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Title of Design: An Automated System for Managing Vegetative Obstructions

Design Challenge Addressed: Airport Operations and Maintenance

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University Design Competition for Addressing Airport Needs

An Automated System for Managing Vegetative Obstructions

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Executive Summary

A primary goal of the Federal Aviation Administration (FAA) is to provide a safe and efficient airspace with the lowest possible accident rate in aviation. One current issue that proves problematic in regards to achieving this goal is the issue of obstructions to airport approaches, often referred to as flight paths. Problems caused by vegetative obstructions such as trees and brush are especially challenging to mitigate. Currently, airports may spend hundreds of thousands of dollars every year identifying and removing obstructions around the airport. Additionally, airports with vegetative obstructions in violation of specific FAA night approach minimums have had to halt nighttime operations for a period of time. This leads to a loss of revenue for the airport and alters commerce and recreational flying by requiring pilots to change flight plans or cancel scheduled flights that utilize those airports.

Proposed herein is a predictive obstruction analysis system (OAS), created by students at Binghamton University, that will allow airports to better forecast and evaluate when obstructions will pose a problem for the airport, thus providing airports with the opportunity to mitigate obstructions before they interfere with the flight path surfaces. This system primarily utilizes information that is currently available, including orthographic and topographic maps obtained from aerial photography. The obstruction analysis system will then integrate this information with data regarding the growth rates of trees in the area. Based on this combined data, the OAS will produce a visual, quantifiable output to allow airport operators to assess the growth and potential of vegetative obstructions in the area around the airport. This in turn will allow the airport to predict when various obstructions will become a threat to the flight path surfaces that must be kept clear as mandated by the FAA. By allowing airports to remove obstructions before they pose a problem, the OAS reduces risk and allows airports to plan for vegetation obstruction mitigation well in advance, greatly improving the current system of waiting until flight minimums are encroached upon to perform obstruction analysis.

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I. Problem Statement and Background

a. FAA Goals

There is a focus within the aviation industry to reduce the risk of accidents by improving current safety practices at airports. Failure of an airport to meet certain FAA standards can result in revocation of certain operating privileges. The FAA considers the presence of obstructions that penetrate various airport imaginary surfaces, particularly those in the approach path, to be a significant safety concern and has identified that addressing this issue is a safety priority. One goal described in the FAA's *Destination 2025*, a document outlining the FAA's plan to provide the safest, most efficient aviation system in the world, is developing new methods for mitigating safety concerns related to runway obstructions [1].

b. Current Methods for Meeting FAA Goals

i. Cataloguing of Obstructions

Over the last several years, the FAA has invested significantly and implemented a number of systems intended to improve the tracking of airport obstacles and obstructions. One such system is an offshoot of the "NextGen" initiative, which includes new software intended to improve airport safety. One of the functional elements of this software is the ability to stream fully 3D rendered terrain to pilots, identifying the locations of known obstacles [2]. This software can be used in conjunction with the Digital Optical File, a database managed by the FAA's Terrain and Obstacle Team that catalogues all current airport obstructions of interest. This database is updated every eight

Figure 1- Trees obstructing the runway at Tri-Cities Airport.

weeks with information about airport obstacles that currently pose a danger to aircraft utilizing the runway in question [3]. These systems assist in notifying airport managers of obstructions that currently pose a risk to airport safety, such as those shown in Figure 1, and help to indicate when an obstacle has penetrated a critical surface and is significant enough to warrant removal.

ii. Removal of Obstructions

Current practices in removing vegetative obstructions both on and off airport property involve either trimming or 'topping', cutting or putting lights on top of the trees that are obstructions to the flights paths of an airport. Often, this process involves environmental studies to identify animal habitat that exists in the area, wetland delineation, land acquisition and then design of a removal project. This can be a very lengthy and expensive process that requires years of time and potentially hundreds of thousands of dollars.

The FAA has detailed guidelines on management of vegetation surrounding an airport. The FAA also recommends preventing any future growth of trees or high standing vegetation by removing the stump and roots or treating the base chemically. If obstructions are on private property, the affected airport then sends a representative to negotiate with property owners to decide whether the airport can remove or trim the trees, such as those seen in Figure 2. If only allowed to trim, the airport then must ensure that what is cut will not be problematic for the next five years at a minimum. In order to estimate this, the airport uses either a normalized growth rate of two and a half feet per year or the local tree growth rate to determine

Figure 2- Trees recently cut down in Queensbury, NY [4]

how much vegetation is to be trimmed. To ensure that trimmed trees do not pose a problem again, the airport must check the trees that they have trimmed every three years to observe whether the estimated growth rate was correct. The checkup the airport does provides a time frame for the next trimming [5].

c. Moving the Industry Forward

Airports around the world use the current practices in trimming or removing obstructions almost universally. There are many flaws in this practice, as the assumptions made regarding the growth rate of trees can be inaccurate, and predicting future obstructions can be difficult. This presents many challenges to airports in knowing when trees need to be cut in order to clear all flight paths of obstructions. A system allowing an airport to successfully analyze, using the accurate growth rates of relevant vegetation to predict what could become an obstruction, would greatly benefit the FAA in their goals of achieving the highest level of safety for airports and efficiency in dealing with obstructions. The design proposed presents a unique systematic approach in the planning and execution of vegetation removal operations.

II. Summary of Literature Review

a. FAA Goals and Safety

The FAA has long been dedicated to providing the "safest, most efficient aerospace system in the world" [6]. One of the FAA's goals for the year 2025 is to have the lowest possible accident rate in aviation [1]. In accordance with this goal, the accident rate (measured as number of fatal accidents per 100,000 flight hours) has been trending downwards in past years [7], and was only 1.05 in 2014 [8].

A major step taken in order to uphold the FAA's mission statement is the implementation of Safety Management Systems (SMS) in airports [9]. The Safety Risk Management (SRM) process is arguably the most significant part of this system. It consists of a series of five phases designed to identify and rectify safety risks quickly and efficiently [10]. The SRM also designates a problem as high risk, medium risk, or low risk based on the severity of the effect of the problem and the likelihood that the problem will occur [11]. Any problem that is not at an acceptable low level of risk must be rectified. This is especially important with problems that pose a high level of risk, as these can be cause for delay or cancellation of a flight [12].

b. Obstructions

One such safety risk experienced in airports is obstructions to aircraft flight paths. The FAA dictates that all aircraft must follow certain slopes (e.g. 20:1, 34:1, 40:1) when flying into and out of airports to ensure safe takeoffs and landings [13]. However, obstructions such as trees, hills, buildings, and poles may penetrate these approach minimums and present hazards to safe flight. Airports are required to deal with these obstacles in the manner outlined by the FAA (lighting them properly so they are easily visible, or removing them from the flight path) in order to be certified and thus allowed to operate [14].

If a possible penetration of a surface is deemed valid, the penetration is then categorized as one of three levels of risk. It is high risk if the penetration is more than eleven feet above the surface, and thus requires immediate action. In the meantime, if the obstacle is not properly lit, nighttime operations must be restricted or ceased. Within thirty days, a compliance report must be issued detailing plans for removal, lighting, or lowering of the obstacle as soon as possible. The obstruction is medium risk if it is between three and eleven feet above the surface. Again, a compliance report must be issued stating that the obstacle will be removed, lit, or lowered within 180 days. A low risk obstruction is one that rises less than three feet above the surface. A compliance report must be issued within thirty days and the obstacle must be removed, lit, or lowered within a year [15]. Procedures and reports regarding the 20:1 surface are reviewed every two years; this is how new obstructions are identified [16].

