

## **Cover Page**

**Title of Design:** Runway Excursion Modeling and Analysis: A Web-Based Geographic Information System Solution

**Design Challenge Addressed:** Runway Safety/Runway Incursions/Runway Excursions

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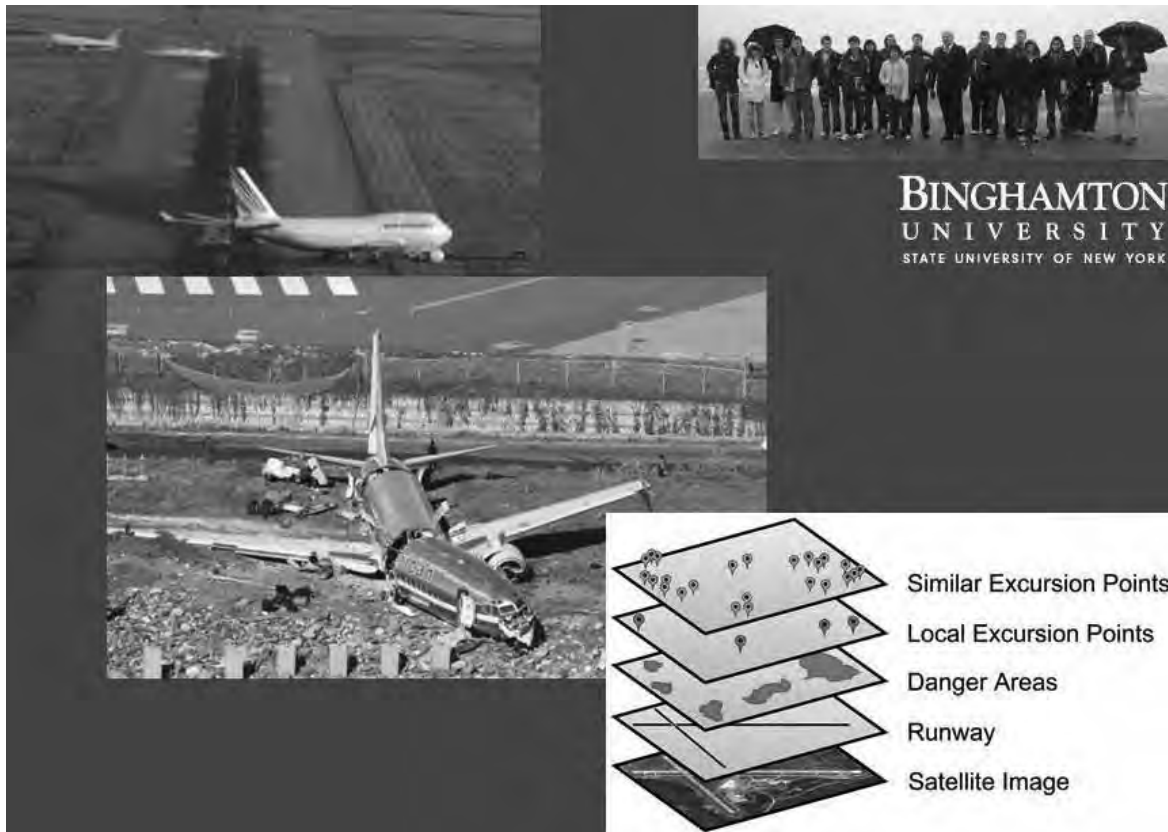
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Federal Aviation Administration Design Competition for Universities  
Runway Safety/Runway Incursions/Runway Excursions Challenges:

# Runway Excursion Modeling and Analysis: A Web-Based Geographic Information System Solution



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## **I. Executive Summary**

**Title:** Runway Excursion Modeling and Analysis: A Web-Based Geographic Information System Solution

Runway excursions are a serious issue in runway safety. These accidents are very dangerous, very costly, and relatively frequent. When an excursion occurs, the crew, passengers, and bystanders are at risk as well as the aircraft itself and any surrounding infrastructure. An aircraft may veer across a busy street, onto another runway, or even into a building.

One of the primary policies currently in place to minimize the severity of runway excursions is to maintain a buffer of open space around the ends and sides of each runway. In particular, most airports have focused on the ends of the runways, under the assumption that most excursions are overruns. For example, many have installed Engineered Materials Arrestor Systems designed to rapidly slow aircraft that experience an overrun. However, little has been done to verify that the most frequent type of excursion at any given airport is the overrun. As a result, many airports may be spending valuable resources protecting against a type of excursion that is actually very rare, while failing to protect against types that are more frequent.

To address this lack of knowledge, a team of 26 students from the Department of Computer Science, Binghamton University, State University of New York herein proposes a system to collect, analyze, and display GIS-based information regarding past excursions and terrain dangers both at a given airport, and at all airports of the same type . This system has the potential, when used by airport officials, to be able to use the generated information to determine where and how to spend limited resources to best mitigate the danger posed by runway excursions.

## Table of Contents

Cover Page .....	1
I. Executive Summary .....	3
Table of Contents.....	4
II. Problem Statement and Background .....	7
i. The Runway Excursions Problem .....	7
ii. Current Runway Excursion Technologies .....	8
iii. Federal Aviation Administration Goals and Flight Plans.....	8
iv. Geographic Information Systems.....	9
III. Summary of Literature Review .....	11
i. Understanding Excursions .....	11
ii. Excursion Prevention Techniques .....	12
iii. FAA Guidelines, Goals, and Flight Plan .....	13
iv. Geographic Information Systems.....	14
v. Safety and Risk Mitigation .....	15
vi. Modeling Risk and Data Analysis.....	15
vii. Ethical Considerations .....	16
IV. Problem Solving Approach .....	16

V. Safety and Risk Assessment .....	19
i. Excursion Analysis Tool Risk Assessment .....	20
ii. Excursion Analysis Tool Safety Implications .....	21
VI. Technical Aspects Addressed .....	23
i. Overview of the Excursion Analysis System .....	23
ii. System Input .....	24
iii. System Output .....	25
iv. Airport Category Selection .....	26
v. The Contour Line Layer .....	27
vi. Obtaining Data .....	27
vi. Combining Layered Excursions .....	28
VII. Interaction with Airport Operators .....	30
VIII. Projected Impacts of Design .....	32
i. FAA Goals .....	32
ii. Increased Safety .....	33
iii. Greater Capacity .....	33
iv. International Leadership .....	33
v. Organizational Excellence .....	34
vi. Commercial Potential .....	34
vii. Utility and Upkeep .....	34

viii. Affordability .....	35
ix. Looking Towards the Future .....	37
x. Sources of Funding.....	37
IX. Summary and Conclusions .....	37
Appendix A: Contact Information .....	39
Appendix B: Description of Binghamton University — State University of New York.....	42
Appendix C: Description of Non-University Partners .....	44
i. McFarland Johnson, Inc. ....	44
ii. The Greater Binghamton Airport .....	45
Appendix D: FAA Design Competition for Universities.....	47
Appendix E: Evaluation of the Educational Experiences Provided by the Project .....	48
Student Evaluation.....	48
Faculty Evaluation.....	51
Appendix F: Reference List with Full Citations .....	55
Appendix G: Photo Gallery of Participation in the FAA Competition .....	61
Appendix H: Ethical Considerations .....	62
Appendix I: Biographies .....	64
Appendix J: Milestones .....	68
Appendix K: List of Acronyms .....	70

## II. Problem Statement and Background

### *i. The Runway Excursions Problem*

Runway excursions (see Figure 1) are accidents that occur when an aircraft leaves the runway during takeoff or landing. The three types of runway excursions are overruns,



Figure 1 Runway excursion depictions from top to bottom: runway undershoot, runway veer-off and runway overrun. [5]

undershoots, and veer-offs. Overruns and undershoots occur when an aircraft goes over the end of a runway or lands short of a runway. Veer-offs occur when an aircraft departs the side of a runway [1].

Runway excursions account for 71% of the world's jet aircraft accidents and 41% of jet aircraft onboard and third party fatalities [1]. Additionally, although the final approach and landing phases account for only 4% of the average total flight time, 52% of all accidents occur during these phases [2] [3].

Two systems currently in use to mitigate the danger from excursions are the placement of EMAS blocks at the ends of runways (see Figure 2) and Runway Safety Areas (RSA), which are cleared areas surrounding the runway [4]. Since EMAS blocks are expensive to install, averaging around \$4.5M for a 150 x 300-ft bed, airports place these systems only at the ends of runways [6]. However, there has been little done to confirm that the ends of runways are

always the best places for EMAS blocks. As a result, it is possible that airports are installing EMAS blocks in areas where they are not necessary, while neglecting areas where they are.

### *ii. Current Runway Excursion Technologies*

A RSA is an area set aside to allow an aircraft space to slow down safely in the case of an excursion. These areas need to be flat and unobstructed in order to minimize damage and passenger injury. Unfortunately, not all airports have enough physical space to surround runways with RSAS of sufficient width [7].

EMAS was developed to deal with this problem [7]. An EMAS consists of “high energy absorbing materials of selected strength, which will reliably and predictably crush under the weight of an aircraft” [8]. Unfortunately, after an excursion, all damaged EMAS blocks need to be replaced before the system is fully functional again.

### *iii. Federal Aviation Administration Goals and Flight Plans*

The Portfolio of Goals outlines what the Federal Aviation Administration (FAA) hopes to



Figure 2 EMAS blocks collapsed to stop a plane that overshot a runway [9].

achieve in the next few years, in particular increased safety, greater capacity, international leadership, and organizational excellence. In order to meet these objectives, the organization intends to lower fatality rates, avoid runway delays, and use improved organization methods provided by NextGen technologies. Because runway excursions account for 41% of aviation



related fatalities, tools for determining where excursions are likely to occur can potentially decrease the total number of fatalities, by helping airport personnel determine where best to focus their resources to mitigate the threat from excursions [10].

