eMerge

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Executive Summary

The clear, concise, correct, and timely transfer of information between entities involved in an emergency response is vital to the outcome of the situation. Important information lost during the communication process, or worse, never communicated at all, has the potential to negatively impact the situation. With so much at stake, it is critical to provide a means of uninterrupted information exchange, and ensure vital items are accomplished and communicated during an emergency response.

Our team devised the eMerge system as a means of improving communication, oversight, and situation awareness during emergency response. Interaction with subject matter experts enhanced the team's understanding of the complexities of an emergency response and related communication difficulties. The primary goal of the system is to provide an efficient and effective platform for information exchange while eliminating possible pitfalls associated with traditional radio communication. Once our team generated the initial concept for eMerge, we developed the concept for the physical system and infrastructure to support our idea.

eMerge displays emergency response tasks in a checklist format on portable digital devices. A centrally located status screen gathers pertinent information from the portable devices and makes this information available to personnel directing the emergency response. As our team routinely reviewed device usability throughout the design process, the system interface and supporting system infrastructure were subject to numerous iterations and improvements. Efficient information transfer is accomplished without having to rely on a verbal system that might be congested when it is needed most.

The design behind eMerge is highly adaptable and can cater to airports of different sizes. As a general system, it is not limited to use in the aviation industry and could easily be adapted for use in different domains.

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List of Acronyms

3G	Third Generation Mobile Telecommunications
AC	Advisory Circular
AirOps	Airfield Operations
AEP	Airport Emergency Plan
AIP	Airport Improvement Plan
ARFF	Aircraft Rescue and Firefighting
ATC	Air Traffic Control
CSS	Central Status Screen
eMergeD	Portable eMerge Devices
EOC	Emergency Operations Center
ERAU	Embry-Riddle Aeronautical University
FAA	Federal Aviation Administration
GPS	Global Positioning System
IC	Incident Commander
IT	Information Technology
KDAB	Daytona Beach International Airport
LCD	Liquid Crystal Display
PIO	Public Information Officer
SME	Subject Matter Expert
SRM	Safety Risk Management
UHF	Ultra High Frequency
USD	United States Dollars

VPN	Virtual Private Network
VSL	Value of Statistical Life
Wi-Fi	Wireless Fidelity

Background and Problem Statement

According to the Texas Airport Emergency Plan (AEP) Guidelines and Template, an airport emergency is "any occasion or instance, natural or man-made, that warrants action to save lives and protects property and public health" (n.d., para. 2). Preparedness is integral to facilitating the timely and appropriate response to emergencies. The ultimate goal of an emergency response is to render necessary assistance and minimize further injury and damage to persons and property involved. Likewise, response-related resources enable quick, efficient, and effective emergency response, limiting the negative impact of these types of events, including liability and post-emergency issues.

Aircraft Rescue and Firefighting (ARFF) personnel respond to airport emergencies ranging from medical emergencies inside the terminal to aircraft emergencies on the airfield. These firefighters rely heavily on their knowledge, skills, and the skills of others to save lives during emergencies. This kind of operation requires extensive cooperation and communication between all parties involved. Firefighters try to save lives while airport operation personnel are working behind the scenes to coordinate various efforts ranging from media staging and Red Cross support to airport security initiatives and medical transport of injured personnel (Volusia County Fire Services, n.d.). None of this coordination would be possible without a sound and reliable communication system.

Most airport emergency personnel currently rely on ultra-high frequency (UHF) two-way radios and push-to-talk cellular devices to communicate (A. Millwater, Volusia County Fire Services Battalion Commander, personal communication, October 6, 2011). However, due to the volume of calls being made with such urgency, these devices are often rendered useless within a few minutes of the alert. The importance of time is reiterated on the Volusia County Fire Services (n.d.) web page:

> *"As the thin walled aluminum exterior of a large commercial aircraft burns so hot and quickly, all lives on board can be lost in less than five minutes making immediacy of response critical."*

Due to radio congestion during an emergency, many needs cannot be communicated until well after the event. These lost or delayed communications would greatly enhance the situation awareness of personnel on the scene and in an Emergency Operations Center (EOC). For example, if the Airport Manager needs to verify the location of personnel, he/she should be able to do this without wasting precious time waiting for a silent moment to speak on the radio (A. Millwater, Volusia County Fire Services Battalion Commander, personal communication, October 6, 2011). The eMerge system allows this information to be updated in real time.

The eMerge system is a simple wireless communication system that can be customized to an AEP. The AEP is a document developed by every airport which, among other things, "assigns responsibility to organizations and individuals for carrying out specific actions at projected times and places in responding to an emergency" (Federal Aviation Administration [FAA], 2009, p. 6). There are many types of airport emergencies that an AEP addresses, including terrorism, natural disasters, and accidents and incidents. For the purpose of this project, our solution focuses on accidents and incidents, but the eMerge system could be modified to incorporate other types of emergencies. According to the FAA Advisory Circular (AC) 150/5200-31C (2009), which provides recommendations for airport emergency plans, accidents and incidents are emergencies that involve aircraft. An incident is any event that involves an aircraft and affects safety. An accident is a type of incident that results in serious injury or death of a person or persons.

However, for the purpose of this paper the terms accident and incident will be used interchangeably.

eMerge consists of a Central Status Screen (CSS) which would be located in the EOC (or other secure airport location) and is the heart of the eMerge system. The eMerge CSS displays the statuses and locations of eMerge devices (eMergeDs), portable tablets carried by personnel involved in emergency handling. This aims at increasing situation awareness of leadership personnel assigned to the EOC during an emergency. Each eMergeD defaults to an AEP checklist, which lists user responsibilities specific to each individual's assigned device. These responsibilities are uploaded to the eMerge system in a checklist format so users can check off tasks as they are completed and post updates as necessary for everyone to see. This allows management to check the status of all tasks by simply looking at a particular user's eMergeD checklist progress on the CSS, instead of tying up radio lines to ask for their status. Additionally, individual users can access other users' checklists to see which of their assigned tasks have been completed.

The eMerge system's primary goal is to increase situation awareness of emergency management plan execution and improve team communications and coordination. The device will ensure that all users have shared situation understanding without the potential misunderstandings and inefficiencies often associated with the current methods of communication. This system is not designed to be used in place of the current methods but is designed to be used in addition to them in an effort to increase overall efficiency. The inherent flexibility of the eMerge system ensures applicability to all airport emergency situations and keeps all involved personnel informed of the situation.

Summary of Literature Review

In the research and development phase of this effort, it was important to understand how aircraft emergencies are handled. The central document that the eMerge design group consulted was the FAA Advisory Circular No. 150/5200-31C (2009), which provided necessary details about airport emergency handling. Through this document and interactions with subject matter experts (SMEs), the eMerge design group learned that it takes a multitude of different agencies and personnel to help with the emergency rescue, handling, investigation, and clean-up efforts.

The UHF radios used during airport emergencies can quickly become congested. Literature regarding communication during emergencies indicated that this problem is not solely present in the aviation industry. A medical handout states that when multiple people talk at once during an emergency, the potential for errors during a time sensitive period is increased (Chase, n.d.). This is the specific problem associated with the current communication methods utilized during emergency situations. Everyone is aware of important information that needs to be transmitted to other personnel which results in limited or no access to radio communications. This limitation leads to increased potential for miscommunications, all of which can contribute to errors in addition to inefficiencies.

Haynes, Schafer, and Carroll (2007) suggest that the key issue with emergency responder communication is information sharing. Efficient information exchange is necessary to ensure good situation awareness and a shared mental model between team members. Shared mental models allow a team to better coordinate and make more efficient and accurate decisions (Salas & Fiore, 2004). Maintaining a shared mental model and good situation awareness is especially challenging during emergency situations, which are often chaotic and confusing.

While researching benefits of checklists during emergency handling, literature about checklist usage benefits in the healthcare domain (Winters et al., 2009) was reviewed. This information indicated that the eMerge system could be beneficial to emergency handling beyond applications in the aviation industry.

While review of the relevant literature proved to be very beneficial, the design process would not have been possible without the interactions with SMEs.

Interactions with Industry Experts and Airport Operators

"One of the costliest mistakes in software development is to develop software that is ultimately rejected by the customer" (McConnell, 1996, p. 237). This statement is true not only for software development, but for the development of any system. For our team, stakeholder involvement for requirements-gathering was considered an integral part of the design process.

Throughout the design phase we consulted various industry experts and airport operators. The initial concept of focusing on communications, particularly in emergency situations, was heavily influenced by our interactions with these SMEs. In an early discussion session with airport operators of the Daytona Beach International Airport (KDAB), Stephen Cooke, the Daytona Beach airport director, revealed that one of the critical focal points of airport operations is effective and efficient communication between airport entities, whether during planned events such as airshows, or during unexpected emergencies (personal communication, September 15, 2011).

