Title of Design: *e*APT: The Electronic Airport Planning Tool

Design Challenge Addressed: Airport Management and Planning

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Executive Summary

Planning large airport events such as air shows requires the coordination of a large amount of information across professionals from a wide range of areas. A single event can take months of planning on the part of airport staff and can require the use of information buried deep in technical documents. A program that allows planners to access and share information easily and intuitively has the potential to reduce planning time while providing a shared picture of an event to all members of a planning team. We propose *e*APT, a map-based planning tool that combines airport pavement information with aircraft specifications to allow users to create and share airport event plans.

Our team utilized human factors and systems engineering methods to elicit requirements from airport planning subject matter experts (SMEs) as well as other stakeholders involved in the planning of airport events. Human-computer interaction standards, guidelines and principals were then referenced in the design of the user interface and system architecture.

*e*APT is a program designed to give airport event planners a reliable and easy-to-use tool for assessing airport surfaces in order to plan aircraft movement and storage. *e*APT is designed around SMART board technology to provide a collaborative planning environment for event planners. Event plans can also be shared with stakeholders and event attendees by means of a print-screen function. While our team has limited the scope of *e*APT to aircraft movement and storage for event planning, there is a wide range of possibilities for expanding *e*APT's functionality to support the display and use of additional information in the future. Such future expansion may allow *e*APT to, for example, additionally support local and wide-scale emergency responding.

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1 Problem Statement and Background on the Design Challenge

Airports must, on an irregular basis, handle events that make unusual demands on resources and operations. Airport managers and operators must be able to adequately plan for these events, but currently have few tools to do so beyond pencils, paper, experience and legal requirements.

An airshow or local event like a NASCAR race will bring in hundreds of aircraft ranging from small general aviation (GA) planes to large military and commercial aircraft. These can easily exceed an airport's normal parking capacity. Unusual aircraft may run risks of causing damage to airport facilities or other aircraft through unusually heavy weight, large wingspan, large jet-blast radius, or poor turning radius. Some aircraft such as military planes or Air Force One will have additional security requirements beyond normal airport requirements, requiring additional resources.

Federal Aviation Administration (FAA) regulations require emergency event pre-planning that must address challenges such as coordinating airport rescue and firefighting (ARFF) personnel and vehicles with outside emergency responders, "hazmat" operations, and security risks due to passengers disembarked away from the terminal.

Airport maintenance projects such as runway repaving will call for intricate planning to minimize impacts on airport operations, for example to keep a primary runway in operation by carefully phasing which sections of the runway are being resurfaced so as to allow a useable section to always remain available.

Planning these events can take a considerable amount of staff time and thus airport money. Airport operators must pull information from disparate sources such as aircraft databases, airport maps and even outside consultants, for example, to determine if a given taxiway or parking ramp can support the weight of a military aircraft appearing for an airshow. Maps must be modified to show security zones or public access zones and modified usage of runways or ramps.

Our team sees a role for a computer-based tool to aid in the planning for these special events, which we have named *e*APT. The *e*APT tool will allow airport staff to model these events in detail using resources and tools that include an aircraft specifications database, weight and clearance checks, and a customizable map display on which users can place aircraft, add notation, and define zones.

2 Summary of Literature Review

A search of literature turned up few resources on the planning of air shows aside from some barebones guidelines for what is required, and nothing at all on tools to assist in the planning.

Of use to our team were:

- FAA Part 139 CertAlert 02-07, which provides guidance on the planning requirements needed to be granted an FAA 7711-1 Certificate of Authorization for legally conducting an airshow (Castellano, 2002). This provides the design basis of the tools designed for the *e*APT program.
- MIL-STD-1472, which was used as a design reference for the user interface for the *e*APT program (Department of Defense, 2012).
- NASA-STD-3000, which was also used as a design reference for the user interface of the *e*APT program (NASA, 1995).
- Apple Human Interface guidelines, which were consulted for elements of the interface dealing with touch-screen displays (Apple, 2012).

- The well publicized incident at the Paris 2011 airshow where a taxiing Airbus A-380 struck a building with a wingtip, which supports the idea that a tool to test such clearances will be useful (Baker, 2012).
- Identification of the need for a single source document to support airport event planning by the Transportation Research Board of the National Academies. (They have begun compiling such a document, but the project will not include any software tools; Staba, 2011.)
- Examination of the report on the AEROS emergency-response training tool by Applied Research Associates showing that experienced personnel had some trouble with the interface of that emergency response training tool, and experienced difficulties completing tasks during emergency-response exercises. This reinforced the teams decision to support emergency events only in the pre-planning stage and to leave actual emergency management functions for future expansion when proper training strategies can be more fully mapped out. (Arcila, 2011)

3 Problem Solving Approach

3.1 Stakeholder Analysis

The stakeholders of a system are individuals and organizations that have a vested interest in the system and stand to gain or lose something from the implementation of the system. Below we will briefly describe our key stakeholders and how they might be affected by *e*APT, and how our design has been tailored to support their goals.

Our analysis of the needs and goals of the stakeholders of *e*APT included information gained from interviews with subject matter experts (SME) and the stakeholders themselves. The stakeholders we have identified for *e*APT are airport operations directors, security personnel, maintenance staff, administrators, fixed base operators (FBOs), air traffic controllers, event attendees, hardware suppliers, hardware installers, and information providers.

The four areas of influence *e*APT has on our stakeholders are usability, cost, maintainability, and "shareability." Usability describes how easily users are able to accomplish their tasks with the system. Cost is the financial impact of the system from acquisition and maintenance to retirement of the system. Maintainability is how the system will be updated with software patches, new data, and hardware fixes/replacement. Shareability is the level to which our system will allow collaboration between stakeholders and includes collaborative planning and the ability to share plans with those not involved with the planning process.

Our team discussed who the stakeholders of *e*APT were with our primary SME, John Murray, and what their roles in event planning are. From this information our team was able to determine the four categories of priorities. From the results of this analysis it is apparent that airport operations managers, such as our primary SME John Murray, are impacted the most by the potential implementation of *e*APT. System maintenance, cost, usability, and sharability are all factors. Security personnel, airport maintenance, FBO's, and air traffic controllers are affected similarly, as a result of their common role as the event planning team.

When designing *e*APT to support our stakeholders, we evaluated several design options including platform, interface type, and method of data maintenance. Evaluation of the design options was performed through group discussion and incorporated qualitative data from our SME's. Table 1 summarizes the results of this analysis.

3.2 Design Decisions Based on Stakeholder Priorities

Table 1

Results of the evaluation of design options based on discussions and qualitative data from SMEs.

	Input Method		**Platform**			**Maintenance**	
Stakeholder Priorities	**Point and Click**	**Touch**	**Mobile**	**Personal Computer**	**SMART Board**	**User Mx**	**Provider Mx**
Maintainability							+
Sharability					+		
Cost	+			+		+	
Usability	+	+	+		+		+
Total	**2**	**1**	**1**	**1**	**2**	**1**	**2**

We found stakeholder support for both a personal computer and the SMART Board platforms; the SMART Board facilitated collaboration in planning more than the PC, however the personal computer option was less expensive because our stakeholders were likely to already own one. We found that between a point-and-click interface and a touch interface there was little if any difference if designed properly. We decided to use a touch interface because it was more compatible with the SMART platform. Manufacturer maintenance presented advantages in ease of maintenance, and user maintenance could potentially be more cost effective. We decided to use a manufacturer maintenance plan because of support for the idea from industry experts.

In conclusion our team assessed stakeholder priorities through information gained from SME interviews and group discussion. Maintainability, sharability, cost, and usability were found to be the most important priorities to the stakeholders of *e*APT. Design features were then evaluated based on what stakeholder priorities they supported.

3.3 Interactions with Subject Matter Experts

Our first interaction with an industry expert was during an in-class presentation given by Mr. John Murray Director of Public Safety for Daytona Beach International Airport on airport operations and event planning. Our team was struck by one example given by Mr. Murray of how he planned for the arrival and departure of a B-52 for the Daytona 500-mile motor race. Due to its size and weight, the B-52 was restricted to a limited number of taxiways and determining which taxiways were capable of sustaining the weight of the aircraft required references to airport plans and aircraft information manuals. After the presentation our team agreed event and surface-use planning was an area in airport management and planning that could be improved. We envisioned a computer program that contains airport pavement data and aircraft information and would be able to indicate where an aircraft could and couldn't taxi.

Our plan for eliciting more information about special event planning involved first holding an unstructured interview with Mr. Murray to determine whether our idea was worth pursuing and what the basic, high level requirements for such a program were. After the first meeting we attempted to contact other airports which could potentially have needs similar to what Mr. Murray described. We used the information gained by these interactions to mockup a basic interface design and functionality. With the design in-hand, we would then meet with Mr. Murray once again to review our design and ask detailed questions. In this design review we then presented our design to Mr. Murray and handed him printed screenshots of our design and allowed him to mark on the sheets while thinking out-loud about potential problems and obstacles. This information was used to make informed design decisions regarding the user interface.

In our first meeting we confirmed there was a need for our proposed product. Mr. Murray indicated to us the importance of having good information on hand: “When you lack the information necessary is when you get into trouble” and “know what your limitations are” (J. Murray, personal communication, September 9, 2012). He explained that the process of obtaining this information currently involves relying on Volusia County’s computer aided design expert and engineers to measure and illustrate portions of the airport capable of handling an unusually large aircraft. This information is then compared to aircraft dimensions and weight, which are stored in manuals or online databases. In this meeting, our team also realized the need for aircraft top-down profiles, aircraft jet blast profiles, changeable aircraft weight based on fuel and cargo load, annotations, and the ability to create shapes on the map. During the meeting, Mr. Murray emphasized the need to plan for unexpected events such as aircraft malfunctions, which require the plan to change.