According to the FAA Strategic Plan, the FAA is improving safety by deploying precautions on runways, developing cost effective systems to improve oversight, and by using data to make decisions that will improve overall performance. Although the FAA is using these methods to lower the risk of accidents such as incursions, the FAA Strategic Plan does not mention anything specific to employ against runway excursions [11].

#### *iv. Geographic Information Systems*

A GIS is a system designed to collect and organize geographical data in the form of maps, reports, and charts. It plots the locations of certain features or relative feature densities, keeps track of what features are present around areas of interest, and maps change in these features over time. Organizing and recording information in this way allows for quick

interpretation of the data, insightful prediction of future developments, and ease of sharing among users [12].

An example of a GIS that is currently in use is the web-based GIS used by the Greater Binghamton Airport (BGM), shown in Figure 3. This product shows developable areas owned by the airport to prospective developers and



Figure 3 The web-based GIS used by BGM [13].

provides BGM with a visual tool to aid in implementing financial planning strategies [14].

Selecting any of the colored, numbered areas will lead the user to a more detailed map of that location. For example, if Area 3 is selected, an enlarged, labeled map of the area with more clickable regions for further detail is displayed, as shown in Figure 4. It shows additional information about the location, including dimensions, geographical features as well as current

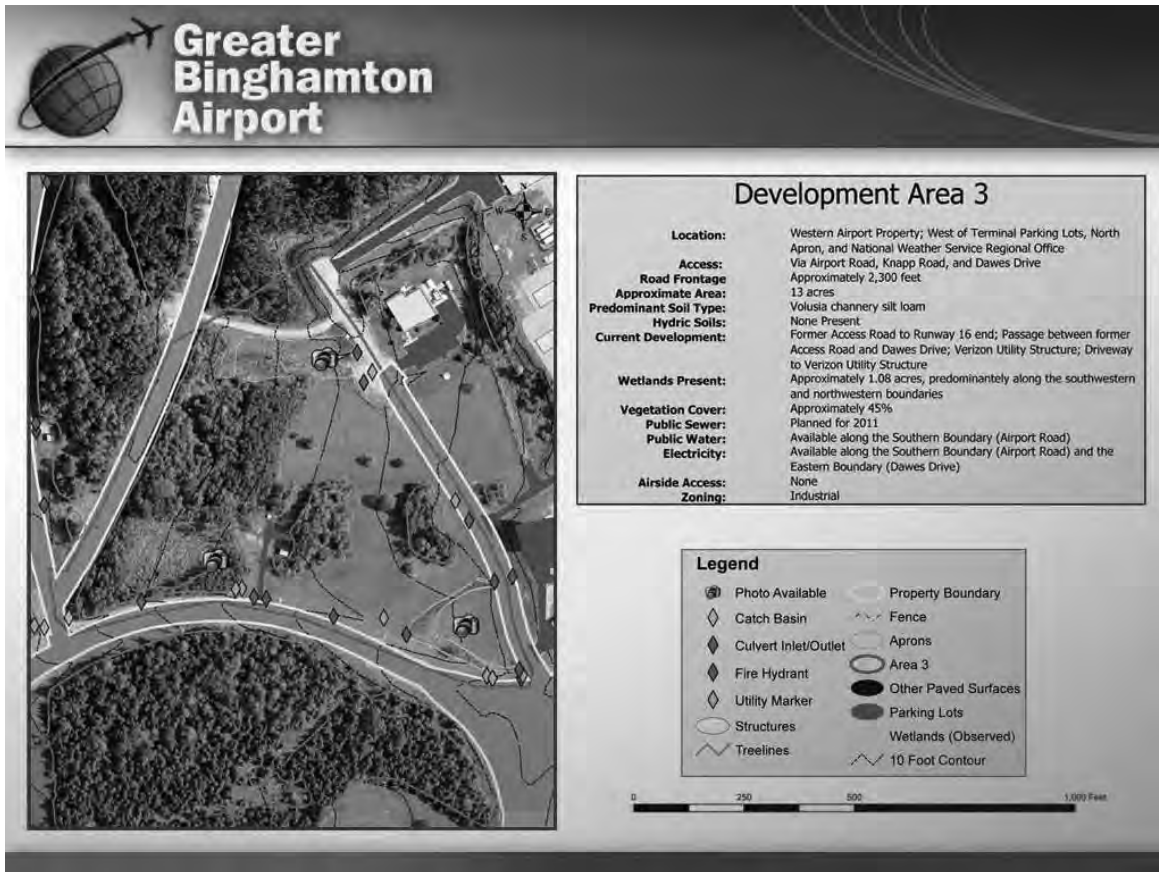


Figure 4 Development Area 3 in BGM’s web-based GIS [13].

and past developments.

In 2010, the FAA launched the Airports Global Information Systems (GIS) program to provide a database of airport information for the FAA and for individual airport sponsors [15]. To institute updated protocols for collecting and submitting airport data in support of Airports GIS, and to comply with Executive Order 12906 to standardize the documentation of geospatial

data and to make that data electronically accessible, the FAA released a set of Advisory Circulars (AC) in 2006 [15][16]. Airports GIS consolidates standardized data and provides a single user interface for access to this information [15]. Airports can then use the information provided by Airports GIS for layout planning and flight path management [17].

### **III. Summary of Literature Review**

#### *i. Understanding Excursions*

A runway excursion occurs when an aircraft departs from the side of the runway surface, departs from the end of the runway surface, or undershoots the designated landing strip [18]. Excursions are caused by such factors as, malfunctioning brakes, hazardous weather conditions, high approach, pilot technique, and an off-center touchdown. According to the FAA, between 1995 and 2008 there were 1,429 commercial aircraft accidents where the aircraft had undergone considerable damage and 417, or 29%, of these accidents were excursions. Additionally, out of the 1,429 accidents, 429 of them resulted in fatalities. Of these accidents, excursions accounted for 34, resulting in 712 fatalities [19].

The Flight Safety Foundation has found that landing excursions occur about four times as often as takeoff excursions. Just about two thirds of the takeoff excursions are overruns while one third are veer-offs. Landing excursions are about 47% overruns and 53% veer offs. The top risk factors for landing excursions include long touchdowns, landing gear malfunctions, and ineffective brakes [18].

Currently, many runways have overrun buffer areas at the ends that give planes extra space should it be needed. Some airports also use EMAS, a system designed to absorb the impact

of an airplane. Many experts believe that a combination of both an overrun zone and an EMAS will greatly reduce runway excursions [4].

### *ii. Excursion Prevention Techniques*

The International Civil Aviation Organization (ICAO) enforces Standards and Recommended Practices (SARPs) for any airport under their contract. These SARPs are in place in order to describe the physical characteristics and obstacle limitation surfaces to be provided for at airports, but does not describe how to operate aircrafts. One means of mitigating excursions that is a part o SARP is to have a safety area at the end of the runway. In general, the safety area must extend from the end of the runway for at least 90m with a width of at least twice that of the associated runway [20]. These specifications are suggested by the Flight Safety Foundation's Article "*Reducing the Risk of Runway Excursions: Report of the Runway Safety Initiative.*" According to the article, runway ends should have a certified Runway End Safety Area (RESA), which meets the specification in the ICAO's Annex 14 [21].

The ICAO also specifies how the runways are constructed and maintained. These rules are used to ensure that there is effective friction available, as well as effective draining [21]. The efficiency of drainage is important, because a wet runway may lead to hydroplaning, which is a cause of excursions.

One of the major causes of excursions is the flight crew's techniques and the decisions made by the staff [22]. Because human error is a predominant reason for excursions, there are various methods suggested to ensure that operators and technicians are better prepared in the event of one. For example, it is recommended that operators should emphasize learning the proper execution of Rejected Take Offs (RTO) [21].

The Flight Safety Foundation offers recommended mitigations for flight operators, airport operators, air traffic management, regulators, and aircraft manufacturers. For example, airport operators must ensure that all runway ends have a RESA, define criteria to determine when to close a runway due to safety concerns, and ensure that aircraft rescue and firefighting personnel (ARFF) are trained and available at all times [23]. Flight operations should have a process for actively monitoring safety risks during takeoff and landing, define and train the execution of an RTO decision, and implement a no-fault go-around policy [23]. Air traffic management must avoid late runway changes, select the preferred runway in use based on wind direction, and provide the most accurate meteorological and runway conditions to flight crews possible [23].

### *iii. FAA Guidelines, Goals, and Flight Plan*

The FAA guidelines provide some suggestions for reducing the danger from excursions. A few examples include using direct warning systems to alert pilots and operators of possible problems, developing techniques to record and analyze data for improved situational awareness, and identifying major causes and contributing factors that lead to excursions [1].

The FAA Strategic Plan outlines the current strategies being deployed to meet the FAA Portfolio of Goals. In general, the plans for lowering fatalities are to improve oversight systems, enhance satellite navigation systems and onboard technologies, and expand cost-effective safety oversight. This includes providing pilots and operators with better tools for controlling and analyzing data. The strategy also includes designing, developing, and implementing an agency-wide Safety Management System. However, while the strategic plan aims to reduce the risk of runway incursions, it falls short with regard to excursions [11].

#### *iv. Geographic Information Systems*

A Geographic Information System (GIS) is a digital system designed to collect and organize geographical data so that it can be easily interpreted and shared. GIS technology maps the locations of certain features or relative feature densities to detect patterns, and keeps track of what features are present around areas of interest. It can also map change over time so users can predict future developments [24].

To improve efficiency in data gathering, the FAA released a set of AC's providing updated protocols, and in 2010 launched the Airports Global Information Systems (Airports GIS) [25][26] The first of these ACs described how to establish geodetic control on or near an airport [27]. The second explained the specifications required for obtaining airport imagery using remote sensing technologies [28]. The third presented the requirements for data collection in support of the Airports GIS program [29]. Together, these three ACs standardize the methodology for collecting survey data at airports. Airports GIS builds upon the foundation these ACs provide by consolidating standardized data to one location and making available web-based access to this data via a single-user interface [25].