In a follow-up meeting with Stephen Cooke and John M. Murray, the operations supervisor of the Daytona Beach airport, we were provided with an overview as to how emergency response is conducted and the different agencies that are involved. Initially we wanted to concentrate on improving rescue and firefighting response. However, we learned that more agencies are involved in an incident than we previously had thought. Some of them, depending on the severity of the incident, include ARFF, Airfield Operations (AirOps), local police, maintenance personnel, airline representatives, and Air Traffic Control (ATC) (S. Cooke, personal communication, 29 September, 2011). Talking to John M. Murray, it also seemed that one of our initial ideas of facilitating local county emergency response by providing a global positioning system (GPS)-based aid to improve coordination with local county emergency responders was, in part, already implemented (personal communication, 29 September, 2011).

Brainstorming Ideas with Subject Matter Experts

Initial communications with airport personnel led our team to brainstorm with the airport operators and broaden our knowledge about emergency response and possible design improvements. We committed to the idea that we now call eMerge. In order to maximize the usability, effectiveness, and efficiency of our project, we scheduled a meeting with stakeholders and potential users of the device. The Volusia County Fire Services Battalion Commander, Andrew Millwater, as well as Stephen Cook, gave us the opportunity to present our eMerge design. Both attested that this design could be very helpful in maximizing the efficiency of communications during airport emergencies while minimizing radio chatter (personal communication, October 06, 2011), and thus, eMerge was born.

Refining the Idea

On a subsequent visit to the KDAB ARFF station we presented our idea to the airport firefighters. Although not every firefighter will be outfitted with an eMergeD, we considered it important to receive their input. The reactions to our design project were very positive. During this tour, we were given a chance to ride in an ARFF truck and explore the firefighters' workspace. At the end of the visit, we consulted again with John M. Murray to help us identify the key leads who could benefit from being equipped with an eMergeD at KDAB.

In order to research the technical feasibility of eMerge, we met with Tony Russell, an Information Technology (IT) Support specialist at Embry-Riddle Aeronautical University (ERAU). Originally, our group considered using a Wireless Fidelity (Wi-Fi) connection between the eMerge tablets and the command center. However, once we spoke to Tony it was apparent that the Wi-Fi idea would not work. Wi-Fi cannot provide enough range for our system to be usable throughout the whole airport (T. Russell, personal communication, November 15, 2011). Thus, we determined that eMerge would have to operate on a 3G network.

A key industry expert we consulted throughout the design phase was Martin Lauth, an assistant professor at ERAU and a retired air traffic controller. Early in the project work, he presented us with an overview on the types of emergencies and the different alert levels associated with them. He also briefed us on ATC's role during an emergency and the resulting ATC responsibilities, such as stopping arrivals to the airport during emergencies and possibly the diversion of aircraft to other airports, depending on the severity of the accident.

Since ATC is usually the first entity to receive important details from the pilot during an emergency pertaining to the aircraft, Professor Lauth suggested implementing a way for ATC to input this information into the eMerge system so that it could be spread to the entities that require those details. This information would include, but is not limited to, the type of aircraft, amount of fuel on board, number of souls on board, and the nature of the emergency (personal communication, November 17, 2011). Being able to add this information and disperse it to key leads with a touch of a button would help decrease radio chatter.

All of the suggestions that we received during our interactions with subject matter experts were implemented into the final design to provide the system's stakeholders with a satisfying product which will fully encompass their needs and enhance emergency handling.

Stakeholder Analysis

The stakeholders in a system are those individuals who are investing and/or gaining from the system either directly or indirectly. As with most systems, eMerge has a number of stakeholders; this analysis identifies the stakeholders who will be directly using the system and those who will be affected by the system. First, the FAA would need to authorize airport implementation of the eMerge system, since safety is the FAA's number one priority. Because its design offers the users a more versatile mode of communication, the eMerge system is capable of delivering the safety the FAA strives to provide. A safety risk management analysis was conducted to help assure this high level of safety and is described in a later section of this report.

The next set of stakeholders is the users of the system. In the case of KDAB, those users are: the Incident Commander (IC), ARFF, the County Sheriff's Department, AirOps, Maintenance, ATC, and the Public Information Officer (PIO). These users will have direct contact with the system, whether it is through the CSS or an eMergeD. The users responsible for responding to and handling the emergency want to do this quickly and efficiently. Therefore, pertinent information should be available immediately to help ensure they perform their functions as efficiently as possible.

Airport IT personnel are also stakeholders. They are responsible for system maintenance and upkeep, and for ensuring that the system is running properly. For ease of upkeep, the system is designed to be installed and maintained without difficulty. In addition, airline passengers are also stakeholders in this system. Ultimately, this system indirectly serves the passengers. In an emergency, every minute counts. The need for successful and efficient communication of important information during an emergency response is crucial to saving lives.

The majority of the stakeholders the eMerge design group communicated with were airport operations personnel. We were able to present our ideas to these SMEs; in turn, they were able to offer us their insight and feedback. This feedback enabled us to make comprehensive changes to the system in order to better accommodate their needs and also provided the foundation for the system's requirements.

High-Level Requirements Analysis

The SME requirements listed in Table 1 were high-level requirements derived over the course of two meetings with Andrew Millwater and John Murray that laid the foundation for the design. The specifications in Table 1 represent functions compiled to ensure high-level requirements were met.

Table 1. *High-Level SME Requirements and Specifications*

SME Requirements	Specifications
Reduces Radio Congestion	Allows communication without using radios Reduces delay in information distribution Reduces redundant questioning Does not replace current AEP (paper document)
Highly Adaptable	Management can input and modify AEP checklist Current airport diagram uploaded Management chooses user capabilities "Incomplete/In-progress/Complete" formatting of all AEP checklists Messaging option available eMergeD automatically synced with CSS (i.e. changes to charts)
Wireless	eMergeD receives signal on and around airfield Tracks live position location of assigned eMergeD
Durable	Withstands elements (i.e. cold, rain, shock, heat) Battery life must be at least five hours
User-friendly	Display is easy to read Work-centered layout and user interface Features touchscreen or other easy-to-use interface

The SME requirements were broken down and used as the basis for the *System Design Requirements*, as shown in Table 2. This table includes a *Specifications Breakdown* column, which translates SME specifications into measurable functions, ensuring that the initial SME requirements are met with measurable results.

Table 2. *High-Level System Design Requirements and Specifications Breakdown*

System Design Requirements	**Specifications Breakdown**
Reduces redundant radio calls and communication of information which is not time-critical	EOC can view team leader checklists on CSS EOC can view location of eMergeD on CSS eMergeD users can view checklist eMergeD users can mark "Incomplete/In-progress/Complete" eMergeD users can view all other user checklists User training developed to ensure ease of use Provides supplemental checklist format of AEP
System can be tailored to individual airports	AEP is modified through CSS software Memory size adequate to support large AEP Airport diagram synced automatically with FAA diagrams User rights assigned by management in CSS When set-up, all checklist questions default to "Incomplete/In-progress/Complete" answer, but can be changed to drop down list or other checklist answer options Messaging function available Checklist answer options can be manually changed once AEP is in eMerge CSS updates are automatically synced with all eMergeD
Wireless	eMerge CSS has wired high speed internet connection which provides wireless link to all user tablets eMergeD use existing 3G network to connect to CSS-Verizon or AT&T eMergeD have GPS locator and transmit location to CSS
Durable in extreme environments	eMergeD tested for use in 0 degrees Fahrenheit eMergeD tested for use in 120 degrees Fahrenheit eMergeD are water resistant (tablets are sealed in a water tight case) eMergeD are shock resistant (tested to a fall of 12ft. or average height of a fire truck) Unit can remain on and in transmit/receive mode for an average of 6 hours
User-friendly	Screen layout is organized and simple eMergeD provides a high-resolution interface eMergeD provides high-fidelity color eMergeD has a responsive touchscreen eMergeD is lightweight and easy to carry around

In order to provide the best possible user-experience and requirements implementation, the appropriate hardware needed to be chosen carefully. Especially selection of the correct hardware for the eMergeD was considered to be crucial.

Review of Relevant Technology

The following is a review of relevant technologies that are identified as potential options for our system design. The top three rated tablet devices were chosen for clarity of display, usability, and ease of integration, connectivity, weight and durability. These factors would be critical to ensure reliability and user acceptance.

iPad 2

The iPad 2 is the highest rated tablet device and the first choice for the eMerge design group. It consistently ranked highest on consumer ratings for user friendliness and reliability. Several design factors were taken into consideration. A review in PC World Magazine states that "the tablet weighs 1.33 pounds" (Perenson, 2011, March 9). We do not want weight to impede the progress of commanding the incident. Additionally, the iPad 2 comes with a 3G radio and wireless adaptation installed, satisfying the requirements for a device that can integrate into our VPN. The iPad 2 is very touch-sensitive and allows easy manipulation of the screen (Perenson, 2011, March 9).

