Cover Page

Title of Design: Smartphone Application to Improve Response Procedures for Downed Aircraft

Design Challenge addressed: Management and Planning

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Federal Aviation Administration Design Competition for Universities
Airport Management and Planning Challenge:

Smartphone Application to Improve Response Procedures for Downed Aircraft

BINGHAMTON UNIVERSITY
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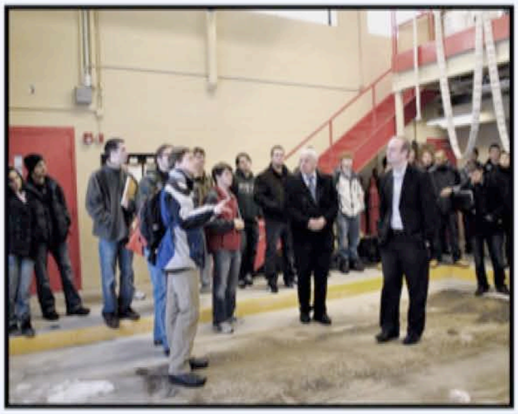

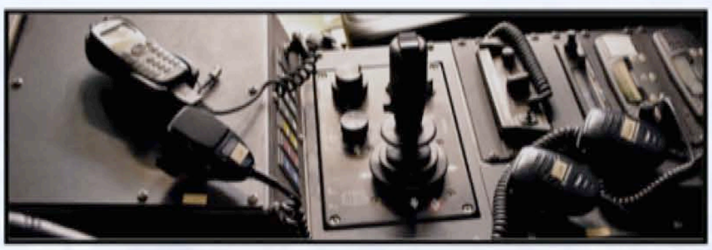

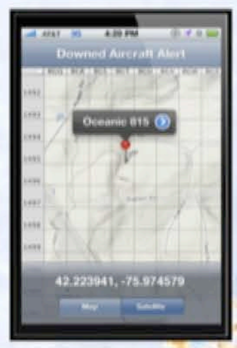

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Figure 1: Emergency responding to Fire and Rescue [1]

I. Executive Summary

Title: Smartphone Application to Improve Response Procedures for Downed Aircraft

In the past a number of airline related fatalities have resulted due to delays in locating a downed aircraft and subsequent delays in reaching the crash site. The Federal Aviation Administration (FAA) identifies that such problems exist and need improvement in order to meet the highest possible safety standards to ensure public safety. A team of 26 students from Department of Computer Science, Thomas J. Watson School of Engineering and Applied Science of Binghamton University, State University of New York worked together with industry experts and local airport operators to develop a solution to minimize the time spent locating downed aircraft and to provide turn-by-turn directions to the crash site to search and rescue teams

Proposed herein is a smart phone application that will integrate with Next Generation Air Transportation System (NextGen) and the Corpas-Sarsat systems, to process the information that is required to locate the downed aircraft, and provide directions (both on-road and off-road) to the crash site. With the new technologies of Automatic Dependent Surveillance-Broadcast (ADS-B) and the current FAA recommended Emergency Locator Transmitter (ELT), both of these systems will provide the Global Positioning System (GPS) location of the downed aircrafts. Using this data, emergency personal will be able to use this application as a tool that will provide faster and accurate directions of getting to the crash scene. One of the goals of this system is to eliminate the human error and subsequent delays in reaching a crash site. With every second being crucial to saving lives, this application will assist and reduce the time required to reach the crash scene both onsite and hard to reach terrains.

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II. Problem Statement and Background

i. The Problem:

When an aircraft crashes outside of the viewing area of an airport control tower, locating and getting to the crash site in a timely manner can save lives. If rescue teams can reach the aircraft without undue delay, fatalities may be reduced. However, locating downed aircrafts and determining how to get to the crash site quickly are difficult tasks. Presently, crash sites are many times located with outdated procedures and technologies. In addition, the FAA Airport Emergency Plan provides no standardized procedure for directing rescue services to downed aircraft [2]. Consequently, current practices vary from airport to airport.

Carl Beardsley, Commissioner of Aviation at the Greater Binghamton Airport (BGM), was able to illustrate a number of scenarios regarding responses to downed aircraft that were specific to BGM:

1. If a troubled flight arranges an emergency landing with the airport, Airport Rescue and Firefighting (ARFF) personnel would assemble at a pre-determined staging area, equidistant to the majority of possible landing places, in order to shorten the travel time to the landed aircraft. The relatively small area of the airport and ARFF's intimate familiarity with its geography allow the rescue team to navigate by sight.

Figure 2: Commissioner Beardsley shows the area around BGM on a rescue grid map

2. If a flight unexpectedly ends up on or around the airport property, ARFF can collaborate with the local emergency services and devise a plan using coordinates off a grid map that both parties share. This necessitates that the location is apparent and not obscured by terrain, trees, lack of visible light, or in a body of water. Even with a map, an exact location of the crash site may be difficult to communicate. A blow-up of the grid map being reviewed by Commissioner Beardsley in Figure 2 is shown in Figure 3 below.

3. The most troublesome and time-consuming situation is when a flight goes down outside of the airport's jurisdiction and outside of the view of an airport control tower. The rescue team finds out about the incident through an emergency dispatcher who receives emergency calls regarding the incident. The

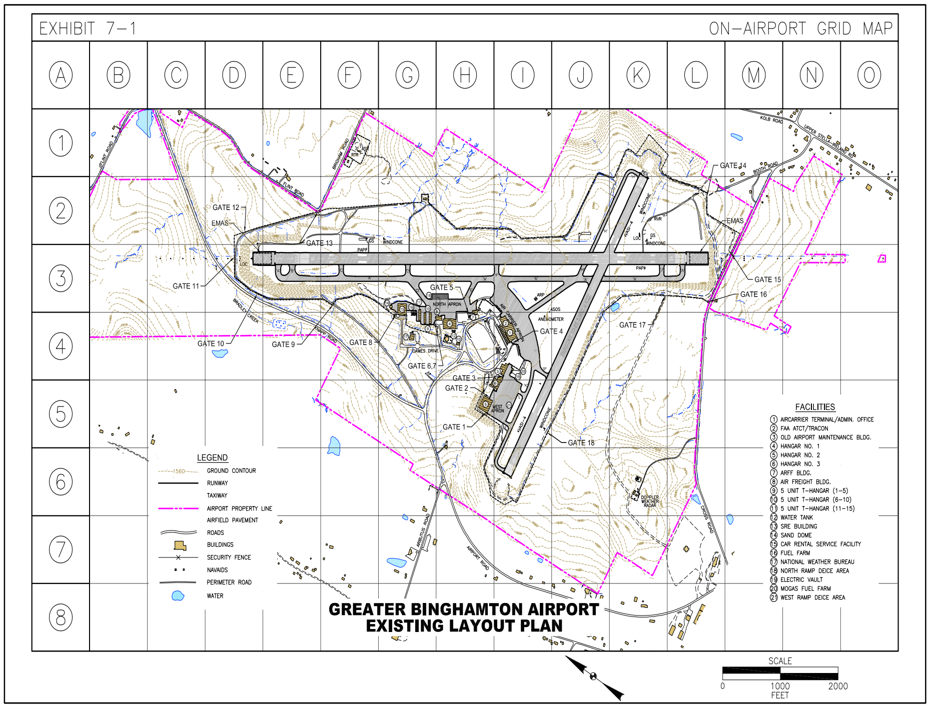

Figure 3: Grid map used by BGM (Source: McFarland and Johnson)

estimated location of the downed aircraft is usually provided by witness with no guarantee of the accuracy of the location. Due to lack of accurate information regarding the exact location of the aircraft, dispatching rescue teams to the downed aircraft outside the airport costs the most time, and would consequently have the lowest rate of success of saving lives of injured crew and passengers. Proposed here is a standardized rescue system that provides an accurate location to the corresponding emergency personnel via a Smartphone application utilizing satellites and the air traffic control towers.

ii. Background: Mobile Phone Applications

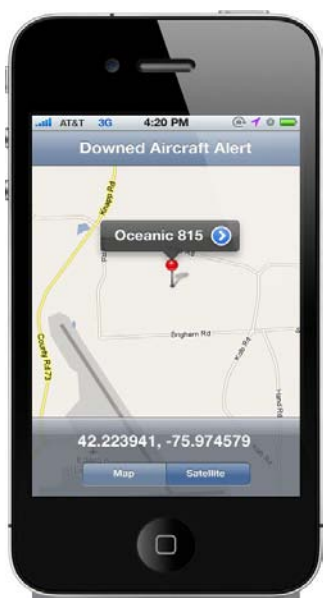

Figure 4: Example of a Smartphone application

Advancements in technology have led to the creation of mobile phone applications as shown in Figure 4. Mobile phone applications have made the thought of owning a Smartphone more appealing to the average consumer, leading to a rise of Smartphone owners in the United States. It is becoming likely to see more Smartphone users than regular mobile phone users by the end of 2011 [3]. In addition, many businesses and jobs have been created for the purpose of developing and selling mobile phone applications to Smartphone consumers [4].

Smartphone’s usually have a full-functional operating system (Android, Apple iOS, Windows Mobile, etc.) and can be thought as a portable computer with regular phone capabilities. With a functional operating system and programming platforms, developers are able to create Smartphone applications for different purposes including entertainment, work, travels, etc.

[5]. The use of mobile phone applications for a variety of purposes has helped turn Smartphone's into a vital piece of technology at home and in the workplace.

The design of a Smartphone application can simplify and complete the same tasks as a typical computer. Most Smartphone applications offer simple interfaces to make it easy for consumers to use and get their information quickly. For example, a navigation application will only require the user to enter the desired destination by voice or by typing to figure out the most efficient path based on the location of the phone [6].

Smartphone applications are currently used, and relied upon by many, to provide useful traveling information. Many applications are designed to provide information about flights, airports, or the services surrounding a destination. For the iPhone, which is the most popular Smartphone, applications such as Flight Update, iFly Pro, and Flight Track Pro all provide the users with general information about their flights and the airport [7]. These Smartphone applications use a live feed with information about each flight provided by the FAA and other agencies, which is delayed five minutes for security reasons [8]. Android phones have applications such as FlySmart and HotelsNearMe that come with similar functionalities. Other applications such as Tripit on the Android system are able to provide a systematic itinerary to minimize wait time at the airport and can prevent missing a flight [9]. Windows Mobile 7, Blackberry and the other Smartphone interfaces all have similar applications that will provide passengers a safer traveling experience with the necessary information.

iii. Background: NextGen

NextGen, the ongoing project by the FAA, proposed one of the critical transitions regarding air traffic management: changing from ground based to satellite based navigation and surveillance [10]. This transition allows air traffic controllers to visualize the aircraft route in the areas without radar coverage. It also improves the safety level by providing situational awareness, new weather information, and additional voice communications [11].

Figure 5: NextGen's automated computer and satellite systems [12]

However, the NextGen project still will not provide sufficient information for locating a downed aircraft for purposes of directing rescue teams to the crash scene. The focus of this proposal is to use the existing technology and equipment from the NextGen project to develop an accurate and efficient Smartphone application for locating crashed aircrafts. The proposed Smartphone application is designed to improve the current rescue procedure and to increase the chances of saving passengers and crew on the downed aircraft. When the Smartphone application is activated, the quickest path to the crash site will be provided to the rescue team.

Figure 6: Rescue scene for Turkish Airlines Flight 1951 [14]

iv. FAA goals and Flight plan

The first goal listed in the strategic flight plan provided by the FAA for 2009 through 2013 is to “achieve the lowest possible accident rate and constantly improve safety.”[13] Under this heading, the first and second objectives are to reduce commercial air carrier and general aviation fatalities [13]. In its Fiscal Year 2010 Portfolio of Goals, the FAA listed its target for the Commercial Air Carrier Fatality Rate as not exceeding 8.1 fatalities per 100 million people on board commercial flights. It also listed a target for the General Aviation Fatal Accident Rate of no more than 1.10 fatal accidents per 100,000 flight hours [14].

The primary objective of the goals listed is to improve safety and reduce fatalities. The Smartphone project proposed here would aid the FAA in achieving these goals by allowing local emergency response teams to reach a downed aircraft in less time than they are able to currently. This will have the potential to save lives because severely injured passengers would typically receive medical care sooner.

As part of its overall strategic goals, the FAA has outlined plans for implementing NextGen [13]. One of the components of this plan is the Automatic Dependent Surveillance-Broadcast (ADS-B). The

ADS-B uses GPS to provide the location of an aircraft. GPS is more accurate than radar, which is used currently to provide positional information on aircraft [13]. The ADS-B system could easily be integrated with the proposed project to provide precise data on the location of a crashed aircraft. If placed in a location on the aircraft where it is likely to survive in the event of a crash, the ADS-B system should remain functional and usable.

v. Solving the problem

With the combination of NextGen and the proposed Smartphone application, the rescue teams would be able to reach the downed aircraft in timely manner and with minimum resources. Additionally, the development of the Smartphone application shall not require any hardware upgrades in the airports or on the aircrafts; the maintenance and further improvements of the Smartphone application could be done through software upgrades, which would make the application reusable for future developments. Overall, in meeting a critical FAA goal, the proposed product will improve response procedures for aircraft emergencies.

III. Summary of Literature Review

To prepare the team for moving forward with a proposal involving a smart phone app to locate and assist downed aircraft, a thorough literature review was conducted on related topics. The primary topics investigated fell into five categories; goals of the proposal, FAA Downed Aircraft Procedures and Rescue Protocols, Rescue Operations, Current Flight Tracking Data Sources, Smartphone’s, Smartphone Applications Related to the Federal Aviation Administration, and Safety and Ethical Considerations.

i. Goals of the Proposal

The FAA released a safety briefing for November/December 2010 outlining a story of how a helicopter containing a pilot, three communications technicians and one of the technician's sons went down in Alaska [16]. Evidence at the crash site showed that more than one person survived the initial impact. Unfortunately, only the 15-year old son was rescued. The reason for this is that it took the search and rescue team 22 hours to find the aircraft, as it was equipped with an older 121.5 ELT rather than a more advanced 406 ELT. Had the aircraft been equipped with proper equipment and had rescue crews been able to get to the scene faster, then they may have been able to transport the other crash victims to the nearby Mat-Su Medical Center, which had a well-equipped trauma center.

In the FAA's strategic flight plan for 2009 through 2013, the first goal as mentioned above is to "achieve the lowest possible accident rate and constantly improve safety [13]." Under this heading, the first and second objectives are to reduce commercial air carrier and general aviation fatalities **Error! Reference source not found.**. In its fiscal year 2010 Portfolio of Goals, the FAA listed its target for the Commercial Air Carrier Fatality Rate as not exceeding 8.1 fatalities per 100 million people on board commercial flights. It also listed a target for the General Aviation Fatal Accident Rate of no more than 1.10 fatal accidents per 100,000 flight hours [18].

The first goal of the Smartphone application is to aid in meeting the Commercial Air Carrier Fatality Rate targets outlined on page three in the Portfolio. It would help to reduce the number of fatalities by allowing Emergency Medical Technicians (EMT) to arrive at the crash site in time to stabilize victims with severe or life-threatening injuries. Under current procedures, the amount of time required to locate the site and direct personnel may prove too great to treat major injuries, such as head trauma and massive blood loss successfully [18].

To demonstrate, it takes an average of 6.8 hours to find a downed aircraft that has a functioning ELT and 40.8 hours to find an aircraft without one [19]. While this demonstrates the importance of having an ELT, it also demonstrates that there needs to be a better way to help the first responders find a downed aircraft. The primary focus of the application is to streamline the response from ground rescue units. With a Smartphone application giving "turn-by-turn" directions, the rescue crews would be able to concentrate their efforts on the current situation, rather than wasting time and energy looking at maps and trying to determine the fastest route manually.

Similar to the above, the application would also contribute to the completion of the General Aviation Fatal Accident Rate and Alaska Accident Rate targets specified on page 5 of the Portfolio. Emergency personnel would be able to reach the crash site significantly faster than possible under current procedures. It would be especially helpful in this area because general aviation flights and private flights in particular, do not have the same flight monitoring structures and tracking capabilities possessed by commercial airliners. In contrast to the current situation, the Smartphone application would not draw a distinction between commercial airplanes and private airplanes, but would locate all accidents with equal speed and accuracy. This advantage would be particularly noticeable in the remote areas of Alaska, where there are few people living in the area capable of reporting a downed plane [18].

