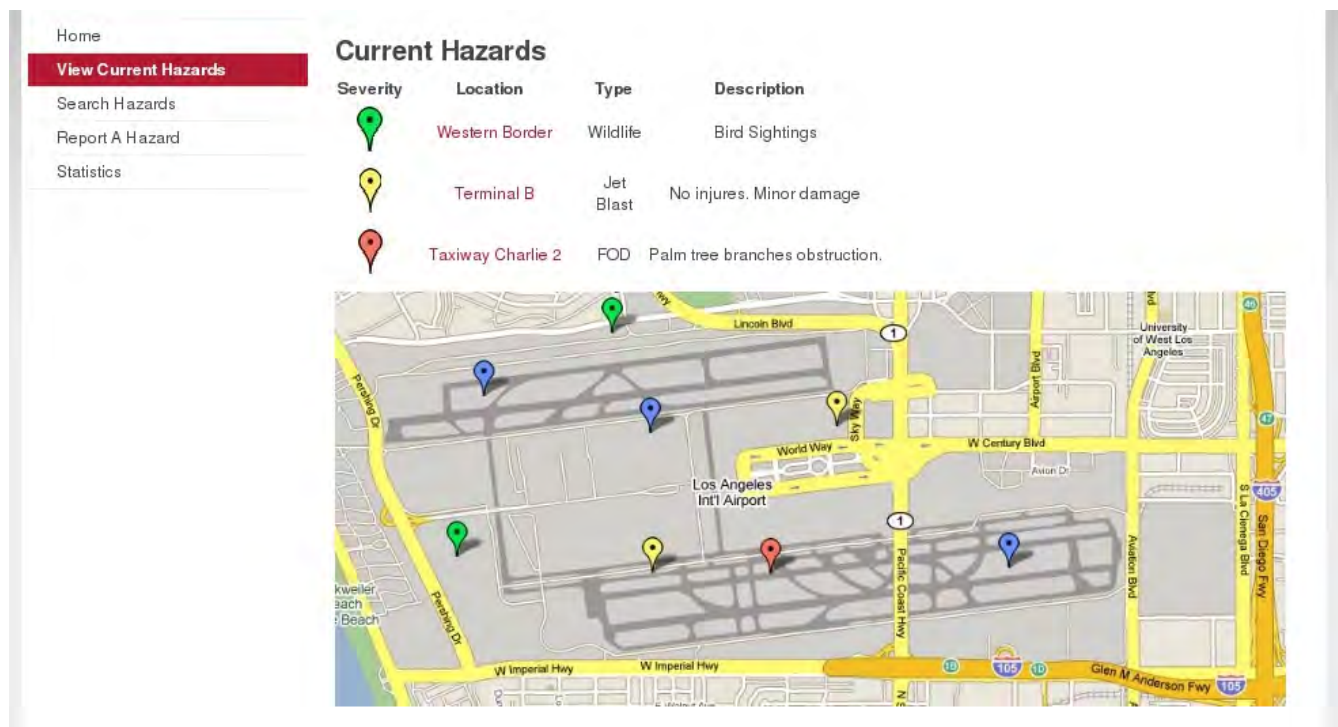


Figure 6.5 – View Hazards Screen

When a hazard’s “view details” button is clicked a page similar to the Add a Hazard screen appears. At this point hazard information can be edited. In order to add resolution details, the user can click the “Add resolution” button. This button navigates to a screen in which the user can enter details about mitigation information and change the status of the hazard. A new hazard is automatically labeled as

unresolved. On this screen this can be changed to *in progress* or *resolved*. Once resolved, the hazard will no longer appear on the View Current Hazards page. After “Save and Continue” is clicked, the user will return to the View Current Hazards page at which the user can edit more hazards or click the “Return to Home Screen” button.