Motorola Xoom

The Motorola Xoom was the second candidate to be the flagship device for the eMerge product. "Built with durability and ease of use in mind" (Perenson, 2011, February 23), the Motorola Xoom comes with the wireless and mobile capabilities necessary for communication. However, there are some issues that may cause the Xoom to be eliminated as an option. According to Melissa Perenson of PC World Magazine, the Xoom compared to the iPad tends to fall short in screen resolution and color (Perenson, 2011, February 23). This is a problem, since the eMerge display design uses color-coding to make user operation more efficient.

Dell Latitude XT2

Unlike the iPad 2 and the Xoom, the Dell Latitude XT2 is significantly more expensive and bulkier than other tablets. It was chosen as one of the three top candidates because it is robust, yet relatively lightweight given the fact that it has a full-size keyboard and features a great multi-touch screen. The hardware keyboard is a unique feature, which would make sending messages more efficient but also adds to the dimensions and the weight of the unit. In addition, the Dell Latitude XT2 has a shorter battery life than the other alternatives (Gladstone, 2009). The bulkiness combined with high initial procurement costs and the relatively short battery life made the Dell Latitude XT2 the last choice for the eMerge system.

Ranking of Different Tablet Devices

The main goal of reviewing different devices was to identify the benefits and drawbacks of each candidate technology, essentially providing a measurable argument for the choice of technology to be incorporated into the eMerge system. Table 3 illustrates how each device was ranked against the requirements of eMerge using user friendliness, durability, and wireless integration as criteria. Rankings are in order from 1, being most suitable for the requirement, to 3, being least suitable. The eMerge design group chose the iPad 2 as the most suitable tablet device for the system, providing all the necessary functionality for the design.

Table 3. *Ranking of Tablet Devices*

System Design Requirements	iPad 2	Motorola Xoom	Dell Latitude XT2
Durability	2	3	1
Battery life	1	2	3
Weight	1	2	3
Display resolution and color-fidelity	1	3	2
Touchscreen responsiveness	1	3	2
Ease of integration	1	2	3

High-Level Design Description

eMerge will feature textual and graphical displays on wireless tablet devices that will be used as a source of status updates to help keep each major emergency team leader informed about progress of the emergency effort and locations of key team members. The eMerge system architecture and user interfaces were developed and refined over the course of numerous team brainstorming and design sessions during which we considered the literature review and experts' feedback described in prior sections of this report. These designs are described below.

eMerge Hardware Architecture

The hardware necessary for our product will include one large monitor, called the CSS, which displays information in the EOC. eMerge will also include several wireless touchscreen devices that can be given to the leaders of specific emergency teams in the field. Figure 1 provides a conceptual image of the information transfer and hierarchy between the CSS and the tablet devices.

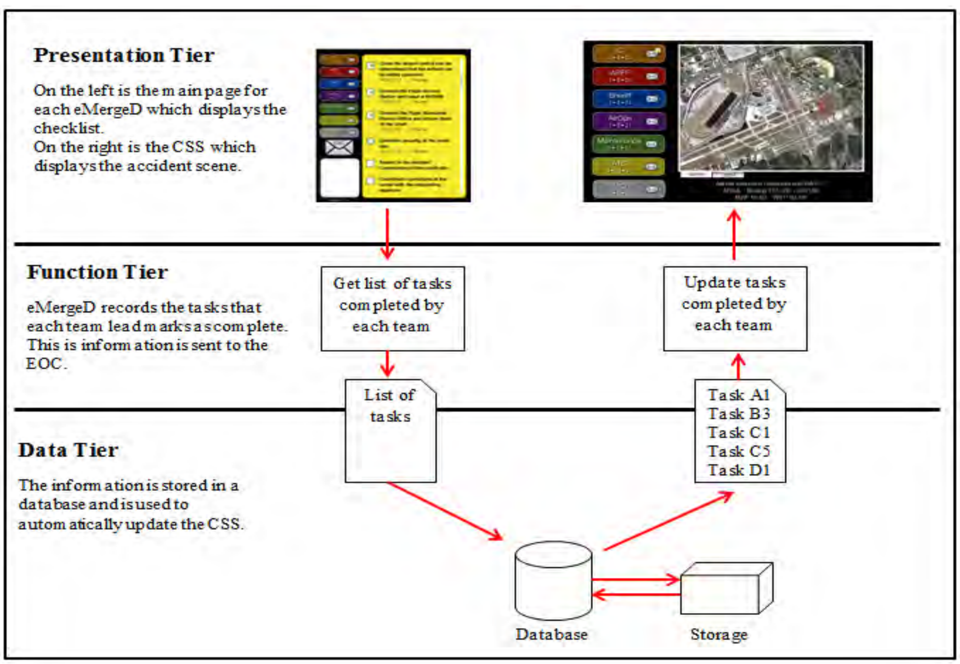

Figure 1. Information Transfer between the CSS and the Tablet Devices

eMerge Communication Architecture

In the EOC, the CSS will have a link to the eMergeD given to each team leader. The number and type of team leaders that receive eMergeD will vary with the size and resources of every airport. Each team leader is outlined in orange in Figure 2, showing which emergency leaders we recommend receive tablets at a midsized airport. These groups include maintenance, ARFF, the PIO, AirOps, and the local Sheriff's Department. In addition, the ATC tower receives a similar tablet device, which will allow ATC to update information about the aircraft involved in the incident. They record important information regarding the accident such as the number of souls on board, the nature of the emergency, and what time the emergency occurred.

The EOC will be able to message each leader and modify each checklist as needed during an emergency response. Each team will also have the capability to message the EOC via the wireless device. In addition, the local county dispatch, outlined in purple in Figure 2, will have a monitor that displays and updates the emergency information, but this display will be for informational purposes only and cannot be modified. The IC, outlined in yellow in Figure 2, will also have an eMergeD but his/hers will function like a portable CSS. This unique device will display, update, and edit the checklists and other information he/she receives.

Each team will have the ability to see the progress the other teams are making by viewing the teams' checklists. The EOC users and all leads have viewing privileges for all eMergeD checklists. However, modification privileges are limited. For example, users are capable of marking items only on their own emergency checklist.

Communication connections utilized in eMerge represent key emergency personnel and are depicted in Figure 2. Alternative suggestions for key emergency personnel can be found in the FAA Advisory Circular 150/5200-31C, which provides suggestions for developing AEPs.

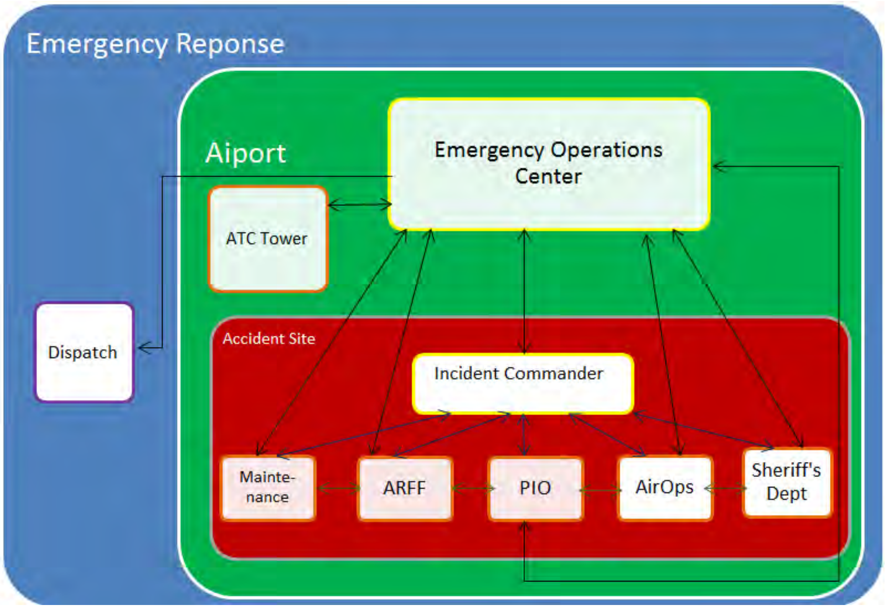

Figure 2. System User Interaction

Central Status Screen Interface Design

Figure 3 illustrates the eMerge CSS, which is located in the EOC in view of the airport operations emergency response staff. The screen should be mounted in a location where the EOC personnel can easily access it since it is a touchscreen display. There is also a keyboard connected to the CSS for typing functions.