Finally, the application would provide a critical piece of the long-term push toward enabling the advanced data communication capabilities of the NextGen Air Transportation System. By bringing the task of locating crash sites and directing EMTs to the scene into the 21st century, the proposal offers immediate benefits, such as significantly reduced response times to crashes, and a drastically reduced chance of misunderstandings between air traffic controllers (ATCs) and emergency teams due to human error. The ability to communicate electronically also provides the capability of instantly sending critical information such as the size and type of the airplane that has crashed to response teams. Additionally, the availability of exact passenger number would enable crash-specific responses to guarantee the arrival of sufficient personnel and equipment to deal with the situation. Overall, the implementation of the proposal offers the ability to save lives by ensuring a timely response to airplane crashes across the country [17].

ii. FAA Downed Aircraft Procedures and Rescue Protocols

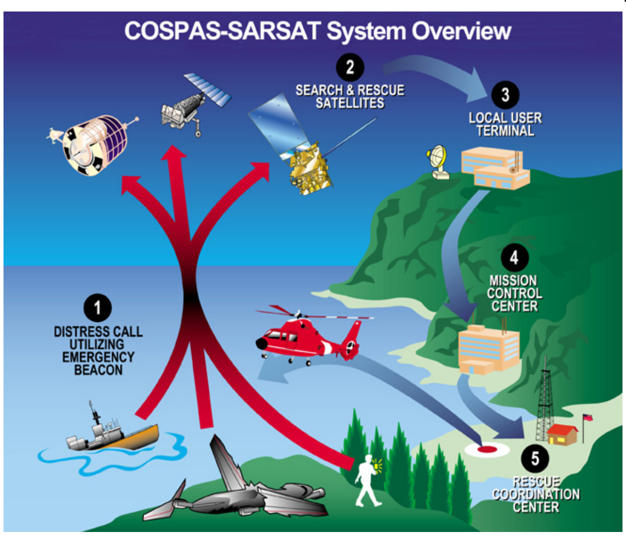

Figure 7*:* Diagram of the COSPAS-SARSAT System [20]

Since 1997, the FAA has provided a data feed of near real-time flight information to the aviation industry. These ELTs help locate downed aircrafts, and are required for most General Aviation airplanes. ELTs are designed to activate automatically in the event of a crash. The latest 406 MHz ELTs can transmit the aircraft's position data to the Cospas-Sarsat satellite system. As displayed in Figure , the Cospas-Sarsat international network of satellites and ground stations monitor for and respond to distress radio-beacon signals across the globe. The National Oceanic and Atmospheric Administration (NOAA) maintains a database of ELT registrations, and operates the United States' portion of the Cospas-Sarsat satellite distress alerting system. In the United States, when a registered 406 MHz ELT is activated NOAA provides alert data to the appropriate Rescue Coordination Center (RCC), and the RCC can initiate a search [21].

In the event of an aircraft accident, the operator of the aircraft is required to notify the nearest National Transportation Safety Board (NTSB) Field Office immediately. The operator can notify the NTSB by direct telephone, telegraph, and by notifying the FAA, who would in turn notify the NTSB. The operator is to provide information related the accident including the position of the aircraft with reference to an easily identifiable geographical point [22].

Radar is utilized by the ATC to determine the position of aircrafts, but not all aircrafts in range can be observed. ADS-B provides improved surveillance services where radar is ineffective. ADS-B may also be used to help search and rescue operations [23].

iii. Rescue Operations

Title 14 Code of Federal Regulations §139.325 requires every airport in the United States to develop an Airport Emergency Plan (AEP). Part of this plan necessitates the description of procedures for responding to aircraft accidents and providing guidance for the parties implementing them. This information includes the contact information for local emergency and medical services, procedures for transportation of survivors and procedures for incidents occurring in bodies of water [24].

The FAA has provided Advisory Circular 150/5200-31C in order to assist airports in developing their AEP. Chapter 6, Section 7, of this document provides guidelines for firefighting and rescue. It suggests that since some situations may require the assistance of both on-airport and off-airport personnel; the AEP should describe the “mobilization processes” of fire and rescue services, and describe the required interactions with emergency response organizations [25]. The Advisory Circular provides no standardized procedure for directing rescue services to downed aircraft. Consequently, current practices vary from airport to airport.

For example, consider the Tampa International Airport's Emergency Response Manual. If a crash occurs on airport property, Hillsborough County Fire Rescue Units would be directed to a pre-defined staging area (described in section 2-330.61 of the manual). If the crash occurs near but not within the airport, Tampa Fire Rescue is dispatched to the scene and Hillsborough County Emergency Dispatch Operation is notified. If the plane crashes in Tampa Bay, water rescue emergency equipment is requested from MacDill Air Force Base, the Coast Guard, and other parties. If the crash occurs outside of the Tampa Bay Area, information about the crash is relayed to an agency that has jurisdiction over the area (e.g. Highway Patrol or Sheriff's Office) [26].

Meanwhile, the Santa Fe Airport (SAF) has a similar but less detailed procedure in their Emergency Response Plan [27]. The Salina Municipal Airport's Emergency Plan only lists a procedure for incidents occurring at the airport and states that events outside of the airport are outside of its responsibility [28].

As shown above, it is relatively simple for a rescue team to attend to a downed aircraft at an airport. The process for crashes that occur outside of an airport, however are is dependent on many factors, such as which agency receives the call first, where the incident occurs or what plans are in place for the given region.

iv. Current Flight-Tracking Data Sources

Figure 8: The Aircraft Situation Display in the Air Traffic Control System Command Center in Herndon, Virginia on December 19, 2007. Each red dot represents a single aircraft [29].

In addition to providing a data feed to emergency services, the FAA has also provided a data feed to the aviation industry, known as Aircraft Situation Display to Industry (ASDI). Similar to the Aircraft Situation Display shown in 8, the ASDI data contains near real time positioning data for every aircraft receiving radar services within the national airspace. The only exceptions are for military operations and other sensitive information. ASDI data was deemed to provide useful information to commercial airlines by assisting their dispatch services, as well as providing opportunities for research and services, which would advance the aviation industry. ASDI consumers are divided into two classes: Class 1 and Class 2. Class 1 users are deemed directly responsible for the dispatch or tracking of aircraft within the industry, and are eligible for the near real-time data. Class 2 users are classified as any other entity, and are eligible for a delayed feed only [30].

In 2007, the ASDI feed was modified to provide its data in the Extensible Markup Language (XML) format. XML describes objects through documents that encapsulate data within well-defined tags [31]. The FAA has published a specification document that defines the XML tags and data format of the ASDI feed. Example tags include the current time-stamp, the aircraft id (ACID), latitude/longitude location, flight origin, and flight destination. Approved consumers of the ASDI data receive the feed by establishing a Transmission control protocol/Internet Protocol (TCP/IP) connection to the ASDI server located in the Traffic Flow Management (TFM) Production Center located at the William J. Hughes Technical Center in Atlantic City (WJHTC), New Jersey [32].

Consumers of ASDI data may display and redistribute flight-tracking data both to their customers and to the public at large. There are multiple web sites which provide flight tracking services by allowing end-users to enter in an airline and flight number combination, and the web site would show the current location of the flight, typically by superimposing the location on a map [33]. The data presented is typically the delayed feed, as the near real-time feed is seen as a potential security risk. Other vendors have provided a means to display ASDI flight tracking data within popularly used mapping tools such as Google Maps or Google Earth [34].

In addition, as part of the plan for implementing the NextGen system, the FAA has begun to implement the ADS-B. The ADS-B uses the GPS to provide the location of an aircraft. GPS is more accurate than radar, which is used currently to provide positional information on aircraft [17].

v. Smartphones

As can be seen above, the information needed to locate a downed aircraft exists. This just leaves the question of whether or not cell phones can handle the type of application that would be needed to make use of such information.

There exists a type of high-end cell phone called Smartphone’s, such as Apple's iPhone and Motorola’s Droid, which have higher processing power than normal cell phones. Appiction describes Smartphone’s as "miniature computers,” capable of performing many of the same tasks that desktop computers can do. These tasks are carried out by software applications, which are stored in the Smartphone’s internal memory, and accessed by a standardized user interface [35].

Smartphone’s are powerful computing devices. Very complex applications that perform valuable services can be run with ease [36]. Most of the newer Smartphone’s being released by major industry manufacturers (such as Samsung) run on processors with clock speeds of up to 1GHz and have more than 15MB of RAM [37]. This is more than enough computing power to run most general applications, such as social media feeds and GPS navigation aids, although extremely detailed 3D games would push the processors’ limits. Additionally, the rapidly expanding market for Smartphone’s has attracted a great deal of attention from both established chip manufacturers such as Nvidia, as well as smaller industry players such as Qualcomm [38][39] [40].

The impressive power and the great increase in portability that Smartphone’s offer compared to a traditional computer have sparked widespread interest in using Smartphone’s as a substitute or even outright replacement for conventional laptop computers. Motorola’s Atrix Smartphone, released in early 2011, attempts to provide this capability. It includes a simple method to connect the Smartphone to a laptop “shell” that provides a larger screen and traditional keyboard and mouse hardware [36]. Some Smartphone applications may demand relatively robust computing requirements to be able to function well. However, today’s emerging and aggressively competitive mobile device market has led to the release of extremely powerful Smartphone’s that are more than capable of meeting the computing power required by all but the most advanced and complex applications [41].

Smartphone’s have the power needed to handle the type of processing needed for the team’s design. The question now is about the nature of Smartphone applications. According to HowStuffWorks, there are seemingly countless applications. Many of them can perform the functions of playing music, games, videos, and organizing personal data [42]. Other applications, such as webmail and map systems applications, are able to utilize the phone's ability to connect wirelessly to the Internet or the Smartphone’s phone network [43]. Most commercial applications are purchasable from an online retailer provided by the Smartphone’s manufacturer (e.g. Apple’s App Store) [35].

Some companies involved in the Smartphone market, such as Apple and Google, have assembled Software Development Kits (SDK) that contain all the necessary tools and documentation required to develop compatible software. These SDKs have been released to the public, allowing anyone who so desires to easily create and distribute custom Smartphone applications [43].

vi. Smartphone Applications Related to the Federal Aviation Administration

Smartphone’s have impressive processing power, and Smartphone applications are relatively easy to develop. There are also varieties of Smartphone applications that are related to airplane flight.

Figure 9: A screenshot of FlightTrack [45]

The vast majority of aircraft-related Smartphone applications focus on providing travelers with real-time information about the location and arrival times of flights. The same principles used within these applications can be utilized in the proposal.

An example of such an application is one offered through the Android Market and Apple’s App Store, called FlightTrack. As seen in Figure, FlightTrack provides real-time status updates for national and international airline flights, as well as cancellation notices, gate numbers, and other related information. It can also show the current location of the airplane [44].

Another example of a flight-tracking application is FlightStats, also for Android based smartphones. It provides a global flight tracker with automatic status updates and information on flight delays and weather in a given area. It also provides contact information for the associated airline and social networking features to allow users to share flight data with friends and family using websites such as Facebook and Twitter [46].

Additional examples include Flight Update, iFly Pro, and Flight Track Pro for Apple's iPhone, all of which provide the users with general information about their flights and relevant airports [47]. Windows Mobile 7, Blackberry, and the other Smartphone interfaces all have similar applications that would provide passengers with the information necessary for a safer traveling experience.

Using the information from the proposed Smartphone application, the rescue teams would be able to reach the downed aircraft in timely manner and with minimum resources. Additionally, the development of the Smartphone application would not require any hardware upgrades in the airports or on the aircrafts; the maintenance and further improvements of the Smartphone application could be done through software upgrades, which would make the application reusable [48]. Despite these advantages, no method to accomplish this seems to exist currently. However, many of the concepts seen in the construction of commercial airliner tracking applications reviewed above have been applied to the proposal.

vii. Safety and Ethical Considerations

As shown above, Smartphone's possess the capabilities needed to implement the proposal. Furthermore, the proposal could go a long way towards improving emergency response time when dealing with a downed aircraft. However, in order to fulfill its goals, the Smartphone application must be incorporated into the airline industry.

The safe integration of all systems of the airline industry is one of the primary concerns of the FAA. In order to address this concern, the FAA has implemented a set of rules and procedures that must be followed by all airports in order to both promote and maintain a safe operating environment. To fulfill this obligation better, the National Airspace System (NAS) has implemented the Safety Management System (SMS), which is an integrated approach to analyzing and evaluating potential hazards [49]. The SMS was designed to work for all civil airports, regardless of size, though it may be modified to better accommodate the unique circumstances of a given airport. The SMS is integrated into all aspects of airport operations, including business and management practices [50].

In order to improve the efficiency of risk evaluation, the SMS was designed with four subsystems: safety policy, safety risk management, safety assurance, and safety promotion. Safety policy manages the safety oversight of the aviation organizations. Safety assurance consists of the processes and tools, such as safety evaluations, that are used for safety control. Safety promotion encourages the implementation of the SMS at airports, as well as the promotion of a general "safety culture." Each process deals with a different aspect of air travel safety and all are of equal importance. However, within the scope of the proposal, the Safety Risk Management (SRM) is of particular importance [49].

The purpose of the SRM subsystem is to perform safety analyses both of the systems currently in use at a given airport, and of any systems that may be incorporated into airport operations in the future. These safety analyses follow seven steps. First, it must be determined if the change involves a control procedure or change of equipment. Then, the procedure is broken down into components, and hazards within each component are identified. Each hazard is then assessed, and the circumstances and likelihood of each hazard is determined. Then, the hazard and incident analysis is examined, and risk mitigations are identified. Finally, Safety Risk Management Documents (SRMDS) are generated [49].

In the proposal, a software application that can provide information on the location of downed aircraft would be incorporated into existing control tower equipment. Since this involves a change both of equipment, and of the procedure for locating downed aircraft, it must be vetted through the SRM [49].

First, our proposal must be broken into components. For example, one component may consist of the transmission from the downed aircraft to the NOAA. A second component may be the stage where NOAA handles the transmission. Within each component, hazards must be identified. For example, a potential hazard in the first component may be a malfunction in the device in the aircraft that transmits the distress signal. Then this and all other hazards would be examined. The effects that the hazard would have on the rescue procedure, the circumstances under which the hazard would occur, and the hazard's likelihood would all be determined. Once this is complete, the risk associated with the hazard would be identified, and a proposal made for lowering the risk if it is too high to be acceptable. Throughout this process, SRMDs would be generated, which document this entire procedure. Once this procedure has been completed, and all risks have been reduced to an acceptable level, the proposal would be considered safe enough to be integrated into current airport operations [49].

Concerns about the effects that the application would have on the FAA do not end with the SMS, however. Search and rescue operations, by their nature, bring a variety of ethical issues to the forefront. Decisions made by all of those involved in the operation can have a direct impact on how many of the crash victims survive. When a plane goes down the response efforts must begin as soon as possible. If the first responders are not able to get to the scene of the accident efficiently, then lives could be lost.

Unfortunately, without proper security procedures and protocols, third parties might have access to this information as well. This could lead to privacy issues, if a media outlet were somehow to get to the scene first or security concerns if this information was acquired by an outside organization. Steps must be taken to ensure that only those intended to receive this information have access to it.

IV. Problem Solving Approach

The Project Leader, Victor Yevtukh, began the project several months prior to the rest of the team joining in. Victor began meeting with Prof. Ziegler to review the competition guidelines and visited the Greater Binghamton Airport and McFarland-Johnson, Inc. in order to collaborate with Commissioner Beardsley and Vice President Chad Nixon. After several meetings Victor and Prof. Ziegler decided to enter the FAA Management and Planning challenge, specifically focusing on improved response procedures for airport or aircraft emergencies. Both Commissioner Beardsley and Vice President Nixon highlighted

Figure 10: The entire team along with Commissioner Beardsley

that aircraft emergencies and response procedure is an area that can greatly benefit from new ideas. With this information Victor and Prof. Ziegler decided to approach the problem of downed aircraft response by using the team's computer science background to create a Smartphone application to aid in response.

Victor organized the entire project and interacted with each team. He attended weekly meetings at McFarland-Johnson, Inc. and visited BGM as needed to discuss project details, including technical design aspects and background research. Later on, a team of 25 undergraduate students joined Victor on the project (*see Figure 10*). The team was divided into four smaller teams, the "Design Team", the "Engineering and Graphics Team", the "Risk Assessment and Research Team", and the "Strategies and Ethics Team". The "Design Team" handled the technical design of the project. The "Engineering and Graphics Team" narrowed down the problem statement, took photographs of the team's interaction with airport professionals and created the various phone screens needed for the project. The "Risk Assessment and Research Team" was responsible for documenting the initial research for the project and analyzing any risks associated with the project design. Lastly the "Strategies and Ethics Team" documented the approach used to solve the design problem, all ethical considerations with the project and analyzed the real world implications of the design. Mark Delanoy was chosen as the project's Technical Leader, and he was responsible for leading the team's technical design aspects. Mark, and the Project Leader, Victor Yevtukh attended weekly meetings at McFarland Johnson and visited BGM as needed to discuss project details, including technical design aspects and background research.

Each sub-team and the overall team met regularly and often to discuss details and work together on the project. Much background research was needed before the team could design the Smartphone application. The FAA Air Traffic Organization and Safety Systems Manual [51] and the FAA Introduction to Safety Management Systems for Airport Operators [52] were used extensively in the team's research regarding airport operations. The team conducted a literature review in order to get up to speed on the FAA procedures for locating downed aircraft. Of particular interest in the literature review was the ELT that transmits when an aircraft is down and the NextGen initiative, an attempt by the FAA to modernize all aspects of tracking and communication of aircraft. This research was supplemented with knowledge from various experts, including Commissioner Beardsley and Vice President Chad Nixon.

Initially the team proposed to develop a Smartphone application that would be available to first responders and aircraft personnel. In the event of an emergency, a person aboard the aircraft could signal and transmit the plane's location through the use of GPS technology. After some background research the team found out about the ELT and began considering the potential use of this device. In order to fully understand the emergency response procedure for downed aircrafts, the team worked on site at the BGM airport.