When given the choice between removing and lighting an obstacle, it is always more effective to remove the obstacle. Simply lighting an obstacle to signal a hazard can greatly reduce the amount of usable runway, as well as the range of aircraft that an airport may support. In contrast, removal of obstacles maintains the airport's range of functionality and offers a much safer solution to the issue [17]. When the obstacle in question is a tree, removal generally refers to cutting the tree; however, if measures are not specifically taken to prevent regrowth, the tree will eventually grow back and become an obstacle to safe flight once more. In this case, tree growth inference provides models and helpful knowledge on the practices of predicting the rates of tree growth. The growth data and applicable standards, when combined with the database of vegetative obstructions surrounding an airport, are extremely helpful in developing a predictive vegetative obstruction tool [18].

c. Current Methods of Managing Obstructions

Airport Obstruction Charts (AOC) are 1:12,000 scale graphics that provide data for maximum landing and departure weights and establishing instrument approach and departure procedures [19]. Universal Dive Data Format (UDDF) Files contain the coordinates and heights of obstructions near airport runways. When UDDF Files and AOC are combined with graphics of the approach surfaces as designated by the FAA, it is possible to identify the obstructions that require removal [20].

A Light Detection and Ranging system (LIDAR) is a cost-effective airborne terrain mapping system that generates a 3D representation of landscapes. This technology may be used in conjunction with Global Positioning Systems (GPS) to assist in modeling the surroundings of an airport, and more accurately outlining all obstructions at the ends of the runways [21].

The Terrain and Obstacle Team of the FAA maps all terrain and obstacles that can intrude upon an airport or cause any risk to pilots taking off or landing on a runway. The team creates a Digital Obstacle File (DOF) that contains all information collected and displays it next to each specific airport. This file is consistently updated every 56 days and contains information from almost all airports located in the United States, Mexico and the Caribbean islands [3].

As mentioned previously, the FAA is currently in the process of developing “NextGen” software intended to improve airport safety. One aspect of this is a fully 3D representation of airport terrain that may be streamed to pilots. This allows for better understanding of where obstacles may be, and of an aircraft’s position in relation to these obstacles [2].

III. Problem Solving Approach

Before the start of this semester, project leaders Jason Moss and Rachel Kiesling had a series of meetings and phone calls with Professor Nixon. Their discussions focused on deciding which design solution to propose for the FAA Design Competition. The categories under consideration for the proposal included Airport Operation and Maintenance, Runway Safety/Runway Incursions/Runway Excursions, Airport Environmental Interactions, and Airport Management and Planning. The discussion was narrowed to two primary topics: runway incursions and vegetative obstructions. One potential solution for the topic of runway incursions was creating an alternative to Engineered Materials Arrestor Systems (EMAS); however, this solution was at a disadvantage because there is currently only one vendor for the products needed. Another potential solution was to use sensors on planes to avoid collisions with airport vehicles like carts and trucks. This solution was at a disadvantage because several systems of this nature already exist. It was agreed that the topic of runway incursions was an issue that many participants would choose to pursue. The group decided instead to choose the topic of vegetative obstructions, which is a subtopic of Airport Operations and Maintenance. This topic would allow the Binghamton team to stand out among its competitors. Additionally, the team leaders and Professor Nixon agreed that a predictive system for vegetation would be extremely useful for airports and has the potential to be developed and implemented in the near future.

At the beginning of the semester, Professor Nixon and the team leaders explained to the team that the basis of the submission to the FAA Design Competition would be to find a way for airports to better manage vegetation that poses a risk to aircraft taking off and landing. From the start of the discussions, the team, pictured in Figure 3, agreed that the basic design that should be pursued was a software program with the ability to provide a predictive model for the growth of different types of vegetation in the area of airports. Many aspects of aircraft operations and vegetation needed to be taken into account before the team could outline the details of such a program. In addition, before determining the details of the design, the team divided into sub-teams to approach the solution through task delegation in an organized manner.

Figure 3 - Zachary Staff met with the team at Binghamton University.

The team for this project consisted of nine undergraduates. The team divided into four different project sub-teams, each with different requirements and tasks to complete throughout the duration of the project. The four sub-teams were the Engineering and Graphics team, the Risk Assessment and Research team, the Design team, and the Strategies and Approach team. Each of these sub-teams had a team leader who was the chief editor of the team’s submissions.

The Design team was responsible for addressing the technical aspects of the project. The Engineering and Graphics team documented the entire team's steps in the project by taking photos and creating graphics for other teams, primarily the Design Team. The Risk Assessment and Research team assessed what risks there were pertaining to the project and researched existing technology that could help to improve the design. The Strategies and Approach team documented the process of how the team worked together and with industry experts in order to produce a final design. Along with these four teams, there were two project leaders who had previously taken part in the FAA Design Competition. They served as advisors and chief editors for the team.

Each sub-team met regularly in order to discuss how to approach the problem and to share findings from their individual research. At the beginning of the semester, it was established that no one on the team had any background in aviation. In order to compensate for this lack of knowledge in the field, every sub-team was required to perform research and complete literature reviews outlining said research. In addition, the team visited Tri-Cities Airport, a small nearby airport pictured in Figure 4. The goal of this visit was for the team to see firsthand how vegetation can pose a threat to aircraft taking off and landing as well as to interact with industry experts who could discuss the process of clearing vegetation for airport safety. Tri-Cities Airport manager Gerard Corprew and Bradford County Airport Manager Heather Blokzyl made themselves available to answer questions. They explained how long and difficult the process of getting approval to remove

Figure 4- The team visited Tri Cities Airport in Endicott, NY.

vegetation is; it is especially complicated when the problematic trees are not on airport land, but rather on private property. Mr. Corprew and Ms. Blokzyl provided information about how vegetative obstructions cause issues for airports and can even hurt business for them. For example, Tri-Cities Airport lost its night flying rights, which can translate into less business during the daytime because the airport loses some credibility.

Once the team outlined a final design, the team sought advice from other industry experts in order to work on the logistics of the design. One of these experts was Zachary Staff, an airport planner for McFarland Johnson, who visited Binghamton University to discuss the project with the class. Mr. Staff was able to offer valuable information including how much money the design, if implemented successfully, could save airports in the process of clearing vegetation, and insight into which aspects of the design should be built upon and which aspects should be adjusted or tweaked. He mentioned that the current range of cost for an obstruction analysis at an airport is seventy five to eighty thousand dollars. The Binghamton team's design could potentially save airports tens of thousands of dollars when they conduct mapping and inspections of their property for obstruction analysis. Another topic discussed was the need, or lack thereof, for maintenance of the design. The purpose of the design is to reduce or even eradicate the need for frequent field surveys of the land around an airport; however, airports may choose to perform periodic surveys or field verifications to confirm the information offered by the model. This practice may be particularly smart during the early stages of use when the model is first adopted. Finally, Mr. Staff, pictured in Figure 5, offered advice about what aspects of airport operations and which FAA requirements were particularly important and therefore should be addressed by the design in order to strengthen the proposal. He stressed the importance of making sure the design complies with key FAA requirements, such as those outlined by Part 77. For example, one requirement listed in Part 77 is that adequate notice must be given to the

Figure 5 - Students present design to Zachary Staff at Binghamton University.

FAA before any proposed alteration or construction described in section 77.9 takes place near an airport [13]. The predictive nature of the OAS allows airports more time to notify the FAA of problems before they need to be dealt with, helping airports to comply with Part 77. Section 77.9 of Part 77 lists all the types of construction that require a notice to be sent to the FAA [13]. These include construction of obstructions that penetrate different surfaces such as 100:1, 50:1, and 25:1, at different distances from the nearest point on the nearest runway or landing at an airport.