McFarland Johnson, Inc., an airport consulting firm based in Binghamton, NY uses GIS to analyze data for a variety of projects. The visuals generated from this analysis integrate attributes such as population density, property boundaries, and locations of geographical features. These visuals can then be used by airports to plan routes, evaluate service areas, and ensure clear airspace. Their technology includes ArcGIS 10, a program developed by the GIS company ESRI, and extensions such as 3D Analyst and Network Analyst [30].

The Greater Binghamton Airport implemented the Master Plan Update (MPU) with the help of McFarland Johnson, Inc. One of the results of this plan was a GIS/web-based product

that markets the key features of developable areas owned by the airport to prospective developers. Another GIS-based product keeps track of the utilities on and around the airport's property, used to assess the need for improvements, new services, and the potential effects of future projects [31].

#### *v. Safety and Risk Mitigation*

In the FAA's effort to identify current and future risk factors, the FAA has created a set of guidelines and measures called the Safety Management System manual to determine the probability of a low, medium, or high risk in a specific aircraft failure [32]. These guidelines help the FAA determine if the frequency and severity of a failure is too unacceptable for public usage. To mitigate further risk, the FAA refers to a risk control strategy that "...helps to develop options and alternatives and take actions that lower or eliminate the risk." In accordance with this control strategy, a set of hierarchical priorities has been created to counter any failures and protect airline passengers and staff members. These priorities include (from highest to lowest priority) designing components for low risk, including automatic safety devices, integrating clear warning signals, and creating procedures and protocols to manually counter risk. To detect changes in risk, safety inspections are frequently done to guarantee safety assurance [33].

#### *vi. Modeling Risk and Data Analysis*

According to an Airport Cooperative Research Program (ACRP) report, risk analysis must be done by modeling frequency, location, and consequences. From the models, risk can be estimated and dealt with accordingly. The ACRP has developed a software toolkit known as "Runway Safety Area Risk Analysis" (RSARA). The package allows airport personnel to perform full risk assessments on runways, incorporating factors such as weather data and obstacles. The software analyzes and categorizes potential risk [34].

### *vii. Ethical Considerations*

Runway excursions have been a persistent problem in the airline industry for much too long. According to International Civil Aviation Organization (ICAO) statistics, there has not been a significant decrease in excursions over the 10-year period ending in 2008. These same statistics indicate that runway excursions are the most frequent accident category worldwide. During the five-year period from 2003 until 2008, runway excursions caused over 10 serious accidents a year [35].

Reducing the number of runway excursions would be vastly beneficial to the airline industry. Runway excursions are responsible for hundreds of on-board fatalities annually, which is unacceptable from a safety point of view. Such excursions also cause significant property damage [36]. There are some estimates, which claim that runway excursions cost the global airline industry \$900 million every year [37]. Clearly, reducing excursions makes sense from safety and financial perspectives.

Ethically, there is very little wrong with the research required to study excursions. Large aircraft operators are already required to report accidents to the IOAC [35]. The proposal to use GIS data to track these changes is little more than a small addendum to already filed reports. While there will be no environmental impact in the study of runway excursions, the environment study should be done before implementing any solution to the excursion problem.

## **IV. Problem Solving Approach**

To start the project, Professor Ziegler met with Andrew Cholewa and asked him to lead the team. Shortly thereafter, Andrew, along with Chad Nixon, Vice President of McFarland Johnson, Inc., Carl Beardsley, Commissioner of Aviation – Greater Binghamton Airport, and



Professor Ziegler met at the headquarter of McFarland Johnson, Inc. The purpose of this meeting was to select a general topic area, which would then be refined by the team as the semester progressed. At the meeting, the topics suggested in the competition guidelines were reviewed and a decision was made to tackle the problem of runway excursions after Commissioner Beardsley informed the group that there have been four runway excursions at BGM. The team's initial belief that runway excursions are a serious problem was then confirmed by other professionals in the field. According to Flight International, runway excursions are the top safety issue in the industry, due to their frequency and widespread occurrences [38].

The first action of the team was to split up into sub-teams. There are 23 students on the team, and each student was asked which sub-team would best suit their strengths. Each sub-team



Figure 5 Chad Nixon (standing next to the EXIT door) shows the class BGM's GIS data.

had unique areas of specialization. The teams were the Design Team, the Risk Assessment and Research Team, the Engineering and Graphics Team, and the Strategies and Ethics Team. All of these sub-teams selected a team leader who reported directly to Andrew. Each sub-team created a weekly schedule to meet and discuss the problem. Additionally, the

entire team met once a week with Professor Ziegler. While these meeting were helpful in the early stages of defining the problem, more help was need from experts in the field when it came time to create a solution.

In order to understand runway excursions, the team met with Carl Beardsley and Chad Nixon at BGM. During this meeting, Chad Nixon and Carl Beardsley went over the use of GIS

in the aviation industry. Chad Nixon can be seen presenting this information to the team in Figure 5. It was clear that GIS would be a very important tool in helping analyze runway excursions, because it has the ability to label excursion points on a runway, as well as mark sections with a high-risk of excursions. As shown in Figure 6, Commissioner Beardsley also took



Figure 6 Commissioner Beardsley, shown on the left, shows the team one of BGM's runways.

the team out on one of BGM's runways, which allowed the team to experience current excursion safety measures first hand.

During the meeting at BGM, Mr. Nixon introduced the team to the National Transportation and Safety Bureau's (NTSB) database on aviation analysis. Using the information found in the database, team

member Adam LaFave was later able to create an interactive map, which displays excursions



Figure 7 The interactive map, which shows where excursions have occurred within the United States.

that have occurred within the United States, as shown in Figure 7. The interactive map provided a useful demonstration of what the team was trying to achieve. The design team then refined the ideas originally presented in the excursion map.

In order to maximize the positive benefits of working with these professionals,

team member James VanBeverhoudt worked on the project at McFarland Johnson, Inc. every week. In this position, James had excellent access to the professionals at McFarland Johnson.



Figure 8 Chad Nixon helped the team finalize features for the analysis tool.

About midway through the project, Chad Nixon came to Binghamton University in order to speak to the team and answer any remaining questions. The design team had brainstormed a tool that would use historical excursion data to help predict future excursions at a particular airport. During the meeting with Chad Nixon, the team's idea was in an abstract and non-

finalized form. As shown in Figure 8, Chad Nixon helped solidify that the team was on the right track and bolstered the team's understanding of how to write down the idea correctly. The team had very ambitious goals, and Chad Nixon helped the team create a robust feature set that was still simple enough to explain clearly and thoroughly.

## V. Safety and Risk Assessment

To better promote and sustain safe operations at all domestic airports, the FAA has developed a Safety Management System (SMS) manual that outlines its safety risk approach and strategy. Outlined in the SMS manual are procedures and guidelines created to mitigate risk. These procedures include describing the system being analyzed, identifying the hazards associated with it, determining the risk posed by these hazards, analyzing said risk, and then taking steps to minimize the risk [39]. This process is part of the FAA's Safety Risk Management (SRM), which is a subset of the SMS. Ultimately, this process creates layers of safety that reduce risk at every level.

The SMS defines safety to be the “freedom from unacceptable risk” [40]. To gauge unacceptable risk, the FAA uses a risk classification matrix, called the Predictive Risk Matrix, shown in Figure 9.

Severity \ Likelihood	No Safety Effect	Minor	Major	Hazardous	Catastrophic
Frequent	Light Gray	White	Dark Gray	Dark Gray	Dark Gray
Probable	Light Gray	White	Dark Gray	Dark Gray	Dark Gray
Remote	Light Gray	White	White	Dark Gray	Dark Gray
Extremely Remote	Light Gray	Light Gray	Light Gray	White	Dark Gray
Extremely Improbable	Light Gray	Light Gray	Light Gray	Light Gray	Dark Gray

<b>HIGH RISK</b>
<b>MEDIUM RISK</b>
<b>LOW RISK</b>

Figure 9 Predictive Risk Matrix [39]

The risk matrix classifies risk based on two variables: likelihood and severity. Risk likelihood is categorized as “Frequent,” “Probable,” “Remote,” “Extremely Remote,” or “Extremely Improbable.” The Risk Severity categories are “No Safety Effect,” “Minor,” “Major,” “Hazardous,” or “Catastrophic” [39]. As the likelihood and severity increases, the more unacceptable the risk becomes.

*i. Excursion Analysis Tool Risk Assessment*

The Excursion Analysis Tool determines the probability of an excursion occurring at specific locations along a given airport’s runways and the expected severity of those excursions. Because the tool is a web-based system that is not directly involved in day-to-day airport activities, it poses no risk to civilians, airport staff, aircraft, or airport infrastructure. The tool supplements existing excursion analysis, and helps airport operators and the FAA make better decisions regarding excursion risk mitigation.

ii. Excursion Analysis Tool Safety Implications

The Excursion Analysis Tool helps determine if proper excursion mitigation techniques

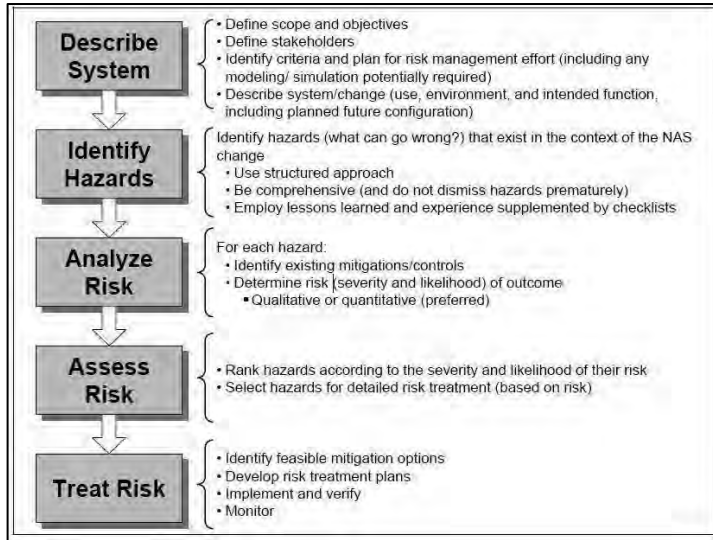


Figure 10 SRM Safety Analysis Phases [40]

are implemented at the correct areas of a runway. Therefore, rather than posing a risk, this tool promotes safety by attempting to eliminate unforeseen and unacceptable excursion risk. Specifically, the tool can become a key asset to the SRM Safety Analysis procedures and phases (outlined in Figure 10). The tool supplements *Phase 2: Hazard*

*Identification* and *Phase 3: Risk Analysis of the SRM*. This in turn affects the *Phase 4: Risk Assessment* and *Phase 5: Risk Treatment* segments of the SRM safety analysis process [40].