In our second meeting with John Murray, we presented the *e*APT interface design and basic functionality and asked him to comment on what would need to be changed, added, or removed as well as his perceived usefulness of *e*APT. His overall feedback for *e*APT was positive, stating we “are definitely on the right track;” additionally, Mr. Murray also provided us with valuable feedback on where *e*APT could be improved (J. Murray, personal communication, October 23, 2012). When asked whether he would prefer *e*APT to indicate where an aircraft could or could not be placed, Mr. Murray told us that he would prefer the program to indicate where an aircraft could not be placed using a red shaded area. Mr. Murray stated that he would like the program to provide feedback about why an aircraft was not suited to a given section of the airport and suggested that “footnotes” pop-up to inform the user of this. We also asked him to comment on the value of using the SMART board platform: “anything that is going to help everyone understand (the plan) is going to eliminate confusion” (J. Murray, personal communication, October 23, 2012). During design meetings, our group debated whether the customer or the software provider should be responsible for updating airport parameters when construction projects are completed; Mr. Murray indicated that he felt it would be easier for the software provider to do this. One of the most important takeaways from our second meeting with John Murray was how he felt it would help people in his position in the future. He explained that he relies on his own experiences from the past when planning, but whoever will replace him will not have those experiences to fall back on. Having a program that provides aircraft and airport information and allows the user to view past plans can help inexperienced event planners get up to speed much quicker.

In addition to speaking with John Murray, our group also interviewed other professionals working in airport planning from across the country. John Greaud, Vice President of Operations for Memphis International Airport stated that a large airport with extensive commercial traffic like Memphis International Airport would not have a great need for a tool like *e*APT because almost all surfaces on the Memphis International Airport are built to withstand the largest category of aircraft. Mr. Greaud did however mention that *e*APT would be useful for airports smaller than Memphis International Airport and would be especially helpful for assisting inexperienced airport planners (J.

Greaud, personal communication, November 15, 2012). David Smith, Airfield and Airspace Planner for Seattle-Tacoma International Airport also felt that *e*APT would be most beneficial to smaller airports and would help orient new airfield planners to their own airport. Mr. Smith supported our idea of displaying the actual footprint of each aircraft as opposed to a generic aircraft shape onto the map because of the unique dimensions and capabilities of each aircraft. Mr. Smith also suggested adding a readout of the actual height and category of aircraft into *e*APT (D. Smith, personal communication, November 17, 2012).

In addition to working with airport planners, we spoke with other individuals involved in special event planning. Mr. Murray identified the organizations involved in the planning of special events to be airport security, the Transportation Safety Administration, airport maintenance, the local sheriff's office, emergency operations command, air traffic control, and airport fixed base operators. Marty Lauth, air traffic controller, commented that having the ability to share the parking data with air traffic control can help the controllers direct arriving aircraft to appropriate locations (M. Lauth, personal communication, November 6, 2012). Richard Moore of Volusia County Division of Emergency Management stated that the overall goal for event planning is for everyone to share the same picture of what is going on including event attendees (R. Moore, personal communication, November 12, 2012). Lieutenant Tim Quigley of Volusia County Sheriff's Office felt it would be important to be able to see what assets are available in the event of an emergency (T. Quigley, personal communication, November 15, 2012).

All individuals our team spoke with were supportive of the functions *e*APT could offer and were very helpful to the design of *e*APT. From the interviews our team learned what features would be needed, who the users would be, and what benefits could be gained from the implementation and use of *e*APT.

3.4 Trade Study Results

Our team conducted a trade study to determine if there were any existing planning tools which met our requirements. One such technology was a program called PathPlanner, by SIMTRA. PathPlanner A5 is software used for planning aircraft movement on airport aprons and taxiways and assessing stand clearances, jet blast impacts, and sweep limits. This software does not cater to event or airport planners, but to runway and taxiway engineers and has a very technical interface, which would only increase the training time for event planners to use. PathPlanner A5 also simulates complex pushback maneuvers and allows for the design of gates. Included in the package is a library of over 375 commercial aircraft, military aircraft and GA aircraft. Although PathPlanner A5 does not have all of the capabilities we envision *e*APT having, its strengths can be noted. PathPlanner has reliable and accurate data such as weight and wingspan for most aircraft and can run simulations of how a plane will turn and maneuver. Despite its strengths, PathPlanner has drawbacks which make it less suitable for event planners. The user cannot add new models of aircraft and the graphical user interface (GUI) is an aging point and click interface. Its capabilities for representing runways and taxiways' specifications are non-existent, so the user has no way of knowing the strength or width of taxiways (SIMTRA, 2012).

AeroTURN is another source of information used for airport surface planning that has similarities to *e*APT. AeroTURN displays wingspan, weight, and jet blast radius. To view these measures, the user must navigate through multiple windows. It supports the modeling of new aircraft with dimensions, such as weight, width, and wingspan, but as in the case of PathPlanner A5, it does not combine aircraft data with runway data.

Google Earth is also a relevant technology. *e*APT will feature many functions similar to Google Earth's, such as map viewing and manipulation. The satellite images used in *e*APT will be similar to those available in Google Earth. This gives the planner a better visual experience than using a computer aided design drawing by allowing the user the able to zoom in or out and manipulate the map. Although its graphical user interface (GUI) is exactly what our team required, Google Earth does not have the data required to add meaningful layers/overlays and lacks the aircraft database. Another relevant map product is the Airports Geographic Information System (AGIS). It has layers similar to Google Earth, such as detailed airfield surfaces, but requires training to use. AGIS isn't meant to be a planning tool for events; instead, it collects data, stores it in one place, and makes sure that everything falls under FAA regulations.

Jane's Book of World Aircraft is easily accessible and has information for most of the aircraft in the world (London, 1929). Currently, airports use data from manufacturer books specific to airplanes, fact sheets published by National Air Transportation Association (NATA) for fixed base operators, Advisory Circular (AC) 150 pavement standards and other products available to the aviation business.

Although the products mentioned all have functions *e*APT needs, none of them encompass the scope of our product, which is to put all information into one package. *e*APT is a new and efficient way to display information. It does so in a way that helps the user make educated decisions. Unable to use off-the-shelf products, which have limited information- either airport specifications or aircraft specifications, but not both, our team needed to design from the ground up.

3.5 Systems Development Methods

Our design process began where every good design should, with the customer. Our concept originated from a presentation given by the management of the Daytona Beach International Airport wherein we learned about a challenge they face. As a team we immediately pursued this issue and began brainstorming ways in which we could alleviate the problem. We were fortunate; we learned about this right before what happened to be our first preliminary design and problem-solving meeting, and we were in complete agreement that this was the problem to be addressed. At this initial meeting we were able to determine the overall scope of the project and the end goal of the design. We also determined the method with which we were going to arrive at our finished product, which is the focus of this section.

To ensure that we produce a system that satisfies our customers' needs and follows our originating requirements, we needed to establish a solid life cycle framework to follow, because as history has shown, any great idea can crumble and fail without the proper management, teamwork and development structure. We looked at several models of life cycle engineering and each had its positives and negatives, but nothing really stood out to us. We knew we needed to keep the customer in the loop as closely as possible, and we knew we needed be able to verify we were on track and that we had fulfilled all of the requirements, so we started to piece together our own framework based on two specific models, the waterfall model and the “Vee” model. Those models, paired with an iterative structured interviewing process, became the method we used to develop *e*APT.

The waterfall model is a systems engineering process model that was initially designed for software development. It usually consists of five to seven steps or phases (Blanchard & Fabrycky, 2012). This model does have its issues, but it has been considered the “granddaddy” of all lifecycle models and it serves as the basis for other models (McConnell, 1996). Similarly, we have chosen it to be the basis for our approach.

The “Vee” model (Blanchard & Fabrycky, 2012) is a system development model that is designed to simplify the complex process of designing a system. The “Vee” model is an expansion and improvement on the waterfall and spiral life cycle models (Blanchard & Fabrycky, 2012). Figure 1 was designed to illustrate this concept. The two sides of the “V” represent system decomposition and definition (on the left) and system integration and verification (on the right).

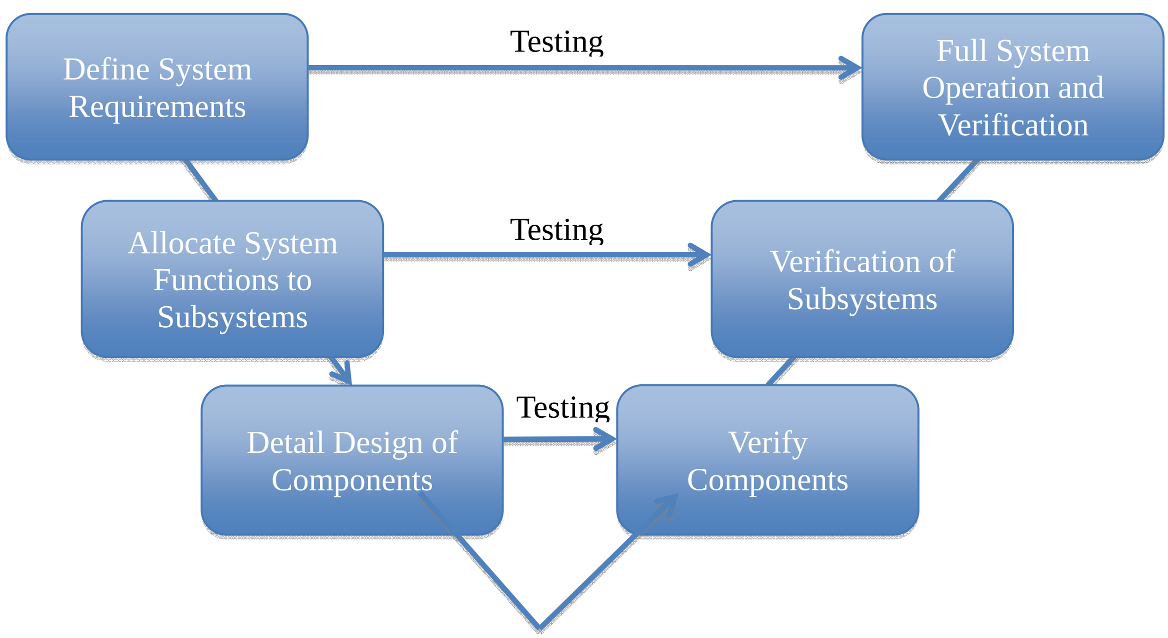

Figure 1. "Vee" Process Model

We are following the steps of the “Vee” model, while using the feedback loop process from the waterfall model, to focus our efforts on preliminary system conceptual design verses final integration and system testing. This combination of strategies is depicted in Figure 2. In particular, Figure 2 demonstrates how we replaced the unidirectional lines of the “Vee” model with bidirectional lines and loops to create a feedback and improvement framework to keep the team organized and keep the system on track.