Overall, participating in the FAA Design Competition was an extremely valuable educational experience. The most obvious aspect of the educational experience is learning about the basics of airport operations and aviation requirements. This was achieved through researching as well as by interacting with numerous industry experts, which were both important skills to develop. In addition, the process of developing a design and compiling a report was a valuable experience because of the teamwork that was involved. The sub-teams within the larger Binghamton team had to communicate and share information in order to produce a cohesive project. The ability to work in a team is surely one that is useful in the real world.

IV. Technical Aspects

The proposed Obstruction Analysis System (OAS) will provide airport owners and operators with automated analyses of FAA imaginary surfaces around the airport to illustrate graphically when trees and vegetation will interfere with approach minimums. The OAS will overlay orthographic photos and topographical maps that will be cross-referenced with growth rates for a wide variety of vegetation relevant to the geographic region of interest. After processing this data, the OAS will illustrate to the user an accurate projection of future vegetative obstructions as well as tabular data and allow airport operators to plan for the mitigation of associated obstructions in a timely manner. The presented case study for Tri-Cities airport in Endicott, New York will demonstrate the effectiveness of the OAS.

a. Data Gathering

Documentation of existing and potential obstructions allows crucial data to be gathered for input to the OAS. Currently, aerial photography via orthophotography or LIDAR is typically used to map general information about size and location of obstructions [23], such as buildings and land surfaces, near airfields. Aerial photography only records the highest point in certain area intervals, such as every 50 or 100 square feet. The OAS focuses on the data gathered regarding vegetation. Most airports have a database with obstruction information from various projects such as environmental assessments, airport planning documents and construction surveys that are updated every ten years at a minimum [23], which is made available publicly via the FAA website [20]. This information is augmented by FAA data sources from flight checks and other airport analyses.

The location and height information from these data sources may be sufficient for OAS analysis; however, additional information on tree types will be included to accommodate predictive functionality. One or more environmentalists or arborists would be commissioned to conduct a walk-through of the land under consideration on and around the airport to confirm major tree groupings. This field verification would be up to a weeklong process and would help to classify trees into different growth groups.

Tri-Cities Airport is not currently in the FAA's obstruction database; an obstruction study would need to be performed or obtained to implement the OAS and a field verification will also be required to determine tree types. The obstruction study for Tri-Cities Airport would gather data for to trees near the runway ends. By examining existing data from the Tri-Cities airport's previous planning projects, information can be gathered about current tree clearing in the wetland areas around the approach surfaces. Trees of particular importance are those near runway three, where the FAA has already suspended nighttime operations.

b. Overlaying Data

The OAS will utilize the inputted obstruction data or data from an existing database to provide the user with an organized and simple representation of the information output. The analysis will use data from these databases, the mapping and survey information from orthophotography or LIDAR described in Section I, as well as existing topographical maps of the area. This information will be displayed using an orthographic photo showing a profile and plan view of the terrain and the highest obstruction at a given point along the terrain. This information, shown in Figure 6, allows for trees within a given area (500 square feet for example) to be represented by the highest tree within that grouping, providing a conservative analysis of the area. Please note that the mock-ups displayed in this section use an exaggerated grid size for the purpose of clarity only. Final versions of the OAS will utilize a smaller grid size for maximum accuracy.

Figure 6- The OAS displays information regarding average tree height, growth rate, and height from minimums for a range of years.

Other pertinent information for OAS users will be the approach surfaces, which pilots use to land planes. The two guiding documents for approach surfaces are called Terminal Instrument Procedures (TERPS) and Federal Aviation Regulation (FAR) Part 77 [23]. All airports are governed by one or more approach surfaces from each flight procedure depending on visibility and weather variables. The 20:1 surface for the TERPS procedure is vital for airport maintenance of night minimums. All airports large and small use the 20:1 TERPS and the 34:1 Part 77 surfaces, while airports with better instrument approaches such as a precision approach use stricter approach minimums (34:1 TERPS and 40:1 Part 77) [23].

One or more of these flight surfaces can be overlaid onto the orthographic photos depending on which are applicable to the airport in question. A completed obstruction analysis will show the orthographic photo of terrain and obstructions, as well as each flight minimum used by the airport in question. By organizing the obstruction heights and locations with the flight minimum requirements that airports must meet, the viewer can see where each obstruction crosses into and interferes with each specific approach surface. Airports can use this information to remove obstructions that can interfere with approaches to the airport and cause hazards for pilots; however, this can still mean that dangers exist prior to the completion of the obstruction analysis, which can lead to the loss of the ability to land at night or total loss of approaches if obstructions interfere with night minimums or other minimums. Adding a predictive element into obstruction analysis, as displayed in Figure 7, allows OAS users to know when vegetative obstructions will grow into the path of various flight approaches well into the future. Given this information, airports can plan for obstruction removal and distribute funding and resources accordingly.

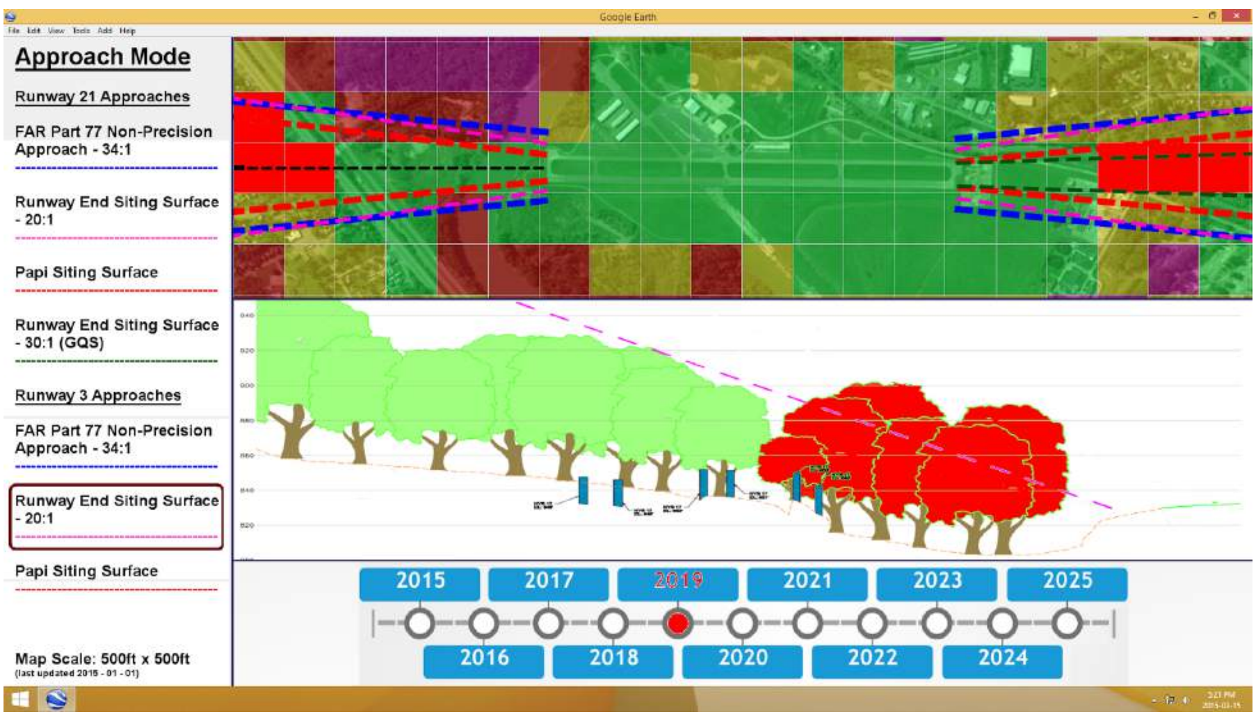

Figure 7- The OAS would mark obstructions that interfere with flight path surfaces in red, indicating that said obstructions must be removed.