Search Hazards

The hazard logs allow the user to see hazards filtered by field reporter, location, date, category, or risk level. Alternatively, the user can choose to view all reported hazards in the system. With this, personnel can track trends of hazards at the airport. There are three different log views. The list view shows a detailed list of the filtered hazards that is able to be sorted in each dimension. The map view displays the hazards similar to the way they are seen on the View Current Hazards page with a map of the airport. From here, the hazard details can be viewed as well. The graph view displays various line graphs and pie charts that visualize various data about the list of the filtered hazards.

7. Description of interactions with airport operators and industry experts

7.1 Overview

In order to approach such a large task and problem, our team felt that interaction with industry experts was of high importance, both as research and for feedback. When first approaching this problem, we realized that to fully understand the problem we would not only need typical methods of research, but we would also need to speak with experts in the aviation field. This led us to interviews with our advisor Thomas Anthony, and various visits to both LAX and Burbank airports, involving lectures, tours, and Q&A sessions. After we had visited each part of LAX and then took the trip to Burbank Airport, our team felt they were better equipped to begin a more thorough design of such a system. Throughout our design process we were required to craft presentations to our class, both of which we presented to Thomas Anthony who supplied us with more criticisms. This led us to actually create a basic prototype, and we were able to complete another partial spiral in our research, requirement,

design and prototype process as a team member was able to take our basic prototypes and get initial feedback from our two largest and most relevant contacts, so that we could further develop the system to what would be really used in the field.

7.2 Thomas Anthony on Airport Safety and Policies

We spoke primarily with experts in the field as a means of research and better understanding the issues at hand. Our primary interaction was through Thomas Anthony, Director of the Aviation Safety and Security Program at the USC Viterbi School of Engineering. Our initial sessions consisted of him briefing us on his views of the reasons behind the need for increased airport security, as well as any technical and political issues he felt may get in our way. These initial sessions are what led us to also begin our research on various sections of relevant literature, such as the ICAO Safety Manual's Annex 14, and other relevant documents. Additionally, he made it clear that a large task this system would have to help overcome is to help bridge the gap between the various silos of institutions located at each airport, since communication is key to increased safety. It also made us realize that to thoroughly understand the complexity of the problem at hand, as well as the context to which a system we would design might be used; we would need to visit an airport. In addition, we continued small discussion settings with Mr. Anthony, both to get further information from him, as well as to get feedback on our ideas as they developed.

7.3 LAX Control Tower Visit

This led us to our first visit to the Los Angeles International Airport on February 17th, where we visited the Control Tower. This trip was hosted by Sherry Avery, the chief of the LAX Control Tower, as well as Tony DiBernardo, the LAX Operations Manager. On this visit, we were given a complete tour of the LAX Control Tower, as well as given a presentation on how LAX is ran from the standpoint of air traffic control, including tower operating procedures, management structures and airport layout, geography, and history. Additionally, we were able to present our initial ideas of a Safety Management

System, and get feedback on its relevance at the airport, as well as information on where it would be likely to be placed. This session brought us to the understanding that while the Runway Safety and hazards are handled through interactions with the air traffic controllers, the full Safety system we were suggesting would be more realistically deployed through the Los Angeles World Airports Operations department. (LAWA), due to the organization's responsibility to mitigate any hazard that may be currently affecting the airport.

7.4 LAX LAWA Operations Division Visit

After the mentioned visit to the LAX control tower, we set up a team visit to see Raymond Jack of LAX Airport Operations. While there, he gave us a presentation entailing exactly how hazards are handled currently the various hazards one might encounter at an airport, as well as putting a large emphasis on the political issues behind trying to deploy the system we were proposing.. Our discussion with him brought out the large concerns of the problems in deploying such a large system across the many silos that exist at an airport, as well as how to make it simple enough for the type of people that are employed at his airport.

7.5 Burbank Airport Survey Visit

At this point, we felt that from a research standpoint, our team had a better understanding of the situation and could do more design; however we felt that we had a limited view on the issues at hand, so we decided it would behoove us to visit another airport, which led us to take a survey of the Burbank airport. There we spoke with [needed], who mainly discussed his concerns & ideas for the system, including a GPS system, which would make determining the exact location of hazards easier, and immediate entry by all airport personnel in such a system. This would make hazard reporting easier, more accurate, and perhaps personnel would be more likely to report incidents and potential hazards.