As explained earlier, risk is composed of two parts: the likelihood of a hazard, and the severity of a hazard [40]. This tool handles the likelihood aspect of the excursion hazard by using information on past excursions to determine where excursions on a given runway are most likely to occur. By displaying the locations of past excursions, the Excursion Analysis Tool would assist airport operators determine where excursions are most likely to occur. Airport operators can then take steps to minimize the severity along areas of the runway where excursions have been relatively frequent in the past.

In addition to determining where an excursion is most likely to occur, the Excursion Analysis Tool also takes steps to determine how severe an excursion at a given location would

be. The severity of an excursion at a given location is predicted by taking into account the surrounding elevation. The more the elevation changes in a given area, the more severe the excursion becomes. With this information, airport personnel can also ensure that not only are relatively frequent excursions mitigated, but also excursions that are especially hazardous.

In brief, the Excursion Analysis Tool calculates the excursion risk criteria (severity and likelihood) at a given location on a runway, and therefore allows the FAA and airport operators to swiftly determine if an area of a runway has a higher, lower, or equivalent risk as previously thought. This, in turn, allows airport personnel to verify that excursion mitigation techniques are being applied to the correct regions of each runway. If in fact, EAT was to receive a risk classification as per the Predictive Risk Matrix shown in Figure 9, it would be rated as *extremely improbable – no safety effect*.

## VI. Technical Aspects Addressed

### *i. Overview of the Excursion Analysis System*



Figure 11. Proposed output of the Excursion Analysis Tool. The red dots display excursions that occurred at BGM. The orange dots are excursions that occurred at other airports of a given category, as if they had occurred at BGM. On the right is where data selected on the map is displayed. The red coloring indicates areas at high risk of

Described herein is a system called the Excursion Analysis Tool, which will help address the problem of runway excursions. This system is a Web based program, designed to aid airport personnel in determining the probable location and potential severity of future excursions on any given runway at any given airport. The program will utilize data gathered from FAA

accident records of past excursions, and airport terrain. By knowing the probable location, and severity of future excursions, the appropriate measures can be taken to warn pilots, build buffers, remove obstacles, and make any other changes to airport infrastructure that will minimize casualties and damage; while maximizing cost benefits. Figure 11 provides an example of the output of the tool. The most hazardous zones are displayed by the red polygons surrounding the runway. In this particular output of the Greater Binghamton Airport, there is a cliff at the end of the runway located at the top left corner of the map. Since such a cliff presents a great danger to aircraft in the case of an excursion, it is signified by a bright red color. Also displayed on the output map are orange points of interest representing excursions from other airports of a selected

type, as well as red points of interest representing excursions that occurred at the selected airport (Greater Binghamton Airport).

### ii. System Input

First, the user chooses an airport whose excursions he/she would like to analyze, using a dropdown menu as displayed in Figure 12. The “Advanced Options” drop down menu will have subcategories large hub, medium hub, small hub, non-hub, reliever, cargo, and general aviation

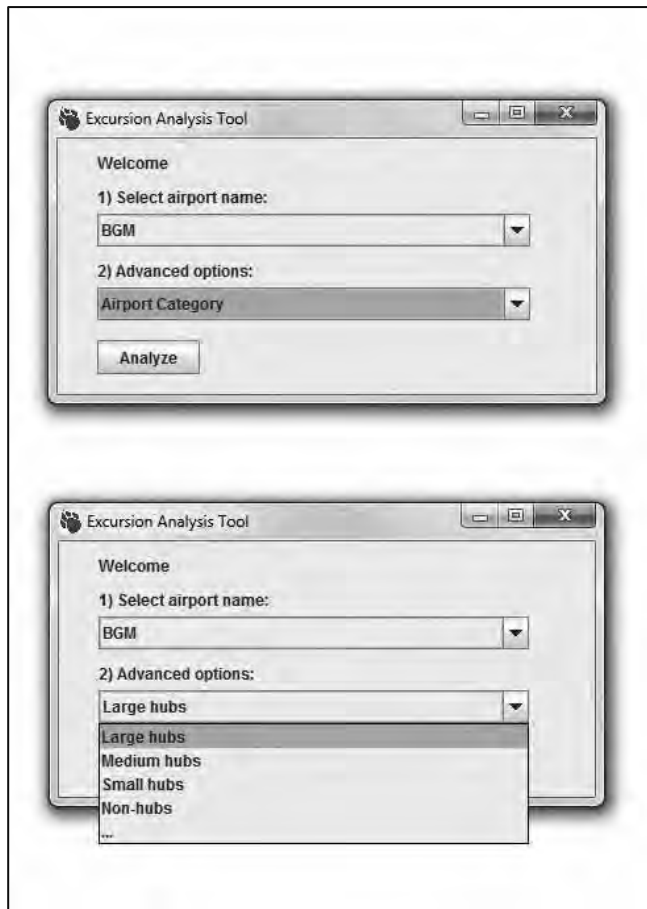


Figure 12. Opening screen of the Excursion Analysis Tool. It allows the user to select the airport to examine. The advanced options tab also gives the user a choice to display excursions from specific airport categories.

airports, referring to the FAA’s airport categories. This drop down menu allows users to display excursions from all airports of the selected category from the past twenty years, as if they had occurred at the selected airport. For example, in Figure 12 the user is choosing to look at past excursions that occurred at BGM and at all large hub airports. In order for the output to make sense, the locations of the excursions at large hub airports are converted to appropriate locations at BGM.

Once the user selects the desired attributes, the “Analyze”



button is pressed, and the output will be produced as seen in Figure 11. Not only does this system incorporate previous airport excursions, but it also includes other factors such as hills and cliffs.

### *iii. System Output*

The purpose of the generated map is to establish a guide for safety procedures such as buffer placement or the length and width of safety areas. Five layers go into the makeup of the display, as shown in Figure 13.

The first layer is the satellite image displayed in Figure 14. All of the other layers are projected onto this layer. It can be attained using any geo-based map.

The next layer includes previous excursions at the selected airport, called native excursions, which show up as GIS points of interest. Once clicked, information about the selected excursion, such as excursion ID, weather conditions, location, and a link to the official detailed excursion report gathered from the NTSB, will be displayed.

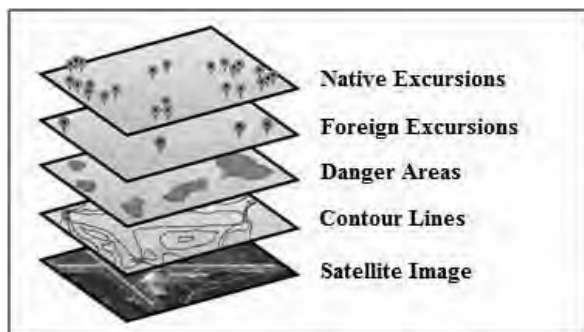


Figure 13. Many different layers are combined into one to make a functional analysis tool.

The third layer displays foreign excursions, which are excursions that occurred at all airports of the category selected upon starting the program from the past 20 years (for example Large Hubs as shown in Figure 12).

The foreign excursions will be displayed in a different color than the native excursions. The means by which foreign excursions are

displayed as if they were native is explained in subsection *vi: Combining Layered Excursions*.

The fourth layer is the contour layer. Contours allow the user to view areas near runways where danger may be present in the form of geographic features. Areas near runways with rapid

elevation changes, such as a cliff, represent a much greater risk for serious damage or fatalities should an excursion occur at that location. Contour lines represent the elevation of that region on the map. When the contour lines are far apart, the elevation does not change quickly. However, lines that are close together represent rapid elevation changes. [41]



Figure 14. A publicly available satellite image of the Greater Binghamton Airport attained from Google Maps.

The fifth and final layer is the danger areas layer. This layer is produced by analyzing the data in the excursion and contour line layers. The darker the area's color, the more hazardous the location is, where hazard is determined by the number of excursions that have occurred in that region, and the rate of elevation change. If the mouse cursor is moved over a danger area, data associated with it will pop up as a white box on the map as shown in Figure 11. This data consists of excursion and terrain information for that area.

#### *iv. Airport Category Selection*

The primary goal of the Excursion Analysis Tool is to find trends in past excursions and use this information to locate excursion danger zones at an airport. However, excursions are typically not frequent enough at a single airport to provide enough data for meaningful prediction. Therefore, the system must also use excursion information from other airports. The "Advanced Options" drop down menu provides the user with the ability to decide from which category of airports the program should draw excursion information. Although any category is possible, it is recommended that the user choose the category to which the selected airport belongs. Many airports of the same category have similar procedures and airport conditions.

Some examples of these conditions are how worn the runway is at which location, airport staff size, level of training, type of training, traffic patterns, runway and road structure, and more.

*v. The Contour Line Layer*

Contours can be applied as a layer to the GIS map and allow the user to view areas near runways where danger from terrain may be present. Regions with contour lines close together would represent more severe risks of danger on the GIS map, since rapid changes in elevation typically represent steep hills or cliffs, which can be dangerous in the event of an excursion. For example, BGM has a steep hill at the end of one of its runways, as evidenced by Figure 15. According to the Commissioner of Aviation Carl Beardsley, there was at least one excursion where an aircraft went off the end of the runway, and fell down the cliff. Such potentialities need to be accounted for when determining danger areas.