At an airport visit the team met with Commissioner Beardsley to learn the exact procedures for locating and responding to downed aircraft (*see Figure 11*). The use of the ELT was discussed and the team discovered that the FAA already locates downed aircrafts, however the process has much room for improvement. First the ATC is alerted of a downed aircraft. The ATC then signals the emergency responders that a downed aircraft is in the area. Paper maps and grids are then used to locate the downed aircraft. Lastly the emergency response team is sent to the scene based on directions from the maps. At each step there is room for potential errors and delays. Not only does the aircraft need to be hand located using the maps, but also the proper directions need to be inferred from those maps, wasting valuable time. The team decided that streamlining this process would greatly reduce the amount of time first responders need to spend locating and reaching downed aircraft. The team determined that additional research needed to be done on the ELT and the data that it transmits.

Figure 11: The team poses for a photo near the BGM airport runway.

After extensive research the Project Leader was able to find out exactly how the ELT operates and its place in an emergency response. This was one of the major challenges of the project. All of the experts that were contacted knew about the ELT but few knew that it transmits the actual latitude and longitude of the aircraft. At that point, the team decided to change the design of the application to make use of the ELT. The reason this approach was taken was that the Mission Control Centers (MCC) already pickup ELTs alerts and send them to the proper ATC. Mark Delanoy, the Technical Leader, proposed that the FAA provide an XML tracking feed that the Smartphone app could monitor for better tracking information. The team then decided that each ATC would maintain a list of registered smart phones to alert in the event that a distress signal is received. The emergency responders will receive notification of a downed aircraft, the location of the downed aircraft, grid maps detailing this location, turn-by-turn directions to the site, and geographic maps in the event of downed aircraft that are not near navigable roads.

Vice President Chad Nixon of McFarland-Johnson, Inc. visited Binghamton University to discuss several design elements with the team (see *Figure 12*). During the visit both the original and current design of the application were discussed. Although giving the pilot the developed Smartphone application would be useful, it was decided that there was not enough reliability with this approach due to possible cell phone signal issues, the aircraft could go down in an area where cell phone service is unavailable. After contemplating Mr. Nixon's advice the team determined that the best design was to use the ELT and ADS-B data that was already tracked by the FAA and streamline the response process. It was suggested that the app be designed to integrate with NextGen systems to increase the appeal of the app and its ability to adapt to upcoming technologies.

Figure 12: Vice President Chad Nixon answers questions regarding the app design.

The team contacted several additional experts to get additional advice on the design of the application. One issue that was brought up was the privacy of the app and whether any information would be exposed to outside parties. The team considered this situation and designed the app to avoid as much information exposure as possible. The ATC would only send alerts to registered smart phones, minimizing the amount of information that is released. Another issue that the experts pointed out was how the application would provide directions to an aircraft that crashes away from accessible roads. The team agreed that this was an important issue that could be addressed by providing detailed maps to the first responders with the location of the aircraft.

In terms of maintenance considerations, the Smart Phone App proposed here will require standard code (computer programming) maintenance. Any software errors that are discovered need to be corrected as soon as possible. Updates can be released for the Smartphone application to fix any issues that are found. ATC servers need to be monitored to ensure constant operation. If a server becomes unavailable due to various reasons (power failure, maintenance, etc.) registered Smartphone's will not receive alerts.

The design of this Smartphone application began as an application that served as both a beacon and a receiver. After several discussions and interactions with airport professionals it was decided that the location of downed aircraft is something the FAA already handles, albeit in an inefficient manner. The team therefore, focused its effort on streamlining the response procedure by providing the exact location of downed aircraft along with detailed maps and directions to emergency responders. *Figure 13* details the alternative designs of the application.

Alternative Designs of the Smartphone Application			
Design	Advantages	Disadvantages	Reason Discarded
Application available passengers and can signal emergency response.	High chance of surviving passenger being able to signal the response team.	Privacy and Security.	The privacy and security issues outweigh the benefits.
Application available to the pilot and can signal emergency response.	App can send location data directly to the first responders.	Pilot and phone may not survive crash. Cell phone signal may not be available.	Design was not reliable enough for emergency response.
ATC alerts registered phone apps in response to ELT and ADS-B signals.	Aircraft information and location already handled by the FAA. Simplifies app design.	Small privacy and security issues.	None, design was chosen.

Figure 13: Table summarizing the alternative designs.

V. Safety & Risk Assessment

The main purpose of this project is to propose a system that has the potential to lower the risk of fatalities related to aircraft crashes. However, as with any new system, the proposed app may introduce a number of hazards, which must be addressed to ensure safe integration into airline procedures. Some of the hazards that would be introduced by the app directly are server crashes, software bugs, false alarms, interception of the communication by third parties, software piracy, lack of phone service in a given area, and the limited lifespan of a Smartphone battery. Weather related hazards include but may not be limited to cease of Smartphone functionality due to extreme temperature, route blockage due to mudslides, avalanches, or similar phenomena, and disruption or degradation of cellular signals due to thunderstorms, precipitation, and even solar weather phenomena. Investigating each of these hazards in detail is beyond the scope of this proposal. Instead, two of the most important hazards were examined, and the corresponding risk levels evaluated, as examples of how hazards related to the proposal would be addressed.

The hazard inherent to the application that was analyzed is that posed by the possibility that the server of the third party mapping software would be offline during an emergency. Initially, this hazard may appear to pose a serious problem, especially since the FAA has no direct control over the stability of this element of the design. However, as shown below, the risk associated with this hazard is low. For the sake of this analysis, it was assumed that the app would utilize the Google Maps software, and that 2007 represents a typical year for both aircraft accidents and Google server stability. In addition, it was assumed that the app would be a part of ATC services, since the ATC would act as a relay of information from the ELT to emergency personnel.

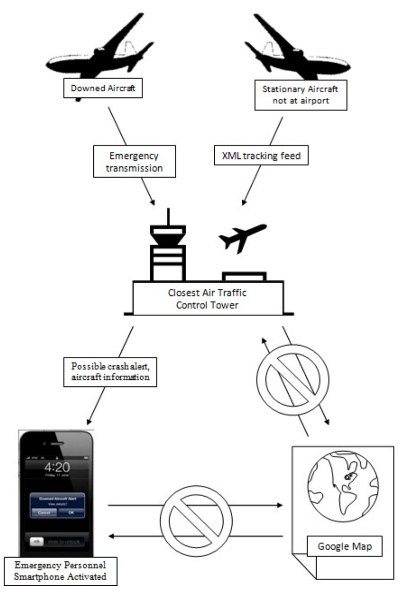

Figure 14. When the third party mapping software server is down, the most critical elements of the design still function.

If the Google Maps server crashed, then turn-by-turn directions and a map of the region of the accident would no longer be available. Either another mapping program would need to be used, or emergency personnel would need to determine the best path to the crash site manually. However, as displayed in Figure 14, even if Google Maps were offline, emergency personnel would still have access to the location, type, and maximum capacity of the aircraft. Therefore, there would be a slight reduction in the ATC services. As such, the severity of the hazard would be classified as minor on the Hazard Severity Classification table (Table 3.3 of the SMS Manual) for ATC Services [53].

In addition, the hazard would have only a remote chance of occurring. From September 2006 through September 2007, the Google servers in the United States were unavailable for a total of 31 minutes, or 0.516 hours [54]. Therefore, there is a probability of 5.890 x 10^{-5} (about 5.9 in 100 thousand) that the Google main servers will be down in any given hour (see Table 1 for a breakdown of all probability calculations). While this statistic applies only to the servers for Google's main site, it provides a useful approximation for this case study. However, it should be noted that satellite services such as Google Maps might have slightly different levels of stability [55].

Table 1: Probability Calculations		
	Calculation	Result
Minutes per accident		5 min/accident
Hours per accident of app usability		8.33×10^{-2} hr/accident
Google downtime in 2007 (hours)		0.516 hr/yr
Pr(Google down)		5.890×10^{-5}
Aircraft Accidents in 2007		1,652 accident/yr
Total hours of app usability	(1,652 accidents/year) × (8.33 × 10^{-2} hours/accident)	137.611 hr/yr
Probability(Google Maps accessed)		1.571×10^{-2}
Probability(Accident, Google down)	**(1.571×10^{-2}) × (5.890×10^{-5})**	**9.253×10^{-7}**
Fatal Aircraft Accidents per year		288 accident/yr
Hours of Fatal Accidents	(288 accidents/year) × (8.33 × 10^{-2} hours/accident)	23.999 hr/yr
Probability (Google Maps accessed for Fatal Accidents)		2.747×10^{-3}
Probability(Fatal Accident, Google down)	**(2.747×10^{-3}) × (5.890×10^{-5})**	**1.617×10^{-7}**

Table 1: Probability Calculations. Probabilities that pertain directly to determination of risk level are in bold

During approximately the same span of time, there were 1,652 aircraft accidents [56]. Under the assumption that the mapping portion of the app would be utilized within the first 5 minutes of each accident, there would be 137.611 accident hours per year during which the app would attempt to access the third party mapping software. Therefore, there is a probability of 1.571 x 10^{-2} (about 1.6 in 100) that the phone app would try to access the third party mapping software in any given hour throughout the year.

The availability of Google Maps is independent of the probability of the app attempting to access it. Therefore, the likelihood of these two events occurring at the same time has a probability of 9.253×10^{-7} (about 9.2 in 10 million) per hour. Based on this, and the Likelihood Definitions table in the SMS Manual, the probability of occurrence of the hazard is classified as remote [53].

It is worth mentioning that the above probability is a maximum. Furthermore, of the 1,652 accidents occurring in a one-year period between 2006 and 2007, 288 of them were fatal. By the same calculations as used above, the probability of Google maps being unavailable at the same time as a fatal accident is $1.617 \times 1.617 \times 10^{-7}$ (about 1.6 in 10 million), which would also be classified as remote [53].

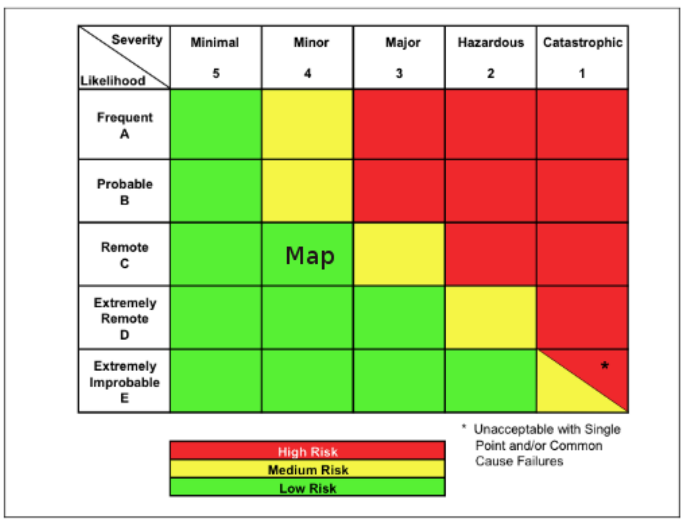

Figure 15: Risk Matrix of the SMS Manual (Figure 7.1) [53]"Map" indicates the projected location of the hazard on the matrix.

Based on Figure5, the above calculations, and the severity analysis, the hazard associated with the third party mapping software's server being offline during an emergency would be expected to pose a low risk [53]. Therefore, mitigation steps are not strictly necessary. However, various steps may be taken to reduce the risk further. For example, the FAA may enter into an agreement with the chosen mapping tool provider (i.e. Google). In such a partnership, the software company would provide emergency servers dedicated specifically to keeping the mapping software online for emergency use in the situation of a server crash. Such a deal would add further redundancy to that component of the design, and steps could be taken by the mapping software company to ensure maximum stability in the dedicated servers. Alternatively (or in addition), a subroutine in the application could be implemented that would automatically use an alternate mapping website, if the primary mapping service is offline. A third mitigation procedure would be training emergency personnel applying the location information provided by the app to a paper topological map swiftly. With such training, the time spent locating the downed aircraft and determining the surrounding geography would be minimized in the event of the unavailability of the mapping software server.

It is unlikely that rescue operations would take place while the third party mapping software server is down. However, rescue operations in poor weather would be far more common. Between 1994 and 2003, 21.3% of aircraft accidents listed weather as a causal factor [57]. Therefore, assuming a relatively quick response time, this statistic would also represent the minimum percentage of response operations in which the proposed app would need to function in poor weather conditions. Even if the Smartphone hardware is protected, the signals relaying information to the app may be affected by the weather during transmission. Therefore, the second hazard that was examined was the possibility that weather conditions might prevent the app from sending or receiving the information necessary for it to perform properly.

Precipitation, in its many forms, can negatively affect the usability of the proposed app. Even though the presence of some moisture content helps in propagation of electro-magnetic waves, extreme humidity can hinder wireless communication due to excessive attenuation of radio signal [58]. Rain affects cellular signals through both absorption and scattering [59]. Absorption occurs when a raindrop absorbs energy from a radio signal and dissipates it as heat [59]. The signal is weakened due to this loss of energy. Scattering, which occurs when a raindrop reflects or refracts a signal, can minutely redirect, and weaken the signal [59]. Other precipitation conditions including fog, snow, and hail interact with cellular signals in similar fashions. Thunderstorms can also have an adverse effect on cellular communication, ranging from high signal distortion to complete disruption of service. For example, storms with electrical discharges (lightning) can create heavy distortion, due to electrical spikes [60].

In both of these cases, the main issue is degradation of the cellular signal. However, although weather may weaken a signal, the signal can still be detected by a Smartphone in most cases. Reliable protocols such as the TCP will cause the application to resend packets of data that were too weak to be detected [61]. Therefore, a strong connection is not necessarily in constant need.

In addition, many Smartphone’s can cache, or store, a limited number of previously acquired directions, maps, and data [62]. As a result, the procedure displayed in Figure 16, and Figure 17 would be a possible mitigation. By utilizing a more stable local wireless network connection at the response station, route planning can be done first and cached, as displayed in Figure 16. In this case, even if there is total signal disruption while traveling, responders would still have terrain information and directions to the crash site, as displayed in Figure 17.

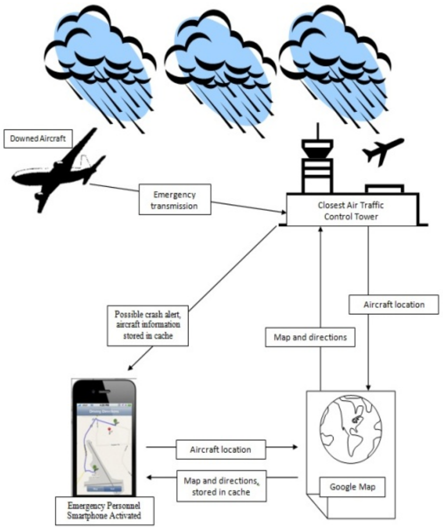

Figure 16: Smartphones can store data in cache while near ATC tower during inclement weather

GPS signals emanating from a transmitter based on a satellite are also a possible failure point, due to solar weather conditions. These conditions, including solar winds, solar flares, coronal holes, and coronal mass ejections, can drown out satellite signals that the app depends on for GPS navigation [63]. Charged particles from solar flares produce intense bursts of radio noise, which could flood the frequency normally reserved for GPS signals [63]. In addition, these geomagnetic storms could last for 24 hours or more [64]. Despite these conditions, the app could still retrieve and store maps and directions at a central station before leaving as previously discussed. It would only lose the ability to track itself in real time. In addition, these types of conditions are not very likely. Geomagnetic storms occur on a solar cycle, peaking every 11 years [63]. Therefore, these events have an extremely remote likelihood of occurring as set forth in Table 3.4 of the SMS manual [53].

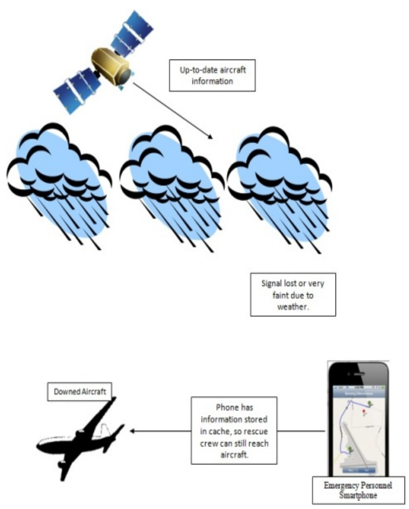

Figure 17: Smartphone contains information obtained near the ATC tower, so emergency personnel still know how to reach the aircraft despite degradation of signal.