7.6 Design Presentations

Throughout our development and design process, we presented our current data in official presentations

to Thomas Anthony. This was significant interaction in this process, as it allowed him to correct anything he felt was an inaccurate representation of the Aviation Industry, be it terminology, concepts or procedure. We were able to have our current understanding of the situations and our current development scrutinized and received critical feedback into what may or may not be good points of interest in such a system. At a certain point, this brought about the feedback that we originally designed too closely around the LAX specifications. For example, how resistant they are to change and how slowly they deploy new technologies and software due to their political structure. This meant a lot of their feedback was shooting down our ideas, while other airports might be far more open to them. This meant we needed to keep in mind that all airports have different operations and deploy differently, which allowed us to modify both our design and future propositions to reflect the need for a highly adaptable system.

7.7 Prototype Interaction and Feedback

Once our team had an actual basic prototype to work with, a member of our team was able to present it to actual people in the industry to determine its ease of use, as well as correctness in the scope of airport operations. We took our prototype, on separate occasions, to both Thomas Anthony as well as the LAX Operations Manager Raymond Jack. We were able to sit them down, present them our system and ask them to complete basic tasks of our system, such as hazard input, resolution, or log interactions, and observe their interactions with our system. By doing this we were able to get feedback on how easily they were able to navigate through our system, what confused them, as well as afterwards getting them to clarify their main issues with both the usability of our system as well as any actual functionality they felt was missing. This was perhaps one of the most integral parts in both the design and further development of our system, since it actually allowed us to see firsthand that the people who could be using our system not only were able to navigate through it, but they also felt that it was a relevant and useful system to get the proposed job done.

8. Projected Impacts of the Team's Design and Findings

8.1 Impact

In November 2005, the International Civil Aviation Organization (ICAO) revised Annex 14, Volume I (Aerodrome Design and Operations), to require member states to have certificated international airports establish an SMS. According to Safety Management Manual released by ICAO in 2006, "a safety management system (SMS) is an organized approach to managing safety, including the necessary organizational structures, accountabilities, policies and procedures." FAA as a member of the International Civil Aviation Organization (ICAO) supports the compliance with international standards and strives to increase safety at its airports. This is reflected in Advisory Circular 14 CFR Part 139 (Certification of Airports). Therefore, in the near future an SMS will become a FAA standard which must be implemented in all airports. Our team, understanding the significance of SMS, offers our own solution to safety challenges in an airport and requirements of both ICAO and FAA.

Runway safety as part of a larger airport safety will be greatly improved upon adoption of our SMS. Collecting and analyzing information about hazards that contribute to accidents as well as incident occurrence will reduce the chance of runway incursions and excursions. Our system will be open to input from all airport personnel therefore making it more inclusive in terms of data collection and effective in terms of incident and accident prevention. It will help in enhancing airport visual aids and expanding situational awareness of pilots and ground operators on the airfield through constant reporting of any hazards or concerns. Mitigation actions may include not only immediate responses but also long-term improvements in an airport.

Another benefit our system will produce is that it will bring together different "chains of command" (different organizations and people such as Airport Tower Controllers, pilots, airlines, fueling contractors, maintenance personnel, etc.). Currently, there is virtually no communication between all of them as a whole despite the fact that they work at the same airport. Our solution will solve this problem by providing centralized platform where all of them can report hazards, view current safety situation,

and share their concerns about everyday operation of an airport and their suggestions how to increase safety.

8.2 Implementation

Implementation of the SMS system at airports is very feasible to accomplish in a relatively short period of time. Once the website and software are developed, it can easily be integrated with an airport's existing intranet system. The following configuration process of customizing the system to a specific airport is quite simple. After an easy registration process, and basic training for authorized users, the system will be ready to use.