Tri-Cities Airport has two runway ends, meaning there are two sets of flight surfaces. The vegetative obstructions opposite runway 3 have already caused that runway end to lose its night minimums. This means those obstructions will already interfere with the overlain flight surfaces and the OAS will automatically identify the problems in that area.

c. Tree Grouping

The predictive function of the OAS hinges on the creation of tree growth rate categories. There are hundreds of types of trees in the United States. Many of these have similar growth rates and therefore do not need a unique category in the OAS. The Missouri Department of Conservation's tree growth chart [22] specifies three main growth groups: slow growing, medium growing, and fast growing. For the OAS, a fourth "very fast growing" group will be included for thoroughness.

The slow growing tree group consists of trees growing 12 inches or less every year. Since most regulations state that trees must be cut to at least 10 feet under any approach surface, these trees would take ten years to grow back to a height that would interfere with TERPS or FAR Part 77. Trees in the slow growing group include eastern red cedar, some hickory trees, white and bur oak, and other deciduous trees [22].

Medium growing trees grow between 12 and 24 inches every year. The worst-case scenario is that a tree in the medium tree growth group will grow back to the lowest approach surface in 5 years based upon the same assumption of cutting 10 feet below the surface. This is half the time it takes for a tree in the slow growing group to reach an approach surface. The medium group includes trees such as red pine, hazel, sumac, walnut, some oak trees, and dogwood trees. The medium growth group contains more species of tree than the small growth group [22].

Fast and very fast growing trees grow 24 to 36 inches a year and 36 inches and up a year, respectively. These trees can become problematic in as little as 2.5-3.5 years after being cut well below the appropriate surfaces. These groups contain three kinds of pine, willows, birch, some oak, mulberry sycamore, maple and ash among others [22]. The faster growing groups contain a wide variety of trees and their quick growth can become a problem, as shown in Figure 8.

The most common trees in New York State are sugar maples, which can grow up to 24 inches a year and would be categorized in the medium growth rate group, red oaks, which would be categorized in the fast growing group, and many species of hickory, which would be classified in the slow growth group.

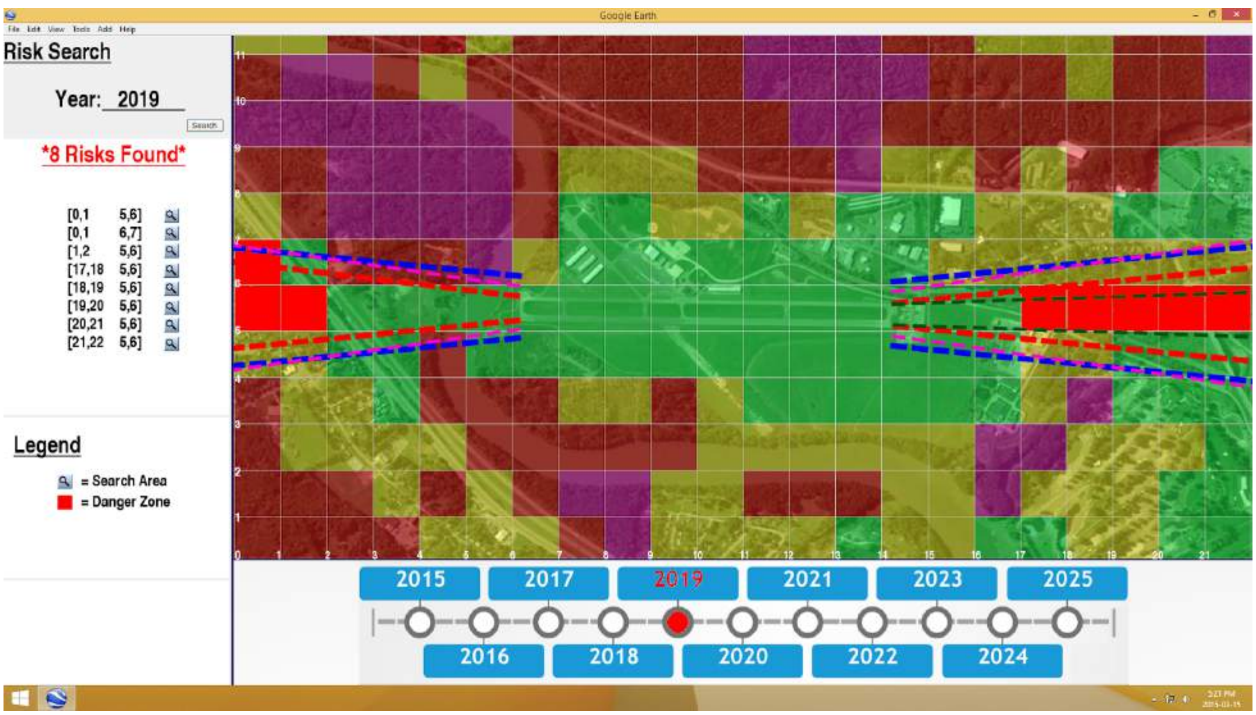

Figure 8- The OAS marks the areas containing potentially dangerous obstructions. Clicking on an identified risk provides a more detailed analysis.

d. Putting it all together

The OAS will use the tree growth rates alongside the obstruction analyses, described above, to predict when obstructions will grow into the path of the approach surfaces. Each section of trees (represented by the highest point within that section on the orthographic photo) would be assigned into a growth rate group as described in the previous section and labeled using a key on the obstruction model output. Using the growth rate groups, a similar model can be made for the following year by extrapolating each section of tree's height. A profile view of the sections can be combined with the flight approach surfaces to provide an image with the same structure as the original obstruction analysis, except with new obstruction heights. The OAS would allow for modeling years into the future for the user to edit the current model in accordance with obstruction removal.

Having predictive models for airport obstructions multiple years into the future would allow airports to see when each section of trees would grow into the flight surfaces that they use, shown in Figure 9. Currently there is no ability for airports to visualize how obstructions or flight paths will be impacted in the future [24]. The OAS will actively identify new obstructions and highlight them on the models from year to year in the output. Tree sections with higher growth rates would become a problem more than once within the ten-year span. To accommodate for this, when a section becomes an active obstruction it will be reduced by 10 feet in the next year's model. This would account for obstruction removal and would be able to show when fast growing trees become a problem for the second or third time.

According to general manager Gerard Corpew of Tri-Cities, grubbed trees have already returned from a removal just a few years ago. The OAS will give the managerial staff of Tri-Cities a prediction of when these trees will grow into their surfaces for a second time and allow them to deal with the obstructions efficiently. Tri-Cities already has current obstruction problems and cannot deal with surprises in regards to trees and flight surfaces. The OAS will help Tri-Cities stay open and plan for the future accordingly.