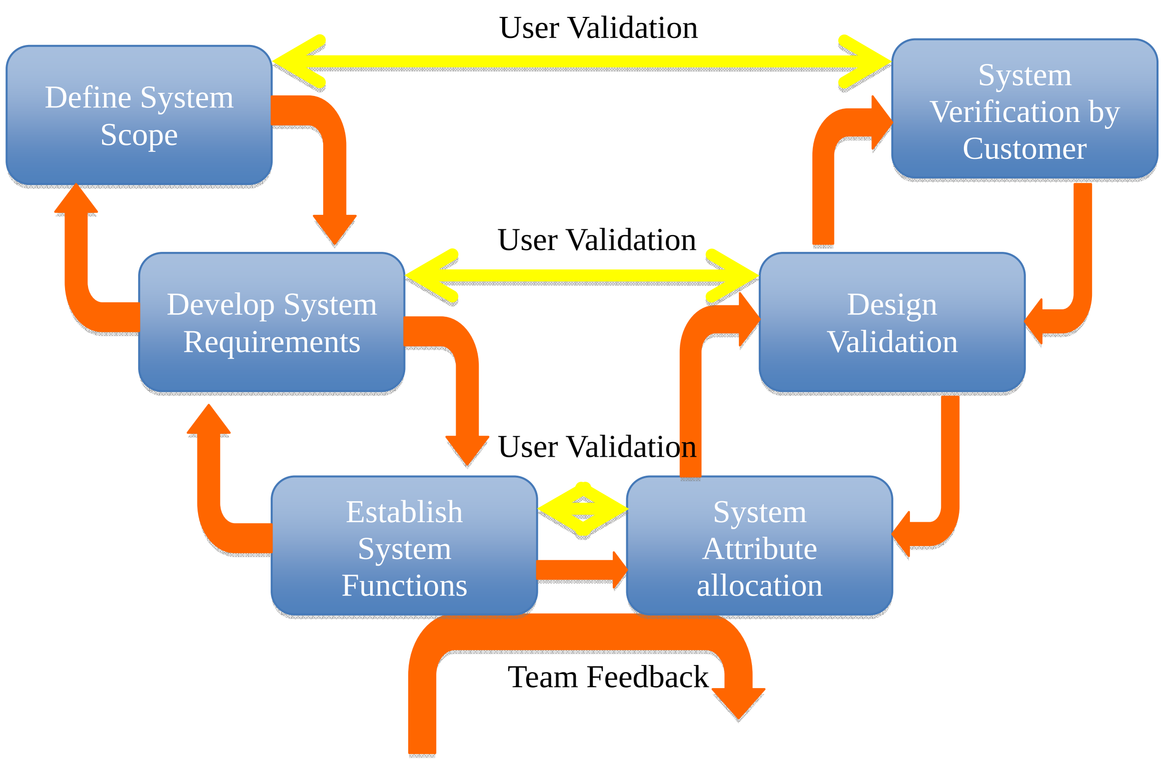

Figure 2. Team Delta System Development Framework

Upon the establishment of the systems development model our team, which had been previously structured to include a group leader, a secretary, a systems development manager, and SME’s of safety systems, engineering, and psychology, defined the scope of the project to be limited to providing airport event planners with the ability to strategically place any aircraft on a simulated virtual airfield. This scope of work was discussed with the available SME, John Murray (airport manager of Daytona Beach International Airport), who optimistically offered up his input on necessary functions of the system. Once our team decided to stick with solving this issue we got to work on identifying requirements. A second meeting with Mr. Murray was used to discuss and review the proposed requirements; Iteration number one.

Our team, Team Delta, created a mockup of the proposed design based on the initial requirements document; the mockup was reviewed and discussed with the SME at the third meeting; Iteration number three. During this meeting it came to light that Mr. Murray needed to add a requirement to the system because the mockup reminded him that he would like to have the option of viewing the turning radius and jet blast of an aircraft to help him determine his preferred placement of the aircraft on the airfield. Because our team had chosen a system development model that allowed for feedback loops it was possible for the requirements document to be edited.

Two more mockups were created (iteration three and four) and each time they were reviewed and discussed with the customer, an individual in charge of planning events at an airport like one of our SME's, Mr. Murray. As every mockup was discussed, the design of *e*APT was validated to reflect the requirements of the system. Allocations of system functions to their respective components were completed in correlation to the validation of system requirements through design iterations.

The purpose of a system development method, such as our modified Vee/waterfall model, is to act as an intrinsic tool that ensures organization and traceability throughout the design process. Considering this outlook, our team did a remarkable job of using the model to assist in the flow of our project structure. This system development method also aided in the planning and scheduling processes as well as final validation of the product to the system requirements.

4 Safety Risk Assessment

The FAA's Safety Management System (SMS) is paramount to modern safety goals and needs. SMS is a systematic approach to tackling risk within an organization by utilizing four basic components (Federal Aviation Administration [FAA], 2007). These components are safety policy and objectives, safety risk management, safety assurance, and safety promotion. Through proper implementation and encouragement, the culture can fulfill its safety goals while constantly improving the SMS (FAA, 2007).

Safety is vital in all aspects of aviation; procurement of products utilized for airport operations should be no different. Through proper use of the SMS one can ensure the best practices are being utilized every day. Safety Risk Management (SRM) is a component of SMS and is intended to identify system hazards and failure modes by assisting the determination of root causes, hazard severity and probability, and verification (FAA, 2008, 2011; See also Alberico et al., 1999; Department of Defense [DoD], 2012; International Civil Aviation Organization [ICAO], 2012). SRM concentrates on safety aspects of the conceptual system which is to be proposed for development (Alberico et al., 1999; ICAO, 2012). The *e*APT team applied the SMS principles to the conceptual design of *e*APT to ensure compliance with the FAA safety goals.

Understanding *e*APT's purpose and components allows our team to proactively analyze the system for potential risks. A preliminary hazard list (PHL) was created early during the design phase to start the process of thinking about risks. This allowed the *e*APT team to begin proactively designing risks out of the system. Proactively assessing the design allowed the *e*APT team to trace risks and assess their impact on the system, its users, and the environment before design decisions were implemented and became intricately intertwined with other system requirements. A list of conceivable types of vulnerabilities that *e*APT needs to account for includes misuse, human error, and long-term maintainability. The following paragraphs will cover these areas of vulnerability and their potential effects.

4.1 Misuse

*e*APT allows for a greater ability to see where aircraft can and cannot be positioned. *e*APT, being so adaptable, may likely be utilized for tasks for which it was not designed. These tasks may be merely daily operations or real-time emergency situations. Along with the visibility of areas deemed appropriate, the ability to provide printouts of positions may unintentionally allow disclosure of designated safety areas of certain “high priority” aircraft. These examples are not what *e*APT is currently intended for, so safeguards will be put in place to remove the likelihood of such situations as uncovered through prototyping. These discovered uses can also be implemented into the system for subsequent iterations. Proactively analyzing and assessing these new functions and uses will provide for hazard mitigation and system reliability.

4.2 Safety Critical Functions

Safety critical functions of systems such as *e*APT are difficult to ascertain until one thinks of their uses. Movement and placement of aircraft, which can cost millions of dollars, allows for a better understanding of *e*APT’s safety critical functions. Through the use of the *e*APT team’s PHL, failure mode and effect analysis (FMEA) and risk matrices, the *e*APT team identified the top three safety critical functions of the *e*APT system. Table 2 displays these three hazards with an example and the mitigations utilized to negate them.

Table 2

Safety Critical Functions

Hazard	**Example**	**Mitigation**
Inaccurate input of user defined parameters	80,000 lbs. instead of 800,000 lbs. being inputted by user	*e*APT will provide feedback if outside database parameters
Retrieval of the incorrect aircraft parameters	User selects Cessna 172 and receives parameters for a Boeing 737-200	Proper procedures followed to verify information within database
Inaccurate presentation of the aircraft placement to the user	A Cessna 172 is depicted as larger than a Boeing 737-200	Proper validation of data and imagery which scales to the interface

4.3 Human Error

*e*APT relies heavily upon stored and user identified parameters for accessing information such as aircraft weight. Aircraft weights can vary depending on the situation. Military aircraft may have a payload higher than the prescribed weight for their daily operations with sufficient permission. This can be inputted by the *e*APT user to account for this increase or decrease in weight. When allowing for such user inputs one cannot discount human error. A sequence of such functions was traced and analyzed to identify errors that could be committed while inputting parameters. This will allow for the proper safeguards to be in place in order to lessen the likelihood of mistyped information. Assume the following scenario: A 737-200 weighs around 800,000 lbs. and if the user accidentally inputs 80,000 lbs. instead of 800,000 lbs., we can see that this would allow the aircraft to be placed in areas potentially unable to handle its weight. Through such scenario-based “what ifs”, our design team was able to incorporate safeguards against such issues.