Once the design is fully realized, the software will be ready for development. The software will be programmed and designed by engineers, website designers and graphic artists according to our specifications. Also, the system will undergo extensive testing by our engineers, congruent with development phase, and additionally for some time afterwards. The software will be tested for security, reliability, and adaptability. This will dramatically decrease the risk of errors, data loss, or breaches of security. Finally, the software will have to be tested externally and certified by the FAA before its final release. During internal and external testing some parts of the system will have to be redesigned and developed. Once the software is deemed acceptable, it will be ready for implementation. Assuming that less than 20 developers are working on the project; Table 8-1 explains the approximate timeline from design to the completion of testing.

Table 8-1: Development Timeframe

Phase	Timeframe
Design	2009 – 2010
Development	2010 – 2013
In-house testing	2010 – 2014
External Verification	2014 – 2015

Because the SMS is a web based system, it is affordable to implement at any airport. There is a short process for configuration and incorporation. The system can be integrated on an existing airport intranet, or a new company network can be developed. An engineer will work with an airport safety manager to customize the system with maps, types of hazards commonly found in the area, and the employee directory. Additionally, customizer will register the users who will have access to the SMS and grant them different levels of clearance according to the manager’s requirements.

8.3 Financial Analysis

It is in the best interest of the FAA that our SMS system be not only functional and efficient, but also affordable. At this point, the estimated cost of developing and distributing the SMS is based on the cost of employees and materials required for producing the software and the approximate time required to complete the project.

After careful research of the average costs and time spent to develop a modern software system of this magnitude, we can estimate financial specs for producing the SMS. By using information from the Bureau of Labor Statistics, we can calculate the expected salaries of the staff required to develop and maintain the SMS over the timing approximations listed in Table 8-1.

Several employees are required to develop the system and their salaries make up the bulk of the development cost. Additionally, several other expenses must be considered; such as office space, computers, servers, software, and web domain, to name a few. Table 8-2 lists the expected staff compensations per year and over the six year development process. Table 8-3 estimates the payroll

figures plus other expected expenses during each phase of development.

Table 8-2: Employee Salaries

Employee Salaries	Cost/Year/worker	Total Annual Cost	Cost Over Six Years
Project Manager	\$100,000.00	\$100,000.00	\$600,000.00
Designers (4)	\$85,000.00	\$340,000.00	\$2,040,000.00
Programmers (4)	\$65,000.00	\$260,000.00	\$1,560,000.00
Testing Staff (3)	\$50,000.00	\$150,000.00	\$900,000.00
Graphic Artist	\$40,000.00	\$40,000.00	\$240,000.00
Totals:		\$890,000.00	\$4,820,000.00

Table 8-3: Total Expenses per Phase

Phase	Cost
Design (1 year)	\$1,011,880.00
Development (3 years)	\$3,005,640.00
In-House Testing (4 years)	\$4,007,520.00
External Verification (1 year)	\$1,011,880.00
Total:	\$9,016,920.00

While these numbers may seem steep, consider the cost of resolving an airport incident or accident. In a large scale runway incursion; replacing the aircraft, cleaning the surrounding area, hiring a team of legal and mechanical and medical professionals, and paying cost per fatality, adds up to a staggering number. However, the average cost of a plane crash can be up to \$1B USD, making the cost of implementing this SMS trivial by comparison.

APPENDIX A:

Students:

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APPENDIX B:

Description of the university

The University of Southern California (commonly referred to as USC, located in the University Park neighborhood in Los Angeles, California, USA, was founded in 1880, making it California's oldest private research university.

According to U.S. News and World Report, USC is listed as the 27th best college in 2009 in the National Universities Category. With a 21% admissions rate in 2008, USC also emerges as one of the "most selective universities". USC was also named "College of the Year 2000" by the editors of TIME magazine and the Princeton Review for the university's extensive community-service programs. Residing in the heart of a global city, USC ranks among the most diverse universities in the United States, with students from all 50 United States as well as over 115 countries.