Taking into account a worst-case scenario, where weather causes a total disruption of cellular signal, the app would still prove to be useful. The app’s ability to cache at the station would still grant the responders access to maps, directions, and terrain information, even if it would not be updated while in

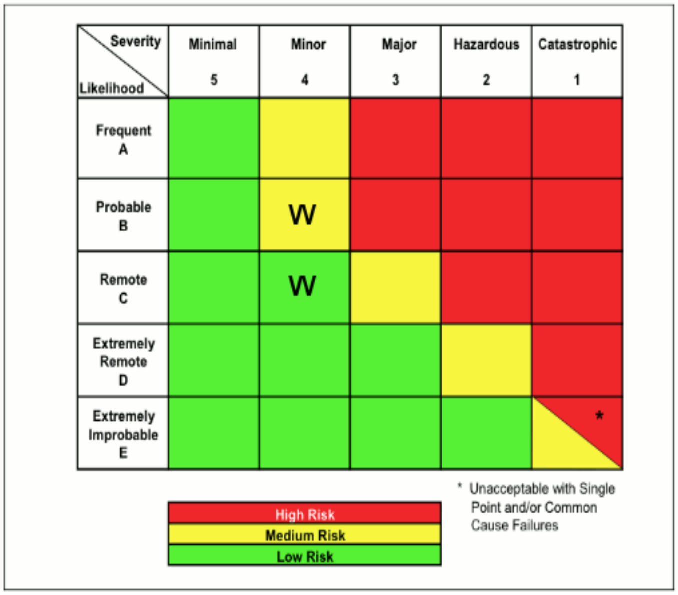

Figure 18: Risk Matrix of the SMS Manual (Figure 7.1) [53]
Hazard level is projected to be at one of the two W's depending on the weather patterns of a given airport's location.

transit to the crash site. Factoring in these mitigation techniques, the risk would only be considered a minor hazard as defined by Table 3.3 of the SMS manual, due to the slight reduction in ATC services [53]. Depending on the weather patterns of the area in question (in particular the frequency of intense precipitation), the likelihood would likely rate as either remote, or probable [53]. Therefore, signal degradation poses, at most, a medium risk, as shown in Figure 18 [53]. This may necessitate more research into improving current GPS and cellular technology. In addition, updating current hardware to increase GPS signal strength might prevent or reduce issues relating to geomagnetic storms [63]. Finally, the maintenance of current procedures should serve as a backup, so that a failure of the app will not result in the failure of the response system as a whole.

There is a common theme running through these analyses. In both cases, even in the worst-case situations, critical data such as the location and type of the downed aircraft are provided. The only time the location of the aircraft, arguably the most important piece of data in the design, would fail to reach emergency personnel would be when the ATC tower fails to receive the ELT signal. Even then, the XML tracking feed, which constantly transmits the position data for each plane, provides a redundant system. It can inform the ATC tower that there may be an emergency if a plane stops broadcasting its position or if the position remains the same when the plane is thought to be traveling in the air. The XML tracking feed can also provide a rough location of the potential emergency, based on the aircraft's last known location.

In situations where the app runs at full capability, emergency responders would not need to use a physical map. Furthermore, the Smartphone app would provide turn-by-turn directions, which would swiftly bring emergency personnel to the nearest road, if not the actual crash site. As a result, emergency personnel would be able to arrive at the site more quickly. Swifter response time would increase the survival rate of the crash victims, especially if they have life threatening injuries.

In short, the emergency response time would improve dramatically, both in situations where the app runs flawlessly, and when less critical elements of its design are unavailable. Even should the app ever fail completely, emergency personnel would be no worse off than they are currently: depending on NOAA to inform them of a possible downed aircraft in the area, and then searching for the crash site.

VI. Technical Aspects Addressed

This proposal consists primarily of two distinct areas that work in concert to bring the process of determining the location of an airplane crash site into the 21st century. The first part of the proposal involves an additional information system that will augment existing emergency response procedures by monitoring a list of activated aircraft ELT's in the United States. For each ELT, the system will generate an automated alert containing all available information about the situation on the computer systems at the closest airport to the crash site. The system will also monitor a list of all aircraft being tracked in the United States and will use this data to help provide additional information about a possible crash to emergency crews. This list will also allow air traffic controllers to more easily determine if an ELT is a false alarm. If the air traffic controllers decide that the alert is likely to be accurate, they will then initiate the second part of the proposal.

This portion is an application on a Smartphone that will provide emergency crews with turn-by-turn directions to the crash site by utilizing the mapping application provided by the Smartphone's operating system. For security purposes, information about the crash will only be made available to the application if the air traffic controllers determine that a response is necessary. This approach will reduce the number of false alarms and greatly simplify the task of determining the best way to travel to a crash site. It will also offer the ability to call up road maps, topographical maps, and satellite imagery of the area surrounding the site, allowing emergency crews to better prepare for the type of terrain they are likely to encounter. All of these features together will greatly reduce the amount of time required to respond to a downed aircraft and will significantly increase the possibility that the first crews to reach the site will be fully prepared to deal with the difficulties presented by a particular crash.

By utilizing advanced technology to almost completely automate the process of responding to a downed aircraft while still preserving a human oversight of the system, this proposal will seamlessly integrate with the FAA's current plans to modernize the process of overseeing the nation's airspace through the NextGen. As responding to downed aircraft is one of the few areas not currently addressed by the initiative, the proposal will fill this gap and allow a more complete transition to a fully modern, computerized oversight system. In addition, the increased commercialization of GPS devices and the current ease of deploying dynamic real-time location tracking to any point on the Earth's surface means that the proposal will not involve a significant financial investment because existing commercially available devices will be capable of providing many of the requirements for the proposal.

i. Integration with NextGen

The FAA's NextGen initiative is a planned system-wide upgrade to all aspects of the process of tracking and communicating with aircraft in flight. The most important aspect of this plan is to replace the ground-based tracking technologies that have been in place for decades and transition to a new satellite-based tracking system. NextGen's satellite-based tracking system offers several advantages over the older terrestrial systems, but the most important is the ability to efficiently track aircraft in any location, no matter how remote. NextGen will also introduce new technologies that will provide more detailed, accurate, and timely weather forecasts in the area. Of particular interest to this proposal are the advanced tracking capabilities that are included in the NextGen plan. These will make the proposed system much easier to implement because of the more unified approach toward handling tracking data compared to current methods [65] [66]

NextGen's satellite-based tracking system, the ADS-B, is the FAA's solution to the problem of providing real-time tracking of an aircraft's location by replacing conventional radio transceivers with GPS-based locator beacons. This results in a much more accurate location estimate for the aircraft and allows pilots to see the same real-time view of the air traffic in the immediate area that is available to the air traffic controllers at the airport. Pilots on aircraft equipped with ADS-B beacons are also able to continuously broadcast other flight-relevant information such as the plane's altitude directly to the air traffic controllers. This information will help reduce flight delays by aiding the air traffic controllers in their scheduling efforts and will also allow the proposed system to easily match specific aircraft to the raw location data. [66] [67]

While ADS-B is mainly designed to support commercial aircrafts, another NextGen tracking technology, Automatic Dependent Surveillance-Rebroadcast (ADS-R), is focused on tracking smaller, general aviation aircraft that use the 1090 MHz band for their communications. ADS-R allows these smaller craft to receive the same real-time view of all the aircraft in the area that is available to commercial flights. With current tracking systems, it is often difficult for air traffic controllers to keep track of these small planes, but the new technology will allow them to appear on the same air traffic display of their commercial counterparts. This approach allows the creation of one universal surveillance system for all types of aircraft, greatly simplifying the difficult task of keeping track of all planes in a particular airspace. This unified approach will also allow the proposed system to easily integrate the tracking information into the data feeds that it will rely on to perform its tasks. [65] [68]

All of the new technologies involved in NextGen will greatly increase the efficiency of tracking and communicating with aircraft in the United States. In addition, the increased accuracy of the routine tracking information and the ease of transmitting the information from the plane to receiving stations on the ground will allow the proposed new computerized tracking system to easily acquire accurate real-time data on the plane's position. Although the new system as proposed will be capable of using location data from older existing systems, the information provided by the advanced NextGen tracking technology will be more accurate and timely. [68]

Furthermore, because the proposed system is designed to augment rather than replace existing NextGen plans, it could be easily implemented without affecting the FAA roadmap that has been developed over several years. It will also greatly benefit the overall plan by addressing the problem of locating downed aircraft, one of the areas that is not covered by the current NextGen plan. This will make the transition to new technology more complete and will be relatively inexpensive to deploy because it utilizes existing hardware and technology that is already slated to be introduced.

ii. Aircraft Location Data Feeds

The proposed design of this downed aircraft locating phone application would utilize the location information provided by either an activated ELT or routine tracking from ADS-B in order to provide last-known location information on the downed aircraft. Extensible Markup Language (XML) is a protocol used to describe documents in a format that allows computers to easily read and extract data from the documents. An Extensible Markup Language (XML)-based data feed to provide the location of downed aircraft would use the currently known ADS-B provided location of a distressed or downed aircraft in order to make the data available to an interface located on a Smartphone device. The XML feed could provide additional usefulness to rescue workers by enriching the location information with other data, such as the combined passenger and crew count.

The ASDI data feed has been provided in multiple data formats since it was first introduced. Prior to 2008, the data delivery was via a proprietary format that required vendors to implement an interface that could decode the ASDI field header and data payload information. However, in 2007, the ASDI feed was migrated to a format utilizing XML. XML is an industry standard, which specifies data files known as XML Documents. XML Documents define the behavior of the computer programs that parse the documents for their contents. XML specifies the meaning of data by declaring an element. The name of an XML element typically describes the attribute logically, and the value of an element is encapsulated by a start tag and end tag that contains the name of the element. An example of an XML element used in aviation is an aircraft ID named “AcID”, and the associated value of the element is the tail ID of a given aircraft (see Figure 19). XML ensures that XML documents and the elements described within are “well-formed”, thus ensuring that the documents can be properly parsed by any computer application which is decoding the data. . [69] [70] [71] [72]

```xml
<asdiMessage sourceFacility="CCZY" sourceTimeStamp="2009-09-21T12:34:31Z" trigger="TZ">
  <trackInformation>
    <nxcm:aircraftId>MES3455</nxcm:aircraftId>
    <nxcm:speed>400</nxcm:speed>
    <nxcm:reportedAltitude>
      <nxce:assignedAltitude>
        <nxce:simpleAltitude>360</nxce:simpleAltitude>
      </nxce:assignedAltitude>
    </nxcm:reportedAltitude>
    <nxcm:position>
      <nxce:latitude>
        <nxce:latitudeDMS degrees="42" minutes="12" direction="NORTH"/>
      </nxce:latitude>
      <nxce:longitude>
        <nxce:longitudeDMS degrees="076" minutes="16" direction="WEST"/>
      </nxce:longitude>
    </nxcm:position>
  </trackInformation>
</asdiMessage>
```


Figure 19: Sample of ASDI XML feed

The ASDI data feed has been provided in multiple data formats since it was first introduced. Prior to 2008, the data delivery was via a proprietary format that required vendors to implement an interface that could decode the ASDI field header and data payload information. However, in 2007, the ASDI feed was migrated to a format utilizing XML. XML is an industry standard, which specifies data files known as XML Documents. XML Documents define the behavior of the computer programs that parse the documents for their contents. XML specifies the meaning of data by declaring an element. The name of an XML element typically describes the attribute logically, and the value of an element is encapsulated by a start tag and end tag that contains the name of the element. An example of an XML element used in aviation is an aircraft ID named “AcID”, and the associated value of the element is the tail ID of a given aircraft (see Figure 19). XML ensures that XML documents and the elements described within are “well-formed”, thus ensuring that the documents can be properly parsed by any computer application which is decoding the data. [73] [74] [75] [76]

The ASDI XML feed is provided to approved vendors by establishing a TCP/IP socket connection to an ASDI server, located in the TFM Production Center located at the WJHTC, New Jersey (see Figure 20). There are two ASDI servers in order to provide redundant connectivity options in the event that one of the

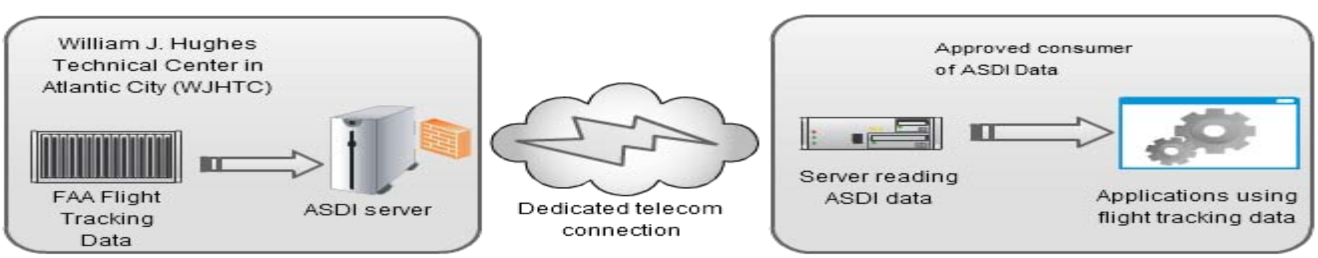

Figure 20: Connectivity to ASDI data center

servers becomes unavailable [77].

Currently, several commercial vendors utilize ASDI data to provide flight-tracking information via the Internet, an example of which is http://www.flightlite.com. Additionally, vendors may repackage the flight tracking data provided within the ASDI feed and provide it to their own clients via an XML feed. As an example, Flightwise provides a product named PlaneXML which allows clients to consume real time flight tracking data based on the Flightwise XML specification rather than connecting to the ASDI servers directly (see Figure 21). [78] [79]

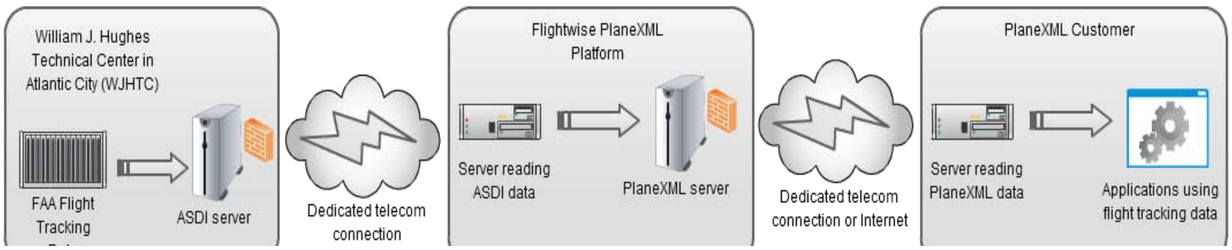

Figure 21: Redistribution of ASDI data by a vendor

The flight tracking data provided within the ASDI feed is radar-based, which is a passive tracking system that has limitations for tracking planes that are close to the ground or on the ground, or in areas that do not have sufficient radar coverage. Incorrect aircraft location also temporarily occurs due to the presence of birds or precipitation in the radar field. As mentioned previously, the NextGen initiative's ADS-B satellite-based tracking system provides data that is more precise than existing radar-based solutions. The ADS-B flight tracking data is real-time, is actively updated from a transponder located on each aircraft once per second, and does not suffer degradation based on terrain or poor coverage areas. [80] [81] [82] [83]

It is currently possible to take in ADS-B data being transmitted aircraft with an ADS-B receiver and use this data to provide a real-time display of aircraft location. An Australian web site, Flight Tracker, provides ADS-B derived flight tracking data in the Sydney area by parsing the raw data output of an ADS-B receiver and plotting the latitude and longitude data onto a map using an Application Programming Interface (API) provided by Google. [84]

As the implementation of NextGen is still in progress, not all aircraft will have ADS-B transmitters in the immediate future. Currently available 406 MHz ELT beacons equipped with GPS can provide the location of a downed aircraft upon activation. Integrating the ELT beacon information into the XML feed along with the ADS-B location data would provide accurate, satellite-based location information for all aircraft in possession of these devices. [68]

iii. Generating a Crash Alert

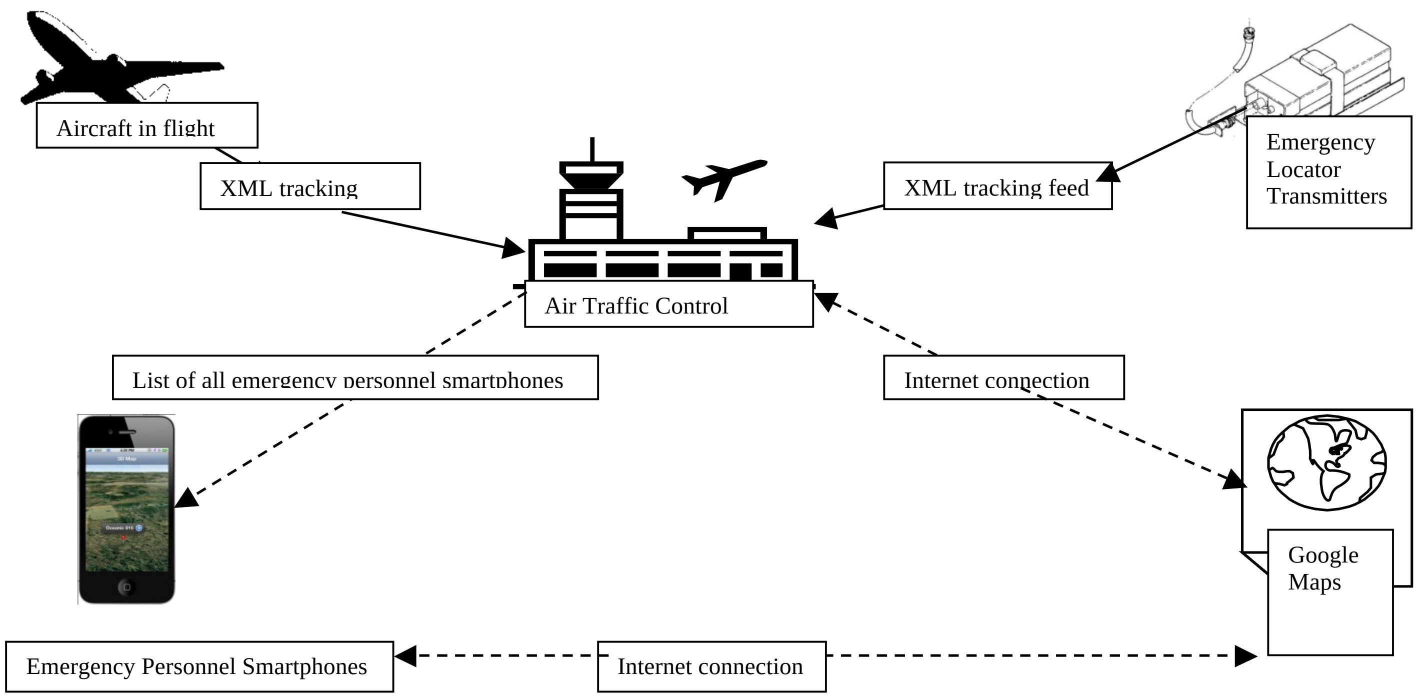

Figure 22: How a crash aircraft alert is generated

The proposed computer system will receive tracking information from the ADS-B system as well as conventional radar-based tracking systems and make this information available to the computer systems in air traffic control towers (ATCTs) in the form of an XML data feed as described previously (see Figure 22). This feed will be similar in format to the existing data feeds provided by the FAA to approved commercial vendors. However, in addition to the location data, it will also include other information about the aircraft such as the type of craft and the number of passengers on board the flight. It will also include information on all aircraft currently being tracked in the United States instead of only commercial flights.