*vi. Obtaining Data*

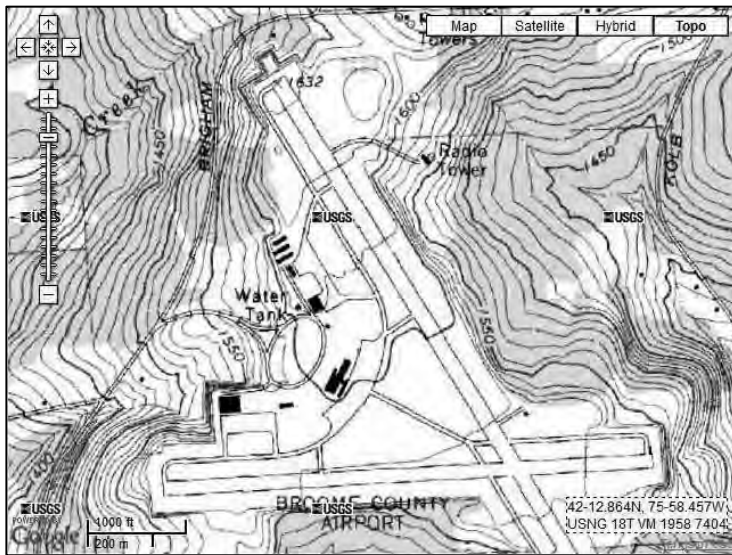


Figure 15. Topographical map of BGM showing rapid elevation changes near the end of a runway. [42]

The National Transportation Safety Board, also known as NTSB, provides the proposed tool with valuable data, including such information as latitude and longitude of the excursion, whether or not there were any fatalities, aircraft damage, and airport name and code [43].

By looking at the public information provided by the Federal Aviation Administration, the excursion's longitude and latitude can be mapped to coordinates of the runways of an airport [44]. The airport code from the NTSB's list of excursions can then be matched with the FAA's "Airport Facilities Data" to get the airport's unique 8-digit code for further specification. This code can be used to determine the longitude and latitude of the runway using the FAA's "Airport Runway Data. See Appendix L for detailed information on obtaining the data as well as separating it prior to use.

#### *vi. Combining Layered Excursions*

Because runways at similarly sized airports are typically not the same exact length, the system must first normalize the excursion locations, and then map those locations to the desired airport. The normalization is done by converting all distances that excursions occur relative to the center of the runway, to percentages down the runway from the center. The fact that airplanes can approach a runway from either direction is taken into account by measuring the percentage that an excursion occurs from the center length of the runway instead of from an end.

For example, suppose a runway is 2,000 meters long, and an excursion occurs 500 meters from the center of the runway in the direction of runway end A. Then, the 500 meters in the direction of runway end A is converted to 50% down the runway from the center, in the direction of end A. In order to determine the percentage down a runway an excursion occurred, the latitude and longitude of the excursion as well as both of the runway's ends are required.

Percentages are calculated as follows. First, the distance between the excursion and the

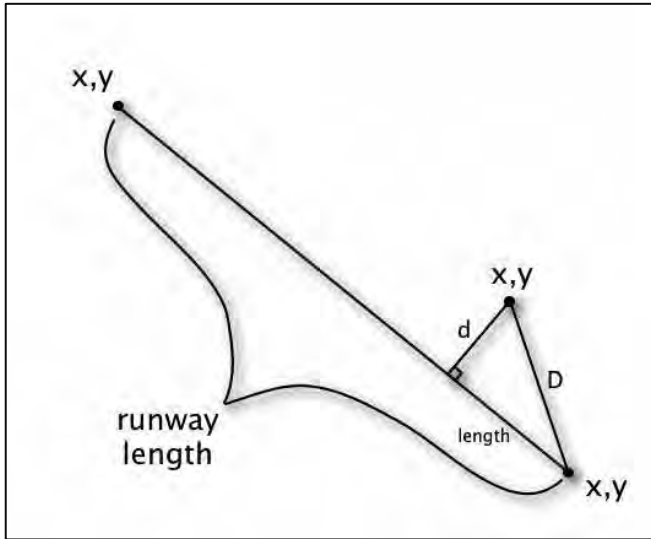


Figure 16. This figure represents a runway with an excursion at location (x,y). This will be used to determine the percentage down a runway that a given excursion occurred.

runway is determined. The distance between the excursion and the closest end of a runway and the distance between the two ends of the runway are also calculated. Now that the lengths of two sides of the triangle formed by the runway and the excursion are found, as shown in Figure 16, the distance down the runway that the excursion occurred from the nearest runway end can be

calculated. By dividing *length*, by the runway length, the percentage down the runway that the excursion happened is finally obtained. One problem is that an airplane can land from either direction of the runway. To remain agnostic to that fact, this percentage must be used to determine the percentage away from the center of the runway by using the following equation:

$$\text{percentage from center} = |50 - \text{percentage down runway}|$$

Another issue that was considered in the design of the system is that many airports have multiple runways, so the coordinates of an excursion will not immediately reveal from which runway the excursion occurred. This can be resolved by determining the distance between an excursion and every runway at an airport and selecting the closest runway, under the assumption that most excursing aircraft come to a halt closest to the runway that the aircraft left.

## VII. Interaction with Airport Operators

The team used BGM as their case study, and as a result interacted with the BGM airport operators on numerous occasions. Commissioner of Aviation, Carl Beardsley was instrumental



Figure 17 Mr. Carl Beardsley, Commissioner of Aviation at the Greater Binghamton Airport, showing the EMAS installation at the airport to Binghamton University students.

in helping the team learn about runway excursions. As shown in Figure 17, Commissioner Beardsley explained the measures that the Greater Binghamton Airport had taken to tackle excursions. For example, BGM installed an EMAS bed at each end of the main runway, because said runway ended near the edge of a cliff. Beyond this,

Commissioner Beardsley also made himself available to the team for any kind of questions, which helped the students in getting a better understanding of the airport operations.

The students also wanted to learn about the measures that other airports were taking in order to avoid excursions. Mr. Chad G. Nixon, Vice President & Business Development Officer at McFarland Johnson, Inc, provided invaluable professional insights about other airports. The students worked closely with Mr. Nixon, whose expertise in the field helped identify and solve potential pitfalls in the team's proposal. Mr. Nixon gave professional opinions on various topics, such as, whether categorizing airports based on sizes or types would be useful in the proposed tool.

Mr. Nixon, shown in Figure 18 along with Commissioner Beardsley, and Professor



Figure 18 Mr. Chad G. Nixon, Vice President & Business Development Officer at McFarland Johnson, Inc and Mr. Carl Beardsley, Commissioner of Aviation at the Greater Binghamton Airport, providing information about excursions to Binghamton University students, at the Greater Binghamton Airport.

Ziegler, pointed out that the students could leverage the publicly available data about each airport, such as runway lengths. In addition, the team could also make use of the coordinates and severity of each excursion, which was available on the National Transportation Safety Board's (NTSB) website.[45] Each recorded

excursion also linked to a detailed investigation report that contained information such as the weather conditions at the time of excursion, possible reasons for the excursion, and interviews with the pilots of the affected plane.

Mr. Nixon expressed his opinion that the proposed tool would provide relevant and important additional information, which would help prioritize where to spend the money to protect against excursions, and hence provide a significant cost benefit.

James VanBeverhoudt worked as a student intern at McFarland Johnson, Inc, and interacted with other officials in the company, such as Zachary Staff, Airport Planner and GIS specialist at McFarland Johnson, Inc, who provided information about different airports taken care of by the company and pointed out some relevant data sources for further information. Rachel Passer, GIS intern from Binghamton University at McFarland Johnson, showed James

how the company utilizes a GIS program called ArcView to map various terrain features into a single file and then display them on Google Maps. James regularly shared his findings with the



Figure 19 Mr. Chad G. Nixon, Vice President & Business Development Officer at McFarland Johnson, Inc visiting Binghamton University campus to help students understand different measures taken by various airports in order to avoid excursions.

rest of the team. This strong communication between the students and employees of McFarland Johnson facilitated the necessary transfer of knowledge from professionals to students.

## **VIII. Projected Impacts of Design**

### *i. FAA Goals*

Four main goals are outlined in the FAA Portfolio of Goals:

1. Increased safety – Achieve the lowest possible accident rate and constantly improve safety.
2. Greater Capacity – Work with local governments and airspace users to provide increased capacity and better operational performance in the United States airspace system that reduces congestion and meets projected demand in an environmentally sound manner.
3. International Leadership – Increase the safety and capacity of the global civil aerospace system in an environmentally sound manner.
4. Organizational Excellence – Ensure that success of the FAA’s mission through stronger leadership, a better-trained and safer workforce, enhanced cost-control measure, and improved decision-making based on a reliable data. [46]

The system proposed herein supports each of these goals.



### *ii. Increased Safety*

Excursions are extremely hazardous to everyone and everything involved, from the airport personnel and passengers, to the aircraft itself. When a plane leaves its designated runway, unknown terrain factors play a vital role in the safety of that aircraft and its passengers. Unfortunately, due to all the various known and unknown factors that contribute to an excursion, it is nearly impossible to prevent them all. However, if the most dangerous excursion zones at an airport are predicted, and buffers are constructed at these locations, excursions in general will be less destructive. This will lead to a lower risk of fatalities, and reduced aircraft and airport damage. For example, strategic placement of an EMAS or safety area at key locations along the runway, will directly improve airport safety, and result in fewer fatal excursions.

### *iii. Greater Capacity*

To avoid congestion and delays, it is important that runways remain open and hazard free. Whether a plane veers off the runway but then returned to its designated path 10 minutes later, or the aircraft is seriously damaged, a delay of some sort is inevitable. The focus of this system is to anticipate where excursions are likely to occur, so that informed decisions can be made to minimize the damage done. As a result, cleanup and repairs will be less time consuming, allowing the airport to return quickly to full functionality.

### *iv. International Leadership*

Research shows this tool would be the first official system of its kind. In assisting airports in other countries to attain this technology, the FAA will set new precedents in organizational improvements and safety management.