The university has a "very high" level of research activity and received \$432 million in sponsored research in 2007. USC is home to two National Science Foundation–funded Engineering Research Centers: the Integrated Media Systems Center and the Center for Biomimetic Microelectronic Systems. USC is also home to Nobel Prize winning Chemistry Professor George Olah, director of the Loker Hydrocarbon Research Institute.

USC is the largest private employer in Los Angeles and the third largest in the state of California and is responsible for \$4 billion in economic output in Los Angeles County; USC students spend \$406 million yearly in the local economy and visitors to the campus add another \$12.3 million.

APPENDIX C:

Non-university partners

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APPENDIX D:

Sign-Off from for Faculty Advisor and Department Chair
See attached form.

APPENDIX E:

Evaluation of the Educational Experience Provided by the Project

Roxanna Aliabadi:

1. The FAA Competition was very important for my education, because it took me out of the classroom and into the industry in a way few assignments can accomplish. Also, it taught me more about working in teams and time management.
2. Our first major hurdle was deciding what the problem was in airports today and how we would address it. After speaking with many people at the FAA and in the airport management industry we were able to find the weakness and design a solution.
3. To develop our hypothesis we considered all the different types of people working at an airport and realized how difficult it would be for hazards to get communicated between people working in different facets. That is how we decided that a universal hazard reporting system could break down the silos and make a difference.
4. This was very meaningful and useful. In a consulting job, this is the process that one would take to design a solution. Also, getting positive feedback from the industry was inspiring.
5. Yes, this project definitely stepped up my education. I have even spoken about the FAA competition extensively at recent job interviews, which greatly impresses my perspective employers.

Katie Altimus:

- 1. Did the FAA Design Competition provide a meaningful learning experience for you? Why or why not?** I do think it provided a meaningful learning experience for several reasons. We were able to take our education outside of a classroom setting and apply it to an actual consultation situation. We were able to visit various airports, and get a view into how technology is used and is important in a totally different forum. Additionally it really gave us the opportunity to work and develop as a team,

with only moderate guidance from our advisor. Overall I feel like we got a very good understanding for how engineering consultants have to approach problem spaces in order to present a solution.

2. What challenges did you and/or your team encounter in undertaking the Competition? How did you overcome them? We had some challenges in working on such a large team. This provided us with the challenge of appropriately assigning tasks, as well as creating many issues in scheduling full team meetings. We overcame this by splitting our group into four major teams, and using scrub meetings within the teams, and only occasional meetings with the group as a whole.

3. Describe the process you or your team used for developing your hypothesis. Our team first met with our advisor, D. Wilczynski, as well as Thomas Anthony. After discussing the matter and related issues in detail, we then did research on several FAA documents, so that we could better understand the problem as it was presented. Once we understood the task at hand more clearly, we were able to do an iterative design to develop our solutions and requirements, continually re-presenting them to our advisors/industry experts, and modifying them.

4. Was participation by industry in the project appropriate, meaningful and useful? Why or why not? Absolutely. Without the vast participation by members in industry, we would not have even been able to thoroughly understand the depth of the issues at hand. Not only did we have technological concerns to take into consideration, but we also spent a notable amount of time considering the political barriers and issues that we would face in deploying a system we were proposing. Had we not had this interaction with industry throughout our iterative design, we would not have been able to correctly address all the issues necessary to make a good SMS system. Additionally we would not have been able to get appropriate feedback as to the viability of our system.

5. What did you learn? Did this project help you with skills and knowledge you need to be successful for entry in the workforce or to pursue further study? Why or why not? This

competition has taught me a great deal when it comes to team dynamics. When to get involved and volunteer, and when to let others take the lead. Additionally it has taught me how diverse other engineering industries are. I definitely feel that it helped with skills that I would need to know in the workforce, as we got extensive practice presenting our ideas along the way, as well as meeting with professionals in the industry both to learn from them, as well as to present further ideas to them to get feedback. I feel much more confident and able to speak and interact with people in a more professional setting.