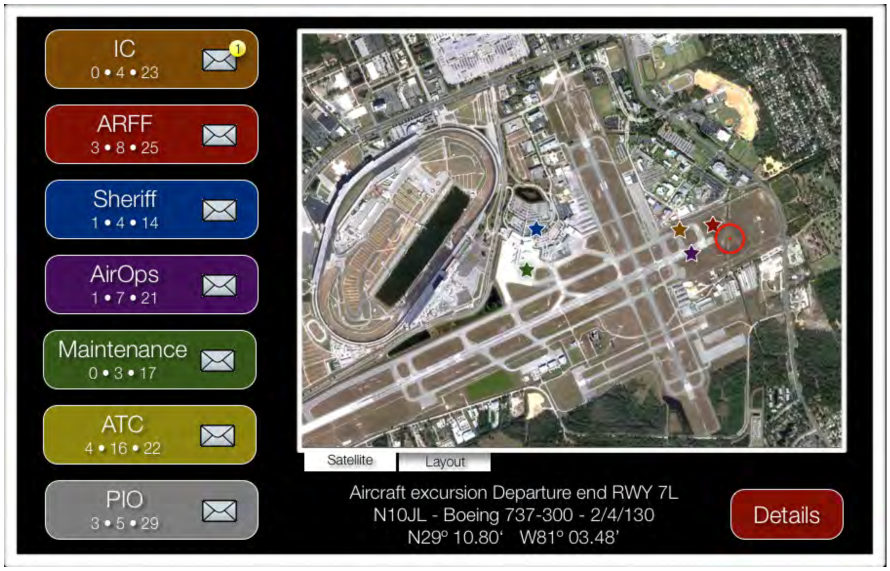

Figure 3. Central Status Screen

The home screen of the CSS displays a map of the airport, description of the incident, and a list of emergency response team leaders in possession of an eMergeD. The map is layered and can be viewed as a satellite image of the airport or an airport layout diagram. CSS users can zoom and pan the map.

The incident location on the airfield map is enclosed by a red circle surrounding the perimeter of the incident area and a red dot identifying the location of the incident. For example, if there is an aircraft crash, the outer circle would delineate the wreckage area and the dot would identify the location of the wreck itself.

The description of the incident located under the map includes the nature of the emergency, general location of the incident on the airfield, aircraft call sign, type of aircraft, number of souls on board (pilots/crew/passengers), and the latitude/longitude coordinates of the incident.

Team leader buttons are color-coded and correspond to the colored stars on the map that identify real-time locations of team leaders. On the bottom portion of each team leader button, there are three numbers: a running tally of checklist items in progress, a running tally of checklist items completed, and the total number of checklist items the team leader is responsible for accomplishing. By tapping on the message icon within each team leader's button, the EOC personnel can access awaiting messages.

Detailed information regarding the status of each individual lead's eMergeD checklist is also available for viewing on the CSS. For example, if the EOC user taps on the AirOps button, the map is replaced with a real-time view of the AirOps team leader's checklist. Refer to Figure 4 for an illustration of this mode of operation.

Figure 4. CSS Screen Checklist Viewing Mode

As the team leader completes checklist items they can be checked off accordingly. On both the CSS and eMergeD, a checkmark indicates the item has been completed. A circle indicates that the item is in progress. No mark indicates that the item has not been completed. As a precaution for inadvertently resetting the checklist item, when a lead taps on the white box, the device will ask the user if he is sure he wants to mark the item as incomplete. Below the checklist item, the EOC personnel can see a time stamp and the first initial and last name of the team leader responsible for marking the emergency checklist item as completed or in progress.

eMergeD Interface Design

Figure 5 provides an example of the interface of an eMergeD. This device provides team leaders with an electronic checklist of their responsibilities during an emergency situation. Each team leader must log into the device with a username and password.

Team leaders are typically higher ranking officers in an emergency service organization, such as ARFF or the County Sheriff's Department, and play a more administrative role on the scene of an emergency, therefore, they will not typically be wearing gloves. However, the eMergeD will come equipped with a stylus pen that the team leaders can use if they are wearing bulky gloves that make operating the eMergeD difficult.

Figure 5. eMergeD Interface Design

Interface Design Influences

When designing a system, the user should always be considered by conducting usability testing. In designing the system, the eMerge group wanted to focus on stakeholders' needs and wants. The proposed design was shown to SMEs as an informal usability test to determine if the system was feasible and if requirements specified by both the FAA System Safety Handbook (2000) and stakeholders had been properly incorporated. They were very satisfied with the proposal and believed that tools like eMerge would be integrated easily while improving communication and efficiency of the airport team as a whole in an emergency situation.

The eMerge group also considered display layout and control, data redundancy and discriminability, functional design, visual alerts, and input/output devices. To improve the layout of displays and control, the font size was increased for ease of visibility and the background was made black for contrast between buttons and other information.

Visual alerts effectively “invoke the necessary operator and maintainer response” (FAA, 2000, p. 4). Based upon information provided by our SMEs, our team leader tabs reflect the composition of a sample emergency response team for a midsized airport. Information access was improved by splitting a ‘satellite’ and ‘layout’ view of the airfield onto two different tabs, reducing clutter and organizing information in a practical and functional way. To help with visibility, an arrow pointing to the emergency location in the first iteration of the design was changed to a bulls-eye to give a better idea as to the perimeter of the accident.

Andrew Millwater, the Volusia County Fire Services Battalion Commander, suggested including a messaging option in case team leaders want to send information to another team leader. Additionally, as recommended by industry experts we included a time stamp, which displays information about who accomplished the task based on the personalized login. To differentiate team leaders locations, color coded stars, which match the color assigned to the team leader buttons, are shown on the map on the CSS. The eMerge design team approached all design considerations from a human-centered view in order to maximize usability and efficiency.

eMerge in Action

In interviews with airport and KDAB ARFF personnel, one of the most common issues identified by the user was the congestion of radio traffic over frequencies used during emergency operations. This limits the ability of firefighters, emergency medical personnel and management personnel to communicate time critical information to the appropriate persons. The following scenarios are designed for mid-size airports and will demonstrate how the eMerge system will benefit emergency response team communications, coordination, and situation awareness. The scenarios help explain the eMerge design and present additional features that might enhance the basic design described in the preceding sections.

Scenario: Monitoring ARFF Location

An aircraft with 125 passengers has crashed at the approach end of runway 7L at KDAB. According to FAA regulations, the ARFF units have 180 seconds to respond to the accident scene and begin combating the fire to protect the occupants as they exit from the wreckage. As ARFF rushes to the accident scene, eMerge continuously updates the ARFF location on the CSS so all personnel in the EOC are aware of the ARFF unit's location. Additionally, the first item in the ARFF AEP checklist states, "ARFF unit on scene" The system, being position aware, recognizes when the ARFF unit arrives on scene, and, in turn, the checklist item is automatically marked as complete, accompanied by a date and time stamp.

The eMerge system allows the IC, and any other person who must execute a checklist, to directly communicate to the EOC without using radio bandwidth, which should be reserved for time sensitive information. In this case, the team leaders and IC are no longer congesting radio frequencies because formal and non-time critical information are being transferred on a non-voice communication network and some communication tasks are even automated, as demonstrated in this scenario. Automating certain tasks will reduce the demand on limited attention resources available in stressful emergency situations.

Scenario: Managing System Errors

All systems have the potential to malfunction; therefore designs must support rapid detection of and recovery from errors. Can you imagine if, while in the middle of an accident scene, a team leader receives an ambiguous error message (i.e. 1340212:341JF Error: Unable to complete command)? If the device does not give enough information about the system malfunction that prompted the error message, the device is rendered unusable. The user ends up wasting time attempting to identify and troubleshoot the mystery problem while further hazards arise and critically aggravate the incident situation. This form of error coding is common in electronic devices and is generally followed by a puzzled look on the face of the user. eMerge attempts to avoid this confusion with a user-friendly system status messages let the user understand immediately the state of the system. This would mitigate the risk associated with a device malfunction during an emergency situation when pertinent information needs to be passed and commands given.

Real-World Impact

"The important thing to remember is that, while emergencies can seldom be exactly predicted, they can be anticipated and prepared for" (FAA, 2009, p. 1). In the AEP AC, the FAA (2009) emphasizes the importance of a strong emergency preparedness program that can assist in limiting the negative impacts of emergency events. eMerge will not only help improve communication, but also heighten situation awareness amongst all team leaders involved in an accident response. As such, it will provide an additional layer of capability during emergency response, increasing the efficiency of emergency handling.

Translating the tasks to be accomplished from the AEP into checklist format and updating the progress of individual checklist completion on the eMerge CSS also provides personnel in the EOC with means to crosscheck what is being done, what is in progress, and what still needs to be accomplished by the team leaders. The ability for a team leader to identify, check, and verify what he/she has done or still needs to accomplish can determine whether that person will succeed in the overall accomplishment of his/her specific task during the ongoing emergency (e.g., Winters et al., 2009). In particular, use of a checklist will ensure that important tasks are not skipped and everything is accomplished.

Growth potential

Due to the highly adaptable nature of eMerge, the system has significant growth potential. Checklists can be modified, extended, and tailored towards individual needs. Considering eMerge's infrastructure, additional eMergeDs can easily be added to the overall system. If new team leaders are identified and changes or additions made to an existing AEP, these changes can directly be applied to the eMerge system so that the system is capable of growing and adapting to the specific airport needs as they might vary over time.