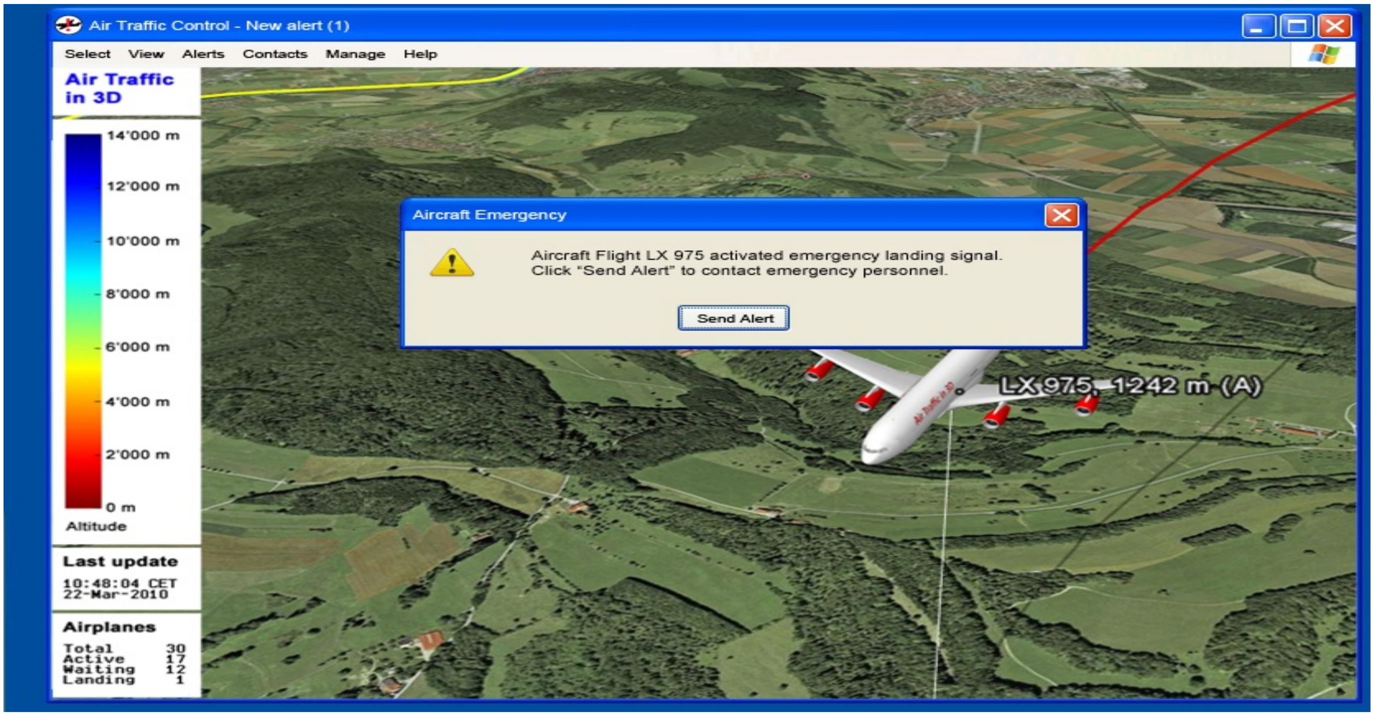

Figure 23: Air traffic control tower computer program with alert

The ATCT computer program will run in the background and automatically monitor the tracking data feed for any anomalies. If any plane ceases moving in a location some distance away from a registered airport, or if the tracking data from a particular aircraft is suddenly cut off, a possible crash alert will be generated on the computer screen in the ATCT of the closest airport to the potential crash site (see Figure 23). This alert will include all available information about the airplane, including its last known position. If multiple airports are determined to be approximately the same distance from the potential crash site, then the program will alert the ATCT at all of the airports in question and will contain an additional notice prompting the human air traffic controllers to the other airports to coordinate a response to the incident. The additional notice will also contain contact info/call-signs for the control towers at the identified airports to simplify the process of communicating between airports. In either case, if the air traffic controllers determine that the alert is likely to be accurate, they will then proceed to the second phase of the proposal as outlined in the next section, if not, they will simply close the alert.

In addition to the tracking data feed, the proposed system will also provide an XML feed of all currently activated ELTs that are being tracked by the NOAA. The ATCT computer will monitor this feed in the same manner as above and will again generate an alert at the airport that is closest to the location being transmitted by the beacon. However, because there is already an established procedure in place to respond to activated ELTs, alerts generated by this portion of the program will require a slightly different response than the alerts produced by the tracking data. [85]

In the United States, the NOAA maintains a database of 406 MHz ELT registrations, and operates the United States' portion of the international Cospas-Sarsat distress signal monitoring system. When a registered 406 MHz ELT activates, the Cospas-Sarsat satellite system decodes the distress signal containing the owner’s information. NOAA then transmits the information to the appropriate RCC. When a RCC receives the alert, it assumes overall responsibility for the search and rescue as designated by the National Search and Rescue Plan. The United States Coast Guard is responsible for maritime search-and-rescue (SAR) operations and the United States Air Force is responsible for inland SAR. [85] [86]

When an ELT signal is detected, the RCC alerts the appropriate airports and law enforcement agencies and SAR operations are initiated. With the current methods, there is no simple way to transmit the relevant data to the ATCT at the relevant airport, but with the proposed system in place, the ATCT will already have all the information that is available from the RCC and will be able to act immediately once the alert has been received. Also, as mentioned previously, the proposed program in the ATCT will automatically determine the closest airport to the location of the distress signal, eliminating the need for the RCC to perform this task. [86]

iv. Responding to an Alert

Once an alert is received by the ATCT at the appropriate airport, the air traffic controllers there will be able to decide whether to send the information to the emergency crews. This requirement for human verification of the possible crash alerts offers many advantages, the most important of which is greatly reducing the possibility of a false alarm alert resulting in a full-scale SAR operation being initiated. This approach will also allow for the possibility of contacting SAR teams that are not located on the airport itself to assist with the emergency response. It will also result in a much more flexible response to take into account what kinds of resources are available and what type of conditions are likely to be encountered by the

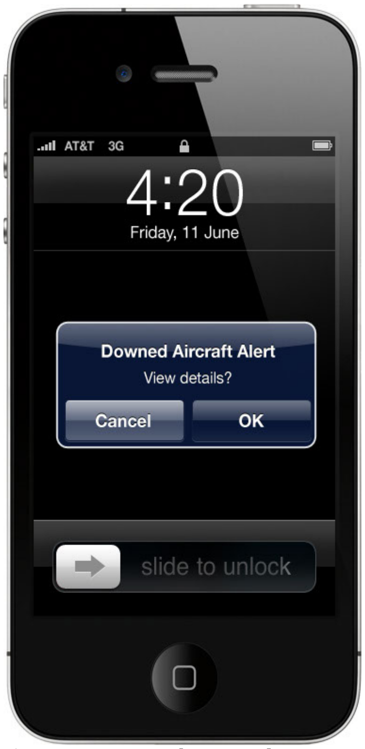

Figure 24: Smartphone application downed aircraft alert

SAR teams in the local area. This human aspect of the response will also permit the air traffic controllers to work within existing procedures for responding to different types of crashes while taking advantage of the greater accuracy and timeliness of the data provided by the new system.

Additionally, the requirement that the air traffic controller will have to approve a response will prevent sensitive information about the location of the aircraft from being transmitted in any form to any device unless it is absolutely necessary. This vastly reduces the amount of data being transferred and thus reduces the possibility of the data being intercepted by a group with malicious intent.

If the air traffic controller determines that the alert is likely to be accurate, they will then send the information included in the alert to the application on a Smartphone that will be provided to airport emergency crews as part of this proposal. The application will display the relevant information on the screen and will include a button that the emergency personnel can touch to get directions to the crash site.

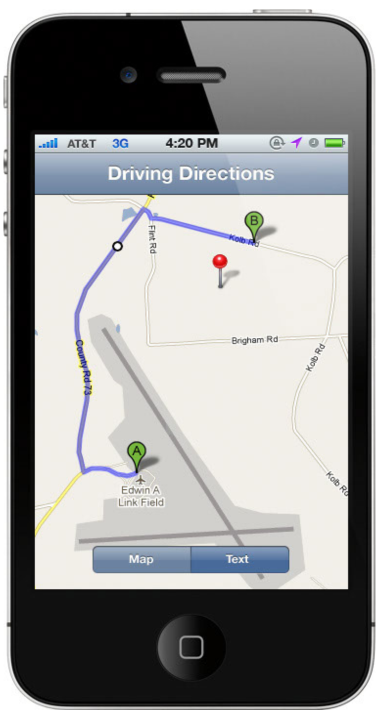

Figure 25: Application displaying directions to the crash site

v. Getting to the Crash Site

Once an alert is received by the Smartphone application (see Figure 24), it will use the latitude and longitude information received from the ATCT program to pinpoint the precise location of the downed airplane. The SAR team members can simply touch a button and all the known information about the aircraft and crash will be displayed. This approach is much faster and more efficient than the current method of responding to crashes near an airport, which involves the air traffic controller using a large physical grid map of the area surrounding the airport to manually determine where the crash is located. The controller is then required to contact the SAR team and tell them the grid

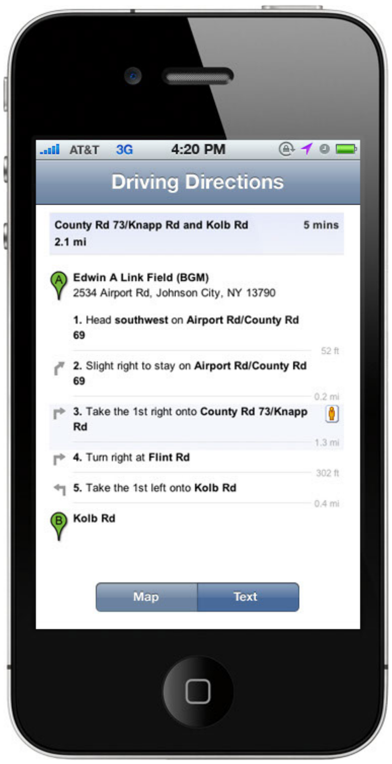

Figure 26: Application with turn-by-turn directions to the crash site

coordinates for the crash site. After this, the SAR team has to go to their own physical map and find the appropriate coordinates on the grid. This is a slow and inefficient method of transmitting the location of the crash site and the large human component of the process introduces many possibilities for errors in communication, which cause further delays.

The proposed application eliminates the possibility of an error in communication between the tower and the SAR team causing a delay by entirely removing the task of explaining where the crash is located from the air traffic controller. The ATCT computer and the Smartphone handle all of the communication aspects of the exchange and the controller is merely required to coordinate the response instead of also having to explain where the crash site is located.

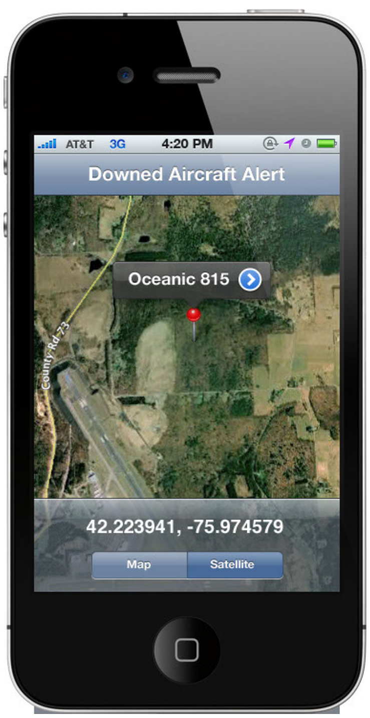

Figure 27: Application displaying satellite photography of the crash

The proposed application will also use the location data received from the ATCT computer to generate accurate directions to the crash site by using the free Google Maps application by Google that is available on all major Smartphone operating systems (see Figure 25). Google Maps provides a robust, reliable, and readily available API that will allow the proposed app to display terrain maps, road maps, and satellite photographs of the entire United States. The directions provided by Google Maps on a Smartphone are similar to those provided by commercially available dedicated GPS devices and are highly accurate (see Figure 26). If the crash site is located away from a public road, Google Maps automatically provides directions to the nearest road. Once SAR teams reach this location, they can use their Smartphone's to determine where they need to go once they are off the road and the terrain maps and satellite imagery provided by Google Maps will allow them to easily determine the best route to the crash site (see Figure 27). [87] Although the satellite imagery in remote areas may have reduced detail, the information provided by the various types of maps available will greatly reduce the amount of time required to reach the site.

To allow the airport SAR teams to perform a smoother transition to the new application, if the crash site is located in the area covered by the existing grid map, the application will overlay a representation of the grid on top of the mapping service. This ability will allow emergency personnel that are accustomed to using the old grid layout to still be able to use it if they so desire.

Because the location information and directions are sent and displayed instantly, the SAR team can immediately begin determining what type of equipment will be needed for an appropriate response. The terrain and satellite maps of the area surrounding the crash site that will also be immediately available will enable to them to perform this task more efficiently because they will know exactly what type of terrain they are likely to encounter once they arrive on the scene.

Although this proposal was designed to use the Google Maps service, the proposed application can be easily adapted for use with any mapping application based on desirability, feasibility, or whatever factors the FAA or rescue workers deem necessary for consideration. Regardless of the mapping service used, SAR teams will be able to instantly pinpoint the location of a downed aircraft no matter how remote the crash site. They will also have immediate access to precise turn-by-turn GPS driving directions to the crash site, similar to what is already available with consumer GPS devices. The application automatically determines the best route to the crash site with no human input required.

vi. Additional Aspects

As mentioned previously, airport SAR teams currently view paper maps to identify the location of downed aircraft. A grid imposed over the map allows the rescue teams to coordinate the location with a descriptor of the form XY, where X may be an alphabetical character and Y may be a numerical digit, i.e. B4. here are often several maps detailing each location within the area, forcing the rescue team to flip B4. There are often several maps detailing each location within the area, forcing the rescue team to flip through the papers to find the specific map for which they are searching. This is a process very wasteful in regards to time consumption when in such a time-critical mission. To remedy this problem, this aspect of the proposal involves replacing the cumbersome paper map with a whiteboard in the ATCT or the emergency response headquarters onto which a projector would display a topographical view of the area in a three dimensional (3D) map (see Figure 28).

The projector will be connected to a computer and will display an advance mapping application such as Google Earth to provide an interface to manipulate and navigate about the map shown on the display. The 3D map will show the local area surrounding the airport, with an indicator showing the precise location of any downed aircraft within the grid. Regardless of whether the mapping application is running on a computer or a tablet or Smartphone, the operators can use application to navigate quickly and efficiently about the map very precisely. The 3D display also allows the operators to view the terrain as it actually exists in reality, rather than attempting to mentally translate two-dimensional elevation lines on a topographical map.

Because the display projects onto a whiteboard, the operators are able to mark the map freely with notes, potential travel routes, landmarks or important locations, or other information of interest. After a particular task related to the map is completed, they can easily wipe it down and start again. The mapping application will also have the existing grid layout for the airport overlaying the map as previously outlined in the description of the Smartphone application. Its purpose will be the same, to identify specific locations with XY coordinates. If a whiteboard and projector solution is not feasible, a large liquid crystal display (LCD) television displaying the same map will achieve similar results, albeit without the ability to notate the displayed map.

