COVER PAGE

Title of Design: ___EyePort____

Design Challenge Addressed: __Runway Safety/ Runway Incursions______________________

University Name: __Embry-Riddle Aeronautical University______________________________

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1.0 Executive Summary

This paper proposes the eyePort to reduce the risk of runway incursions and increase the situational awareness of pilots. Over the last several years, runway incursions have become a major concern to Federal Aviation Administration officials. Through literature reviews, distinguished subject matter expert interviews, and a variety of systems engineering problem solving approaches, the eyePort system shall not only increase the situational awareness of pilots, but also add an extra layer of safety to the aviation community. EyePort achieves this by integrating existing technology that is currently used by pilots and aviation officials, into a common interface. EyePort design benefits are demonstrated through cost and safety analysis and scenarios. EyePort has the potential to make a positive impact throughout the aviation community.

2.0 Problem Statement

The Federal Aviation Administration (FAA, 2009) defines a runway incursion (RI) as "any unauthorized intrusion onto a runway, regardless of whether or not an aircraft presents a potential conflict." In other words, whenever an unauthorized aircraft, vehicle, or person enters a runway without clearance, regardless if there is a hazard, a RI has occurred. In October 2007, the FAA adopted the International Civil Aviation Organization's definition of RIs, which expanded their definition to include potential aircraft conflicts—such as an unauthorized aircraft crossing an empty runway—that were formerly classified as surface incidents (FAA, 2009). When a RI occurs, the FAA categorizes the incident into one of four severity categories; Category D is least severe, while Category A possesses the most risk for severe consequences. With the new definition of RIs, incidents that were formerly classified surface incidents are now categorized as Category D or Category C RIs. These are less-severe incidents that provide the pilot with ample time and/or distance to avoid a collision. Categories A and B are much less frequent than C and D (FAA, 2007). However, their consequences more than compensate for their relatively low frequency. The FAA provides the following chart, Figure 2-1., to display the categories of RIs based on their level of severity:

Category	Description
Accident	Refer to ICAO Annex 13 definition of an accident.
A	A serious incident in which a collision was narrowly avoided.
B	An incident in which separation decreases and there is a significant potential for collision, which may result in a time critical corrective/ evasive response to avoid a collision.
C	An incident characterized by ample time and/or distance to avoid a collision.
D	Incident that meets the definition of runway incursion such as incorrect presence of a single vehicle/person/aircraft on the protected area of a surface designated for the landing and take-off of aircraft but with no immediate safety consequences.

Figure 2-1. Runway incursion severity classifications (Adopted from FAA, n.d.)

In addition to classification by severity, the FAA categorizes RIs by who was at fault. An RI can be caused by pilot deviation (PD), any action of a pilot that violates FAA Regulations. An operational error (OE) is caused by Air Traffic Control (ATC) when an aircraft or vehicle is inappropriately cleared. RIs can also be attributed to vehicle or pedestrian deviation (VPD), when a vehicle, non-pilot operator of an aircraft, or pedestrian deviates onto a movement area, including a runway, without ATC authorization (Runway incursions, 2007).

Between 2003 and 2006, there was a 60 percent increase in RIs due to an increase in air traffic and the redefinition of classifications (NASA, 2008). Although the number of serious RIs (categories A and B) dropped by 55 percent from fiscal year 2001 to 2007, less severe RIs increased (FAA, 2009). The Air Line Pilots Association (ALPA, 2007) estimates one RI occurs daily, which is of great concern to the FAA.

The worst accidents in aviation history have been due to RIs. The worst accident resulted when two Boeing 747s collided on a Canary Island runway, killing 583 people. This accident was due to factors that included poor viability, miscommunication, ambiguous phraseology between ATC and the pilot, and high ATC workload (The deadliest place crash, 1997). The deadliest U.S. RI accident occurred in 2006 when a Comair flight took off from the wrong runway, killing 49 passengers. Among other contributing factors, the pilot of this crash had an outdated diagram of the airport layout (National Transportation Safety Board, 2010). Another deadly RI occurred in 2001 in Italy, when an airliner hit a private jet that wandered across the runway, then staggered into an airport building, killing 118 personnel. This accident was due to low visibility, language problems, and unfamiliarity of an airport (Baron, 2002). These incidents can be attributed to low visibly due to weather conditions or time of day, miscommunication, unfamiliarity of the airport, or a combination of the stated, all of which contribute to a pilot's situational awareness (SA). With the appropriate tools and communications, these accidents may have been prevented.