Future growth potential also includes the fact that the functionality of the system can be expanded since its hardware components are not tailored for, and thus not limited to, the initial uses of eMerge. As such, the basic functionality can be enhanced via software changes beyond the capability of electronic checklists and messaging. In addition, data about tasks accomplished, including a time-stamp and a history of the physical position of the eMergeD, are electronically available. This data could be used to improve future emergency operations. One possible trend item could be how long it took for a certain checklist item to be accomplished which might, in turn, lead to focusing on ways to improve the performance of that item.

Commercialization potential

Every airport that is certified under the FAA Code of Federal Regulations Part 139 needs to maintain and abide by an AEP (FAA, 2009). With eMerge enhancing the usability of the AEP, there should be an interest in the system at various airports throughout the country. The system, in its basic functionality, provides the possibility for information exchange between a CSS and eMergeD and thus the possibility of monitoring checklist accomplishment from various eMergeD on a centralized system. Furthermore, the position of the eMergeD can be tracked and displayed, providing the potential to extend beyond emergency handling. For example, airlines could implement the usage of eMerge for their ground operations. eMerge could even extend far beyond the aviation industry with possible usage in disaster response or in the medical field.

According to Winters et al. (2009), checklists, being powerful tools to standardize work processes and help prevent the omission of steps in safety critical fields, have been used predominantly in the field of aviation but are relatively underused in medicine. Furthermore, Winters et al. state that checklists have tremendous potential to improve safety and quality and reduce the cost of health care. The use of checklists to ensure that all elements or actions are addressed is of particular importance in an intensive care unit setting (Winters et al., 2009). eMergeD could be used as checklists for individual doctors and nurses while the progress could be displayed on a CSS which is monitored by management, double-checking progress of the individuals in order to provide supervision and ensure completion of all pertinent tasks. In summary, commercialization potential of the device can extend far beyond the aviation industry. With such a broad scope and a zero tolerance for mistakes when it comes to emergency handling, risk assessment, and risk mitigation, which are vital to an effective emergency system.

Project Risk Management

During the course of this project, we made sure that we took steps to address possible risks that could prove detrimental to the success of the project. These risks included communication, planning, scheduling, and other similar issues. Each risk was given a priority, based on its likelihood of occurring and the impact it might have. We would then determine possible mitigation strategies to address these risks, starting with the most important; and, finally, choose which strategies seemed best. Due to space constraints, these risks and strategies are not presented in this report.

Safety Risk Management

According to the FAA (2007), Safety Risk Management (SRM) is a procedure used to identify, analyze, and treat risks.

There are five phases of SRM: describe the system, identify hazards, determine the risk, analyze the risk, and treat the risk (FAA, 2007). These phases are to be conducted in the order they are given. Phase 1, describe the system, has already been addressed in the High Level Design Description. Phases 2 through 5 are shown from left to right in Table 4.

In accordance with the FAA Safety Management System Manual (2004), each identified risk is assessed through determining the likelihood of occurrence and the severity of the risk. These assessed likelihoods are shown in parentheses in the *Risk Assessment* column in Table 4 and are used to determine the overall risk according to the predictive risk matrix in Figure 6.

Table 4. *Safety Risk Management*

Hazards (in order of priority)	Risks	Risk Assessment	Risk Mitigation Strategy
Overreliance on system	Systems become a crutch. Users don't know how to communicate efficiently during an emergency without the system.	High (Probable, Hazardous)	Train users how to act in an emergency with and without the aid of the system.
Team leaders are unfamiliar with system or similar technology	Older team leaders might not be as technologically savvy as younger generation and find the tablet's touch screen interface as confusing.	High (Probable, Hazardous)	Train team leaders on how to use the client device and client program.
Durability	Devices fall prey to being dropped (physical damage), scratched (illegible screen), or exposed to extreme weather (cold, heat, water damage).	High (Probable, Major)	Consider having backup devices. Periodically evaluate state of each device and consider repair/replacement. Consider investing in protective equipment for devices and/or training designed to instruct users on how to protect devices.
Storage failure in EOC	Loss of valuable data for post accident analyses (who did what, timestamps, etc.)	Medium (Extremely Remote, Hazardous)	Automated backup i.e. Cloud function
Client devices using outdated checklists	Outdated client devices will likely only be missing nonessential features, though it isn't impossible for it render it incompatible with the system.	Medium (Probable, Minor)	Update entire system at once. Consider option for automatic updates.
Device not charging properly	There have been reports of devices not charging properly, because older computers don't have enough power to support it.	Medium (Remote, Major)	Monitor/track the compatibility between client devices and technology used to charge them. If possible, consider implementation of charger compatibility in team leader vehicles.
Client device lost or stolen	Team leader unable to utilize system.	Medium (Remote Major)	Can use backup device (if available). Can resort to alternative method (radio communication with possible addition of paper backup).
Team leaders receive wrong client device/checklist	Team leaders are unable to modify their checklist and have the ability to change others' checklists.	Low (Extremely Improbable, Hazardous)	Team leaders must be signed in to determine proper checklist. Team leaders should be able to easily recognize something is wrong with their checklist, but additional training is still a possible consideration. Team leaders can sign out and sign back in. Can use backup device (if available). Can resort to alternative method (radio communication with possible addition of paper backup).
Failure of client device	Client program freezes, client device shuts down, etc., so team leader isn't able to utilize it.	Low (Extremely Remote, Major)	Workarounds such as rebooting client program. Can use backup device (if available). Can resort to alternative method (radio communication with possible addition of paper backup).
Total system failure/wireless network failure	All users are unable to utilize the system.	Low (Extremely Improbable, Major)	Resort to old method (radio communication with possible addition of paper backup).

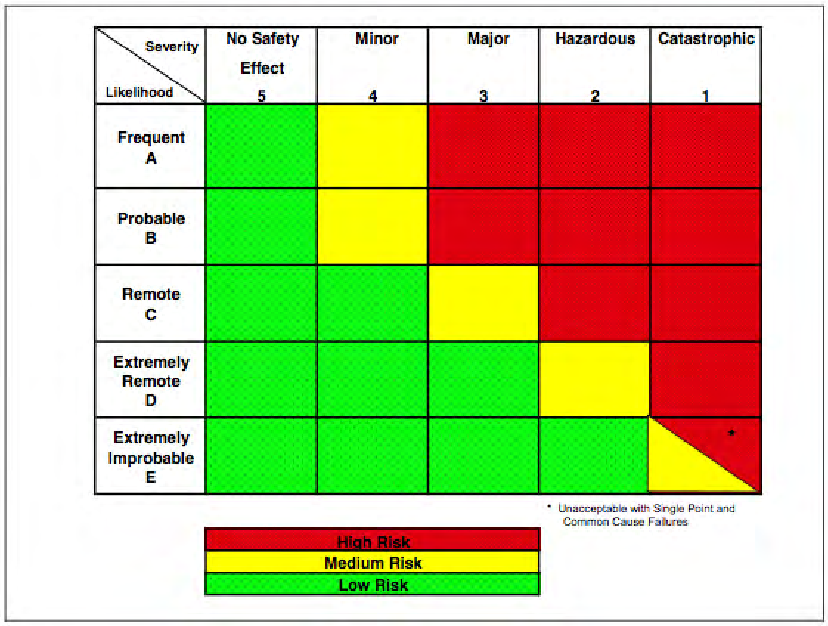

Figure 6. Predictive Risk Matrix. Adapted from "Federal Aviation Administration Safety Management System Manual" by Federal Aviation Administration, 2004, p. 46.

Implementation Plan

In order to implement eMerge at individual airports, airport personnel at a given airport must choose a smartboard model to purchase for installation as the CSS, in the EOC, as well as the number of tablets to purchase. These decisions require research on cost and which system configuration fits best for a particular airport. After the hardware has been selected, the software must be installed. The software installation process will involve the help of FAA developers so that the software complies with FAA regulations. Airport operators must ensure adequate 3G network coverage, so that weak signals do not hinder communication during an emergency response.

The determination to use a 3G device was made because it uses a Global System for Mobile Communications (GSM) satellite signal which ensures limited accessibility. Additionally we decided to establish a virtual private network (VPN) for communications. To provide these services, a business contract with a service provider will be made. The exact service provider will depend upon which one has a better coverage of the area around the airport and testing must take place to ensure the system is working properly.

Lastly, users must be trained in order to establish familiarity and promote confidence with system usage. During the training phase, users will be exposed to the benefits and limitations of eMerge. The training should be conducted prior to the airport's annual emergency drill, which will preserve the functionality of the system and expose any recurring and/or hidden problems that need to be rectified. In these drills, personnel will be equipped with two-way radio communication systems and backup measures (i.e., paper copies of checklists), in case of eMerge system failure. After an emergency exercise incorporating the eMerge system has been conducted, training sessions will be carried out on a regular basis to reemphasize familiarity and confidence in using the system. The system should take no more than six months to implement from the decision making steps to the first emergency exercise.

eMerge was designed to be user-friendly, affordable, and inexpensive to maintain. The flexibility of its design means that unforeseen changes (e.g., new additions to airport layout after construction) would not be costly in terms of money or time. Factors affecting cost are described in the cost-benefit analysis section that follows.