Unexpected terrain obstacles are among the biggest challenges faced by rescue teams today. Using the topographical 3D satellite-generated maps, the controllers will be able to review the location of any potential crash sites and alert the rescue teams of any terrain challenges they may encounter. Airports in areas such Binghamton, New York face the problem of being located in a hilly, forest-rich area, which causes seemingly direct routes to take unexpected turns. This could very easily result in a situation where the SAR teams are told the crash site is in location B4 but when they arrive there, they find out they are on the wrong side of a hill, necessitating a time-consuming trip around the hill to the correct site. A mapping application would permit the controllers to anticipate such obstacles beforehand and allow the rescue teams a chance to better prepare for the terrain surrounding the crash site.

vii. Data Security

The last aspect of this proposal involves the security of the potentially sensitive data being transferred between the various devices in the system. Since real-time information of where aircraft are located could potentially be used for malicious purposes, all information being sent by any component of the proposal will be encrypted while in transit using a modern encryption standard such as the Advanced Encryption Standard (AES) used by the United States government. The proposal will also make use of the Secure Hypertext Transport Protocol (HTTPS) when transferring data over the public internet to ensure that sensitive information cannot be retrieved even if the communication is intercepted while in transit. HTTPS is already widely utilized by commercial websites to ensure that customer information such as credit card numbers remains private and it enjoys near-universal support across the computing industry. Additionally, AES encryption support is built in to all major personal computer and Smartphone operating systems, enabling the proposed applications to make use of the standard with little or no difficulty.

As an additional layer of defense to prevent information from falling into the wrong hands, the Smartphone application will only be distributed to Smartphone's issued by the FAA and will not be transferred over the public internet at any time. In addition, as outlined previously, the application will not be able to access the XML location data feed at any time and will only be able to receive the potential crash alerts if the air traffic controllers decide that it is necessary to send the alert to the Smartphone. This will effectively limit the amount of information available to a stolen Smartphone and will also reduce outright the amount of information being transferred by the system.

Finally, all modern Smartphone operating systems provide a suite of security services such as password protection to a central controller They also offer the controller the ability to erase the phone remotely in a process called remote wiping. The most popular operating systems currently are

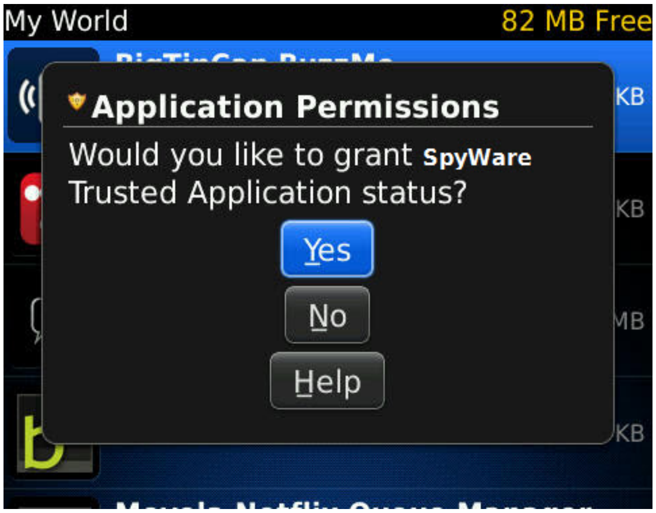

Figure 29: Blackberry security options. Source: [121]

Research in Motion (RIM)'s Blackberry, Apple Inc.'s iOS (formerly iPhone OS), and Google's Android. Of these, Blackberry is already widely used by businesses to provide their employees with the ability to securely login to business email accounts and other services on a corporate intranet from anywhere in the world. RIM also specifically designs many of their phones to meet government mandates for security and several of them are capable of meeting the requirements of the Department Of Defense for Public Key Infrastructure and Secure/Multipurpose Internet Mail Extensions. Additionally, Blackberry provides built-in functionality to encrypt all content of a communication through all points between the sender and the receiver. Furthermore, Blackberry provides administrators with the ability to prevent applications from accessing sensitive areas of the operating system (see Figure 29). All of these security features together would make it highly unlikely that flight data and location information could be intercepted in transit to the phone. [88] [89]

Although iOS and Android are not currently as widely accepted in the corporate world as Blackberry, both operating systems provide security features with a wide-ranging functionality. Both iOS and Android have the ability to encrypt data for transmission and they both provide features such as remote wipe and password protection enforcement. However, they largely lack the advanced security features available on Blackberry such as the above-mentioned ability to restrict applications' access to the operating system. Despite this, the security features they do have, particularly relating to communication with a remote server, will be adequate to prevent location data and other information from falling into the wrong hands. [90] [91] [92]

VII. Description of Interactions with Airport Operators

In order to obtain expert opinions and analysis regarding the project the team interacted with various aviation industry professionals. These professionals helped the team solve issues with the project and helped shape the design. A large part of the team's industry collaboration was with Chad Nixon, Vice President of McFarland Johnson, Inc., and Carl Beardsley, Commissioner of Aviation for the Greater Binghamton Airport. Figure 30 lists the industry professionals the team contacted throughout the project.

Airport Operators and Industry Professionals		
Carl Beardsley	Greater Binghamton Airport	Commissioner of Aviation
Chad Nixon	McFarland Johnson, Inc.	Vice President
Christopher Oswald	ACI-NA Safety and Technical Operations	Vice President
Jose R. Ruiz	Southern Illinois University Carbondale	Associate Professor Aviation Management and Flight
John Greaud	Memphis International Airport	Vice President of Operations
David Hickling	Greater Binghamton Airport	Deputy Commissioner of Aviation
Richard L Lucas	McFarland Johnson, Inc.	Airport Planner

Figure 30: Table of industry professionals that contributed to the project.

The project leader, Victor Yevtukh, continuously met with Vice President Nixon and Airport Planner Richard Lucas of McFarland Johnson, Inc. The procedures that command and control takes when there is an emergency and the efficiency of emergency communication and methods were discussed at these meetings. Victor, Mr. Nixon, and Mr. Lucas also went over the technology used to locate aircraft, including the NextGen system, the ADS-B system, beacon systems, and the ELT, as well as incorporating ELT data in the app. With this device, the team gained valuable information to continue developing the project.

The team worked at the BGM with Commissioner Beardsley and David Hickling to acquire a deeper understanding of how airports respond to downed aircrafts (Figure 31). The procedures that the airport undertakes when there is a distressed aircraft in its airspace were described.

The team also studied the emergency response equipment stationed at BGM including the Oshkosh fire and rescue trucks (Figure 32), the electronic equipment available inside the emergency response vehicle (Figure 33), emergency locator grid maps (Figure 34), and other maps (Figure 35). The team decided that the phone app would be a great asset for reducing response time to downed aircraft and potentially saving the lives of injured passengers.

Figure 31: Team members worked with Commissioner Beardsley at the Greater Binghamton Airport.

Mr. Nixon assisted team members on site at the Binghamton University campus to discuss the project (Figure 36). Additionally, several team members met with Binghamton University President Peter Magrath, Vice President Brian Rose, Mr. Nixon, and Professor Ziegler as shown in Figure 37.

Figure 32 Team members inspect an Oshkosh fire and rescue truck at the Greater Binghamton Airport.

At one point during development of the project, the idea was proposed that the pilot should have the phone app in order to help locate the plane; however, following discussions with Mr. Nixon, the team determined that there was a high probability that the pilot's phone might not operate following a severe crash.

Figure 33: Team members examine the interior electronics of an Oshkosh fire and rescue truck.

In addition to the industry professionals local to the Binghamton, NY area, the team sought independent professional advice through three outside experts. The first contact was Christopher Oswald, Vice President of ACI-NA Safety and Technical Operations. Following discussions with Mr. Oswald, the team determined that the app could fundamentally improve the way that rescue crews respond to emergencies, and minimize the risk of miscommunication between rescue crews. It was also recommended that the app should work with existing technologies that rescue crews

Figure 35: Team members study the Greater Binghamton Airport's grid map.

Figure 35: Team members view the different maps used by the Greater Binghamton Airport emergency response team.

Figure 36: Team members meet with Chad Nixon during his executive visit to Binghamton University.

currently use, such as geographical information systems, for a more fluent transition to the new technology.

A second professional that was contacted was John Greaud, Vice President of Operations at Memphis International Airport. The exchange with Mr. Greaud led to the conclusion that the app needed to have off-road direction capabilities in case rescue crews could not directly access the aircraft from the road.

Mr. Greaud suggested that if the phone app were to be developed, that it be securely distributed to avoid providing information to people who could interfere with the rescue effort. From Mr. Greaud, the team learned that radar determines the location of downed aircraft neither reliably nor accurately.

Lastly, the team contacted Jose Ruiz, Associate Professor of Aviation Management and Flight at Southern Illinois University Carbondale. Mr. Ruiz questioned if commercial airlines would be willing to release data about their flights and what information would be need to be provided to aid rescue crews. Mr. Ruiz concluded that the app was both innovative and practical.

VIII. Projected Impacts

In summary, the team worked with and/or consulted with seven industry professionals, and even the president and vice president of Binghamton University. Each contact provided a wealth of knowledge to the team.

According to the FAA Portfolio of Goals, the performance target for fiscal year 2010 for the commercial air carrier fatality rate was that the rate would not exceed 8.1 fatalities per 100 million passengers. Additionally, the FAA has a long-term performance target of reducing commercial this fatality rate by half by 2025. The FAA conducts these measures to make it easier for the flying public to understand and measure their individual risk and therefore sharpen its focus on helping air travel become even safer. Furthermore, the FAA portfolio of goals document also stated that approximately 80% of fatal accidents are directly related to some form or combination of human factors. These human errors include misperception errors and judgment and decision-making errors. [93]

Figure 37: Team members meet with Chad Nixon, Binghamton University President Peter Magrath, and Vice President Brian Rose.

The systems in this proposal will directly address some of these issues by automating many of the tasks related to responding to an airplane crash. The ATC computer program removes much of the possibility of human error from the response procedure by automatically determining the location of a downed aircraft and displaying that information to the air traffic controllers. The ability to electronically transfer this information directly to the SAR teams at the airport also reduces the possibility of an error in communication causing a delay and features the additional benefit of being much faster and more efficient than current procedures.[93]

The Smartphone application also reduces the responsibilities of the response teams by shouldering the task of calculating the best route to the crash site. The SAR teams and air traffic controllers are then free to focus on the overall coordination of the rescue efforts without having to worry about how to travel to the crash site. The accurate GPS turn-by-turn directions provided by the application will also allow emergency crews to arrive at the crash site much faster than is possible with current techniques. Additionally, the ability to view terrain maps and satellite imagery of the area around the site will allow the controllers to quickly determine the type of equipment that will be needed for a specific crash and will allow the SAR teams to easily prepare to deal with the challenges posed by different physical environments. All of these improvements will greatly reduce the amount of time that is required for emergency crews to arrive at a crash site. Since the ability to recover from many serious injuries is dependent on receiving treatment very quickly, the reduction in the response time will save lives and by extension will address the FAA's goal of reducing commercial flight fatalities.[93]

Similarly to the above, the FAA has also set an aggressive goal for the reduction of the general aviation fatal accident rate. The performance target for FY 2010 is 1.10 fatal accidents per 100,000 flights hours with the additional long-term goal of reducing the fatal accident rate by 10% over the period 2009-2018. Because the tracking of non-commercial flights is currently not as rigorous as with commercial flights, the possibility of missing a downed aircraft is higher. These non-commercial flights are also not required to fly within as strict parameters as commercial flights and are sometimes not maintained to the same high standards as those required by commercial aircraft. Both of these factors lead to a greater possibility of a crash for general aviation aircraft and increase the difficulty of locating the crash site. Additionally, the fact that these types of planes often lack the advanced safety features present in larger commercial airplanes leads to a greater possibility an accident being fatal. [94]

Although the proposed system will not directly address the number of accidents occurring among general aviation aircraft, it will address the FAA's goal of reducing the fatality rate by making the task of locating and getting to the crash site much simpler. As mentioned in the previous section, the sooner SAR teams arrive on the site, the greater the possibility that any life-threatening injuries to the passengers will be treatable. Also, because the proposal will utilize NextGen technology to track general aviation in the same manner as commercial aircraft, the possibility of an aircraft crashing without anyone knowing where it is located will be greatly reduced. [94]

This proposal will also address the FAA's goal to reduce the number of general aviation fatalities in the state of Alaska in the same manner as above. Although this ability will not address the portion of the goal that focuses on reducing the number of accidents in general, it will greatly aid in reducing the number of accidents that result in fatalities. [95]

As mentioned in the Portfolio of Goals for FY 2010, much of Alaska is an extremely harsh, remote, and untamed wilderness. As such, there are few roads and large portion of the population relies on aircraft as a primary form of transportation. Because of this, a large number of pilots operate small planes that lack the advanced navigation and safety features of more advanced aircraft. This fact, along with the extremely dangerous and challenging operating environment, results in a disproportionally large amount of crashes occurring in the state. Additionally, the remote nature of most of the state makes even locating a crash an extremely challenging endeavor and the lack of roads means that many crashes are not reached for several days. [96]

As outlined previously, the proposed Smartphone application and computer application will address this problem monitoring ELT beacon activations and instantly notifying the appropriate authorities that a signal has been received and where the beacon is located. In the event that the crash site is located near a road, the Smartphone app will provide directions for emergency crews to reach the site. However, even if the airplane did not crash near a road, the app will still provide the exact location of the crash. This location information is absolutely essential if a timely rescue is to be arranged and is especially important in a remote environment such as the one found in Alaska. [96]

In addition to addressing several aspects of the FAA's Portfolio of Goals, this proposal will also aid in meeting several objectives in the FAA Flight Plan for the years 2009 to 2013. Objective one, "Reduce commercial air carrier fatalities", and objective two, "Reduce general aviation fatalities", are rightly focused on implementing updated technology, infrastructure upgrades, and new operational procedures to eliminate the occurrence of fatalities linked to accidents by aircraft operators. The implementation of GPS based technology via ADS-B will allow operators and controllers to safely direct the paths of aircraft while in close proximity to other aircraft, minimizing accidents. [96]

However, in the event of an aircraft accident, timely response of search and rescue teams of an appropriate size is instrumental in minimizing additional fatalities by passengers and crew that survive the initial impact. The use of GPS tracked coordinates provided via NextGen technologies such as ADS-B will provide rescue crews with the same precise real-time location tracking that will allow aircraft operators to operate along more efficient flight paths. [96]

Objective five of the FAA Flight Plan, “Enhance the safety of FAA’s air traffic systems”, includes a strategy to identify and reduce factors contributing to operational errors, while objective six, “Implement a Safety Management System for the FAA”, calls for the implementation of a SMS for all appropriate FAA organizations. Enriching downed aircraft location data with other relevant information, such as the number of persons on the flight, or the amount of fuel on the aircraft, would allow rescue crews to deploy the exact resources that should be deployed for a given incident. Providing rescue crews with the precise directions to aircraft location, passenger count, and fuel volume of a downed aircraft would help eliminate operational errors in the rescue process. Additionally, the standardized adoption of this Smartphone application by all airport rescue crews could fall under SMS for airport regulation and certification as defined under objective six. [96]

As outlined previously, shortening the time from crash to rescue substantially improves the odds for survival. After 24 hours from the time of a crash, the probability of death from serious injury greatly increases. Knowing the location of a downed aircraft significantly reduces the response time of search and rescue (SAR) teams. The average time from the last known position (LKP) to rescue is 42 hours and 24 minutes for an aircraft with no flight plan on file. The average time from the LKP to rescue is 13 hours and 6 minutes for an aircraft with a flight plan on file following Instrument Flight Rules. [97]

The implementation of the proposed system should significantly reduce the response times of SAR operations. The proposed system shall determine the appropriate recipients of the SAR at each phase of the search process data and automatically alert them. By using a computer system to relay information, information is transferred more reliably and efficiently. As a result, the system allows coordinators to process the information sooner. SAR teams can shorten their response time by utilizing the Smartphone app, which replaces time costly paper map analysis and route planning. With latitude and longitude coordinates of the distress signal transmitted to the Smartphone's of SAR personnel, SAR teams can mobilize immediately when the actual search mission is launched. The Smartphone app shall determine the quickest route and provide turn-by-turn directions to the location of the aircraft. With precise coordinates, the Smartphone app can navigate SAR teams to the downed aircraft even when the aircraft is not in view. [97]

With the current state of the FAA methods to reach a downed aircraft, the possibility for human error is at a level that is not desirable for a task that can determine the fate of human lives. Whether it be pinpointing the exact location of the crash, or determining the correct route to the crash site some factors like stress, lacking the skills to determine the best route, misperception errors and many more could all lead to a delay in aiding the injured. With the proposed NextGen surveillance and broadcast technologies in place the methodology currently used to determine the location of the downed aircraft will be obsolete and simply not necessary. As the new technology becomes available the air traffic controllers will be able to view the location all aircraft in real time, thus able to determine where it has landed on the latitudinal and longitudinal grid of the Earth. With the proposed application, that geographical location will be able to retrieved through the same sources and broadcast directly into the application for the rescue team to consume. Not only will the application if implemented increase the speed at which the best possible route to the scene of the crash can be determined, it will fully remove the possibility of human error from the equation. Using an implemented shortest path algorithm there will need to be no human involvement when determine the best path from "point A to point B" and thus saves time of any possible need that the rescue team might have to change paths prior to reaching their destination.