2.1 Focus and Background of Study: Increase Situational Awareness

In a study completed by the FAA (2009), it was found that the majority (63 %) of RIs are due to PD. Figure 2-2 displays a graph of the distribution of who was at fault for RIs during FY 2008.

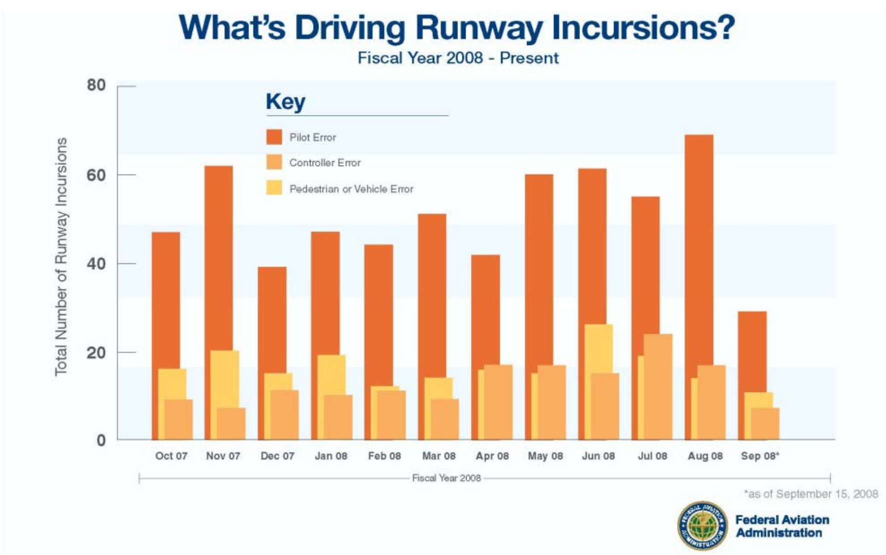


Figure 2-2. What's driving runway incursions (Adopted from FAA, 2008)

To reduce the risk of PDs, SA—"being aware of your location on the airfield, and how that location relates to your intended taxi route, and to other aircraft and vehicles that may be operating in the airfield" (FAA, 2007)—needs to increase. In other words, SA is "a pilot's continuous perception of self and aircraft in relation to the dynamic environment of flight, threats, and mission" (Carroll, 1992, as cited in Bell & Waag, 1997, p. 5). When pilots think of SA, often their minds turn to the sky. Pilots are taught to stay two steps ahead of the airplane by drawing a mental map, anticipating the next turn, and knowing where other aircraft are. Pilots, and other ground operators, need to recognize SA is equally important on the ground.

Although pilots and airport operators have strategies for maintaining good SA, the complexity of the airport ground operations environment can sometimes overwhelm their efforts. As noted above, there are environmental factors that often lead to RIs including: navigating in unfamiliar airports, navigating during nighttime; and navigating in fog, rain, snow, or other weather conditions that can reduce visibility (Wright, n.d.). Other factors that can reduce SA include aerodrome design (when an aircraft is obliged to cross an active runway to reach parking or another active runway), multiple line-up (aircrafts depart from same runway at different positions), simultaneous use of intersecting runways, late issue of departure clearances, non-standard or non -adherence to standard phraseology, workload, and distraction (Runway incursions, 2010). An interface that integrates multiple sources of information could provide a more cohesive awareness of the dynamics of airport ground operations.

The eyePort interface will streamline and integrate multiple modes of information and warning signals that will increase pilot SA, thus reducing the chance of RIs. The interface of the eyePort will be an expansible system that can display a multitude of information types in a useful form. Pilots will be able to choose what information they would like displayed. Potential information could include weather updates and alerts, aerodrome designs, existing aviation technology, warnings of potential RIs and other hazards, location of other aircraft, and other information to increase the SA of pilots. EyePort can be used in commercial and general aviation. EyePort will increase pilot SA, which potentially could have a positive impact on the aviation community.

2.2 Existing Technology

A vital aspect of eyePort is that it takes advantage of existing technology and has an integral relationship with existing commercial off the shelf (COTS) products, which may shorten the time-to-market. The Garmin G1000 Global Positioning System (GPS) will be the prototype platform for eyePort's map and interface because it is an all-glass avionics suite that presents flight instrumentation, navigation, weather, terrain, traffic and engine data on large-format, high-resolution displays (G1000, 2010). Smartphone and GPS platforms use their own Code Division Multiple Access (CDMS) based wireless communication networks to connect to servers. Smartphone technology enables eyePort clients to transmit additional information to be fused with the servers, which connect to existing, low technology risk data, displayed in Table 2-1.