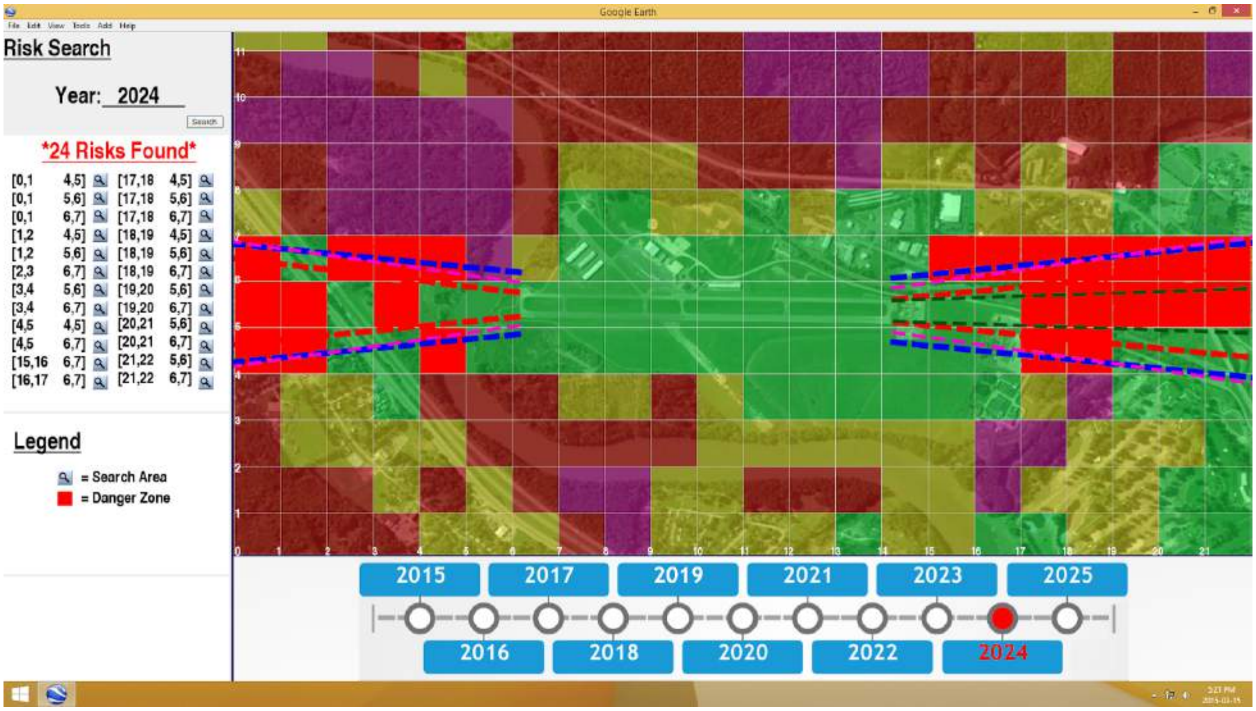

Figure 9- Analyzing obstructions further into the future identifies more risks, allowing airports to predict when issues with obstructions will arise.

e. Integrating System with Existing FAA technology

The FAA's current interactive obstruction database using Google Earth contains an abundance of information that can be used in the OAS. Combining information from the OAS with Google Earth allows for the integration of a large amount of relevant obstruction data with relative ease and minor cost. Although the OAS would not be implemented by the FAA to update their databases, it would be a useful and usable tool for local airports [24].

V. Safety and Risk Assessment

Maintaining and improving the safety of air travel is a major goal of the FAA; as such, safety-related measures are included in the FAA Portfolio of Goals. For instance, an important objective listed in the 2010 Portfolio of Goals was the implementation of Safety Management Systems (SMS) in "all appropriate FAA organizations," including the Air Traffic Organization (ATO), Office of Aviation Safety (AVS), and Office of Airports (ARP) [9]. Safety Management

Systems are described in much more detail in the FAA Safety Management System Manual. The main components of an SMS are Safety Policy, Safety Risk Management, Safety Assurance, and Safety Promotion [10]. Safety Risk Management (SRM) is a crucial component of SMS, and is made up of five phases. They are: describe the system, identify the hazards, determine the risk, assess and analyze the risk, and treat the risk [25]. It is through the SRM system that risks are mitigated.

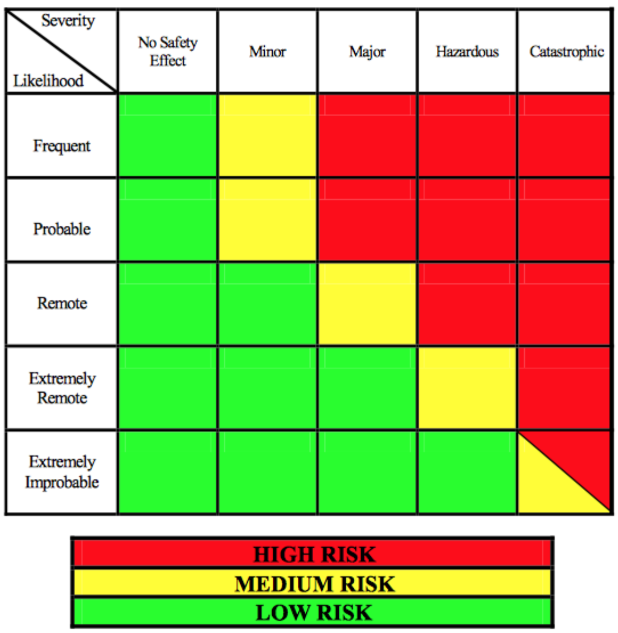

Figure 10 - FAA Safety Risk Matrix [25]

As part of Safety Risk Management Policy, projects are evaluated as low risk, medium risk, or high risk, based on their anticipated effects. This evaluation is performed using a biaxial risk matrix, shown in Figure 10. The y-axis of this matrix ranks an event based on its likelihood of occurrence, from frequent (likely to occur many times, e.g. at least once per month) to extremely improbable (almost inconceivable that the event will occur, e.g. once every ten years). The x-axis assesses the severity of an event, from “No Safety Effect” to “Catastrophic.” The green region of the matrix represents low risk, and projects with predicted effects in this area require little to no attention or alteration. Yellow represents medium risk, and means that a project may be implemented, but should be closely monitored. Projects that are anticipated to cause effects in the red region are high risk, and immediate action must be taken to mitigate the potential effects [25]. According to our evaluation, our proposed Obstruction Analysis System (OAS) will be in the low risk area, and thus may be implemented immediately.

The OAS is a very safe tool that is essentially free of risk. It decreases the likelihood of collision with obstructions, while increasing the reliability of obstruction prediction. Possible risks associated with the OAS were compared against the FAA Safety Risk Matrix and produced encouraging results.

There are two main areas in which the OAS could be a source of risk: utilization and implementation. Using the tool to observe the predictions of tree growth is inherently risk free. Viewing predictions requires simply looking at a computer screen. Following the categories of the predictive matrix, the likelihood of risk while in use is extremely improbable. In addition, the level of severity is “No Safety Effect.” This would place utilization of the OAS in the green region of low risk. Implementation of the tool involves primarily data collection. In order for the predicted tree heights to be as accurate as possible, an environmentalist, botanist, or other vegetation expert must field verify the land on and around the airport to confirm the types of trees and vegetation in the area. This additional step puts the likelihood of danger in this situation as extremely improbable, and the severity of risk is “No Safety Effect.” In many cases, much of the other information needed for the OAS, such as the heights of trees and the flight surfaces of an airport, can be found on the FAA’s public database. Obtaining this data would be inherently risk free. If the information cannot be found on a public database and a plane is needed to do aerial photography to assess the area, the level of risk would be the same whether the aerial photography was performed to collect data for the OAS or for a different database. Mandatory flyovers are conducted approximately every five years under the current system. Therefore, implementation of the OAS is either explicitly in the green area of low risk on the predictive matrix, or it does not alter the level of risk from prior to implementation of the system, which is most likely in the green area of low risk because it has been in place for many years without alteration.

Another aspect of the OAS that could potentially produce risk is if there is overreliance on the system. As such, a tool that has never been implemented in a real-world scenario may have unanticipated flaws in the system that can lead to some obstructions going unchecked. To combat this problem, the OAS predictions should be verified for a few years after implementation before this safety net is removed. If the predictions prove to be accurate and useful, then the risk of the OAS remains in the green area of low risk on the predictive matrix.

Overall, based on preliminary analysis, the OAS is a very reliable system. The ability to predict tree growth on and around an airport ten to possibly fifteen years in advance is a huge breakthrough and will save lives, time, and money and increase safety by reducing the potential of aircraft collisions with vegetation. With the increasing enforcement of a number of rules and regulations set by the FAA concerning flight minimums and approach surfaces, many airports have or will have to remove vegetative obstructions or risk closure of their runways to nighttime operations. Especially for smaller general aviation airports, this can present a sizeable financial problem. If airports are not open at night, they cannot supply fuel for planes that need refueling. Closing even for a short amount of time can create a negative reputation for the airports that will hurt them monetarily. The OAS will not only decrease safety risks, but also decrease financial risks, helping many general aviation airports as well as some commercial, especially non-hub and small-hub, airports tremendously.