Suela Buzi:

Participation in FAA Design Competition has been an excellent learning experience. I had personally never looked at the airport environment from a management and operation point of view. I was amazed to find out the amount of detail involved. When we were first introduced to the competition topic I had a hard time understanding what could possibly be done to improve the system. That was because I did not fully understand the problem.

We certainly encountered some challenges working as a team. All of our team members are Senior students enrolled in four to five classes this semester, and scheduling meetings to accommodate everybody's schedule was difficult at first. As we progressed through the project we got to know each other better, recognizing each other's strengths and weaknesses. Overall we were able to effectively communicate and function as a very proficient team.

Developing the hypotheses required more than simply understanding the project's theme. We went through extensive research, analyzing documents such as FAA Advisory Circular, and FAA Safety Management System Manual, ICAO (Annex 14) etc. We also had meetings with LAX representatives, visited the LAX control tower and met with Raymond Jack, LAWA operations manager.

Thomas Anthony, our advisor and mentor for the project, was the one leading us in the right direction. He informed us of the new and existing legislation mandating SMS at all airports, as well as the FAA guidelines and current operating procedures. As we received feedback from the industry contacts and

through our mentors we made several revisions to our initial hypotheses.

Focusing on the “big picture” has been an educational experience in itself. I was amazed and pleased; to see the effort, skill and innovation that everybody was able to bring to the team during this developmental process. Although working with others inherently brings up new challenges the overall experience was gratifying and rewarding.

Nicholas Haskell:

The FAA design competition was truly a unique experience. Thrown into the deep end of the aviation safety pool, it took us a few weeks to really learn how to swim these treacherous waters. That said, participating in the FAA design competition was definitely a meaningful experience for me. My group and I had a crash course in *real* engineering practices, including customer feedback, domain analysis, scrum meetings, and above all, group dynamics. We faced myriad challenges, including several late reworks of the core idea, the loss of a group member, and a challenging deadline. Nevertheless, our team overcame these challenges through an engineer’s best sidearm – sheer perseverance. Initially, our hypothesis began as an idea from the mind of our key advisor, Thomas Anthony. He informed us of the impending legislation mandating SMS at all airports. He then informed us of just how sequestered each agency in an airport is from its neighbors in terms of safety. This notion led to our decision to design our system around unifying these disparate reporting agencies. Thomas Anthony was an invaluable part of this project, securing several “inside” opportunities for us at the LAX control tower and Burbank airport. The professionals we met at these sites were informative, welcoming, and kind. They briefed us on all the terrifying minutiae that keep an airport of any size running. The look at a control tower was particularly exciting – after seeing how everything operates in there, I submitted an ATC employment application! Overall, this experience was a positive one. The splitting of the project into 4 distinct phases – Research, Requirements, Design, and Prototype – was a new experience for

someone who has really only participated in the latter two before. It was very exhilarating to be crafting a project all on our own, and I feel like it assuredly prepared me for future employment doing the same. The tribulations we encountered were also very meaningful, as I have definitely taken away the idea that a strong manager who involves everyone in the project early and often is a key factor in successful projects. Though I feel like our overall submission could have been stronger had we a few extra weeks to work on it, I am nevertheless proud of the work that I have done.

Askhat Issakov:

The experience I gained while participating in the FAA Design Competition is valuable and meaningful because I learned how to work in a team of knowledgeable engineers solving a real-world problem. It brought me one step closer to my future career as a software engineer.

The biggest challenge for us was to combine two sets of requirements we had for our project. The FAA Design Competition asked us to solve a problem of runway incursions, while requirements of the class addressed a broader problem of Safety Management System. We focused on Safety Management System because we believe that a system, which will gather complete information about hazards from everyone working in an airport, would be able to solve a problem of runway incursions.

Our team and I in particular did a lot of research concerning operation of airports and we made several trips to nearby airports to learn more about existing solutions and problems they have. It was very helpful and useful for developing of our system. In general, I think we came up with a good solution to the problem and with further development it can make operation of airports safer.