The *e*APT team developed a way for the information within the *e*APT database to be used to verify user inputted data. *e*APT will default to the highest weight for the aircraft unless otherwise specified by the user. The specific aircraft parameters may be between 80,000 lbs. and 90,000 lbs. By verifying the user’s data against these scales, one can ensure the user will be notified of such discrepancies. *e*APT will provide feedback to the individual via dialog box. If the data are outside of the expected parameters the *e*APT user will be ask if they wish to proceed or modify the inputted data. The process repeats in order to provide for the safest most robust means of entering this data.

4.4 Maintainability

Lastly, an analysis was completed that allowed for the *e*APT team to make the soundest choice of who will maintain *e*APT. It was found the best way to support *e*APT maintainability is by assigning maintenance responsibilities to the company that provides the software. This potentially mitigates numerous risks. For example, the operator will not be able to modify the airport image nor modify the aircraft images themselves. This will prevent the owner/operator from accidentally modifying critical information incorrectly. Transferring the responsibility of maintenance to the software provider will offer the greatest ability to mitigate these potential hazards.

Much work has been done to prevent *e*APT user(s), the interface, and the environment from exploitation, human error and maintenance error. Through the use of these analyses and proper SMS techniques, in both the immediate future and long term, *e*APT will be able to meet and exceed the principles found within the SMS process. The *e*APT team will ensure validation and verification of hazard mitigations implemented through assessments and scenario based “what ifs” throughout the prototyping phase. The analyses will account for and support mitigation efforts and will be documented. These efforts will allow *e*APT to be proficient at its tasks while providing the safest operation available.

5 Description of the Technical Design

5.1 Concept of Operations

The *e*APT system architecture and design were conceptualized and devised over the course of several group meetings, preliminary research efforts including literature reviews, and interviews. The architecture and design descriptions are presented in the following sections.

5.2 System Goal and Overview

*e*APT will be used by airport event planners to improve efficiency, flexibility, and accuracy of event plans and the planning process. *e*APT will include graphical representations of the airfield and individual airplanes as well as textual displays of aircraft nomenclature and specifications, which will be customizable to suit the operator’s needs. The information will be displayed on a SMART Board so as to allow airport event planners to interact with the system directly. Event planners using *e*APT will be able to manipulate the orientation and placement of multiple aircraft on an airfield related to specifications of the airfield such as pavement load handling ability.

5.3 *e*APT Architecture

The hardware needed to use *e*APT includes a computer with a Microsoft based Windows 7 operating system, a SMART Board (the projector and screen), SMART pens, and internet connection for a database uplink. Because each *e*APT system is customizable, airport visual layout computer aided design files and specific airport data would be defined in and stored directly to the program itself. However, an internet connection would be needed so that *e*APT has the ability to automatically update aircraft specifications and aircraft selection options from the online database source (for example: eAPT.com/database). No user interaction would be needed for this action to take place, but users would be able to click on the "updated as of" timestamp at the bottom of the program which would act as a hyperlink and direct the user to the online database source.

The graphical and textual information will be displayed on a SMART Board as to allow airport event planners to interact with the system on a two-touch basis. Because the SMART Board projects a display onto a 5'x4' screen and tracks the motions of a static pen across the screen, users can touch the screen with the pen two times to access all possible commands for the system. This simplistic design allows for speedy creation of events and this method of accessing controls means that users do not have to memorize commands or search for them. Figure 3 was created to provide a conceptual image of the integration of system components for the *e*APT interface.

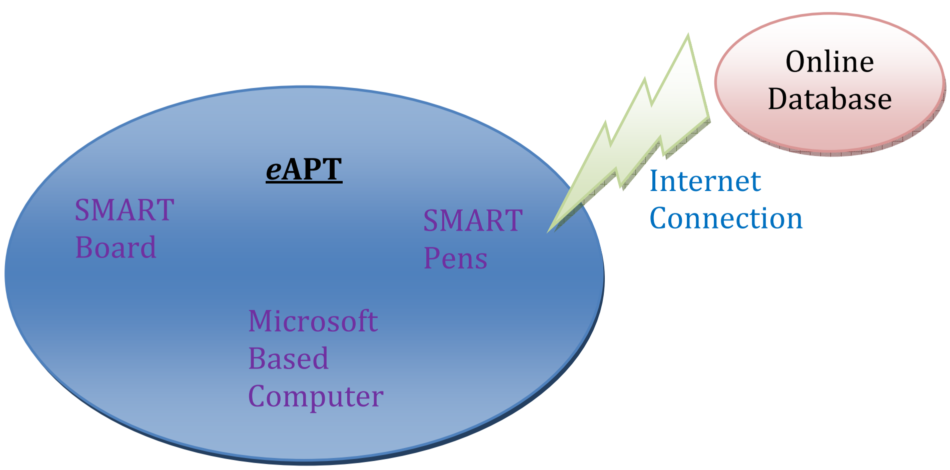

Figure 3. *e*APT Conceptual Design

Please see Appendix G for detailed examples of the interface for *e*APT. Upon initiating *e*APT, airport event planners will see the saved airfield data for their particular airport as the basis for an event plan. This data would include the layout of the airfield, pavement weight bearings, and runway centerlines (see Implementation Plan for further explanation). The airfield on *e*APT can be viewed in either satellite imaging or computer aided design format. Users can zoom and pan the map. Next, airport managers can choose aircraft to place on the airfield from the selection panel on the left side of the screen. *e*APT validates the aircraft scale according to the scaling of the airfield to ensure accurate aircraft representation after an aircraft is selected. It displays the selected aircraft's parameters, such as empty weight and wing span, to allow the airport manager to make adjustments to the aircraft's parameters, such as its expected weight with a load.

Once an aircraft has been successfully selected and its specifications edited to the airport event planner's liking, the aircraft is displayed on the airfield. Portions of the airfield where the aircraft cannot be stored or parked, because of the aircraft's footprint or weight, will be highlighted in red. By touching the static pen to a highlighted area and holding it there, users will be able to see why that specific aircraft is unable to be parked in that location. Now the aircraft can be dragged and dropped to a desired storage area capable of accommodating that specific aircraft.

Objects can also be added by selecting them from the dropdown menu on the display. Available objects such as security zones, fixed base operator stations, and operator created zones (no park areas, private parking areas, etc.) can be placed on the airfield. After an object is selected from the menu, the color of the object and its label can be edited. Now the static pen can be used to draw the parameters of the object on the map of the airfield. This feature allows the user to adapt and evolve the system over time so that *e*APT can continue to support the ever changing needs of airport planning. By these means, the expected lifetime of *e*APT is significantly increased.

*e*APT has the ability to store and save events for later viewing on the Microsoft based computer. This can be done by touching the static pen to the save icon, denoted by the floppy disk symbol, in the top left corner of the display. Saved events can then be exported and sent via email to additional stakeholders.