VI. Description of Interactions with Airport Operators

a. Team Visit to Tri-Cities Airport

Figure 11- The team met with Gerard Corprew, the manager of Tri-Cities Airport.

The Binghamton team visited Tri-Cities Airport located in Endicott, NY on February 12, 2015. During the visit to Tri-Cities Airport, the team had the opportunity to interface with Gerard Corprew, the manager of Tri-Cities Airport, and conference Heather M. Blokzyl, the manager of Bradford County Airport, located in Athens, PA. Through this experience, the team, pictured at the airport in Figure 7, became familiar with airport policies and procedures, and analyzed how vegetative obstructions violate FAA regulations and compromise airport safety during takeoffs and landings. Tri-Cities Airport is a one-runway airport and currently does not host any commercial flights. Mr. Corprew's guidance during this visit was helpful in providing the Binghamton team background knowledge about non-commercial airports, which represent the majority of airports in the United States.

Through interactions with Tri-Cities Airport personnel, the team learned that the airport lost FAA permission to support nighttime operations specifically due to trees that were identified as obstructions to the 20:1 visual surface at the airport. Mr. Corprew explained that the inability to land planes at Tri-Cities at night has significant financial impacts and that many airports had experienced this same issue. Tri-Cities, like many non-commercial airports, generates large portions of net income through fuel sales. Without the option to provide such services to night flyers, the airport suffers financially. The team learned how a predictive analysis tool would be helpful to the many airports that are in risk of losing night operations due to vegetative growth on and around the airport that has not been analyzed recently. In addition to losing night clients, the airport loses reliability. Ms. Blokzyl explained how customers start going elsewhere during the day as well, and went on to say that she is interested in seeing operators being proactive rather than having to be reactive to such issues. Ms. Blokzyl explained that 5010 airport inspections report on current conditions and often indicate concerns only after issues of penetration of the surface are noticed. Then, inspection results are not available for 2 months. Without appropriate resources, airport management has far less knowledge to act on and have to respond to the problem after it arises, which delays mitigation by months or even years if removal of the penetrations requires acquisition of property not under airport control.

One major issue for the Tri-Cities Airport is that many of the problematic trees are off the airport's property. No agreement with the nearby landowners exists to take preventative action. Cutting these trees is at least a three-year process involving environmental studies and grants that begins only after the problem becomes apparent. Mr. Corprew explained that many obstructions are not noticed until they are hit or the FAA charts and reports them.

b. Industry Official Zachary Staff Visits Binghamton University

Figure 12 - Students present to Zachary Staff during his visit to Binghamton University.

On March 5, 2015, Zachary Staff visited the team at Binghamton University to review the design solution and offer his professional advice. Mr. Staff, pictured in Figure 8, provided relevant information about FAA regulations and airport operations. This would help the team develop appropriate logistics for the design solution. He made himself available to answer any questions while working on the project.

Mr. Staff was able to provide insight on several topics relating to the project. For example, he was able to give the Binghamton University team an idea of what is involved in the current process of clearing vegetation, including necessary inspections, duration, and associated costs for an average-sized airport, based on his previous experience. This information proved difficult to find through preliminary research and is important when considering a cost/benefit analysis of the design solution. In addition, Mr. Staff provided planning level estimates of how much money could be saved by an airport if its staff used a predictive obstruction analysis system, as well as information regarding current databases referenced to assess problematic vegetation areas.

c. Design Team Phone Conference with Dr. Michael McNerney

On March 31, 2015, the Design team, Team Lead - Jason Moss, and Professor Nixon had the privilege of speaking with Dr. Michael McNerney of the FAA Airport Engineering Division. Dr. McNerney has over 30 years of experience with aviation studies and is considered an expert on the FAA's data collecting and its uses pertaining to obstructions. Professor Nixon provided Dr. McNerney with a high-level overview of the proposal and goals, followed by a more in depth strategic approach summary from the Design team. Dr. McNerney then commented on the proposal, indicating that the FAA has been attempting to incorporate tree growth information into existing databases. He explained that the FAA has recently preferred to expand geospatial data collection and representation so the airports can visualize the collected data, and that the proposed system falls in suit. Dr. McNerney confirmed with the team that this tool will be most beneficial for airports, particularly on the planning side, and that currently no tool exists with a predictive functionality for this issue. Dr. McNerney concluded with an offer to provide the team with any other contact information for industry personnel that may have relevant insight.

VII. Projected Impacts

The FAA's Strategic Plan and Portfolio of Goals were used to set important benchmarks for this system's design. Along with meeting the intent of the Strategic Plan and furthering these goals, the system has well defined commercial potential and a clear process for implementation. Affordability and utility are also important aspects of this system as they affect its real world impact and potential.

a. Meeting FAA Goals

The FAA states, "we're moving away from the anecdotal approach to safety and instead using data-analysis to prevent accidents before they happen." [26]. The system is in direct accordance with this policy as it produces predictive models to detect problems before they arise. The OAS will mitigate safety concerns before they occur, reducing risk in the National Airspace System (NAS) during flight operations.

Another goal of the FAA is to create the National Airspace System of the future. Creating large databases of information along with the systems needed to analyze that data is setting the FAA up for a future in which streamlined modeling systems and solutions help to make airspace regulation safer and more efficient [26]. The solution presented herein is a system designed to analyze data, which is most of which is already available, in order to increase safety and decrease costs for airports. By virtue, this system will be a part of the NAS in the future and increase air safety on a large scale.

b. Commercial Potential

While the OAS meets the FAA's goals and safety requirements, it is also important for the OAS to be successful as an industry-accepted product. The commercial potential of the OAS is dependent on it being better than systems or plans currently applied. The OAS would be as effective as any obstruction analysis tool immediately, as it is based on FAA's own obstruction database and augmented with obstruction data already gathered for existing, less automated, obstruction analyses. The most striking difference between the OAS and the traditional obstruction analysis process is in its ability to retain its usefulness. The OAS incorporates a predictive aspect that current systems do not have and has the ability to help airports analyze vegetative obstructions for at least ten years into the future and perhaps much longer.

The standard for current obstruction analyses is that airports update their databases approximately every five years or at least every ten years for their Master Plan Updates [23]. These updates are needed due to the static nature of the current analyses. Static in this case indicates that the analyses are a snapshot in time of where the obstructions currently exist; however, there is no information provided on how these obstructions, specifically vegetative obstructions, will grow over time. The OAS would not need to be updated as frequently and would provide significant additional benefit due to the predictive modeling function of the system. Less frequent updates would save resources, and boost the system's commercial potential. Additionally, the OAS is more accurate and helpful for a number of years after the study is done. This is appealing to airports that do not have the time and resources to update their analyses. The FAA has recently increased enforcement of obstruction criteria due to incidents of collision with terrain and/or vegetation. This has resulted in the loss of night approaches at airports such as Tri-Cities Airport, which is discussed further in Section VI. The OAS will prevent this occurrence due to the predictive nature of the model allowing airports to be aware of vegetative obstructions well in advance, remove those that are a problem and ensure that all approach minimums are satisfied.

c. Process of Implementation

The ability of the OAS to help increase the safety of airports depends greatly on the ease of replacing the current system with the OAS. Due to the extensive amounts of data that have already been collected, implementation of the OAS will be accomplished with relative ease. Airports currently have plans in place to perform basic obstruction analyses every five to ten years [23]. By using data from these analyses as well as from scheduled flyovers, there is an abundance of data already available for the OAS to use to analyze obstructions. In addition, the time, energy, workload, and type of work that is applied to current data charts and analyses could be used to complete the OAS instead.