Cost-Benefit Analysis

In order to better assess both the utility and affordability of the eMerge system a cost-benefit analysis was performed, which identified costs and benefits associated with system implementation, operation, maintenance, training, and other life-cycle considerations. Both quantitative and qualitative factors were taken into account when performing this analysis.

This cost-benefit analysis is broken down into three major sections. First, hard costs associated with the commercial potential of eMerge are addressed. This section includes a description of costs required to bring the design to the working product state, with emphasis on system affordability and utility. Second, benefits associated with using the system are discussed. Since the design is conceptual in nature, theoretical benefits are discussed using a realistic approach as to how the design meets airport and FAA goals. Third, a potential strategy to mitigate costs associated with implementing eMerge is discussed.

eMerge Costs

The eMerge system is an innovative application for improving airport operations and maintenance. Thus, costs associated with implementing eMerge fall primarily on the airport owners and operators. Table 5 lists costs an airport should take into consideration when assessing the economic feasibility of purchasing the eMerge system. Estimates are derived from current industry standards and explained below. Calculated costs are for system acquisition at a mid-sized airport, such as KDAB. As indicated in Table 5, these costs can be subcategorized as initial hard costs or recurring soft costs. Initial hard costs can be further subdivided into hardware component costs and software component costs.

Table 5. *Mid-Sized Airport Implementation Costs*

	Cost per Unit (USD)	Total Cost (USD)	
Initial Hard Costs			
eMerge Hardware Components			9,232.00
eMergeD Device		*4,753.00*	
16GB 3G Wi-Fi iPad 2	629.00	4,403.00	
Hard Shell Waterproof Case	50.00	350.00	
Central Status Screen (CSS) and Server		*4,479.00*	
LCD 42" TouchScreen Display	2,599.00	2,599.00	
Mac mini 2.3GHz 500GB	599.00	1,198.00	
Keyboard	30.00	30.00	
Mouse	15.00	15.00	
Drobo 4-bay Storage Array	279.00	279.00	
1TB Hard Drive	149.00	298.00	
APC Battery Backup	60.00	60.00	
eMerge Software Components		2,140.00	2,140.00
application for eMergeD devices	20.00 ea	140.00	
software for CSS and server		2,000.00	
Installation		1,000.00	1,000.00
Total Initial Hard Costs			**12,372.00**
Recurring Soft Costs (Annual)			
AT&T 250MB Mobile Broadband Plan	14.99/mo	179.88	
Software Maintenance/Training		39,787.00	
Hardware Maintenance		2,000.00	
Harware Replacement		950.60	
Total Recurring Annual Soft Costs			**42,917.48**

Initial Hard Costs

Hardware component costs include the costs for eMergeDs and the CSS. Each team leader will be assigned individual eMergeD with a hard shell waterproof case. In the case of KDAB, there are seven team leaders who would require an eMergeD. The EOC is outfitted with a touchscreen display and necessary hardware. Note the requirement for system redundancy is taken into consideration with the inclusion of an extra computer, mirrored data storage array, and battery backup.

Software component costs include the cost of the application for eMergeD and the software for the CSS and server. In calculating these software component costs for the airport, the eMerge design group needed to consider the costs involved in developing necessary system software.

Digital checklist software is not a novel concept. What the eMerge design group is proposing entails harnessing existing technology and applying it to a new domain. The medical field is an excellent example of an industry that has embraced mobile technology, adopting the use of electronic surgical safety checklists in operating rooms. Furthermore, software has been developed that commissions the use of these digital checklists on devices such as the Apple iPad, iPhone, and iPod Touch. Therefore, the design group's assumption is that modeling our software and application after existing commercial off-the-shelf software renders it less cost prohibitive and will reduce the expenses associated with developing and debugging the eMerge software and system.

The typical cost of designing, implementing, and deploying an application for a device such as the iPad can range between $30,000 and $45,000 (Maxwell, 2011). The eMerge design groups strategic business plan entails absorbing these costs initially and ultimately recouping them by capitalizing on the competitive product sales of the system. Thus, the costs to the airport will depend on the size of the purchase order and complexity of software desired by the customer. Purchase costs for the CSS, server software, and device application for an airport the size of KDAB are calculated at $2000.00 and $140.00, respectively.

Installation costs for the eMerge hardware should be negligible. The hardware requires standard electric supply and commercial grade outlets and data ports. The airport's EOC should already be equipped with the facilities needed to accommodate the eMerge system hardware and server; installation should not obligate on-site infrastructure changes.

Recurring Soft Costs

Recurring costs for implementation of the eMerge system include costs associated with operation, maintenance, and training.

Wireless mobile broadband Internet service must be supplied by a company that offers 3G mobile telecommunications with secure VPN. Service provider costs will vary depending upon which mobile carrier provides the best coverage in the airport location. The amount of data transfer is negligible, so the lowest (250MB) 3G wireless data plan will suffice. The cost in Table 5 is for a personal plan, however, it is more likely that the airport has a business contract with the carrier and adding devices that utilize the service will not raise existing costs. In general, line items such as broadband service and electricity bills are considered negligible since they are likely already incurred in airport expenditures.

Perhaps the biggest cost associated with the eMerge system is the labor associated with tailoring the software to meet the AEP requirements, updating the software as necessary, and continuously training the users such that they can make the system work to their maximum advantage. The CSS and eMergeDs are designed to be user-friendly and should not require in-depth training. However, the airport operators must know how to effectively utilize and maintain the system software. Typically, the IT department would be best equipped to handle this task.

While the airport would not be required to hire a full-time employee for this task, it would be in their best interest to budget an equivalent cost associated with the aforementioned tasks. The median expected salary for a typical Applications Systems Specialist in Daytona Beach is $39,787 (Schweitzer, n.d.).

Because this system employs modern technology that is low-maintenance and requires minimal investment to keep it running smoothly, the cost of hardware maintenance is anticipated to be low. However, the airport should consider annual replacement costs (at a 20% replacement rate) for the eMergeD, in the event that a device is mishandled, broken, or lost during an emergency. Similarly, the costs associated with continuously operating the eMerge system should not be high. With the exception of software maintenance, the system does not require additional staff or facilities.

In general, costs must be adjusted for other airports, depending on factors such as the number of team leaders requiring the portable eMergeD, available broadband service, etc. An attractive feature of the eMerge system is that the purchase package can be modified to fit the user's needs. For example, the number of eMergeD can be adjusted according to airport size and demand and the software package can be tailored to any airport's AEP.

eMerge Benefits

Optimizing efforts associated with the eMerge system requires balancing the cost of implementation against the economic benefits derived from its use. Unfortunately, it is difficult to place a monetary value on the benefits reaped by using the eMerge system. The theoretical benefits of using eMerge system are not necessarily tangible and therefore difficult to quantify.

One way to approach the dilemma of intangible benefits is to calculate mitigation costs by assigning a value to lost lives and damaged property. Revised Department of Transportation guidance defines the Value of a Statistical Life (VSL) as the value of improvements in safety that result in a reduction by one in the expected number of fatalities. The FAA estimates the VSL at $5.8 million, the cost of serious injuries at $333,500, the price of a totaled general aircraft at $172,084, and the price of a substantially damaged aircraft at $35,000 (FAA, 2008; GRA

Incorporated, 2007). Note that these figures do not account for supplementary costs associated with airport emergencies, such as accident clean-up, passenger delays, or internal investigations. The team is not claiming that the eMerge system is directly capable of saving a human life or property. However, the contribution eMerge makes to the overall safety and coordination involved in an airport accident argues in favor of a return on this investment.

Cost-Mitigation Strategy

The Airport Improvement Plan (AIP) provides grants to public agencies for the development of public-use airports that are included in the National Plan of Integrated Airport System. One type of project eligible for funding involves improvements related to enhancing airport safety, capacity, security, and environmental concerns (FAA, 2005). It can be argued that the implementation of the eMerge system would qualify as an approved grant project.

The FAA also stipulates that aviation demand at the airport must justify the projects. KDAB is a public county-owned airport. For a 12-month period ending April 30, 2010, the airport averaged 796 aircraft operations per day (“Daytona Beach”, 2011). For large and medium primary hub airports, the grant covers 75 percent of eligible costs. Professional services related to the planning and design of the projects are eligible for funding; however, operational costs are not.