Table 2-1. Existing aviation technology to be integrated into eyePort

Existing Aviation Technology	Description
Notices to Airmen (NOTAMS)	System that notifies aircraft pilots of any hazards en route or at a specific location (Aviator, 2010)
Meteorological Aviation Report (METAR)	International standard code for hourly surface weather observations (National Weather Service, n.d.)
Airport Movement Area Safety System (AMASS)	Visual and audio alert system that detects potential runway and taxiway collisions (FAA, 2004)
Instrumental Lighting System	Sytem that uses transmitters an radio signals to land in IFR conditions (AllStar, 2008)

The Next Generation Air Transportation System (NextGen) has similar technology under development that is expected to be deployed in 2025. NextGen relies on Automatic Dependent Surveillance-Broadcast (ADS-B), which provides high precision location reports and repeated broadcast mesh network. EyePort's aim is to start simple and build upon its framework. EyePort is a low cost and timely alternative until NextGen's completion. Further, NextGen developers can use eyePort to evaluate the usefulness and design of functions and capabilities that are proposed to use in NextGen. NextGen's high aspirations may potentially fall short in the long term due to the everyday advancements in technology (Joint planning and development office, 2006). With eyePort acting as a prototype for NextGen, an evolutionary timeline should emerge paving the path for an auspicious NextGen.

3.0 Literature Review

Extensive research was conducted prior to the concept of eyePort. Initial research was focused on understanding the environment in which pilots operate. Airport signage was researched to gain understanding of why pilots may get lost on taxiways. ATC and pilot communication was studied, by streaming live audio from airports, which aided in understanding how phraseology could lead to confusion, thus leading to a RI.

After becoming familiar with operational language and taxiways signage, solutions were discussed, and the concept of eyePort was born. To ensure eyePort was feasible, yet unique, more research was conducted. Much literature focused on current technology, and revealed many potential resources for eyePort to utilize. A potential platform for eyePort's native device would be Garmin G1000 because it is already approved by the FAA. The three initial existing, technological outputs for eyePort would include:

1. Airport mapping and route planning: This feature makes use of several resources. GPS location, AMASS (FAA, 2004), Automatic Dependent Surveillance-Broadcast (ADS-B), and NOTAMS (Aviator, 2010). NextGen research ("NextGen implementation plan," 2010) discusses the potential of these systems. An opportunity to link these data sources,

via GPS mapping, would likely increase the SA of pilots. Knowing where they are and where other planes are in relation to them, pilots can make informed decisions. Also, by linking NOTAMs and route planning, eyePort can reduce confusion due to communication breakdown or unfamiliar airports.

2. Current weather information: Accurate weather information is hard to acquire and difficult to interpret during takeoff. Linking Meteorological Air Reports (METARs) with eyePort and creating a simple, easy to understand interface can increase SA.
3. En Route Notification: NOTAMs provide immediate status changes on an aeronautical facility, service, procedure or hazard, improving efficiency and SA.

4.0 Problem Solving Approach

4.1 Stakeholder Analysis

Table 4-1 displays the stakeholders that would have vested interest in the implementation of the eyePort and their areas of interest. By identifying the specific interest areas, we can determine when each stakeholder should be integrated into the development and implementation process.

Table 4-1. Stakeholders interest areas

	Interest Areas						
Stakeholders	Regulations	Integration	Training	Finance	Usability	Operational Changes	System Maintenance
Pilots		●	●	●	●		
Air Traffic Controllers		●	●		●	●	
FAA	●	●	●	●		●	●
Airport Operations		●	●	●	●		●
Software Developers		●		●			●
Hardware Developers		●		●			●

4.1.1 Interviews with Airport Operators and Industry Experts

While literature reviews were being conducted, interviews with Subject Matter Experts (SMEs) were also held to discern which technologies would be most beneficial for aircraft operators and airport personnel. Table 4-2 displays SME names, job titles, and qualifications, and is followed by comprehensive summaries of SME interviews.