The only additional aspect of the OAS that would need to be accounted for is a field verification process. This process is used to confirm existing information on the types of trees around the airport, which would be used as part of the predictive function of the OAS. An environmentalist or arborist would be hired to identify and document sections of trees around the airport by species, and then place them into growth groups. This process would take approximately 33 man-hours per acre to complete [27]. This means three environmentalists or arborists could document almost 4 acres worth of trees in the standard workweek of 40 hours. The applications of the growth groups and tree identification data would be applied to the obstruction analyses using computer-modeling programs.

d. Affordability and Utility

An important attribute of the OAS is for it to be more affordable and more efficient than current systems. The system already meets the FAA’s safety goals to a greater extent and efficiency is mostly dependent on how much, if at all, the cost of the OAS would exceed current obstruction analysis costs.

The current price of an obstruction analysis for most airports is around $75,000, with $40,000 of this used for mapping and surveillance [23]. If data from the previous obstruction analysis at an airport is accurate, the mapping and surveillance costs are negligible. Any changes in the FAA's mapping standards would impact the cost of the OAS and the cost of any current system equally, meaning that there would be no cost increase for this aspect of the system.

Field verification could cost as little as $5,000 for a smaller airport or one that has fairly consistent tree types but could range up to $10,000 for more extensive fieldwork [23]. According to Carol Lurie of VHB, the price for an acre of documentation would be approximately $3,100 in the highest cost areas such as the Boston Metro area. This estimate is for densely wooded areas of 400 or more trees per acre and would be less for areas with a lower density. In addition, the data does not have to be gathered for the entire airport, only for areas under important flight surfaces [28]. Trees also do not change species so the data collected from the botanist would be accurate for as long as that tree remains un-grubbed. As a result, the tree grouping can be considered a one-time investment. If the OAS were to draw from existing mapping and obstruction data, the cost could quite possibly be less than obstruction analysis costs currently. Obstruction analyses would have to be done less often and they would be cheaper. This increase in affordability would allow the OAS to be much more efficient and effective than most other systems implemented currently.

e. Cost Analysis

Although the primary goal of the OAS is to improve safety at airports by predicting obstruction growth, it is also cost efficient for airports. Much like current obstruction analyses, the OAS requires a one-time cost in the first year it is implemented. However, the OAS would require updates or a second implementation less frequently. The estimated cost of removing trees is the same for the OAS and the current system and varies depending on the airport. The OAS would also provide savings based on the reduced number of accidents and the reduced amount of time spent with night minimums suspended. Benefit would be seen when the current system would have to be updated, allowing for an estimated total cost benefit of $75,000 at year five, shown in Table 1. This provides a present value of $53,473.96 to airports implementing the OAS. This means the net present value of the OAS over a ten-year span would be$43,473.96. The present value and the net present values were calculated using a discount rate of 7% [29].

Table 1- Cost Analysis of the OAS

ear	**Cost of OAS**	**Cost of Previous System**	**Total Benefit**	**Discount Factor**	**Present Value**
	90000	75000	-15000	1	-15000
	0	0	0	0.93	0.00
	0	0	0	0.87	0.00
	0	0	0	0.82	0.00
	0	0	0	0.76	0.00
	0	75000	75000	0.71	53473.96
	0	0	0	0.67	0.00
	0	0	0	0.62	0.00
	0	0	0	0.58	0.00
	0	0	0	0.54	0.00
0	75000	75000	0	0.51	0.00
	Discount rate =	0.07		NPV =	38473.96

VIII. Summary and Conclusion

The FAA has outlined its expectations regarding the improvement of safety for airports. Since compliance with safety regulations is necessary for efficient and safe airport operation, there is a need for streamlining the process of documenting and addressing safety concerns. This documentation works to reduce the risk of accidents or violations of FAA regulations. The FAA has implemented practices that serve to improve safety in the airport environment; however, these implementations have not successfully addressed all possible sources of risk within the aviation industry. New strategies for dealing with these additional risk factors are necessary to meet the goals set forth by the FAA and individual airports in their efforts to improve airport safety.

Vegetation growing into airport approach surfaces and potentially reducing approach minima greatly increases the risk of an aircraft collision and poses problems for FAA regulatory compliance. Currently, many airports that consistently deal with vegetation related problems assume that trees grow at an estimated rate of two and a half feet per year and must plan to trim them based off that. This assumption does not take into account the wide variation in growth rates of different trees. Error created by this assumption can lead to trees growing into critical airport approach surfaces without the airport's knowledge. The students at Binghamton University - State University of New York have developed an automated systematic approach for dealing with any type of vegetation as a potential obstruction. The team has researched the relevance and magnitude of the problem at hand, and has developed a system that synthesizes publicly available information and site-specific data related to vegetation to produce an accurate obstruction prediction visual output. This obstruction analysis system (OAS) accurately analyzes and predicts the effects of tree growth in all zones surrounding an airport's runways that could be problematic. If implemented, this low cost system will significantly improve the efficiency of tree cutting and the overall safety of an airport by accounting for all trees to avoid unexpected obstructions. This solution seeks to further the FAA's mission to "provide the safest, most efficient aerospace system in the world," and addresses an important value identified by the FAA, safety.

Appendix A: List of Complete Contact Information

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

Figure 13 - The Binghamton- State University of New York campus [30]

Binghamton University (BU), pictured in Figure 1, is part of the State University of New York (SUNY) system of higher education, which consists of 64 campuses all over the state. The University consists of six schools: Harpur College of Arts and Sciences, the College of Community and Public Affairs, the Decker School of Nursing, the Graduate School of Education, the School of Management and the Thomas J. Watson School of Engineering and Applied Science [31]. These schools provide education to over 13,000 undergraduates and over 3,000 graduate students [32]. The University as a whole offers over 130 educational programs in a wide range of subjects [33].

Binghamton University has earned number of accolades that set it apart from other universities. In 2014, *Kiplinger's Personal Finance* ranked Binghamton University 15th in the nation in terms of best value education for money spent. Also in 2014, *The Princeton Review* ranked the school 10th in the nation for best value of public universities. Binghamton ranked as one of the nation's top 50 public universities for the 17th consecutive year as of 2014 [34]. *U.S. News and World Report* ranks Binghamton 88th in the nation on the list of best colleges [35]. In addition to being academically prestigious, Binghamton also has proven to be culturally diverse. The University has students from almost all 50 states and from over 100 different countries [36]. To accommodate this diversity and interests of the student population, the University has over 250 student organizations [36]

Appendix C

a. Tri-Cities Airport, Endicott, NY

Tri-Cities Airport is a village-owned, public use, general aviation airport located in Endicott, New York. The Tri-Cities Airport served as the primary airport for the Endicott area from the 1930's through the early 1950's, losing popularity because Greater Binghamton Airport was able to accommodate larger passenger airplanes. Tri-Cities Airport covers 230 acres at 833 feet above average sea level and has only one runway, which measures 3,900 feet by 75 feet. As of January 2015, there were 46 aircraft based on the field, 41 of which were single-engine airplanes. Additionally, at that point the airport was averaging only 125 aircraft operations per week [37].

The current manager of the airport is Gerard Corprew. Mr. Corprew has managed the Tri-Cities Airport since January of 2009 and is responsible for airport maintenance and budget planning. Mr. Corprew is also a licensed pilot [38]. When the Binghamton team visited Tri-Cities Airport, he made himself available to answer questions.

b. McFarland Johnson, Inc.