The above cost discussion already illustrates how minimal the costs are associated with implementing the eMerge system. If an airport qualifies for funding under the FAA’s AIP, costs would be reduced that much more. In the case of KDAB, for example, the grant would cover 75% of all costs, with the exception of operational costs. In the process of applying for the grant, operational costs would have to be clearly defined and removed from the equation. Nevertheless, KDAB, for example, potentially qualifies to save up to 75% of costs through an AIP grant, reducing the bottom-line cost for eMerge system implementation from $55,289.48 to $23,101.37.

Summary

Emergencies are relatively rare events. Even for well-trained response teams, emergencies are chaotic, albeit controlled, situations that demand people to function at a high cognitive level. The eMerge system proposes implementing a technology that reduces radio chatter not necessarily relevant or time-critical to individually assigned jobs. Moreover, real-time and accurate transfer of pertinent information enhances situation awareness and provides a platform for a common mental model among emergency response team entities. This type of integrated technology allows for efficient sharing of information, collaborative decision-making, and coordination across responding individuals, teams, and agencies. It enhances individual and group potential to respond to the emergency in an organized and comprehensive manner. Any technology that supports coordination and streamlines communication during an emergency enhances team member performance, ultimately benefiting the organization as a whole. Additionally, because the eMerge system can be utilized as a fundamental resource for supporting an emergency response in ways that yield the maximum benefit at a low cost, any airport genuinely interested in enhancing overall operations, particularly in the event of an emergency, can justify the expense of the eMerge system.

Appendix A

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Appendix B

University Description

At Embry-Riddle Aeronautical University, what we do – and do best – is teach the science, practice, and business of the world of aviation and aerospace.

Since it was founded just 22 years after the Wright brothers' first flight, the University and its graduates have built an enviable record of achievement in every aspect of aviation and aerospace. The curriculum at Embry-Riddle covers the operation, engineering, research, manufacturing, marketing, and management of modern aircraft and the systems that support them. The university engages in extensive research and consulting that address the unique needs of aviation, aerospace, and related industries.

Residential campuses in Daytona Beach, Florida, and Prescott, Arizona, provide education in a traditional setting, while Embry-Riddle Worldwide provides instruction through more than 130 campuses in the United States, Europe, Canada, and the Middle East, and through online learning. All academic programs at Embry-Riddle are approved for veteran's educational benefits and are accompanied by personalized academic advancement.

ERAU prides itself for the diverse education its students receive. Academics at ERAU include aviation operations, meteorology, human factors psychology, systems engineering, software engineering, humanities, international relations, communication, mathematics, aerospace engineering, physics, business, and much more. The university community is additionally proud of the quality of the education obtained. Class size at both the Daytona Beach and Prescott, AZ campuses averages 24 students and the overall undergraduate student-faculty ratio at these campuses is 16 to 1. Low class sizes make possible the use of interactive and authentic approaches to learning, such as project-based learning approaches.

The university values community diversity and actively encourages diversity by means of programs aimed to support and provide education about minority groups, including ethnic minorities, gender-identity minorities, religious minorities, students with handicaps, and so forth. The ERAU Office of Diversity Initiatives was created by the current ERAU President, Dr. John P. Johnson, to help build a positive climate in which all students, faculty and employees are encouraged in their professional, social, and intellectual pursuits. Among its many efforts, the ERAU Office of Diversity Initiatives is involved in community outreach programs designed to foster interest in science, technology, engineering, and math among women and underrepresented groups in the K- 12 educational system. Pilot projects include a GEMS (Girls Exploring Math and Science) Camp during summer months and the introduction of an aviation/aerospace program for all 6th graders at Campbell Middle School in Daytona Beach. Both ERAU campuses participate in the Ronald McNair Scholars Program, a program that seeks to increase the number of Ph.D. degrees obtained by students from underrepresented segments of society.

Appendix C

Description of Non-University Partners

Appendix E

Evaluation of Educational Experience

Martin Lauth and Kelly Neville, Team Advisors

The eMerge team worked hard and with earnestness but also managed to have a good time with this project. They were eager to identify a feasible idea that would be of value to the aviation community and in October, some team members started to become a bit anxious. Despite this anxiety, the team refused to skimp on the time or effort needed to come up with and define an idea. They steadfastly continued to research the literature, talk to aviation professionals, and brainstorm together until they arrived at a solution they felt could truly contribute to safety in aviation.

The eMerge team had an interesting mix of outspoken and introverted team members, something the team seemed to recognize and address fairly quickly. We were impressed with how proactive they were about taking steps to ensure this did not translate into a design effort that was dominated by a subset of the group. The team made a point of monitoring the balance of inputs during their meetings and ensuring that the more outspoken team members took breaks to ask the quiet team members to share their ideas and perspectives. The strategic treatment of this aspect of their teamwork is something we can recommend to our teams next year and is probably an idea that each eMerge team member will carry forward to benefit his or her future team efforts.

Interacting with aviation and engineering professionals was one of the highlights of this project. Not only did the eMerge team appreciate the assistance of these seasoned professionals; they were also quick to recognize the criticality of their interactions with them. Through their interactions, the students learned that successful engineering depends on frequent and rich interactions with a range of subject matter experts, future users, and other stakeholders.

It is rewarding to see how proud the eMerge team is of their product. A number of them have expressed interest in continuing to work on it beyond the competition’s end in order to see it through to fruition. Participation in this competition truly gave them a sense of pride and ownership in their work, and those who didn’t already now realize the valuable impact they are capable of having on aviation and beyond.

We have a difficulty imagining a project that could be better suited for preparing our students for careers involving research, problem solving, design, and engineering. The students learn to work as a team over an extended period of time, experience multiple phases of a project, and importantly, don’t just develop a solution that’s been handed to them. They must gain an understanding of the *problem space*—the problem, constraints and opportunities, resources, stakeholders, stakeholder concerns and priorities, and much more. Then, using all that information, they must figure out and ‘grow’ a solution over time.

We do not have any changes to suggest for future years. The project guidelines do not impose specific constraints or requirements and this is a great beauty of the competition. The competition guidelines allow teams a wide range of options for approaching the project. The competition is well run and perceived as fair, resources are available, and questions are always answered quickly.

Yolanda Andrade
HFS500/Dr. Neville
Appendix E
08 December 2011

The FAA Design Competition provided a meaningful learning experience as to how important communication between emergency response and the airport operators is during an airport emergency.

One of the challenges that we encountered during the competition was making sure each team member's opinions and ideas were heard and taken into consideration. To overcome this challenge, we made sure to ask each member to voice their opinion after each idea was expressed. Another challenge we encountered was finding an idea that would provide a real world application and enhance overall safety. When our subjects matter experts emphasized the need for better communication during one of our meetings, we decided to focus on communications in maintenance and operations. Because radio chatter is a problem in communication among emergency response teams, our team came up with the idea of the eMerge system that will allow key leads to access and check off their checklists, reducing radio chatter. Participation by industry and airport experts throughout the project was useful because we were able to present them with our ideas and assess whether or not the ideas were already in use and if they would be beneficial to communication. This competition helped me learn to work better with people who have different undergraduate and work backgrounds. Working with others is a skill that will be beneficial when entering the workforce. In addition, I was also able to learn how to find what needs to be fixed in communication during airport emergencies and then be able to develop a system using inputs and requirements from different sources including our own ideas.

Ren Araujo
HFS500/Dr. Neville
Appendix E
08 December 2011

I consider the FAA Design Competition as one of the most significant projects I have ever worked on because it abundantly enriched my college experience. This competition has taught me lessons that will benefit me in the future. One challenge we faced at the beginning of our journey was that it was easy to feel down when an idea did not work out in our favor. The best and only thing to do is to toss the idea out the door and move on to bigger and better things and that is exactly what we did. Our process consisted of coming up with an idea, talking to SME's, and then improving or abandoning the idea. Sometimes after improving the idea, we ended up disposing the idea in the end. Our system was developed after many trials and errors and we could not have done it without the help of those who work in the industry. We all have strengths and weaknesses and even though we come from a variety of backgrounds, it was not enough to allow us develop a good system without the help of SME's. The feedback provided was informative and affected our system in a constructive way. One of the most important things I learned was the value of SME's. I reemphasize that their feedback was important to our system design. I also learned that the development process takes time and must be approached carefully. This project has shown me how to work with people from different educational backgrounds, which is important for when I enter the workforce. Another thing I will keep in mind when I go out into the real world is that there are no stupid ideas or questions. You cannot know if something will not work unless you try it.

Claas-Tido Boesser
HFS500/Dr. Neville
Appendix E
08 December 2011

The FAA design competition was both a challenge and a great learning experience. It is very rewarding being able to apply theory to real-world applications because in the end everything just seems to fall in place. What has been studied becomes more meaningful with practical application.

One of the challenges was to find an idea that not only fulfilled the requirements of the competition but something that people were passionate about and willing to invest time to achieve a great product. After-class meetings and late night phone calls over ideas and improvements showed that everybody was willing to contribute a lot of effort towards this project. I think giving our idea an inspiring name and laying out design graphics early, if only preliminary, helped to make the idea more tangible from the beginning.