5.4 Mockups

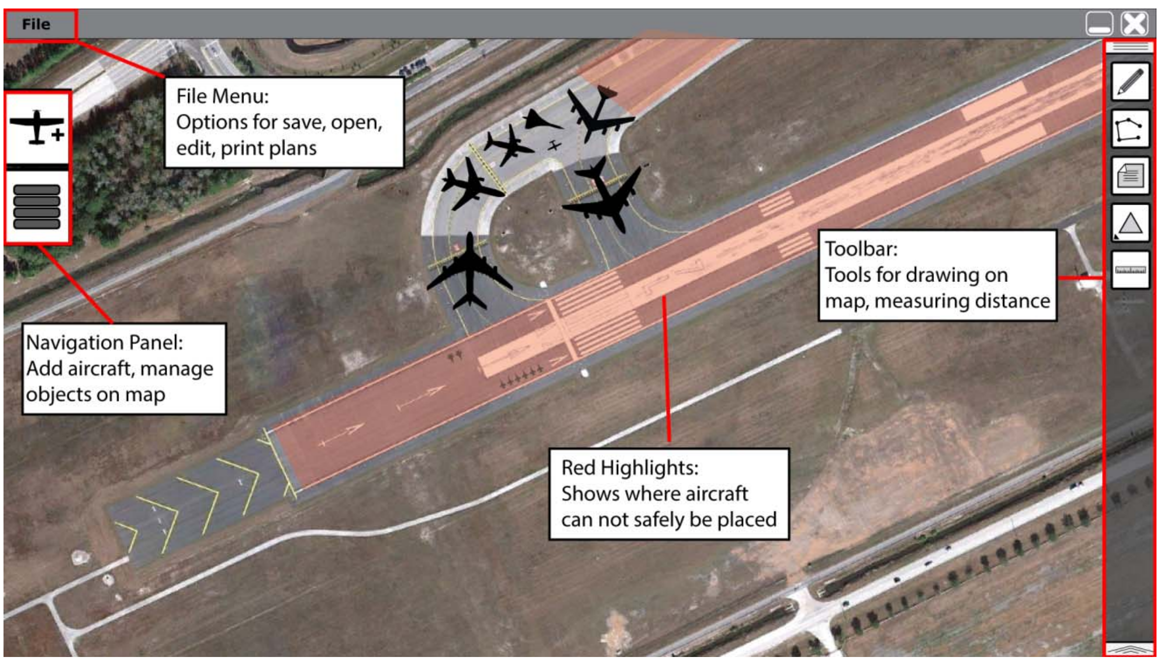

Figure 4. Overview of the *e*Apt user interface developed by Team Delta

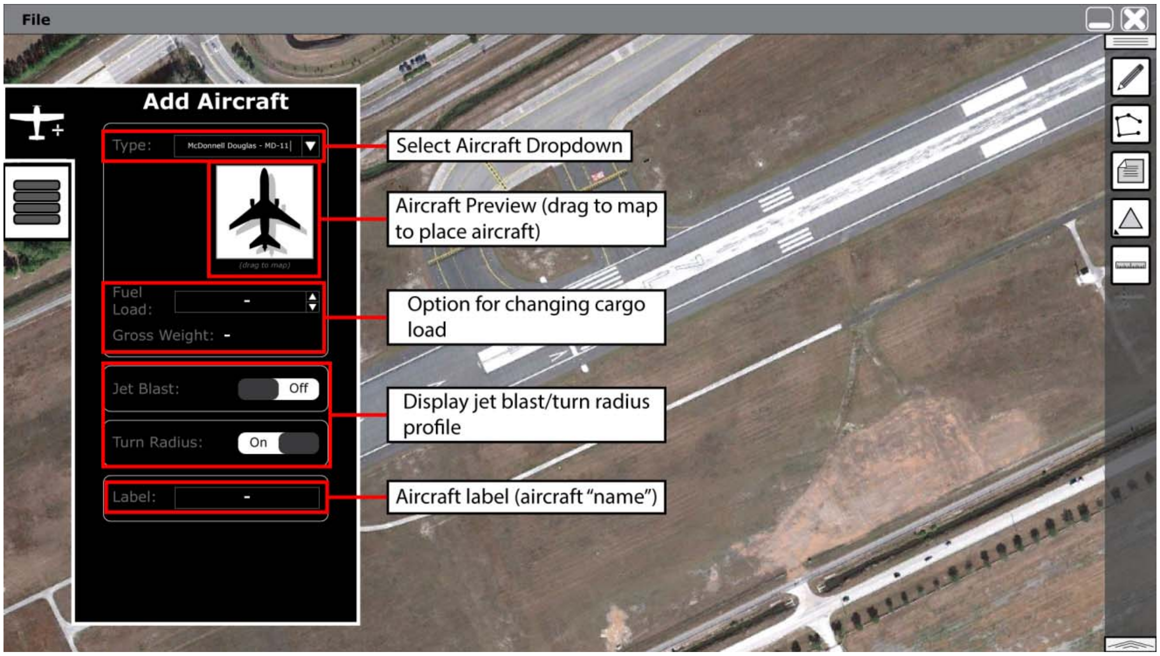

Figure 5. "Add Aircraft" panel in the user interface developed by Team Delta

5.5 Human-System Interaction

Per the INCOSE Systems Engineering Handbook v 3.2, Human Systems Integration (HSI) is defined as a practice in which human centered design principles are incorporated into the systems engineering (SE) procedure in order to guarantee that the users' (i.e. system owners, operators, maintainers, trainers, technical support personnel, etc.) general capabilities and limitations are understood and included in the system (Haskins, Forsberg, Krueger, Walden, & Hamelin, 2010). Based on this definition, HSI principles will be applied in order to mitigate issues that include SMART Board interaction and accessibility problems, potential cognitive overload, mistrust in the system and its data, and lack of user appreciation for qualifications needed to conduct airport planning.

The success of a system is dependent upon the system's ability to interact with its operator/user in an efficient and effective manner. In addition to information input methods, the system's environment must be taken into account. Since the primary users of *e*APT are airport event planners, the device can be expected to be used most often in a planning room or office. Therefore, the system does not have to be portable or compatible with outside lighting conditions and unique information delivery methods can be explored.

*e*APT has been designed to be used with SMART Board devices specifically in order to allow for point and click interaction and to assist with large scale visual representation. Because SMART Boards require their users to stand and physically touch the display in order to input commands, some individuals who experience physical disadvantages may not be able to use the SMART Board interface method. However, *e*APT is also compatible with windows desktop computers so that events plans can be backed up and accessed quickly in case of an emergency. It is this compatibility that also allows users who are not able to interact with touch user interfaces (TUI) to operate the system using a mouse. *e*APT's ability to be operated using a point and click graphical user interfaces (GUI) adheres to human engineering standards as outlined in MIL-STD-1472G and NASA-STD-3000.

*e*APT offers its users the option to display additional information in the manipulation stage such as the expanded selection menu. This may present a problem as users can become overloaded with information and visual stimuli. As per our requirements *e*APT must be fully operational under the control of just one person. This issue can be mitigated by employing cognitive work load assessments such as Cooper-Harper assessments, Situational Awareness Subjective Workload Dominance (SA

SWORD) methods, and NASA Task Load Index (TLX) assessments to ensure that *e*APT meets this requirement.

Doubt in *e*APT's abilities to assist in accurate airport planning is a potential risk that users may encounter. This may be due to the fact that the users do not know where the airplane specification data is being drawn from, or how recently these specifications have been updated. This risk may be mitigated by incorporating a hyperlink in the bottom right corner of the screen that displays an 'updated-as-of' time stamp. Another solution may be to have the hyperlink connect to an online database of aircraft specifications so that airport event planners can check the information. Training may also help to alleviate a user's mistrust in the system. By providing online training tutorials, users can verify that they are indeed using the system properly and utilizing the system to the best of its ability. HSI in the interface design process may also assist in increasing the trust a user has in the system by creating simple, direct, and intuitive interface command options so that there is no doubt in feature functions.

Finally, a risk that the use of *e*APT may bring about is a lack of user appreciation for qualifications needed to conduct airport planning. *e*APT is designed to assist airport planners and not to replace them. This system cannot replace the priceless value of user experience and qualifications. However, due to the incorporation of HSI principles into the design of *e*APT and the simple interface structure, higher-level users (i.e. airport managers) may be inclined to allow unqualified individuals to design airport event plans. This risk can be mitigated by not allowing airports that do not have qualified personnel on staff to purchase this product. Another way to ensure that capable individuals use the system is to include a username and password for the system that is only distributed to qualified airport personnel.

6 Projected Impacts of Design

6.1 Scenario-Based Design

In interviews with airport personnel at the Daytona Beach International Airport, the most prevalent issue identified for airport event planning was time efficiency. Currently Daytona Beach International Airport outsources event planning to a computer engineer for the county. This process by which the computer aided design mockup of the airfield and its designated parking areas are created and determined is explained in the Concept of Operations section of this report (Section 5.1). *e*APT removes the need to involve a second party in the event planning process. The system's user-friendly design allows designated airport event planning staff to create visual models of aircraft placement plans themselves. This process, which generally takes days to complete, is made much more time efficient when using *e*APT. The following scenario describes how *e*APT relieves the need to outsource airport event planning and assists with efficient event planning even under time sensitive conditions. These scenarios can be applied to any size airport but are tailored to the Daytona Beach International Airport. The scenarios were used in the design process to communicate the role of the product and its design features to the SMEs who were consulted for this project.

Scenario One

Daytona Beach International Airport is hosting an air show and expecting 200 aircraft for the weekend. More pressing, however, is the B-52 that will be landing on Friday. The airport manager must take into account the weight of the B-52 when parking the aircraft as certain paved lots have not cured completely. Since an aircraft like the B-52 has such a large wingspan, event planners and airport management must be concerned with allotting room for the aircraft to maneuver at the end of the runway while keeping both the wings and wheels within the runways parameters. In order for the air show to be a success, all expected aircraft must be placed in accordance to security zones, aircraft specifications, aircraft type (general, commercial, military), and arrival and departure times. Luckily *e*APT can make this task much less daunting!

The airport manager, Bob, who has taken on the task of creating the plans for this upcoming event, heads to his office and starts up the Microsoft Computer and the Smart Board. Bob selects the *e*APT program and opens it. *e*APT shows that its database is up to date and Bob is assured that his aircraft selections and their parameters will be accurate. A visual of the Daytona Beach airfield is already displayed. Bob moves onto selecting the aircraft that are expected for the air show. Bob selects the B-52 first, as this aircraft poses the biggest risk, and edits the expected weight, since the aircraft will be filled to capacity. Now the B-52 appears on the map of the airfield scaled to size. All areas where the B-52 cannot be parked are highlighted in red, making it simpler to see where the B-52 should taxi to after landing. Bob moves his SMART pen over the red highlighted areas and reads a description of why the aircraft cannot be placed in these locations (the weight of the aircraft exceeds the pavement limits).

Bob decides to park the aircraft in a lot near the runway that the B-52 will be landing on, as to remove the need for the pilots to complete unnecessary maneuvers when taxiing the aircraft to its parking location. Now that Bob has placed the B52, and is aware of the space he needs to keep clear in order to accommodate the aircraft, he can move onto adding the rest of the aircraft that are expected for the air show. Because he was able to see the space required for the movement of all the aircraft, Bob left adequate room for all of the expected aircraft in the planning process. Therefore, he does not have to be concerned with the ever changing arrival and departure times of the aircraft. When Bob has finished adding aircraft, editing their specifications, and placing all expected aircraft he can save his event by touching the floppy disk icon in the top left corner. Exporting and sending the event is quick and easy as *e*APT allows users to save created events to the desktop of the Microsoft based computer. Bob distributes the plans to all FBO's on the airfield as well as his security staff so that they can all be prepared for the event.