#### *v. Organizational Excellence*

To be considered a successful leader in airport technologies, passenger safety, worker safety, environmental concerns, and cost-effectiveness issues need to be considered. In the worst situations, excursions can negatively affect all of these. First, excursions are dangerous for passengers as well as the environment. Furthermore, cleanup of fuel and fire are hazardous to both worker safety and the environment.

The system proposed here would be able to provide airports around the globe with more reliable data on excursions. Based off the data, the airport can better decide where to spend money to help prevent dangerous excursions from taking place.

#### *vi. Commercial Potential*

The proposed Excursion Analysis Tool offers high commercial potential. Firstly, the system's ability to predict the most likely locations for excursions offers insight into where resources should be allocated to minimize excursions and the resulting damages and injuries. Constructing safety zones or EMAS at the locations where excursions are most likely to occur will help ensure that limited funds are spent in areas yielding the greatest safety improvement.

The proposed system also has environmental benefits. In the worst-case excursions, not only could lives be lost, but also fuel leaks and fire could be damaging to the environment. Mitigating the chances of damage to the aircraft due to an excursion would prevent environmental disasters that could lead to costly cleanup efforts and runway closures.

#### *vii. Utility and Upkeep*

From a financial perspective, the system would permit airports to better allocate resources to mitigate damage due to excursions. The major commercial benefit of the proposed system is made possible in part because of the low upkeep cost of the system. The costs of the

system include servers to house the collected and generated excursion data, and computational power to run various queries. The hardware would most likely consist of existing FAA web-based servers. The software would need to be developed and would be relatively inexpensive. Excursions (both past and current) are already logged on FAA servers, so there is no additional cost for simply adding data as new excursions occur.

*viii. Affordability*

In helping predict future excursions, this project will increase affordability in a few ways. Damage to the aircraft must be repaired and there may be environmental impacts that could need addressing. Loss of life due to an excursion is incalculable. However, this tool will act as a base

Year	Reason	Year Cost(\$)	Accumulative Total (\$)
1	D, T, IM, TR	154,000	154,000
2	M	6,000	200,000
3	M	3,000	203,000
4	M	14,000	217,000
5	M	1,000	218,000

D = Design  
 T = Testing  
 M = Maintenance  
 TR = Training  
 IM = Implementation

Figure 20. This table shows the yearly cost of the proposed system including implementation, design, testing, and ongoing maintenance.

reference to place EMAS strips and safety zones in the areas of highest risk for an excursion, which will help prevent excursions that are more devastating.

Each EMAS block costs about \$1000 and depending on the size of the runway, each EMAS strip can have hundreds of blocks. If damaged, the EMAS must be replaced and storage and maintenance of EMAS costs are applied depending on the airport size and location.

Installing and maintaining these strips at both ends of each runway at an airport costs millions of dollars. The goal of this system is to ensure that the EMAS strips and safety zones are constructed in the most useful locations. To calculate the startup cost of the proposed system, the following factors were considered.

Given a team of three experienced software engineers, the current end system would be finished in no more than 7 months. The process would consist of 4 phases: design, testing, implementation, and on-going support. The design process will take no more than 1 ½ months costing \$144,000 (40 hours per week \* 4 weeks per month \* 6 months \* \$150 per hour). This process consists of designing and writing the system. The testing process should take no more than one-half of a month costing \$12,000 (40 hours per week \* 4 weeks per month \* 0.5 months \* \$150 per hour), though testing should also be done once every 3 years to make sure the system is fully operational.

The implementation process, which would consist of installing the system into a given airport, will take around one-half of a month as well. This time includes the training hours of airport personnel to become familiar with the system. The cost would be \$12,000 (40 hours per week \* 4 weeks per month \* 0.5 months \* \$150 per hour). As seen in Figure 20, the first year costs the most because this is when the majority of the work will be accomplished. Training consists of a presentation of the system as well as more formal training in maintaining the system. Training will take no longer than 1 week. Maintenance includes storage of the system as well as power to the system. The total cost would be greatly reduced if the FAA's own developers programmed the system at less than \$150 per hour. This is less than one EMAS strip at a large hub airport. Once completed, the system can be applied to any airport with few, if any, modifications.

### *ix. Looking Towards the Future*

In its current form, this system is a powerful tool for predicting the most likely locations of excursions. When looking to the future, it has tremendous potential. The system currently uses two known factors to help airports understand and prepare for excursions: contour lines and previous excursion data. Since current trends in airport technology indicate that GIS use will continue to grow, it is likely that more geographic data about airports will become readily available for use by the system. More data will mean that more factors can be included to improve the accuracy of the system. For example, a few factors that McFarland Johnson currently has information about that could be used by this tool include fencing, wetlands, tree lines, and streams.

### *x. Sources of Funding*

An applicable funding source for Excursion Analysis Tool would be the FAA. The Airport Improvement Program (AIP) offered by the FAA funds 75% to 95% of eligible projects. Eligible projects include those improvements related to enhancing airport safety, capacity, security, and environmental concerns. [47] Though operation costs and salaries related to maintaining the funded projects are not typically funded this tool has very low maintenance costs, so basic maintenance of the system should not be a concern for most airports.

## **IX. Summary and Conclusions**

Runway excursions are responsible for both property and aircraft damage, and numerous fatalities. In an effort to minimize the threat posed by excursions, airports provide buffers of flat space or EMAS beds around each runway, so that excursing aircraft have room to slow down

safely. However, little has been done to determine where on a given runway an excursion is most likely to occur. This makes it difficult for airports to prioritize resources dedicated to protecting against excursions. To remediate this problem, the team developed a software solution that could determine areas along a given runway that pose a high risk of excursions.

The proposed system uses available excursion data for a given airport to display the danger zones on a map of a runway. Data from a specific airport can be augmented with excursion data from all airports of a specified category. Additionally, the proposed system uses features of the runway and its surrounding area to pinpoint areas of the runway where an excursion would be particularly dangerous. For example, the system uses contour lines to analyze the changes in elevation around a runway. The system can conclude where there are sheer cliffs, and where there are large, flat expanses of land, modifying the danger zones accordingly.

The Excursion Analysis Tool has profound impacts for aircraft safety. The tool will produce a visual GIS map that highlights specific danger zones and other important data such as past excursion points. With this tool, airport officials will be able to make more informed decisions about where to allocate their limited resources to deal with excursions. This will not only lead to more effective spending, but could also lead to more lives being saved each year, permitting safer aircraft travel throughout the United States.

## Appendix A: Contact Information

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## Appendix B: Description of Binghamton University — State University of New York

Founded in 1946, Binghamton University (shown in Figure 21) is one of the 64 campuses that comprise the State University of New York, and is located in Binghamton, NY. It is consistently ranked as one of the top public universities in the nation. Despite its comparatively



Figure 21, Binghamton University [48]

short existence, Binghamton University is regarded as an excellent institution with renowned research and degree programs.

Binghamton University enrolls over 14 thousand students in over 100 degree programs. Nearly 12 thousand of these students are

undergraduates, and nearly three thousand are graduate students. Fifty-seven percent of admitted students were in the top tenth of their graduating class and 60 percent had a grade point average of 3.75 or greater. The middle 50 percent SAT score of new students ranges from 1,800 to 2,060. Binghamton University's students are diverse, with almost half of students being of non-Caucasian ethnicity. [49]

Binghamton University is comprised of six colleges and schools: Harpur College of Arts and Science, Thomas J. Watson School of Engineering and Applied Science, Decker School of Nursing, School of Management, School of Education, and College of Community and Public



Affairs. The Thomas J. Watson School of Engineering, which contains the Department of Computer Science, was founded in 1983 and named after the founder of IBM, Thomas J. Watson Sr., an early supporter of the University.[50]

The *U.S. News & World Report* has ranked Binghamton University among its top 50 schools for 13 consecutive years, and *Fiske* denoted it “the premier public university in the northeast” in 2010.[51][52] *Kiplinger’s Personal Finance* has regarded Binghamton as the best out-of-state value for three years in a row [53], and *The Princeton Review* named it the fourth best-value public university [54], Binghamton University is one of only 16 colleges to have received *The Princeton Review’s* “green” rating for environmental responsibility.[55]

## Appendix C: Description of Non-University Partners

### *i. McFarland Johnson, Inc.*

McFarland Johnson, Inc. (MJ-Inc.) was established in 1946 with a focus on strong



Figure 22 McFarland Johnson employees at the company headquarters in Binghamton, NY.

collaboration between its employees and communities in the United States.[56] MJ-Inc. provides services in infrastructure planning, design and construction management, and aiding the environmental, building, land and transportation markets. As shown in Figure 22, MJ-Inc. provides these

services with a diverse staff, consisting of such specialists as planners, civil engineers, construction inspectors, structural engineers, environmental analysts, mechanical engineers, and computer/CADD specialists.



Figure 23 Chad Nixon shows the group BGM's GIS data.

Chad G. Nixon, pictured in Figure 23 speaking with the team, serves as Vice President & Business Development Officer at MJ-Inc. Mr. Nixon provides oversight over new services and growth opportunities, and serves the role of Special Projects Manager, where he

supervises a multitude of aviation planning projects.[57] In 2008, MJ-Inc. completed the Master Plan Update at the Greater Binghamton Airport, which included implementing GIS infrastructure and a drainage plan. MJ-Inc. has been very closely involved in the FAA Design Competition with teams from Binghamton University for the past four years, meeting up with teams and providing crucial information and advice. MJ-Inc. has also supported the Morristown Municipal Airport, Hascom Field, and Chemung County's Elmira Corning Airport. MJ-Inc. also has provided business-planning services for 23 airports, with each receiving operational and economic performance recommendations.[58]

*ii. The Greater Binghamton Airport*

The Greater Binghamton Airport, which is shown in Figure 24, is located in Johnson City, New York.[59] It supports three airline carriers: Delta, United Express, and US Airways Express.[60] Recently, the Greater Binghamton Airport received \$12 million for safety improvements on the primary runway: runway 34.[61] It was one of many safety



Figure 24 A model of the Greater Binghamton Airport, which was used as part of the McFarland Johnson Airport Master Plan.

improvements and infrastructure expansions to occur over the years.