Table 4-2. Airport operators and industry experts interviewed

Name	Company	Position
Mark Beaton	Federal Aviation Administration	National Air Traffic Control Representative
Vincent Camino	Federal Aviation Administration	Runway Safety Program Manager
Marty Lauth	Embry-Riddle Aeronautical University	Air Traffic Control Professor
John M. Murray	Daytona Beach International Airport	Operations Supervisor
John Pieraccini Jr.	Delta Airlines, JFK International	Mechanic
Steve Ward	Daytona Beach International Airport	Airport Operations Agent and Wildlife Coordinator
Andrew Smith	Embry-Riddle Aeronautical University	Corporate Pilot - Currently Student

Marty Lauth, ATC professor at Embry-Riddle Aeronautical University (ERAU), was interviewed on 23 September 2010 following a presentation on RIs. The interview, combined with the team literature review, led to an understanding of the most common causes of RIs and the importance of SA for air traffic controllers and pilots. From the interview, the team decided to pursue a ground based GPS system for taxiing airplanes.

On 30 September 2010, John Murray and his airport operations team from DAB presented their daily personnel duties. He and his staff of six are in control of terminal functions, air, fuel, lighting inspections, and baggage assistance to name a few. Throughout the day, he and his team are in contact with the tower, the police department, ATC, and fire/rescue teams. Steve Ward, the DAB wildlife coordinator, introduced the commonality of wildlife at the airport and the methods used to keep the animals clear of the runway, such as firing blanks from rifles and grenade launchers. Due to the variety of tasks grounds crews have in maintaining airport operations, eyePort will encompass them as well .

Andrew Smith, an inactive commercial airline pilot finishing his degree at ERAU, spoke with the project team on 18 October 2010. He discussed what elements to include in the eyePort and provided feedback on the team's current design and ideology. He helped narrow the eyePort scope and come up with a plan how to model the future system growth.

Vincent Cimino, Runway Safety Program Manager for the FAA, was contacted on 1 November 2010. He provided information on the most common causes of aviation accidents and how accidents are analyzed by the FAA. He described the complexities of accidents due to the interplay of multiple elements. One of the main points emphasized was the need for the human element to be included and taken into account throughout the development of all NextGen technologies.

On 3 November 2010, Mark Beaton, National Air Traffic Control Association Representative for DAB, provided a tour of the Daytona Beach tower and facilities. In the Traffic Control (TRACON) Room, he explained the critical tasks, how tasks are divided, how information is communicated, and how information is displayed to everyone. In the tower, there was constant communication with the pilots, but limited communication between controllers. Several individuals conveyed their concern over the danger of automating to the point that the human element is eliminated from the system and expressed the need for humans to be present, interact, and make decisions in an ever changing air environment.

John Pieraccini Jr., mechanic, was interviewed on 3 November 2010. He described the current runway safety concerns in aviation and provided comments on the implications of eyePort and runway safety. His main concern was SA amongst aircraft and airport personnel. While his response to the eyePort was positive, he clearly stated the device should be used only to assist the human and never to be used in place of human. During these interactions, the importance of creating a helpful system that was not excessively distracting became very apparent.

4.1.2 House of Quality

After meeting with SMEs, requests and concerns were discussed and specified into tangible customer requirements. Based on SME feedback, these requirements were given a value of importance (5 = most important and 1=least important). An expanded list of requirements was developed to specify what needs to be done to satisfy customers' requirements; these became engineering requirements, displayed in Table 4-3.

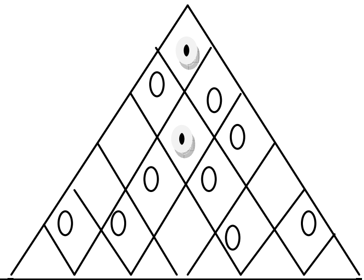
Table 4-3. High level customer and engineering requirements for eyePort

Importance	Customer Requirements	Engineering Requirements
4	Notify of Change in Environment	Display Aerodrome Design
5	Keeps Human in the System	Allow User to Select Information Display
3	Update Ground Operations	Integrate NOTAMs/ AMASS
3	Low Technology Risk for Interface	Enable Integration of New Technology
5	Do Not Impose on Current Workflow	Multiple Data Sources on One Interface
4	Provide Weather Conditions Update	Display METAR Reports

The House of Quality (HoQ) can be a powerful, efficient tool to generate and link customer and engineering requirements (Deal, n.d.). The HoQ aids in translating customer requirements, based on market research, benchmarking data, and stakeholder interviews, into an appropriate set of engineering targets to be met by a product design (Tapke, Muller, Johnson, & Sieck, n.d) and in determining how a product is living up to customer needs (Hut, P., 2008).