The longer it takes for the airports rescue team to reach the crash site, the more damage is done to both the aircraft itself and the surrounding area, causing the necessary dollars spent to remedy the situation to skyrocket. The proposed application gives the FAA and the individual airports the ability to cut down that time. With one of the ultimate goals of the implementation of the application to cut down on costs associated with downed aircrafts the initial costs estimation for creation and implementation of the application are depicted in the table below. [98]

Application Developed	Number of Developers	Total Hours	$ Per Hour	Total Cost
Twitterrific	Two	1,110	$150	$250,000
The Barack Obama App	Three	500-1000	$100-$150	$50,000 - $150,000

Table 2: Cost estimation

IX. Summary and Conclusion

i. Problem and Summary

The longer it takes a search and rescue team to locate a downed aircraft, the lower the chance of survival for injured passengers. Current methods of locating downed aircraft leave much to be desired: air traffic controllers are able to follow a plane's path in the air by use of radar, but there is little in place for localization at ground elevation. Location of the downed aircraft, especially for non-commercial flights, typically relies on information provided by witnesses to the crash, which provides little assurance as to the accuracy of the information. Moreover, even with a known location, rescue teams still need to overcome geographic challenges such as rivers, forests, deserts, etc., to arrive at the crash site in a timely manner.

The proposal herein, to create a smart-phone application to locate downed aircraft and provide turn-by-turn directions to the crash site was created after a lengthy study of current procedures related to downed aircraft was developed by a team of 26 undergraduate students. The group was split into four sub-teams

(Design Team, Risk Assessment and Research Team, Engineering and Graphics Team, and Strategies and Ethics Team), each of which had specific roles and contributions to the completion of the project.

ii. Overview of the Process

The Greater Binghamton Airport was used as a model to conduct the research phase of the project including on-site reviews of rescue operations and facilities. The entire team worked with the airport commissioner, toured the rescue facilities, and received valuable first hand information, photos, and records. Furthermore, Chad Nixon, Vice President and Aviation Director of McFarland Johnson Engineering Inc., worked closely with the team and provided professional direction and advice. The information gathered from industry professionals helped the team to develop a practical and efficient design.

iii. Alternatives Considered

During the design phase, the team came up with an alternative design of the Smartphone application for locating downed aircrafts that included a publically available shared channel between aircrafts and Smartphone’s. In the final design, the emergency signal from a downed aircraft will be redirected from smart phones in air traffic control towers to appropriate Smartphone’s of search and rescue crews. Although the alternative design sounds more efficient, it risks the air traffic security by publishing the coordinates of the aircrafts. As a result, the alternative was replaced by the final design, which is more precise and secure.

iv. Proposal

The purpose of this project is to provide a more efficient method to locate downed aircraft and to precisely direct the search and rescue team to the crash site. The Smartphone application designed for the project will provide emergency services with an accurate location of the downed aircraft, and then directions to arrive at the crash site as quickly as possible to potentially reduce fatalities.

The Smartphone application is portable, accurate, reliable, cost efficient, low maintenance and very easy to update. The proposed design provides a solution to the FAA's goal of reducing fatalities in aircraft emergencies.

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Appendix B: Description of Binghamton University – State University of New York

The State University of New York (SUNY) consists of over 467, 000 students on 64 campuses [100]. Binghamton University (see *Figure 39*) was founded in 1946 as a branch of Syracuse University. It was brought into SUNY in 1950. It is currently located above the Susquehanna River in the Binghamton suburb of Vestal, NY near upstate New York [101]. Binghamton's mission is "to provide an affordable, world-class education to high-caliber students from culturally and economically diverse backgrounds" [102]. There are currently 11,706 undergraduate students and 3,007 graduate students spread across its six schools; Harpur College of Arts and Sciences, Thomas J. Watson School of Engineering and Applied Science, Decker School of Nursing, College of Community and Public Affairs, School of Management, and the School of Education. With an average SAT score range of 1190 – 1340 the university is both academically competitive and challenging [103]. Binghamton University offers nearly 130 undergraduate and 70 graduate academic majors, and over 30 doctoral programs [104]. Students at Binghamton University, who are involved with any of the 38 club sports on campus, compete against other colleges and universities [105]. The university consists of six residential communities; College-in-the-Woods, Dickinson, Hinman, Mountain View, Newing, and Susquehanna/Hillside Apartments [106].

Figure 38: Students mingle on campus [99].

The 2010 edition of US News and World Report magazine ranks Binghamton University #37th among public universities and colleges and #80th among all universities. The Princeton Review ranks Binghamton the fourth-best value in the nation in its "Best 371 Colleges" listing [107]. Additionally, Forbes places the university at #197th out of 610 colleges in their annual "America's Best Colleges" ranking [108].

Binghamton University's student body is very diverse, with students from 100 different countries and all 50 states. Approximately 75% of students are from New York, while 16% are from the other states and about 9% are international. About 55% of the student body is male, with the remaining 45% female. Students of Binghamton University are also very ethnically diverse. According to the College Board, about 14% are Asian, 9% are Hispanic, 5% are black, 12% are non-resident aliens, and about 51% are white [109]. Many students that attend Binghamton University speak languages other than English, with 36% of students speaking non-English languages in their homes. Students are also academically successful with an average high school GPA between 91-96 for the class of 2013 and an average GPA of 3.4 for incoming transfers. The University maintains a very high freshman retention rate, 90%, compared to the national average of 65.7% [110].

Appendix C: Description of Non-University Partners

McFarland Johnson, Inc.

McFarland-Johnson, Inc. (MJ-Inc.) is an engineering consulting firm established in 1946 and has been the team's primary business partner for this competition. The company's headquarters are located in Binghamton, NY with seven other locations spread throughout Connecticut, Massachusetts, New Hampshire, New York, Pennsylvania, and Vermont. MJ-Inc provides engineering consultation in multiple fields including aviation, bridges, and highways. The company's team of skilled planners, engineers, technicians, inspectors, and analysts provides a wide array of consulting services. In 2010, MJ-Inc. received two Engineering Excellence Awards from both the American Council of Engineering Companies of New Hampshire and Vermont [111]. The company has experience working with varying sizes and types of airports as well as the full design process, from project planning through construction inspection [112]. The New York State Department of Transportation has designated MJ-Inc. as a prime consultant. As such, the company has prepared business plans for 23 separate airports across New York State [113]. MJ-Inc. recently completed a Master Plan update for the Greater Binghamton Airport and currently works with the airport to maximize the efficiency of the newly implemented Master Plan [114].

Chad Nixon, Vice President, Business Development Officer, and Special Projects Manager for aviation projects at McFarland Johnson, Inc., has been instrumental in assisting the team. In addition, Nixon serves on numerous aviation committees and boards of directors. In the past, Nixon has served as an air traffic controller in the United States Navy as well as an airport operations manager and aviation planner. Nixon received his MBA from Embry-Riddle Aeronautical University with expertise primarily on the business side of aviation such as economic analysis and airport negotiations. [115].

Greater Binghamton Airport

The team worked extensively with the Greater Binghamton Airport (BGM). Plans for a new airport in Broome County, NY began in 1944. Construction began in 1945 on what would eventually be The Greater

Binghamton Airport, with an official opening in 1951 [116]. BGM is a medium-sized regional airport located in Maine, NY. It is the premier airport for the area with nonstop flights offered to Philadelphia, Washington DC, and Detroit. The airlines offered at BGM include Delta, U.S Airways Express, and United Express [117]. The airport has two grooved, asphalt runways. The main runway is 7100 feet long, with the secondary runway at 5002 feet [118]. In recent years, BGM has collaborated with Binghamton University and McFarland-Johnson Inc. to work with students entering the FAA Design Competition [119].

Figure 39: Carl Beardsley meets with the team at the Greater Binghamton Airport

Carl Beardsley, the current Commissioner of Aviation at the Greater Binghamton Airport (see *Figure 40*), has played a key role in assisting our team. Commissioner Beardsley previously held the position of Deputy Commissioner of Aviation, nearly eight years, and assumed the role of Commissioner of Aviation in 2005. In September 2010, The New York Aviation Management Association elected Commissioner Beardsley as President of the organization. Commissioner Beardsley has implemented improvements at BGM including a full rehabilitation on the primary runway, worth approximately $30 million, and has been instrumental in securing a major Fortune 500 company to lease a large hangar at the airport.

FAA Expert Advisors

The team contacted several advisors externally. The first advisor is Jose R. Ruiz, Professor of Aviation Management and Flight at Southern Illinois University. The second advisor is John Greaud, Vice President of Operations at Memphis International Airport. The third advisor is Christopher Oswald**,** Vice President of ACI-NA Safety and Technical Operation. The FAA has designated each of the contacted advisors as experts.

Appendix E: Evaluation of the Educational Experiences Provided by the Project

Student Evaluation

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

The FAA Design Competition was an excellent learning experience. The team consisted of 26 students and teamwork was imperative. Each member of the team experienced the importance of communication, finishing assignments in a timely manner, and providing constructive criticism when necessary. Due to the size of the team, sub-teams with team leaders were formed. These team leaders were also exposed to the tasks of delegating and assessing assignments, organizing and leading group meetings, and providing leadership to the team.

There were numerous occasions when the team consulted with industry professionals, via e-mail, phone conversations, and in person. As a result, there were many opportunities for the students to practice professional conduct, which is often overlooked in education. In addition, since the team consisted mainly of computer science students, the smart phone application solution to locating downed aircrafts provided the team with the opportunity to perform research, design, and write a proposal about a project similar to one they might encounter upon graduation. The tools that were learned in this experience have made each team member much more prepared and qualified for working in a professional environment.

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

Throughout the completion of the project, some of the greatest challenges were presented by the size of our team. As a result, one of the obstacles that needed to be overcome was compiling written works from members with very different writing styles, vocabulary, and understanding of English grammar. Even the use of slightly different word processors, including separate releases of Microsoft Word, Word for Mac, and OpenOffice presented complications that needed to be addressed. In order to attend to these stylistic issues, the team decided upon one standard format. All pieces of the project were compiled in Microsoft Word and the content reviewed by the team leaders for consistency in formatting and content flow.

Another challenge was presented by the variety in team member's course schedules. Since team members were full-time college students, varying courses made meeting times difficult to establish. The entire team would meet in class once a week, since the project was part of a two-credit senior computer science course. Then, sub-teams of six students would schedule their own group meetings, in some cases they even had to break the sub-team in half. This also presented a disparity in work load throughout the project. Some weeks certain team members would have midterms, large projects, or just many homework assignments. Team leaders had to be fair when distributing assignments, but also take into consideration that each student also had other responsibilities.

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

The process was a hybrid of group brainstorming sessions and then dividing the work of implementing the results of these sessions. Many of the weekly class meetings were spent discussing the strengths, flaws, and elimination of flaws, in the design. During these sessions, the class worked as a single unit, with individuals getting involved in elements of the proposal in areas outside the responsibility of their group. Then outside of class, different groups would take different aspects of these initial ideas and develop them. Whenever specific questions were raised or details could not be found, contact with industry advisors helped resolve them.

This process proved to be very successful, both in developing ideas, and in contributing to a sense of one team made up of different but equal parts, rather than a loose collection of smaller groups. Every group brought unique perspectives to the project and in the end, all of these ideas created a robust and complete proposal.

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

The interaction that the team had with industry partners and experts was invaluable to the development of the proposal. There were multiple occasions where the team or team leaders met with experts, including Carl Beardsley of the Greater Binghamton Airport (see Figure 41) and Chad Nixon of McFarland Johnson. Both Mr. Beardsley and Mr. Nixon provided the team with an understanding of the current protocols surrounding an aircraft accident. These insights were integral to the design of the application, because the team wanted the solution to incorporate and expand on current procedures. In addition, several other experts were contacted with details about the project's proposal and they provided the team with additional considerations. These ideas added depth to the project and made it more practical for use in airports.

Figure 40: meeting with Carl Beardsley at Greater Binghamton Airport.

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?

The work that went into this project has given the team a much better understanding of the process of developing a product. Throughout many educational experiences, understanding individual concepts is stressed, without much thought to a larger picture. However, with this project, individual concepts could not be considered in isolation. Every aspect of the product and its impacts had to be considered. This proposal contains various sections outlining the basic concept, specific details of the design, risk and safety assessment, communication with industry, cost analysis, visual aesthetics of a proposal, and much more. Understanding and having experience with all of these tasks will be valuable for entry into the workforce.

Even those who intend to pursue graduate school, rather than entering the industry, acquired valuable skills. Throughout the development of this proposal, much research had to be put into many different technologies associated with smart phones, existing applications, GPS systems, ELTs RADAR, and current protocols. After obtaining a sufficient background in each particular area, the team had to come up with a creative and effective solution to the downed aircraft problem. These tasks are consistent with those needed to effectively propose a research problem and work towards its solution in graduate school.

Faculty Evaluation

1. **Describe the value of the educational experience for your student(s) participating in this Competition submission.**

Real world experience can never be gained by sitting in a classroom. Several of my students participating in this competition have never even been on a plane; most have never consulted with experienced professionals, nor ever had to solve a technical problem that did not come out of a textbook. Certainly none of them ever experienced the once-in-a-lifetime experience of examining behind-the-scenes technical operations at an airport. They have never had to perform real research on a topic they began knowing nothing about, they have rarely worked in teams, and they have never had to collaborate with so many individuals. When they can learn and experience all of those lifelong skills by working on this project, then they truly have had an educational experience that is simply immeasurable in value.

2. **Was the learning experience appropriate to the course level or context in which the competition was undertaken?**

When I describe the project that my students worked on for the FAA competition, people are quite surprised that the primary goal of the project is to make my students better communicators. The competition was undertaken as a class project in a required senior level undergraduate course titled Professional Communication and Ethics. The course is intended to bridge academe and professional practice within the themes of communication and ethical decision making. The students in this project are stretched far beyond their comfort zone, but the learning experience presented by the FAA competition is exactly what should be expected of all students as they approach graduation.

3. **What challenges did the students face and overcome?**

There were four primary challenges that the students needed to overcome. First, the students are all undergraduate computer science seniors with no experience relating to air travel, airports, aviation, etc. However, they are experienced at problem solving, research, and communication, which are the foundations of the competition. Their lack of experience relating to the aviation industry took them far from their comfort zone and that was quite a challenge for them.

The second challenge was that of communication. The student team consisted of over 20 students, far too many for such a project. However, as the students learned, sometimes you have to seize the moment when opportunity arises, and the FAA competition was such a moment. As I tried to explain to the students, you do not always get to work on the ideal team, the perfect team size, or the perfect project; the idea is to learn and adapt as you go. They will realize later that the technical and communication challenges they faced on the FAA project prepared them well for the future.

The third challenge was that of motivation, and the methods to deal with the students who fall into the category of the *weakest links*. Some students are content to just *get by*, while others are striving for perfection. The challenge is how to deal fairly with the two extremes, especially in a competitive situation, where the weakest links can bring down the entire team. As a professor, I constantly face the reality that students rise or fall to their own motivations. However, for this competition, my role as professor turned into more of the role of a coach. I refused to allow the unmotivated students to bring down the rest of the team to their level, which required several very uncomfortable discussions with various individual students and teams during the project. There were times when I am sure that some of the students were not happy that I was making them rise to their true abilities. In the end, I hope they have learned the true meaning of teamwork and responsibility, and to take pride in their work.

The fourth challenge is getting all students on the team to understand the value of the FAA project. I do not think that all of the students grasp how real this is and how this competition will prepare them for the realities that will face them, once they leave college. I try to follow the saying, "*keep talking, they'll listen*", but I wish they knew how valuable this experience is for them, right from the start.

4. Would you use this Competition as an educational vehicle in the future? Why or why not?

I am already making plans to enter my students in the competition next year. This has been a fabulous experience for not only the students, but also our aviation partners who assisted us in the competition, our local community, the university, and of course for me. I have reviewed and analyzed every action and decision throughout the competition with the goal of making the experience for my students even better the next time around.

5. Are there changes to the Competition that you would suggest for future years?

The FAA competition is by far the best-organized competition I have seen in my 33 years in higher education. Because my students are computer scientists, this competition was quite a stretch for them. However, the educational value and experiences presented by participating in the competition is simply unmatched anywhere else, so I am willing to go the extra effort to bring my students up to speed, just to be able to participate.

Because my students have submitted six proposals to the FAA competition in the last three years, I worry that fresh ideas regarding the topics listed in the competition guidelines may get more difficult for those of us who are regular competitors in the competition. I do not want my students to work on any projects that have been submitted to the FAA competition in the past, because I feel it will be too easy for them to use existing information rather than starting from scratch. I also do not want it to appear that we were copying ideas that had already been presented at some earlier time. I am not sure what can be done by the FAA to avoid this situation, but if the list of topics was expanded, that may help.

Regardless of any changes in the list of topics, I am looking forward to having my students compete again next year.