Scenario Two

There is a large airport nearby Daytona Beach International Airport that services multiple commercial airlines (Orlando International Airport: MCO). The airport is abruptly shut down as a result of a security breach and all traffic is diverted to the surrounding airports, including Daytona Beach, Tampa, Melbourne, and Sanford. The Daytona Beach airport manager, Bob, must scramble to develop a plan for parking the many aircraft that will be landing shortly. Bob rushes into his office and the starts up the Microsoft Computer and SMART Board. Bob selects the *e*APT program and opens it. *e*APT shows that its database is up to date and Bob is assured that his aircraft selections and their parameters will be accurate. A visual of the Daytona Beach airfield is already displayed. He adds the aircraft to the map and begins to place them strategically around the airport based on their size, weight, and the amount of space needed to unload passengers and cargo. Bob establishes different security zones by adding objects to the airfield map and setting their parameters. He quickly saves the event and exports it to his email. Bob emails a copy of the event map to the air traffic control tower, security manager, emergency services and each airline's operation centers. Now everyone has an updated plan for where to store the incoming aircraft and the air traffic controller can direct the aircraft to their designated parking locations without confusion.

Shortly after Daytona Beach International Airport starts taking on the diverted aircraft from Orlando International Airport a 7-series aircraft flying by on their way to Miami experiences smoke in the cockpit. They must make an emergency landing at Daytona Beach International Airport, which does not normally service large commercial aircraft such as this and is already taking on more aircraft than expected. Bob returns to his office and opens the *e*APT program. He uses his SMART pen to open the previously saved event he created earlier that day by selecting the folder icon in the top left corner of the screen. The event is displayed on the SMART Board.

Bob uses the zoom tool to get a better view of the entire airfield. He selects the Boeing-747 that is making an emergency landing. Bob selects the expected weight of the aircraft to be associated with a full payload. The 7-series aircraft is displayed on the airfield and is sized accordingly. All of the places where the aircraft cannot be stored are highlighted in red, making it easy to see where the aircraft should taxi to after landing. These red highlighted areas are determined to be incompatible with the incoming aircraft due to relating the parameters of the expected aircraft to the available space and pavement weight limits. Bob quickly saves the revised plan and exports it to his email where he sends out a new plan to the air traffic control tower, security manager, emergency services and each airline's operation centers. A crisis has been averted thanks to *e*APT!

6.2 Implementation Plan

The implementation of *e*APT would require the customer to purchase a SMART Board, which is an interactive whiteboard, and a desktop computer preferably with a Microsoft Windows operating system (OS). The Microsoft Windows OS is preferred over a Mac OS because of the computing ability required to process image algorithms. SMART Board models 600, 600i, 800, and 800i would be more suitable for this project as these models are specifically designed for government use; nevertheless, it is up to the discretion of the airport operations' manager to make this decision. Smart Notebook software is embedded in the SMART Board and allows the user to process images, create or accumulate notes and also use any other software such as AutoCAD. As noted in our cost benefit analysis, this software will cost $12,000.

It should be noted that *e*APT needs to become FAA certified before the system is fielded and becomes operational. *e*APT is required to meet the FAA rules and regulations which are mentioned in CFR part 139, Certification of Airports. To ensure that *e*APT meets the FAA standards, our team would need to start working with an appropriate FAA certification engineer early in *e*APT's development, and would create a certification plan that would be submitted to the FAA for approval.

Once *e*APT has been certified and approved by the FAA, *e*APT needs to be tested for integration into airport planning. For the testing process, *e*APT would be initially installed at the Daytona Beach International Airport. Our team would collect user feedback and review the results to see whether *e*APT needs to undergo any changes, and if so, what the required changes would be. After acquiring a list of required changes, the feasibility analysis of implementing those changes will be performed. A significant factor of implementing *e*APT at airports other than the Daytona Beach International Airport is the acquisition of airport specification satellite images and AutoCAD versions of the airport map.

6.3 Potential Real-World Impact

As of now, Mr. Murray, the manager at Daytona Beach International Airport, has to contract out the creation of the AutoCAD version of the runway which would enable him to analyze whether it is possible for an aircraft to land on the airports runway. For example, if a big and heavy aircraft with a wide wingspan, such as B-52, requested to land and park at Daytona Beach International Airport, then the authorities would need to compare many specifications such as the weight of the aircraft to the strength of the pavement or the width of the runway to the wingspan of the aircraft. In addition, Mr. Murray spends an enormous amount of time collecting data and performing analyses in order to figure out which part of the airport would be most appropriate for parking the aircraft. With the help of *e*APT, an airport operations and/or events manager can easily view where the aircraft can be parked. In contrast to current methods of determining the placement of aircraft, *e*APT will match the aircraft specifications, such as the wingspan, gross weight, tire pressure, and jet blast radius, to the runway specifications in a relatively short period of time. In contrast, using the current process means it can take months to plan events such as the Wings and Waves airshow. Using *e*APT, the airport operations or events managers can significantly shorten the time to plan an event of that scale. Feedback from Mr. Murray suggested that *e*APT could save a planner days' worth of work and would serve as a means for storing and passing on 'corporate' knowledge.

6.4 Commercialization Potential

There are many airports around United States of America as well as around the world, which have to deal with events such as air shows and therefore might be interested in investing in *e*APT. With the implementation of *e*APT, event planning will become relatively easier and faster. *e*APT also provides the airport authorities with the ability to save their event plans digitally for future use. This software has a potential for use by the airports in the United States of America and by other countries around the world. An analysis of similar systems was conducted, such as the Path Planner, and it was found that no other system, concurrent to *e*APT's design, is currently in use anywhere else.

In the future, *e*APT can have a capability to simulate aircraft movements, include flood zones, send assigned aircraft paths to the pilots directly so that the pilot would have an idea of where he has to park his aircraft and whether he/she needs to plan any maneuvers, and lastly, help airport authorities respond to emergency situations such as the one experienced by the Daytona Beach International Airport during the 9/11 attack. During emergency situations, the airport authorities would be able to make a quick decision on whether the aircraft can and should be diverted to a particular airport or not. If a large number of aircraft needed to land, *e*APT could tell airport staff how many aircraft and which types of aircraft could be accommodated by the particular airport. Thus, *e*APT has the potential to improve the efficiency of event planning, which can consume much of the airport staff's time, while simultaneously increasing an airport's emergency preparedness, and still other uses may emerge over time.

The *e*APT strategic marketing process consisted of a SWOT analysis (strength, weakness, opportunities and threats) which helped in segmentation of various airports on the basis of airport exposure, i.e., the non-primary airports versus the primary airports. In addition, the SWOT analysis also helped determine that the implementation of *e*APT would be most beneficial for the airports which conduct sporadic events such as airshows. As will be discussed in the financial analysis below, *e*APT includes a library of most commercial, military and GA aircraft, the entire airfield and customizable presentation modes. Also, *e*APT will cost $12,000 with an additional $850 for software maintenance agreement (SMA). *e*APT provides a user with better and more user friendly functions at a comparatively cheaper overall price as compared to PathPlanner by SIMTRA which costs $7,190 with a network configuration fee of $2,990 and a SMA of $1,940.

*e*APT will be offered to a small number of key airports that will not produce a profit in order to begin building a customer base and generate word-of-mouth endorsements in the relatively small community of airport managers.

After *e*APT has proven itself at a higher commercial level, we will target the bigger airports. This process would involve talking to the airport authorities and gathering all the data for the functions specifically requested by the particular airport while maintaining all the FAA rules and regulations. We will also explore the potential for using *e*APT in other markets for example, Department of Defense air bases and carriers, in aircraft cockpits, and marinas & boat storage.

6.5 Financial Analysis

To evaluate the financial feasibility of our product, a cost/benefit analysis was conducted and is summarized in Table 3. As with any new product, the cost of initial implementation can be high. Our application will be installed on SMART Boards which range between $1,500-$7,500. The upper limit was used in Table 3 to evaluate costs. The cost just to purchase PathPlanner A5 by SIMTRA, a competing technology described in section 3.2, is $13,830 with an annual SMA fee of $2,730 (SIMTRA, 2012). Therefore, we estimate that *e*APT, which includes a library of most commercial, military and GA aircraft, the entire airfield and customizable presentation modes, will cost approximately $12,000 for an airport to purchase. There will also be an annual SMA of $850. This program includes software updates, bug fixes, technical support and adjustments to the computer aided design when the airport undergoes runway construction and/or remodeling.

Although the initial cost for airports to purchase *e*APT may be high, it is unlike any comparable (by price) technology available, and it can complete an entire event planning process on a single interface. Workload will be cut down for the airport planners, and efficiency will be increased. Fewer calls to military pilots will be made to make sure they can land directly on the center line. Fewer calls will be made to runway engineers to determine if runways and taxiways can support emergency incoming or military aircraft. Less time will be spent looking through thick manufactures' books to determine the wingspan and exact weight of aircraft. So there will be a reduction in man-hours, which can be focused on other airport operations.

Since *e*APT is designed to support, and not change, airport-planning tasks, the duration of training is projected to be short. Our application is also user friendly and allows the user to interact with the SMART Board in whichever way they feel comfortable, either using touch screen or point and click interfaces. These characteristics will help minimize training hours. Training for implementation and operation is projected to cost the airport, independent of the number of users, $1,000 for a maximum of eight hours. If there are fewer users, the training duration will be shortened. This cost covers the developer's on-site training and resolution of any questions or concerns the users have about the usage and content of *e*APT.