Once requirements were specified, the relationships between customers and engineering requirement were assessed in terms of whether the requirements help or hinder overall system performance and whether conflicts existed between certain requirements, seen in Figure 4.1. These conflicts, which may not have otherwise surfaced, were addressed and minimized. For example, the engineering requirement “Allow User to Select Information Display” conflicts with customer requirement “Low Technology Risk for Interface”; yet, when the eyePort team addressed this conflict it was determined that the benefits of the user selected interface outweigh the technology risks. Also, the HoQ identifies conflicts amongst engineering requirements. When a negative correlation surfaces within the HoQ, it indicates the original design may need reevaluation.

The HoQ supported the supposition that the customer and engineering requirements are able to work together to increase the SA of pilots. The importance of each engineering requirement is calculated by multiplying the relative importance by the relationship factor (strong positive (**O**) =5, positive (O) =3, negative (X) =-3). Columns are then summed to determine the overall importance of an engineering requirement. Engineering requirements with the greatest sums signal to engineers that requirement is extremely valuable to product success and customer satisfaction. For the eyePort, aerodrome design display and NOTAMS/ AMASS integration were determined to be the two most important engineering requirements. However, all engineering requirements for the eyePort have a relatively high weighted importance.



●	Strong + Relationship
O	Positive Relationship
X	Negative Relationship

Engineering Requirements / Customer Requirements	**Relative Importance (1-5)**	Display of Aerodrome Design	Allow User Select Information Display	Integrate NOTAMs/ AMASS	Display METAR Reports	Multiple Data Sources on One Interface	Enable Integration of New Technology
Keep Human in the System	5	O	●	O	O	●	O
Low Technology Risk for Interface	3	O	X	O	O		X
Update Ground Operations*	3	●		●		O	●
Notify of Change in Environment	4	●	O	O	●	O	O
Do Not Impose on Current Workflow	5	O	●	O	O		
Provides Weather Conditions Update	4		O		●	O	O
Weighted Importance		74	65	66	64	58	45

* Construction, closed runways, vehicles on the runway, wildlife, interference on the ground

Figure 4.1. House of Quality shows the relationship between customer and engineering requirements.

4.2 Functional Concept

4.2.1 Concepts of Operation (CONOPS)

EyePort works to satisfy two high level goals. The first is to improve the safety of ground operations, and second is to improve the efficiency of ground operations; both which can be results of increased SA. It treats taxiways, runways and other ground facilities as “resources” and looks for “resource contention” i.e. two entities trying to access the same resource in the same space/time, which represent a scheduling efficiency concern and potential safety issue. It uses cumulative probability based on system knowledge of possible trajectories and resource states to detect and alert users of potential conflicts and conveys the degree of uncertainty associated with that potential. It is informational, not decision automation, and relies on the proper actions of its users, as they would normally act, to provide the margin of safety.

While the principal users of the eyePort are pilots, ATC and ground operators are major beneficiaries. By providing an extra safety layer, ATC can maintain SA while moving control functions from aircraft to aircraft and have more attention to provide to managing the overall ground traffic. It can be especially useful in airports with mixes of commercial and general aviation, for the controllers to have immediate feedback of the intentions and knowledge of general aircraft intentions.

EyePort is designed to work in conjunction with the radio voice communication system and other control procedures already in place between pilots, ATC and other ground personnel. It does not impose on workflow of any operator, and its use is not mandatory, it merely reports on the states of instruments, aircraft and operators, according to the confidence associated with the data source. It will provide assistance and additional safety layers without including automation that requires a “lock step” adherence to a prescribed workflow. It does not impose new tasks on the pilots; it merely provides information they already have to search or request. Its strength is in sharing the information more quickly and conveying, at a glance, a sense of the uncertainty associated with the information.

4.2.1.1 eyePort Architecture

The interface of eyePort is composed of a set of FAA approved smart phone and GPS “apps,” collectively called the “client,” which resides on a smart phone or portable GPS type device. The initial fielding is on the Garmin G1000 and a Smartphone device, for those aircraft not so configured. Each client is capable of displaying a user selected subset of information regarding the state of an airfield’s taxi and runway layout and usage, ground and navigation equipment, track data from AMASS, ADS-B and/or eyePort enabled aircraft, surface weather and applicable NOTAMS affecting ground movement. Figure 4-2 displays connection of operations of the eyePort users.