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Appendix G: Photo Gallery



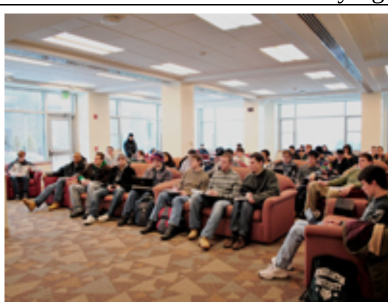
Team members working with Commissioner Beardsley at the Greater Binghamton Airport



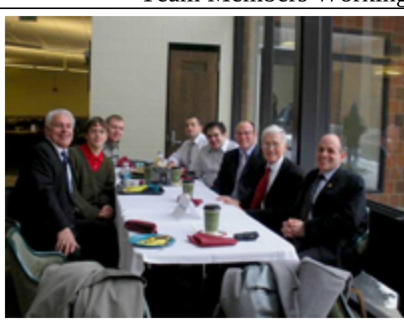
Studying rescue procedures and equipment at the Greater Binghamton Airport



Studying rescue operations at the Greater Binghamton Airport



Team Members Working with Industry Professional Chad Nixon at Binghamton University



Left: Team meeting with Chad Nixon, Binghamton University Interim President Dr. C. Peter Magrath, and Vice-President Brian Rose

Right: Team leaders working together outside the class

Appendix H: Ethical Considerations

The use of a Smartphone app to locate a downed aircraft would have a positive impact on air travel with few drawbacks. By quickly providing emergency responders with the location of a downed aircraft and the most direct route to the scene, the response time can be greatly reduced. Getting emergency responders to the scene faster will allow more time to treat serious injuries before they prove fatal. The risk for loss of property will also be diminished as dangerous situations, such as fires, will be counteracted quicker. These improvements also have the potential to reduce the liability concerns of rescue crews that could result from a slow response.

Another ethical benefit of using a phone app is the low cost of equipment. Smart phones are becoming increasingly popular while the prices continue to drop [120]. The computing power of these devices is also constantly improving. The use of a Smartphone app and existing cellular networks avoids the costs associated with purchasing specialized equipment for emergency response units and building support infrastructure. Instead, each mutual aid company would need a minimum of one smart phone to run the app on. It would also be possible for each individual responder to have a phone with the app installed.

In contrast to the potential benefits, the drawbacks of using an emergency phone app are minimal. Privacy and security are issues, as the phone app would make information about active aircraft more accessible. The information is not highly sensitive and is only made available to approved vendors over secure connections. During an emergency situation, the air traffic control tower will make the information available to the app. This prevents unauthorized individuals from receiving information during normal operations.

The ethical benefits of using a Smartphone app to locate downed aircraft far outweigh the potential drawbacks. Faster emergency response times will provide greater protection for the public and property while reducing liability concerns of emergency responders. The use of existing cellular infrastructure and devices will reduce costs while increasing availability to emergency response units. Data about active aircraft would be more accessible, but can be kept secure though security measures included in the system.

Appendix I: Biographies

Joel J. Brandhorst expects to graduate in May 2011 from Binghamton University with a BS in computer science. He previously worked as a project manager for software firms in the securities trading industry. He is a member of Upsilon Pi Epsilon (UPE), the international computer science honor society.

Anthony Canino is currently pursuing a BS in computer science at Binghamton University, with an expected graduation date of May 2011. He is a member of UPE. He is involved in grid computing research with Prof. Michael J. Lewis and Prof. Brent Rood. His professional experience includes two Research Experiences for Undergraduate Students: one pursued at Binghamton University and the other at the University of Notre Dame. He is currently interning as a software developer at Diamond Visionics in Vestal, NY, a company devoted to developing “Virtual Worlds in Real Time”. He will be attending graduate school and pursuing a PhD in computer science.

Edward Cheung is an undergraduate student at Binghamton University, pursuing a BS degree in computer science. He is currently the vice president of the Association for Computing Machinery (ACM) at Binghamton University, and the secretary for UPE at Binghamton University. Previously, he was an IT intern at the Walt Disney Company in Orlando, Florida. His primary career objective is to become a prominent software engineer.

Andrew Cholewa is currently studying mathematics and computer science at Binghamton University, with an expected graduation date of May 2012. He intends to pursue a PhD in either mathematics or computer science after graduation. His research interests include algorithm design and formal language theory. He is a member of the Binghamton University Scholars Program and the UPE. He is a recipient of the 2010-2011 Lockheed Martin Honors Scholarship for Computer Science.

Nicholas S. Ciaravella is a senior at Binghamton University pursuing a double degree in computer science and mathematics. He is a member of UPE and the ACM. His research interests consist of cryptography, steganography, information security, and digital forensics. His hobbies include ice hockey, tennis, programming competitions, and digital photography.

Osman Dandia is currently pursuing a BS degree in computer science from Binghamton University in New York. He is working at Wilson Hospital, United Health Services, doing work as a mainframe operator / IT help desk representative. He will spend summer 2011 as a software developer intern at IBM in Endicott, NY, and will be graduating in fall 2011.

Jonathan A. Delanoy received an AS in computer science from Broome Community College in Binghamton, New York in fall 2010. He is currently a full-time student at Binghamton University in Binghamton, New York, from which he expects to receive a BS in computer science in December 2011. His primary areas of interest include machine learning and network security. Outside interests include horseback riding and cycling.

Mark Delanoy is an undergraduate student at Binghamton University. He is pursuing a BS in computer science. He completed three semesters at Broome Community College prior to transferring to Binghamton University. His primary fields of interest are in information technology services, security, web design, and maintenance. He is planning to graduate in fall 2011 and expects to pursue a career in information technology services.

Christopher J. Ellsworth is currently a full-time student at Binghamton University. He is scheduled to graduate from Binghamton University in May 2011 with a BS in computer science and a BA in biological sciences. In 2010, he spent the summer and winter as an intern at the Secure Decisions division of Applied Visions, Inc. in Northport, New York, where he contributed to the development of a DARPA-funded cyber security product. He currently holds the position of public relations coordinator at Off Campus College Transport, Inc., the university's student-run bus company, where he strives to expand the availability of information in electronic form.

Seth Engel is currently a senior studying computer science at Binghamton University. He is a member of the UPE. His academic interests include networking, computer graphics, and software design. His personal interests include video games and ping-pong.

David Foley is a senior at Binghamton University studying computer science. He plans on graduating in May 2011 and then pursuing a MS degree in computer science. His research interests are machine learning and mobile/electronic learning. In his spare time, he enjoys playing games and sports.

Justin Fyffe is currently a full-time student at Binghamton University and is planning to receive a BS in computer science in May 2012. In summer 2010, he worked as an application developer for Progressive Insurance. He will be working as an intern financial software developer at Bloomberg L.P. in summer 2011. His passions outside of education include website development, video games, and researching new technologies.

Kevin Hannon is an undergraduate computer science student at Binghamton University. He is currently employed by the Multimedia Computing Research Lab at Binghamton University as an undergraduate researcher. Additionally, he is currently a member of ACM and has competed for Binghamton University in the International Collegiate Programming Contest. In his free time, he enjoys playing the trumpet and is a black belt in karate.

Nick Kovurov is a full-time student at Binghamton University. He is expected to graduate from Binghamton University in May 2011 with a BS in computer science. In summer 2010, he worked as an intern in web development and database management for the North Shore Long Island Jewish Health System. His passions outside of school include web design, film development and basketball.

Si L. Lai is currently a full-time undergraduate student at Binghamton University. She expects a BS degree in computer science and a BA degree in mathematics from Binghamton University in May 2011. She was hired by NextSource as a consultant to work in New York Life Insurance Company in Corporate Information department from May 2010 to August 2010. She worked in the department of Technology Infrastructure in CITI Bank (China) from June 2009 to July 2009 as an intern. She also worked in the Computer Science department of Binghamton University as a course assistant from September 2009 to December 2009. Her primary interests are database management, information retrieval, and computer security.

Jyoti Lakhani is pursuing a BS degree in computer science from Binghamton University, and she is expected to graduate in May 2011. She has completed a number of website and website optimization projects as a webmaster for Shadduck Insurance, Smooth Street Ballroom, and The Doctors' Internet. She is currently an intern at Amir A. Trading in New York City as a Search Engine Optimization Specialist. She is a member of the Society of Women Engineers at Binghamton University.

Philabian A. Lindo received the AS in computer science from Broome Community College in New York. He is currently a technical assistant in the Web and Media Resources department at Broome Community College. He is also a student pursuing his BS at Binghamton University, majoring in computer science. His interests include software development for many different platforms, including mobile phones and the web.

Jason A. Loewy is currently a senior computer science student at Binghamton University. He is currently in his final semester prior to graduation with the plans to pursue his MS degree in computer science beginning in September 2011. During his six semesters at Binghamton University, Jason has achieved the Dean's List three times. He is also a member of the UPE.

Walter Lundahl is a senior computer science major at Binghamton University and is expected to graduate in May 2011. He is the current web master of the Binghamton University club ice hockey team and hopes to pursue a career in either web development or network security. Outside of work, he enjoys playing ice hockey.

Simon Mark is currently a senior at Binghamton University studying computer science. Simon plans to enter the IT field after graduating in 2011. He is also considering the opportunities presented by the U.S. Air Force. He enjoys competition, in ACM programming events, basketball, and mixed martial arts.

Jordan Montpetit is an undergraduate at Binghamton University. He is currently pursuing a degree in computer science with an expected graduation date of May 2011.Upon graduation he will be seeking a position as a software engineer. His technical interests include web development, cloud computing and social media. In his free time, he enjoys watching movies, guitar and video games.

Thomas O'Rourke is currently enrolled as a senior at Binghamton University, anticipating a BS in computer science. He currently lives in Newport, Rhode Island.

Atul Sharma is currently a senior at Binghamton University pursuing a degree in computer science. His academic interests include networking, operating systems and software engineering. He intends to enter the IT field upon graduation and plans to pursue a MBA. He has been a state-level table tennis and badminton player. His personal interests include tennis, cricket and soccer.

Jonathan Sherman is a full-time student at Binghamton University, working towards a BS degree in computer science, which he expects to receive in December 2011. In high school, he earned the award of Eagle Scout from the Boy Scouts of America, along with Eagle Project of the month for his council in western New York. Outside of education, his interests include web design, mountain biking, and snowboarding.

James Spinosa expects to graduate from Binghamton University in May 2011 with a BS in computer science. He spent five years as a technology specialist at Bethlehem Central School District, near his hometown of Albany, NY, developing new ways to cut costs and integrate technology in the classroom. In 2007, he launched his first company, an internet marketing company focused on social media and search engine optimization techniques. At the end 2010, he co-founded an internet startup called GroupReviews.com, which will give consumers a place to share their experiences with internet based and retail companies. His hobbies include politics, marketing, video games, and reading.

Victor Yevtukh grew up in Ternopil, Ukraine and immigrated to the United States in 1995 to Binghamton, NY. He received Associates in computer science from Broome Community College. He is currently a senior at Binghamton University and is expected to graduate in May 2011 with a BS in computer science. Victor is planning to start in the Engineering Leadership Development Program at BAE Systems after graduation. Aside from computer science and work, Victor enjoys spending time with family and playing golf, soccer and basketball.

Appendix J: Milestones

Milestone 1

Location: **Binghamton University Engineering Building**

The project leader, Victor Yevtukh, met with Professor Ziegler before the full team was assembled to begin the planning stages for the competition. The decision was made to enter the competition in the Airport Planning and Management design category. The project leader began researching information about downed aircraft and met with Carl Beardsley (Commissioner of Aviation at Greater Binghamton Airport) at Greater Binghamton Airport and visited Chad Nixon (Vice President of McFarland-Johnson, Inc.) at McFarland-Johnson to gain further insights from industry experts.

Milestone 2

Location: **Binghamton University Science Library**

Speaker: Professor William Ziegler

The complete team met as a group for the first time and the details of the competition were described by Professor Ziegler. The general concept for the downed aircraft smart phone app was explained to the team. Preliminary research was presented on search and rescue procedures, emergency locator transmitter (ELT) technology for aircraft, and current smart phone applications. Members of the team were split into internal groups (Design, Engineering & Graphics, Risk Assessment & Research, and Strategies & Ethics) based on their knowledge and skills.

Milestone 3

Location: **Binghamton University Science Library**

Speaker: Professor William Ziegler

The team worked together to brainstorm ideas for the app such as how it would gather data, what would be displayed on the screen, and how to provide turn-by-turn directions to the scene of the crash. In the original design pilots would have the phone app and that in the event of a plane crash would be able to send out an alert signal with coordinates to help first responders get to the scene. After further research that idea was altered to use existing emergency locator technologies instead to gather positional data. The team also began the process of doing research for the project and compiling it into a literature review.

Milestone 4

Location: **Greater Binghamton Airport (BGM)**

Speakers: Carl Beardsley (Commissioner of Aviation at BGM) and Professor William Ziegler

The team met with Carl Beardsley, Commissioner of Aviation of Greater Binghamton Airport, at BGM to discuss the exact search and rescue procedures involved with a downed aircraft. The team went to the rescue operations building to gain first hand experience with the equipment and procedures that would be used in an emergency. The paper maps which would be used in the case of an actual emergency were brought out. The entire team realized that streamlining the response efforts through the phone app could have a large impact on search and rescue operations by streamlining the process.

Milestone 5

Location: **Binghamton University Science Library**

Speaker: Professor William Ziegler

The project leader presented further details on the differences between the 406 megahertz (MHz) beacons, older 121.5 MHz ELTs, and the ADS-B technology associated with the NextGen system. It was decided that the older ELTs that send out only a 121.5 MHz frequency signal would not be supported by the phone app as the FAA no longer supported the older ELTs.

The team decided that more research was necessary to determine exactly what information was transmitted by each type of emergency locator device. Members of the team came up with a list of issues that had not yet been addressed so the team could get the most out of a meeting with Chad Nixon, the Vice President of the engineering firm McFarland-Johnson, Inc.

Milestone 6

Location: **Binghamton University - Bingham Hall Lounge**

Speakers: Chad Nixon (Vice President of McFarland-Johnson, Inc.) and Professor William Ziegler

The team met with an aviation industry expert, Chad Nixon, Vice President of McFarland-Johnson, Inc., who has also worked as an air traffic controller to figure out some of the technical aspects of the phone application. Mr. Nixon explained what data emergency beacons transmit and which organizations would have access to that information. Regulations regarding ELT's, the flight information air traffic controllers have access to, and information about the FAA's NextGen program were also discussed during the meeting.

Mr. Nixon's experience as an air traffic controller proved crucial as he was able to help everyone understand how information is conveyed from the control tower. Suggestions were made about which individuals should receive what information from the application. The user interface design was analyzed to make it simpler for the end users while providing additional functionality such as using separate tabs for different views and applying the grid used by airports to the terrain.

Milestone 7

Location: **Binghamton University Science Library**

Speaker: Professor William Ziegler

The team addressed a variety of technical aspects to ensure that all members understood and agreed upon the way the phone app would work. Security and privacy concerns brought up by an industry expert were addressed and it was decided that access would be restricted to a smaller group of people. Design changes were made to localize the alerts and feed information through local airports and to integrate existing technology such as Google Maps for the turn-by-turn directions and satellite imagery capabilities.

Milestone 8

Location: **Binghamton University Science Library**

Speaker: Professor William Ziegler

The team discussed ethical considerations for the project along with the financial costs and potential savings that would result from the phone app. The technical aspects of the phone app were finalized along with much of the written work for the project. All remaining work was divided up amongst the team. This meeting served as the last push for the whole team to come together and finish work on the project.

Milestone 9

Location: **Binghamton University Science Library**

Speaker: Professor William Ziegler

The team met for the last time to put together all remaining work from each group. Each portion of the project was reviewed and final touches were put on the document. The competition document was now completed and the only remaining work was a final revision of the document to ensure there were no errors that had not been caught during team reviews. There was a great feeling of accomplishment at the end of the meeting as the team had worked together throughout the whole project and the entire team was proud of the final product.

Appendix K. List of Acronyms

ACID	Aircraft ID
ADS-B	Automatic Dependent Surveillance-Broadcast
ADS-R	Automatic Dependent Surveillance-Rebroadcast
AEP	Airport Emergency Plan
AES	Advanced Encryption Standard
API	Application Programming Interface
ARFF	Airport Rescue and Firefighting
ASD	Aircraft Situation Display
ASDI	Aircraft Situation Display Industry
ATC	Air Traffic Controller
ATCT	Air Traffic Control Tower
BGM	Greater Binghamton Airport
ELT	Emergency Locator Transmitter
FAA	Federal Aviation Administration
GPS	Global Positioning System
HTTP	Secure Hypertext Transmission Protocol
LCD	Liquid Crystal Display
LKP	Last Known Position
MCC	Mission Control Center
NAS	National Airspace System
NextGen	Next Generation Air Transportation System
NOAA	National Oceanic Atmospheric Administration
NTSB	National Transportation Safety Board
OS	Operating System
RCC	Rescue Coordination Center
RIM	Research in Motion
SAR	Search and Rescue
SDK	Software Development Kit
SMS	Safety Management System
SRM	Safety Risk Management
SRMD	Safety Risk Management Documents

SUNY	State University of New York
TCP/IP	Transmission Control Protocol/Internet Protocol
TFM	Traffic Flow Management
WJHTC	William J. Hughes Technical Center
XML	Extensible Markup Language