Planning events requires a lot of time investment from certain people. A computer aided design engineer designs all the diagrams and layouts for the Daytona Beach airfield. This engineer is on salary with Volusia County for $53,000 a year. In an interview, Daytona Beach International Airport Manager John Murray, stated that the computer aided design diagrams take about two weeks to complete. This is costing the county $2,000 (See Table 3) every time there is a change in the airfield. Our SMA covers these changes and will relieve the airport and county of future charges (Murray, 2012). Planning for events takes weeks, and this requires a lot of an airport manager's time. Mr. Murray also stated that consultants charge $150 an hour to give information on the runway stats, and they usually work for about three hours. At Daytona Beach International Airport, there are three large events per year. If the airport uses consultants for each event, this will add up to a cost of $1,350 (Table 3). Our software will eliminate, or significantly reduce, the need for these consultants. When large scale, annual events are planned, the events can be saved and retrieved the following year. If there are no major changes in airfield layout or incoming aircraft, the event can be reused, further reducing planning time.

Table 3

Projected Annual Cost Breakdown

Item	Estimated Costs	Estimated Benefits	Total Benefits
SMART Board	$7,500		
*e*APT Software	$12,000		
Training	$1,000		
First Year Total	$20,500		
Annual Software Maintenance Agreement	$850		
Changes in Runway/Airfield		$2,000	
Consultant's Time per Event		$1,350	
Total Benefit		$3,350	
1st Year of Implementation	$21,350	$3,350	($18,000)
2nd Year of Implementation	$850	$3,350	$2,500
3rd Year of Implementation	$850	$3,350	$2,500
4th Year of Implementation	$850	$3,350	$2,500

Although during the first year of implementation the costs to the airport seem high, the payoffs and benefits are higher. After the first year, the airport will only be responsible for the SMA fee. The benefits, on the other hand, will apply not just during the year of implementation, but for years to come.

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Appendix B: Description of University

On December 17, 1925, exactly 22 years after the historic flight of the Wright Flyer, barnstormer John Paul Riddle and entrepreneur T. Higbee Embry founded the Embry-Riddle Company at Lunken Airport in Cincinnati, Ohio.

In 1965, Embry-Riddle consolidated its flight training, ground school, and technical training programs to Daytona Beach, Florida. Expansion of the University began when a former college in Prescott, Arizona, became the western campus of Embry-Riddle in 1978.

In addition to its two traditional residential campuses, Embry-Riddle Worldwide provides educational opportunities for professionals working in civilian and military aviation and aerospace careers. Of today's more than 150 Worldwide Campus locations in the United States, Europe, Asia, Canada, and the Middle East, the majority are located at or near major aviation industry installations, both military and civilian.

Though it began as a school for pilots and aircraft mechanics, the University now offers more than 40 undergraduate and graduate degrees and provides the ideal environment for learning. Degrees at ERAU include Aviation Business Administration, Aerospace Engineering, Human Factors and Psychology, Safety Science, Homeland Security, Engineering Physics, and more. Even though Embry-Riddle is primarily a teaching institution, research plays an important role for students and industry. The focus is on applied, solution-oriented research. ERAU combines an impressive faculty with state-of-the-art buildings, laboratories, classrooms, and a diverse student population. Embry-Riddle's students represent all 50 states and 126 nations.

As aviation and aerospace continue to evolve, so does Embry-Riddle. The

University is committed to the expansion of opportunities for students to work more closely with the aviation industry in the United States and in other countries. Guiding the process of evolution are dedicated teachers, administrators, alumni, trustees, and advisory board members who share the students' love of aviation and who strive to ensure Embry-Riddle's continued position as the world's premier aviation and aerospace university.

Appendix E: Evaluation of Educational Experiences

Nathalie Vazquez

Competing in the FAA Design Competition was more beneficial and educating than any class assignment could have been. It taught me the best way to gather requirements from potential clients and how to validate and verify them throughout the systems development process. It showed me the meaning of great teamwork and collaboration.

An initial challenge that my team encountered was coming up with a new design. We all come from different academic backgrounds and hence had so many different ideas. Once we settled on a design, we had other challenges to overcome. Staying inside the scope of our project and avoiding requirements creep were a couple of issues we had to address. To overcome this, our team had several meetings to establish the high level requirements and decide what we wanted to leave out for future expansion.

For developing our hypothesis, our team used several forms of communication to make sure we were always connected. We set up a folder in Google Drive so that we can upload recorded interviews, mock ups, sections of the papers, and other design related materials. We also stayed connected through a mobile application, Whatsapp, so that we could share ideas outside of meetings. As team lead, I used Whatsapp to give my teammates reminders of approaching deadlines.

Participation by industry in this project was very useful. With the help of a potential user, we were able to build requirements based on what SMEs really needed. It's also worth mentioning that without a presentation from SME's, we wouldn't have come up with the idea for our design.

I learned so much from this experience. Through the challenges, clear communication was vital in ensuring everyone understood the scope of our project. I learned the importance of time management and setting goals and milestones for my team to accomplish. These are skills I can take to any workplace and help my team succeed with the project at hand. I also feel that this experience has prepared me to be a better team lead in future endeavors.

Michael Vincent

This was my first group project I have worked on as a graduate student at Embry-Riddle and I am happy to say that I was impressed with how committed and hardworking my group really was. Our team was comprised of people with a wide range of backgrounds that each contributed something different. Despite our diverse range of experiences, we learned to harness our combined knowledge and skills to develop *e*Apt. We relied on each other's expertise for different areas of research such as risk management, cost analysis, and human-systems integration.

I think the most important lesson we learned from working on this project is how to manage team dynamics. Many times in team discussions, our team would get so far into the "weeds" of the development process that we had to force ourselves to step back and consider what was really best for our design and our potential users. When we were unable to come to a consensus about a design or development area during team meetings, we agreed to allow data from future system evaluations determine the details of that area. In doing this I feel that we learned to be an advocate for our system and our users. We also found that working together in an area where it was easy to listen to each team member one at a time facilitated team discussion and kept everyone "in the loop."

All in all, I am happy to have contributed my own personal experiences and knowledge to *e*Apt and feel I have gained an insight into systems development processes as well as the domain of airport planning and management.

Stephen Tignor

The FAA Design Competition did provide a meaningful learning experience for me. Interaction with my teammates was a great aspect of the process and vital to the learning process. Our group was extremely well rounded with individuals from many different backgrounds. This diversity allowed for an environment in which I learned many different ideas. As well, this diversity allowed for a better understanding of the differences in many opinions which arise when all teammates are from different backgrounds.

The FAA Design Competition allowed for a real world twist on a project. This real world application allowed me to gain a better appreciation for the work involved in such processes. Many projects do not entail stakeholder interaction which takes away from the realism. This competition brought that to the table and allowed for a flexible choice of what problem(s) to tackle as well. This flexibility allowed me to feel more at ease with designing a solution to a current or foreseen problem.

Group difficulties are inevitable. Our group had difficulties in the perfect meeting time for all group members. Setting up a seven person meeting when everyone has another job(s) and other classes is difficult. When it came down to it long meetings after classes and multiple late night gatherings allowed us to overcome this issue. Communication was strengthened by the use of a group messaging application which allowed us to reach all group members simultaneously. This application removed the delay and clutter of email communications and the intrusion of multiple phone calls.

The process our team took in order to develop our hypothesis was simple. After gaining a topic we researched the issue. From the research the conceptual design was born. This design allowed us to hypothesis the benefits of such a product.

Participation by the industry experts was essential to much of my learning experiences. Interacting with these experts allowed for current needs to be uncovered and adopted into the design. These individuals played key roles in understanding the purpose of our work and the benefits which could be had if implemented. Without the knowledge these individuals added to the project, the end result may have been significantly different. One problem with the experts is one may rely heavily on their input. Many students may feel they are more knowledgeable and therefor do not counter or question any suggestions with the students supported point of view.

Although everything is a learning experience the project taught me numerous application skills. This was a great opportunity to apply the knowledge gained through prior experiences. The competition allowed for the practicality of using real stakeholders and their needs to provide a conceptual solution to a perceived problem. Justifying design requirements to stakeholders was a great learning experience as well. Researching the safest, most user friendly and cost effective means for the design was exhaustive. The exhaustive research resulted in confidence in our design with all credible justification needed for the claims. The steps involved in being able to confidently justify the design choices allowed for a priceless real world learning experience.

Hemali Virani

Yes it did. Coming from an Aerospace Engineering background it was difficult for me to understand the concept of Human Factors and Systems. However, I was able to gain knowledge about various principles of Human Factors and Systems while preparing our project for the competition.

As a team we worked together with every aspect. Due to the fact that I have an engineering background and that English is my third language, it was difficult for me to write my section of the report with fluency. The fact that I asked for help from my team and Dr. Neville who helped me overcome this challenge.

We spoke to Mr. Murray, who was out Subject matter expert, and were able to set up an informal interview with him. After the interview we were able to make a list of things which would help make his task easier, which eventually helped form requirements for the projects. Once the requirements were attainted we were able to compile each and every section.

The participation by industry in the project was appropriate and very meaningful as well as useful. Without the help of the airport management we would have not be able to get an idea to develop software such as *e*APT. The management provided us with crucial information which was utilized in the project.

Coming from an engineering background and with no knowledge about Human Factors and systems, this project helped me appreciate the HFS and also I was able to understand the importance of HFS in the real world. With the help of this project I also learned about various FAA rules and regulations, airport safety and management, and above all I understood the importance of implementation plan and real world impact.