Initially, our team brainstormed a lot to generate possible ideas. It was great to see that the group had a very diverse background with everybody actively participating from the very beginning. When we talked to subject matter experts, we were very open about the fact that we wanted honest inputs. If a design did not make sense overall we needed to know early before following a wrong path for too long. The subject matter experts' inputs really helped to shape our idea.

Subject matter experts' inputs were very useful. In the end, it will be the customer working with our product so we concentrated a lot of effort on compiling and integrating their inputs. This project would not have been possible without the help of all our industry and airport contributors.

Along the way we learned quite a lot. Not only about the aviation industry and systems design but also about working together as a team and I think we had a great time and can all say: The journey was the reward.

Jennifer Cabrera
HFS500/Dr. Neville
Appendix E
08 December 2011

The FAA Design Competition was certainly a meaningful learning experience for me. Initially, I was overwhelmed by the idea of generating a large document by piecing together the input of eight different individuals. In my experience, it is typically extremely difficult to create a shared mental map in groups consisting of more than two individuals. However, in this case, our team's group dynamic proved that it is possible to consider and incorporate multiple inputs in an effective manner.

One of the challenges we faced was ensuring the integration and synthesis of individual contributions while managing to meet external deadlines. In order to mitigate risks associated with this consideration, our team agreed to abide by internal deadlines and allot ourselves twice as much time as we thought necessary to meet these deadlines. We also learned as a team how to avoid pitfalls commonly associated with project management by anticipating these pitfalls and capitalizing on individual strengths to handle them in advance. Another challenge typically seen in group projects is an uneven distribution of effort. Because we allowed people to pick their individual responsibilities from the start, there was never a sense of being "stuck with" a certain task. Likewise, team members were extremely supportive of one another. If one person voiced difficulty approaching a task, other members immediately offered suggestions or their assistance.

Participation by industry experts was not only appropriate but key to the process of developing our design. Each group member had their strengths in terms of subject knowledge; however, the feedback of SMEs was imperative to identifying design considerations that lay outside the domain our personal experiences. Also, these SME's were able to bring our team members "into their world" (literally and figuratively), which provided us with a perspective that we would not have had otherwise.

This project allowed me to develop and enhance my skills and knowledge that will prove essential to my success in the workforce. More important than the design itself was the process of generating it. It was interesting to see how our design progressed over the semester and how this progression was a function of group dynamics and our ability to accommodate different personalities. The majority of our group was made up of "Type A" personalities. Under normal circumstances, I would have expected this to hinder our progress. Instead, we were able to make it work toward our advantage by adjusting our approach and strategy of attack to fit individual temperaments. We broke down the project tasks into smaller, bite-sized pieces and divvied them up among team members. When it came time to synthesize information, our team proved to be quite capable of using a single goal-directed approach to maintain our sense of focus and motivation.

Angela Cox
HFS500/Dr. Neville
Appendix E
08 December 2011

During the FAA design competition I discovered the complexities of building a system. Although our system is not terribly complicated or complex, it is a system. Throughout the process I had the opportunity to work with some great professionals in hope of making their jobs easier and more efficient. That experience was an opportunity of a life time to see a conceptual project go from start to finish. Although difficult, tedious and time consuming, I believe it was a learning experience that could not be approached any other way and it gave me a better appreciation for those in the systems field.

One of the first challenges that my team discussed at length was our topic. Because the competition gives students a great deal of options on where their focus can be, it allows each group member to bring their own experience and ideas to the table to direct group efforts. Additionally, I had never worked with seven people before to complete a project. Although the size of the group helped, because it allowed the project to be split between more people, it hindered the project at times. We ultimately decided in order for the project work, we would do everything as a team. This lead to some long group meetings and late nights, but in the end I believe the eMerge system was better off for it.

The eMerge system was designed based on an idea born out of a presentation on the first day of class. The professionals from KDAB gave us a general idea of how the airport runs. We took one statement of the whole presentation and began building our system on it. That statement, “communication is always a problem, especially during emergencies” became the foundation for our design and where we began focusing our efforts. Our initial idea was in the early stages and we contacted the KDAB personnel once again to make sure we were on the right track. Unfortunately and thankfully, we found out that that idea was already being implemented. Therefore, we discussed ideas to redirect our efforts, which lead us to the design of eMerge. Due to the dynamics of an emergency situation and to meet stakeholder requirements, we continued to verify system feasibility with airport personnel throughout the project to ensure success. This worked extremely well and allowed us to enhance the system in several ways.

Designing the eMerge system was an enlightening experience. I believe the knowledge and skills developed through the entire process will help me in future career efforts by giving me a different perspective of the design and development process. Additionally, being part of a design project like this, which could potentially help emergency personnel to be more efficient and effective in helping people in crisis situations, is a rewarding task.

Shannon Cummings
HFS500/Dr. Neville
Appendix E
08 December 2011

The FAA Design Competition offered a unique learning experience that helped me to learn more about airport operations and the various problems at airports. This experience also gave me an opportunity to work with real industry experts and get a chance to get real experience. When undertaking the competition, our team faced many challenges and obstacles. The biggest challenge was determining a topic. When we started our research we found that there were so many possible topics and problem areas, all of which seemed interesting. We finally picked a topic by talking to local airport officials and focusing on issues that directly affected the local airport and seemed unique and interesting. We developed and product and hypothesis by talking to the head of emergency operations at the Daytona Beach Airport. We gave him our ideas and allowed him to make suggestions. This allowed for our product to be more practical and helped us to realize issues that we could not have thought of due to lack of experience. The design competition gave me a different type of experience working on group projects. Because this project was not just for class, our team had to conform to unfamiliar rules and policies when completing the project. This taught me a lot about the project process and learning to work with new guidelines and styles.

Michael Fitzgerald
HFS500/Dr. Neville
Appendix E
08 December 2011

The FAA Design Competition provided a meaningful learning experience for me. This was by far the largest project I've ever worked on. My project group was the biggest and most diverse I had ever been a part of. This caused some issues, such as organization, decision making, and scheduling conflicts. However, we overcame these challenges and managed to produce what I believe to be a great project. We shared ideas freely, which could have proved problematic, seeing as how most of our group was outspoken, while one or two individuals were quieter in nature. However, some of the more outgoing members would make it a priority to periodically interject and ask the quieter members to share their thoughts, so that everyone could share their ideas. We would continue discussing until consensus was reached and would then act accordingly. I felt that the participation by industry experts was priceless, and something I wish I had access to in my past school projects. They were able to provide feedback that gave us some real-world insight into the problem that our proposed system would operate in. I learned a lot, both from my team mates and industry experts, ranging from design approaches to real world attitudes about change, as well simple tricks in Microsoft Word. Overall, this competition was a memorable experience and, I believe, greater prepared me for success in the rest of my schooling, as well as in the workforce.

Ben Graham
HFS500/Dr. Neville
Appendix E
08 December 2011

The FAA design competition provided a meaningful learning experience for me in that it allowed me to work with a team and not only learn about the system design process, but to experience it. Both positive and negative aspects of the design process helped me understand what to look for in future team environments in projects I may have in my further studies or in industry.

The challenges that were overcome by the team in undertaking the Competition are the same things that afflict most teams during a project. The main challenges we faced to maintain our goal of designing a system with a specific purpose and to not creep away from the requirements that we set forth at the beginning. This was discussed as a potential issue in the very beginning, and we constantly worked to mitigate digressions that would further complicate the design of the project.

The process used by our team to develop our hypothesis was the following. From presentations that we had observed in class, it was clear that communications during an incident or on airfield accident have always been a problem. Specific problems consistently noted by SMEs was the clutter of radio chatter of non-essential information, such as formal reports, would inhibit the ability of rescue and operations personal to convey pertinent information of the radio waves. It became clear to us that inventing a new device or procedure would not be the most viable solution, but instead to design a new system that would eliminate part of the radio chatter, namely the non-essential situation reports made by incident commanders and streamlining the information process. Through this thought process we arrived at our hypothesis.

Participation by industry professionals was meaningful, appropriate and most importantly extremely useful. The input we received from the Subject Matter Experts that we met with during our meetings inside and outside of class helped us refine our design, and many of our SMEs would be potential users of our system. This allowed us to constantly reevaluate our design strategy and mitigate any potential flaws in our design by conferring with industry experts. It also helped guide our design process in the direction of a highly problematic but very underrated issue within airport operations.

The greatest lesson learned during this project was to ensure constant reevaluation of a design or idea in order to make sure that the end result is as close to the goals set forth in the beginning of the design process. It was also a lesson in being flexible both in a team environment as well as the design environment. Some parts had to be removed and other additions had to be made, and the lesson learned here was that it was necessary to be flexible in order to allow for changes in requirements that may have arose during the design process. This helped me prepare for entry into the industry workforce because I understand what to expect in future projects I may be a part of in the industry.

Appendix F

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