McFarland Johnson is a multi-disciplinary engineering consulting firm with its corporate headquarters in Binghamton, NY and multiple branches throughout the eastern coast of the U.S. It is 100% employee owned [39]. McFarland Johnson's mission, according to its website, is to "be recognized as a progressive company comprised of innovative employee-owners working together as a team in a fun and learning environment, who are dedicated to achieving our customers' goals while improving our communities, our families and ourselves" [40].

The company has handled hundreds of aviation projects at a wide range of airports throughout the Northeast and the rest of the United States. The services McFarland Johnson offers include grant writing, environmental services, aviation planning, and geographic information system (GIS) capabilities [41]. McFarland Johnson maintains up to date GIS technology that can be used for land planning, site selection, and airport obstruction analysis [42].

Zachary Staff, an airport planner for McFarland Johnson made himself available to the Binghamton team to offer insight and answer many questions. Mr. Staff has worked as an airport planner at McFarland Johnson since July of 2007. He has worked on airport master plans, grant assistance, environmental analysis, and GIS Development. Zachary Staff is also a member of the American Planning Association and the New York State GIS Association [43].

c. VHB

VHB is a company that works with both industry and government to develop and enhance communities while practicing environmental responsibility [44]. VHB provides a variety of services such as transportation planning, land development services, planning and design, and environmental services [45]. Their environmental services include environmental assessment, climate adaptation, environmental compliance, and wetlands mitigation [46].

The Binghamton team contacted Carol Lurie of VHB to discuss the environmental impact of the project. Ms. Lurie is a Principal at VHB and leads the firm’s National Airport Team. She has managed sustainability projects at airports across the United States [47].

Appendix E. Evaluation of the Educational Experience

<u>Student Evaluation</u>

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

This Design Competition provided a meaningful learning experience, primarily through the unusual format of the class. Rather than sitting through weekly lectures leading up to a final exam, we worked in teams on separate aspects of a long-term project to reach our goal. This introduced us to a variety of skills that will be applicable not only in higher education, but also in the workforce. Teamwork and communication were very important, as well as time management. While the design proposal seemed overwhelming as a whole, breaking it down into smaller tasks and delegating assignments made it much more manageable.

In addition to the format of the class, the project itself offered an excellent educational opportunity. Individual as well as group research had to be performed throughout the course of the project. Also, by creating a complete design proposal, we learned about the design process in detail. This provided an experience similar to one on the professional level, and served as useful preparation for a future career in engineering or related areas.

Finally, this competition afforded us the chance to tackle a real-world problem and think about real-world solutions. This is a rare occurrence in most classes, so we were provided a uniquely significant educational experience.

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

The main challenge we encountered was that we had no prior knowledge of the aviation industry and its problems. The acronyms, terminology, and regulations were all unknown to us;

however, this obstacle was easily overcome by dedicated research. Meeting with experts was also helpful. Over time, we all became much more familiar with the issues we were dealing with as well as how to address them.

Another challenge we met was working in a large group. Because each team worked individually on disparate pieces of the project, at times it was difficult to know what work was expected or required of us. In order to improve our communication and cohesion, each team gave an update of what they were doing and any assistance they required from another team at the beginning of each class.

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

We began with a very general idea of the direction in which we wanted to take our project. The first step we took to refine this idea was to research the FAA, its current regulations, and its goals for the future. We discussed this research as a group, and supplemented these talks with interactions with industry professionals. This provided further insight into the problems the FAA faced and the best way to combat those problems. Finally, using the background knowledge we had obtained and the concepts brought up in discussions, we honed in on what we agreed was the best method to approach the problem at hand.

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

Participation by industry in the project was extremely helpful in several ways. Firstly, the experts were able to provide succinct and appropriate information that simply could not have been obtained by searching the Internet. They also directed us to additional information that could be accessed online that was very useful. Secondly, discussion with industry professionals gave us a better understanding of the problem, and brought the reality of the issue into focus. It allowed us to evaluate exactly what was needed from our project in the context of the current practices at airports, and how the people who would actually use the design would receive different aspects of our project.

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 taught us how to be helpful and productive members of a team, which is an ability that is essential to success in both higher education and the workforce. It includes skills such as communicating well with team members, being organized and responsible, demonstrating leadership while also working in a group, and solving any problems encountered quickly and efficiently. We also learned how to manage our time effectively, and how to approach a larger project by breaking it into smaller tasks and delegating. In addition, this project gave us experience with the design process, as well as working towards a long-term goal.

Although we learned these skills in a teamwork context, many of them apply to individual work as well. For example, being organized and responsible is necessary to success in education or the workforce in general, regardless of whether the work is being done independently or in a group.

Faculty Response

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

Experiential learning is a critical element in the overall academic experience. One of the goals of Binghamton University is to increase this type of learning and this competition advances that goal. While lecturing and laboratory time have great value they are limited in their ability to allow students a real world experience on a project team. The FAA Design Competition provides the opportunity for students to take an idea, their idea, all the way from the brainstorming stage to a well-researched concept that has real potential for implementation. Creating their own solutions that do not currently exist for challenges facing an industry such as aviation allows the students to take true ownership in the educational experience.

Over the course of the design competition, a team of diverse students had to not only develop a sound proposal but also gain trust in each other by working in teams. Individually and collectively they had to deliver on milestones each week to ensure that the proposal stayed on track for meeting the submission deadline. This is a life skill that cannot be easily taught in class and the FAA Design Competition provides this critical educational opportunity.

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

The group of nine (9) students involved in this design competition were not accustomed to working in the team setting. This opportunity required a high level of effective communication, management of schedule and assets in the form of smaller teams working on individual project components. Although this was new ground for most of the students, it pushed them to improve their communication and time management skills. This is a key element of the learning experience and one that will help the students as they complete their education and move into a career. Overall, the experience was appropriate and effective.

3. What challenges did the students face and overcome?

The students had several challenges to overcome during the development of their proposal for the competition. Creating a design proposal from scratch is something that they have never undertaken before. They are similarly not familiar with working and depending upon all team members to make the project a success. This presented an additional challenge to the proposal development. Lastly, the competition deadline requires that they work quickly, with minimal rework and that time within the project team and external industry advisors is effective and efficient.

Regarding the development of the proposal from scratch; the team was able to overcome this challenge through near flawless teamwork and well organized project leaders. The project leaders set the tempo and checked in frequently with the team to organize assignments and make sure that the groups involved in the proposal were working cohesively.

The competition deadline, while challenging, was achieved through disciplined delegation of duties through the entire project team. The entire class was well aware that if any of the students or the teams did not perform at the highest level that the entire team would suffer. This created a camaraderie amongst the team that was evident during weekly check-ins where team members provided me assessments or ‘grades’ of how the other team members were performing within the group.

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

I would highly recommend this competition to future students and faculty. I have presented this competition at Binghamton University’s Engagement Expo as an example of how to engage students in ‘real world’ learning. As previously mentioned, this particular competition gives students a very different experience than they gain from typical courses and classroom activities. The significant collaborative effort that is required to develop a winning proposal is something that cannot be easily taught. This competition provides for an educational experience on communication, time management, team building and original writing that will serve the students well as they enter the workforce. I am confident that you will see Binghamton University participating in the competition again.

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

New topics and categories have been added to the competition over the last couple of years. This is important to keep the competition interesting and relevant. The continued addition of new areas of focus would be my primary recommendation for future years. The FAA may also want to consider a research and development pipeline tied to winning proposals. Not all of the ideas are easily adopted; however, certain proposals should be advanced to at least the prototype level and possibly beyond. Ultimately, the competition serves as an important introduction to innovation in the aviation industry but could be more with additional federal funding and visibility to potential private investors. Overall, the competition is extremely well run and represents the type of educational opportunity that is critically needed in academia.

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