In the 1940's, the development of a new airport for the Greater Binghamton Area, which would eventually be known as the Greater

Binghamton Airport, was begun by Dr. Frank Moore. One interesting little story, is that

even before the new airport was finished, two F-86 fighter jets made emergency landings on the unfinished runway. The Greater Binghamton Airport was officially completed in 1951, and has been satisfying the long-range transportation needs of the public ever since.[63]

## **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 provides an excellent learning opportunity. It addresses a key area that many university curriculums are lacking: real world project experience. It is rare for university students to participate in projects involving 25 students. The size of the project exposed the team to the reality of large-scale project management. Each sub-team was tasked with assessing assignments, delegating responsibilities, and independent research.

Furthermore, the nature of the field required teams to refer to industry professionals both in person and via electronic means. Because of this, students were able to practice professional conduct and gain experience interacting with professionals who may not be experts in the same field as that of the students. Both are activities difficult for academia to manufacture in the form of classroom assignments. The unfamiliarity of airports and excursions to computer science students gave us firsthand experience with projects a team might face in practice. Such projects would likely involve more than just the computer science skills we have developed in the classroom. Overall, the FAA Design Competition has left our class better prepared to enter the profession after graduating from college.

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

##### **How did you overcome them?**

Throughout the project, a challenge consistent with all team members was unfamiliarity. The majority of the class began the project with little to no knowledge about airplane excursions.

Just as few members were familiar with managing a project with 25 group members or the process of producing a professional level technical document. Adhering to standards for minute details such as vocabulary, writing style, grammar, word processors, and even email formatting took a period of acclimation. Good organization was required to coordinate all the sub-teams and keep them in unison.

The topic of excursions was also unknown to the majority of the class. In order to proceed with the proposal, the team required extensive study on the subject to get us up to date and ready to propose solutions. We overcame this lack of knowledge with the aid of industry professionals Carl Beardsley of the Greater Binghamton Airport and Chad Nixon of McFarland Johnson.

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

The process we used to develop our hypothesis was accomplished in five primary steps. First, the project leader, Andrew Cholewa met with aviation professionals and Professor Ziegler to review the competition guidelines and to brainstorm ideas. Andrew already had first-hand knowledge of the Greater Binghamton Airport from his participation in the FAA competition last year.

Then to familiarize the team with the problem of excursions and related topics, we performed an extensive literature review. We looked at statistics for excursions amongst other airplane accidents as well as studied previous attempts to fix the situation. The review was invaluable in deciding which facets of excursions we should focus on to provide a new solution.

The third stage of the process was having the entire team of 23 students visit the Greater Binghamton Airport to meet with Carl Beardsley and Chad Nixon. We described our initial

solution to them and took notes on their feedback. Their input was crucial to determining which directions we should pursue with the proposal. The Greater Binghamton Airport then allowed us to tour their runway and inspect their own excursion prevention systems called EMAS.

After gaining an understanding of the issue, the team brainstormed on possibilities to enhance the study behind the cause and prevention of excursions. During scheduled classes and within the design team meetings, the strengths and weaknesses of the geographical information system were discussed. The team brought up and accounted for design flaws to perfect a proposal.

The fifth and final stage was to create a comprehensive solution based on the designs agreed upon by the entire team. The team built a web based graphical interface to prototype the idea. It employed database techniques to parse incident reports and model buttons to demonstrate options a potential user could have when analyzing excursions.

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

Participation from industry partners was crucial to the completion of the proposal. The team was able to meet and consult with Carl Beardsley of the Greater Binghamton Airport and Chad Nixon of McFarland Johnson. Mr. Beardsley and Mr. Nixon provided valuable information and sources, such as aircraft incident databases, demonstrations of current geographical information systems at airports, and airport regulations. These insights allowed the team to focus on aspects of excursions most useful for the project. Industry participation was instrumental in helping the team become familiar this unfamiliar field. The team was provided access to the Greater Binghamton Airport and to key employees at McFarland Johnson, Inc.

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

This project provided many opportunities for the students involved to hone skills usable in the workforce. The project allowed students to experience all aspects of completing a solution for real world problems. The team was able to work first hand with industry representatives, brainstorm ideas for real problems, and execute their ideas. The students learned to manage a large project and exercise organization skills necessary to succeed. The experience gained during the course of developing the proposal is something seldom processed by students attempting to enter the workforce. They should be an advantage for the team as they further their educational careers or enter the field.

*Faculty Evaluation*

**I. 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. The majority of students at Binghamton University participating in this competition 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 within a large team, 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?**

People that I speak to about the FAA Competition are quite surprised to learn that my primary goal is to provide my students with an opportunity to become better communicators and problem solvers. The competition is 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, problem solving, 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. 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 consists of 23 students, which is 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. 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, they will face 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 34 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 put in 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 appreciate the fact that several new categories and topics were added to the competition this year and if a couple more could be added each year, that would be wonderful.

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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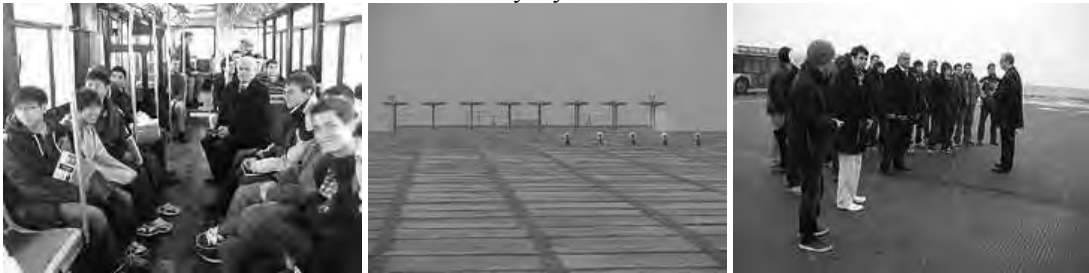
## Appendix G: Photo Gallery of Participation in the FAA Competition



Industry professionals brief the team on an overview of the airport.



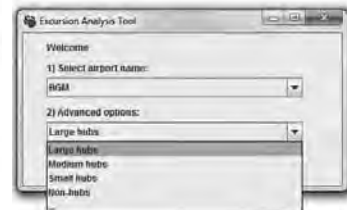
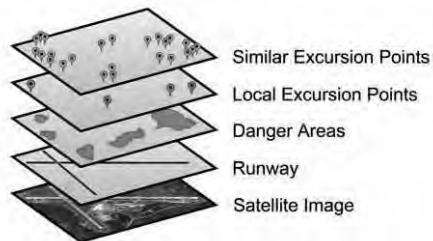
The team learns about runway layout and the current GIS in use.



Students study current technologies at the runway, such as the EMAS.



Chad Nixon, VP of McFarland Johnson, answers questions regarding the project at Binghamton University.



Mapping excursion data points and a proposed GUI for the excursion analysis tool.

## Appendix H: Ethical Considerations

Any software tool, but especially a tool involved in safety analysis, has a unique set of ethical considerations that need to be addressed. The primary goal of the Excursion Analysis Tool is to help make flying safer by providing an accurate analysis of past excursion data and using that analysis to predict future location and severity of excursions. As a result, implementing the Excursion Analysis Tool would have a positive impact on both airline passengers and operators. However, while this project has the potential to be of great benefit, the tool would exist in an ethically unexplored area. Examples include circumstances where it may have limitations or situations where it may produce erroneous results.

An accurate analysis of runway excursions will allow better safety planning for airports. The improved safety planning will ensure that passengers are better protected. Airport operators



Figure 25 American Airlines flight 331 overran the runway at Norman Manley Airport and split in half.[62]

also benefit from better safety planning, because the cost of an excursion is extremely high. Figure 25 shows that a considerable amount of damage can be done to an aircraft that experiences a runway excursion. In the case of American Airlines flight 331, the Boeing 737-823 was damaged beyond repair. [64] By utilizing the Excursion Analysis Tool

to help maximize the number of excursions that occur along a region of the runway that is sufficiently protected, airports will be able to reduce the frequency of irreparable damage due to excursions.

As a software tool, the Excursion Analysis Tool faces a complicated ethical dilemma. It is expected that any given human will make errors, but the same is not expected of software. Whereas a specific human can be blamed for his or her failure, where does the onus fall for a software bug or miscalculation? This is especially true for an error that causes bodily harm to a passenger or worker. This ethical dilemma is not new, and is faced in many industries where new software is being introduced. In order to deal with these ethical considerations, careful planning will need to be done ahead of time. First, accountability must be decided. For instance, software developers must be held accountable for critical software bugs. However, the software developers must also be given adequate time to test their code to reduce the frequency of bugs. By carefully considering the potential areas in the process of developing and using the software where things may go wrong, and carefully documenting all actions taken at those steps, accountability can be determined in the case of a serious error. Furthermore, steps may be taken to ensure that such errors do not happen again.

## **Appendix I: Biographies**

### **Kelvin Chen**

Kelvin Chen is a computer science student working towards a BS at Binghamton University. He is currently a senior residential computer consultant at Binghamton University. He is also participating in undergraduate research on wide-scale agent-based modeling using GPUs. He is a member of the Upsilon Pi Epsilon honor society.

### **Andrew Cholewa**

Andrew Cholewa is currently studying computer science and mathematics at Binghamton University, with an expected graduation date of May 2012. In August 2012, he will begin pursuing his PhD in computer science at the University of Illinois at Urbana-Champaign. His research interests include formal software verification, computational linguistics, and theoretical computer science. He is a member of the Binghamton University Scholars Program, the Upsilon Pi Epsilon Computer Science Honor Society, and the Pi Mu Epsilon Mathematics Honor Society. His favorite pastime is to engage in “leisure learning,” which is to study independently something that he finds interesting without the stress associated with deadlines.