Amanda Peterson

By participating in the FAA design competition I have a better understanding of the system development process in practice. This experience has helped me to become comfortable with varying leadership roles delegated to me by my colleagues. Because my project group consisted of a wide range of backgrounds, I gained experience in working with others who do not share the same knowledge on aspects of the system and the development process as I do and vice versa. Having this kind of an integrated product development team worked very well, as we all respected each other's areas of expertise and related opinions and the project profited off of the collaboration of many different viewpoints. Including Subject Matter Experts (SME) and industry personnel in the early development stages helped us to define the role and requirements of the end user of our system.

One issue that Team Delta faced in the preliminary stages of the project was an undefined scope of the project. Because we had not limited our focus on one area of airport planning, feature creep occurred and the project had to be brought back to earth and the product concept narrowed. However, I had a wonderful experience with my project group. Not only did I learn from my colleagues, but I also built close relationships. One of the methods of group cohesion that we put into practice for this competition project was electing a leader, co-leader, and secretary. These individuals helped to keep everyone focused and on time with internal deliverables. This project was extremely meaningful to me as I was introduced to the system development and management process. I would like to focus my career in this area and I hope that this

FAA competition will open these doors for me and provide me the opportunity to pursue a career in that line of work.

Marcus Peterson

For this project I was in charge of researching the different system development and lifecycle models and choosing one to use within the group. The information and understanding of the system development process that I gained from conducting this research and employing a system development in practice will help me as an employee if I am ever involved in the production and creation of a system. I feel confident that the experience I have gained from participating in this FAA competition has impacted my ability to lead, my ability to explain my ideas or opinions related to my area of expertise to others, and my understanding and respect for individuals in alternative backgrounds. As a group, one of the challenges we faced was that we delegated specific areas to project team members and then split up to collect research on our own. In this way we brought finished portions of the project that we had done on our own together at the end to integrate the report into one. The problem was that there was a lot of overlap between project sections. We attempted to stop this from happening by having weekly review sections of each other's sections. However, this was not as effective as group collaboration on each section of the report may have been. I am very happy with my group and our methods for developing the *e*APT system. I hope that participating in the FAA competition will open new professional doors for me and help to enhance my experience of real world project work and system development.

Appendix F: References

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Appendix G: Additional Images

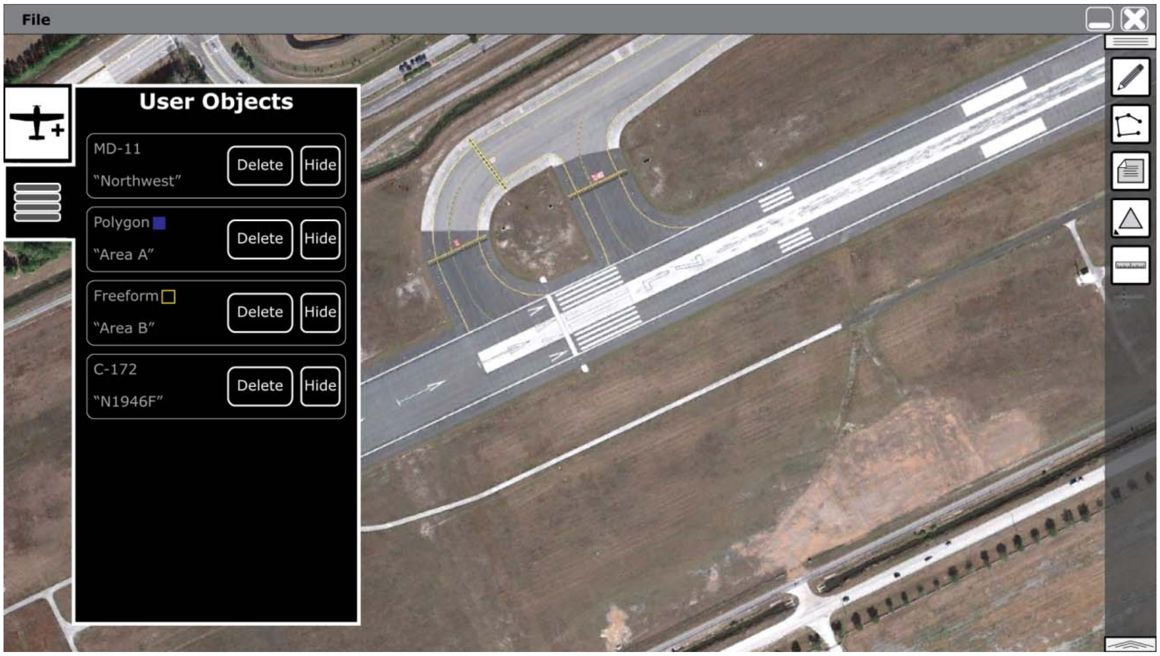

Figure 6. "User Objects" screen for management of on screen user-created objects.

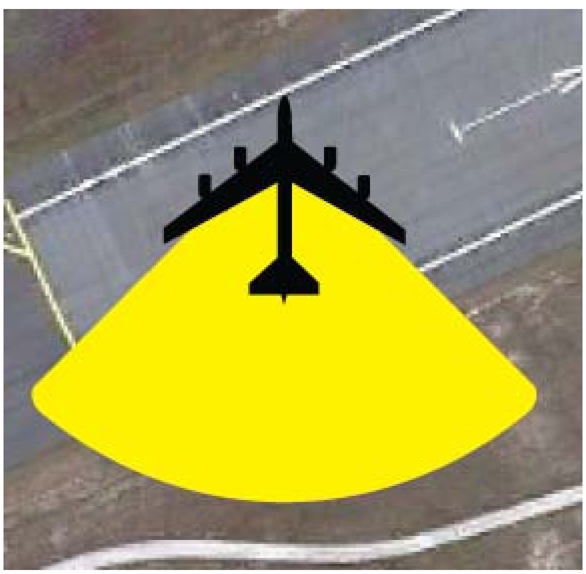

Figure 7. Example of the blast radius overlay option.

Figure 8. Example of the turning radius overlay.

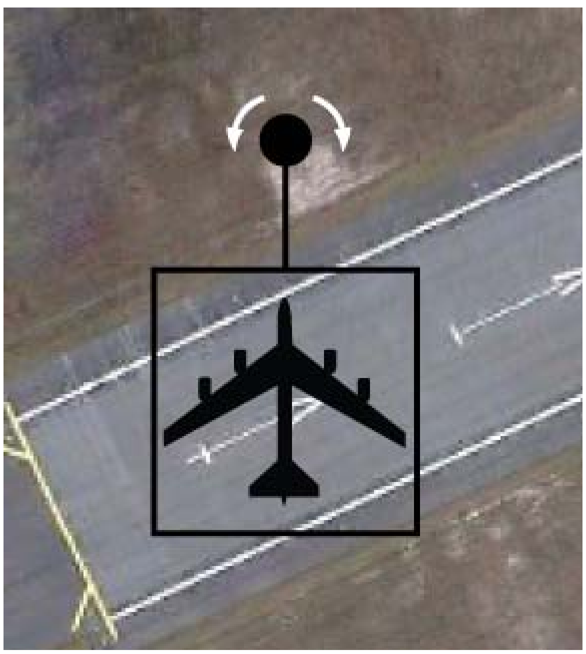

Figure 9. Appearance of an aircraft profile when “selected”

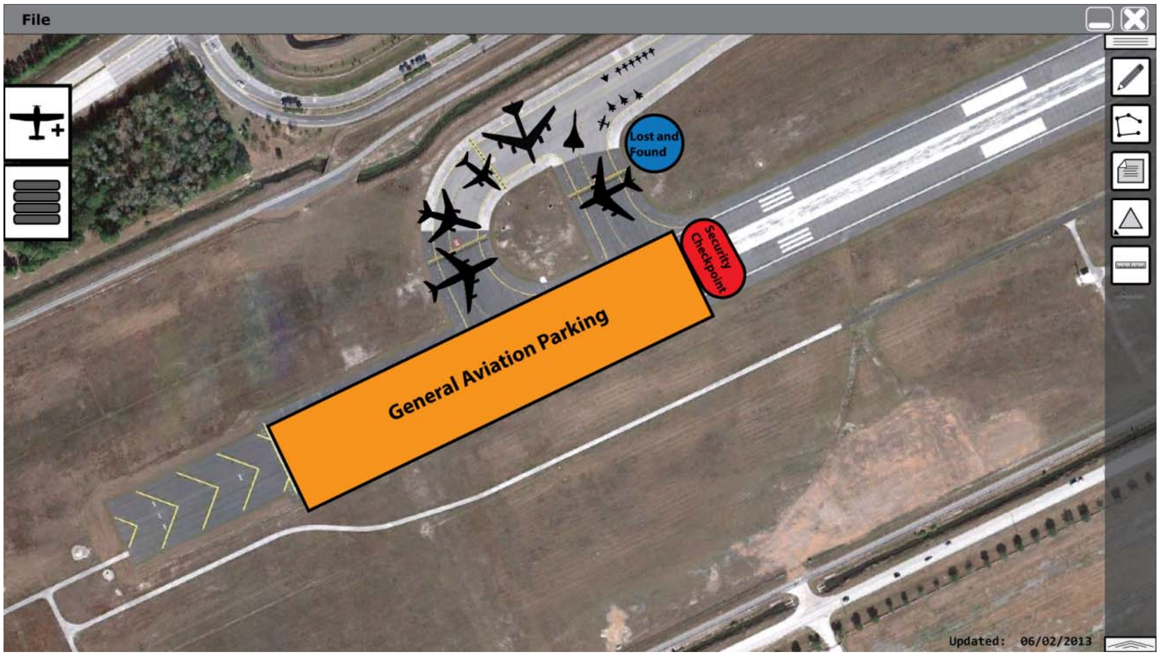

Figure 10. Example of an airshow plan using *e*Apt.