Sharaf Nassar:

The FAA Design Competition provided me with an opportunity to learn more about airports and their organization. Through it I was able to interact with meaningful professionals that provided me with a unique insight on day to day operations as well as problems that arise from having various vendors

working in the same workspace. I also had the opportunity to be “behind the scenes” at Burbank Airport, helping me understand a basic airport structure and possible hazards our system will have to deal with.

Our biggest challenge during this project was designing a system that would unite airport personnel into a community while actively bettering their safety. We overcame this by splitting our system into two components – a public one for general airport employees and a restricted one for safety operators. This eased the design process by allowing us to focus on the two main aspects (unifying the airport and of dealing safety issues) separately as opposed to trying to build a system that did both at once.

To develop our hypothesis, we looked at the different requirements for a Safety Management System specified by federal and international aviation authorities and began brainstorming different methods we can use to satisfy them. The greatest aid, I believe, to defining our hypothesis was the study of current safety procedures used at airports through direct contact with airport safety personnel. This aided us in identifying the strengths and weaknesses of current procedures in an effort of providing a more complete system.

Other than learning about airports, I also got the opportunity to learn how to create, setup, and manage a Content Management System (CMS). This will prove very useful during my entry to the workplace as CMS websites are becoming an integral part of web development. By the end of the project I am confident that if needed, I could individually get a website up and running from scratch using a CMS.

Meera Srinivasan:

1. Did the FAA Design Competition provide a meaningful learning experience for you? Why or why not?

Yes, it was definitely a great learning experience. Being in the senior capstone class for computer science, I only expected to learn a lot of technical skills, but this project has enhanced my interpersonal skills in addition to enriching my technical skills. I also gained a thorough knowledge about the aviation safety domain, and the procedures currently in place. The most valuable experience though was understanding how engineers approach real world problems especially in such important domains.

2. What challenges did you and/or your team encounter in undertaking the Competition? How did you overcome them?

One major issue was of team dynamics. The large team of seven didn't always function as one unit. The main way we overcame this is through breaking up into smaller sub-teams, and delegating tasks based on interest and skill levels.

3. Describe the process you or your team used for developing your hypothesis.

We first discussed extensively with our two advisors, David Wilczynski and Thomas Anthony to thoroughly understand the domain and the problem given to us. We then used literary materials such as FAA documents to understand regulations and procedures currently in place. Then we brainstormed possible requirements with various designs. Through further interactions with our advisors in addition to industry experts, we narrowed the options down to a solution that seemed to best meet our requirements.

4. Was participation by industry in the project appropriate, meaningful and useful? Why or why not?

Very much! These industry participants provided us with the understanding of the domain we needed. They also gave us insight on how the industry views technology and feedback on the feasibility of our various designs. This interaction also led to our decision of addressing the bigger issue of the "silos".

5. What did you learn? Did this project help you with skills and knowledge you need to be successful for entry in the workforce or to pursue further study? Why or why not?

I learned a lot about the possible industry applications with a degree in computer science. This experience showed me what working in such a field would be like. With hard deadlines to meet, and working in a team environment with limited guidance, I feel these are the skills every professional should have. Interacting with so many experts increased my curiosity and encourages me to see past the tip of the iceberg. Overall, it has prepared well to be an engineer in the professional arena.

APPENDIX F:

Reference List with Full Citations

Federal Safety Administration, "Runway safety report," September 2007,

<http://www.faa.gov/runwaysafety/pdf/rireport6.pdf>

International Civil Aviation Organization, "Manual on the Prevention of Runway Incursions,"

http://www.icao.int/fsix/res_ans.cfm

“Los Angeles Tower Standard Operating Procedures,” June 11, 2007

This Advisory Circular (AC No: AC 150/5200-37)

http://www.faa.gov/airports_airtraffic/airports/resources/advisory_circulars/media/150-5200-37/150_5200_37.pdf