### **Katie Eng**

Katie Eng is currently pursuing dual degree in computer science and music at Binghamton University, with an expected graduation date of May 2013. She has previously participated in the Research Experiences for Undergraduates (REU) program at Binghamton University, sponsored by the National Science Foundation (NSF), in which she worked with Dr. Lijun Yin in the Graphics and Image Computing Laboratory. She is a member of Upsilon Pi Epsilon, the International Honor Society for the Computing and Information Disciplines, and is a recipient of the 2011-2012 Lockheed Martin Honors Scholarship for computer science.

### **Greg Flynn**

Greg Flynn is a senior computer science major with experience in web applications and web design. Previously, he spent three semesters at Onondaga Community College before transferring to Binghamton University. His interests beyond the web include Information Retrieval, Data Mining, and Computer Graphics.

### **Max Gale**

Max Gale is a senior studying computer science at State University of New York at Binghamton. By the end of 2012, he plans to obtain a Bachelors of Science from the University. During his time in Binghamton, he received the Lockheed-Martin honors scholarship. For the previous two summers, Max has interned at Amazon.com, Inc.

**Mudit Goel**

Mudit Goel is a computer science student at State University of New York at Binghamton. He has a math minor, and he is expecting to graduate in 2012. His professional experience includes interning at Intuit, Inc. in San Diego, and aiding operating systems research at Binghamton University. Mudit also volunteers to tutor elementary school children.

**Ryan Halegua**

Ryan Halegua is a senior at Binghamton University and expected to graduate May 2012. Ryan has completed two internships at New York Life Insurance Company. Once he graduates, he plans on working as a software developer. He hopes to pursue a sustainable career in Computer Science.

**Geoffrey Hetherington**

Geoffrey Hetherington is a senior at Binghamton University and expects to graduate in May 2012 with a B.S. in Computer Science. Geoffrey is also expected to graduate with his M.B.A. in May 2013. Previously, Geoffrey has completed an internship at the U.S. Air Force Research Laboratory in Rome, NY during summer 2011. His interests include computer networks, machine learning, and hiking.

**Stephanie Huber**

Stephanie Huber is pursuing a BS in Computer Science at the State University of New York at Binghamton, and is expected to graduate in 2012. She is a member of Upsilon Pi Epsilon, the International Honor Society for the Computing and Information Disciplines, and a recipient of the Jack Knoll Scholarship for Women in Computer Science and Engineering. Currently she is developing Java and Android applications for web-based startup companies. Aside from software development, her interests include Japanese culture and language.

**Chris Kant**

Chris Kant is pursuing a BS in Computer Science with a minor in Math at Binghamton University. He expects to graduate in May 2012. Chris has interned as a software developer at defense contractor Lockheed Martin as well as NYC web startup Behance. His interests range from applications programming to iOS development. He is fascinated by new technologies and innovative development tools and ideas. After graduation, he will be working as a Software Development Engineer at Amazon.com.

**Jie Hui Kuang**

Jie Hui Kuang is a candidate for a BS in computer science with an expected graduation date of December 2012. He previously interned at OTC Markets Group Inc. as a system administrator. He is a recipient of the National Science Foundation's Science, Technology, Engineering and Math (STEM) Scholarship. He actively works on mobile application development on the iOS/Android platforms as a hobby and plans to pursue a career as a mobile application developer after graduation.

**Adam LaFave**

Adam LaFave is a senior undergraduate at Binghamton University – State University of New York and is pursuing a bachelor's degree in Computer Science. He has had multiple web development internships and will pursue a career in web development.

**Edwin Lee**

Edwin Lee is currently a senior pursuing a degree in Computer Science at Binghamton University, and expects to graduate in May 2012. He has completed two summer internships with Telephonics Corporation in 2010 and 2011 as a Software Engineer Intern. He is currently the webmaster and tutoring coordinator of Upsilon Pi Epsilon. His academic interests include web development, database management, and Android development. His hobbies include badminton, table tennis, and playing piano.

**Arthur Livetsky**

Arthur Livetsky is currently pursuing a Bachelor's of Science in computer science at State University of New York at Binghamton. He is part of the Computer, Robotics, & Engineering special interest housing community that partakes in various software engineering projects. His primary interests include software development and music production.

**Steven Mance**

Steve Mance is currently pursuing a Bachelor's degree in Computer Science at Binghamton University expected May of 2012. His past work includes interning at Interos LLC designing web-based applications and working for Binghamton University IT Services as a Residential Computer Consultant. His interests include web design and computer graphics.

**J. Andrew Marshall**

J. Andrew Marshall is a senior undergraduate currently pursuing a Bachelor's of Science in computer science at State University of New York at Binghamton. He has free-lanced actively for five years building web applications for clients, as well as interning for the web development company Case Commons in New York City during summer and winter 2011. His interests include creating beautiful and elegant code, software development practices, programming languages (in particular Ruby), and photography.

**Nathaniel Roman**

Nathaniel Roman is a full time student attending Binghamton University and is planning to receive a BS in Computer Science when he graduates in May 2012. He is a member of Upsilon Pi Epsilon, the computer science honor society.

**Aaron Shipper**

Aaron Shipper is a senior graduating in May 2012 with a dual degree in Computer Science and Mathematics. He conducts research in a psychology lab on neural networks and works supporting general research on the Binghamton University campus as a research aide at the Innovative Technology Complex. His academic interests include applying mathematical concepts and computer science problem solving skills to real life issues.

**Evan Sussman**

Evan Sussman is a senior from East Hills, New York, majoring in Computer Science at State University of New York at Binghamton. Previously, Evan has completed an Internship at Open Link Financial. His interests include fitness, programming and tennis.

**John Thorsen**

John Thorsen is pursuing a BS in Computer Science at the State University of New York at Binghamton with an expected graduation of May 2012. He actively seeks to educate himself on a wide range of programming languages as a hobby and to better prepare himself for the real world. Previously he was an owner of an L.L.C. that provided open source web software. Outside of programming, he enjoys watching and playing sports, reading and listening to a variety of music.

**James VanBeverhoudt**

James VanBeverhoudt is a senior undergraduate at Binghamton University – State University of New York. He will graduate in May 2012 with a B.S. in Computer Science. The end of the semester will also sum up his internship with McFarland Johnson. His interests include soccer, tennis, piano and volleyball.

**Michael Wang**

Michael Wang will graduate from SUNY Binghamton with a BS in Computer Science in May 2012. He is a native of New York City and avid basketball fan. He will begin work at Deutsche Bank as an analyst after graduation. His interest in investment banking involves prime brokerage.

**David White**

David White is a senior in the computer science department at Binghamton University. Knowledgeable in a variety of languages including C++, Python and Java, he has contributed to projects at all stages of the software development process. Current software interests include Android mobile development and OpenGL graphics.



## Appendix J: Milestones

- Milestone 1:* The project leader, Andrew Cholewa, and Professor William Ziegler discussed potential project ideas with Vice President of McFarland Johnson, Chad Nixon and Commissioner of Aviation Carl Beardsley.
- Milestone 2:* Professor Ziegler and Andrew discuss how the class will be split up into different teams, each focusing on different aspects of the project.
- Milestone 3:* The entire project team meets for the first time as a group. Professor Ziegler goes over what is expected of each team and its responsibilities. An overview is given about the competition and the problem to which the class will need to present a solution.
- Milestone 4:* Each individual team meets separately for the first time and begins working on literature reviews.
- Milestone 5:* The class wants to use the factors that cause excursions such as brake failures, pilot error, worker error, weather conditions, and airplane type to create an excursion system.
- Milestone 6:* The class visited the Greater Binghamton Airport (BGA). Commissioner Beardsley explained that airports tend to focus only on the front and back of the runways for excursions. Chad Nixon from McFarland Johnson showed a demo of a GIS system. The team took a bus out on the runway to see one of the EMAS beds on the primary runway and to get a close-up understanding of excursions.
- Milestone 7:* Through the visit to the airport and discussions, the class decides it is too difficult to quantify brake failures, pilot error, worker error, weather conditions, and airplane type.
- Milestone 8:* A team member found prior runway excursion files. The class wanted to use this data as the primary means of predicting high-risk areas for runway excursions.
- Milestone 9:* The class decided to use these past excursions and incorporate them into a GIS.
- Milestone 10:* Completed Appendix A: Contact Information.
- Milestone 11:* Chad Nixon of McFarland Johnson visited the class at Binghamton University. The class discussed whether to use FAA categories and how to deal with military versus commercial airports.
- Milestone 12:* Completed Appendix B: Description of BU.

*Milestone 13:* Completed Appendix C: Description of Non-university Partners

*Milestone 14:* Completed Appendix D: Design Proposal Submission Form

*Milestone 15:* Completed Appendix G: Photo Gallery.

*Milestone 16:* Completed Appendix I: Biographies of all teams.

*Milestone 17:* Completed Appendix F: Reference List With Full Citations.

*Milestone 18:* Completed Appendix E: Evaluation of Educational Experience.

*Milestone 19:* Completed Appendix H: Ethical Considerations.

*Milestone 20:* Completed Appendix J: Milestones.

*Milestone 21:* The team created drawings of the system

*Milestone 22:* The team completed the FAA competition written entry

## Appendix K: List of Acronyms

<b>AC</b> Advisory Circulars	<b>MJ-Inc.</b> McFarland Johnson Inc.
<b>AIP</b> Airport Improvement Program	<b>NTSB</b> National Transportation Safety Board
<b>BGM</b> Greater Binghamton Airport	<b>RSA</b> Runway Safety Areas
<b>EMAS</b> Engineered Material Arresting System	<b>RSARA</b> Runway Safety Area Risk Analysis
<b>FAA</b> Federal Aviation Administration	<b>SARP</b> Standards and Recommended Practices
<b>GIS</b> Geographic Information System	<b>SMS</b> Safety Management System
<b>ICAO</b> International Civil Aviation Organization	<b>SRM</b> Safety Risk Management