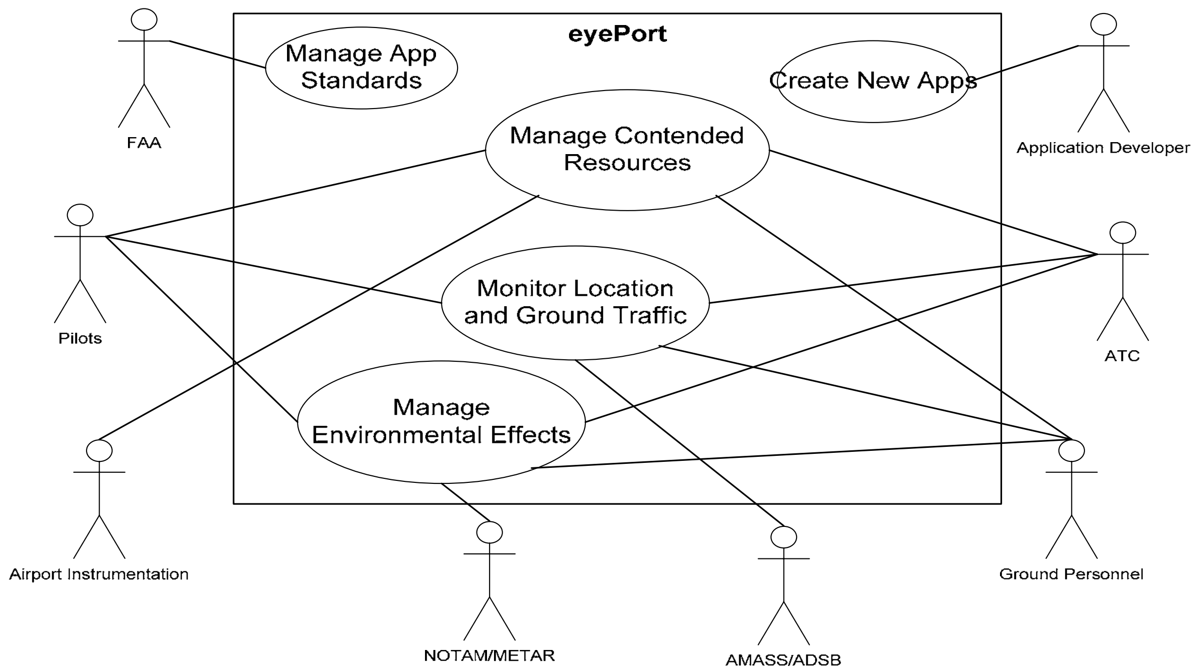


Figure 4-2. Operational use case diagram

The data requests from each client are transmitted to centrally located communications servers managing all system data in a “publication/subscription” type architecture, allowing for more efficient usage of network bandwidth. The servers create subscription lists for each client, and then publish the requested information, to be picked up by the client, through the communication networks provided by the device manufacturers and their CDMS providers.

The servers are connected to a set of application servers which manage data for a local geographic area (which may include the local airport as well as nearby non-towered facilities) to collect, evaluate and disambiguate inputs from existing data sources, NOTAMS, METARs, AMASS and a digital to analog conversion of airport instrumentation, such as the Instrument Landing System (ILS). These data are relayed from the application servers using the subscriber list of client devices connected to them via the communication server.

EyePort integrates incoming analog and digital data (inputs, pictures and alerts) into visual and audio information. There are four layers to the system, displayed in Figure 4-3: external systems, information servers, communication servers, and client components.

External Systems, in the far-left column of Figure 4-3, are sources of analog data from airport instrumentation control systems, such as airport lighting and the ILS, and digital data including: AMASS, METARs, and NOTAMS.

Application Servers, in the next column, convert both forms of data into eyePort-formatted communications/ transmissions as well as fuse data, received from the client. Users can input to the client status information, such as push-back, short-hold, taxi and transit status updates. Client hardware automatically updates eyePort aircraft position and orientation data determined via GPS; then, user identification data mapped to aircraft configuration data. User selections, such as map size and other preferences, display to the Communication Servers.

The Communication Servers, shown in the third column, determine the user’s data interests, such as user identification data and filter layers, based on active applications. From this, it maintains a subscriber list for each attached client. The data are mapped into four categories of user information; alerts, messages, overlays, and tracks, which are conveyed through messages back to the client. The next section describes the interfaces, displays and message content in detail.

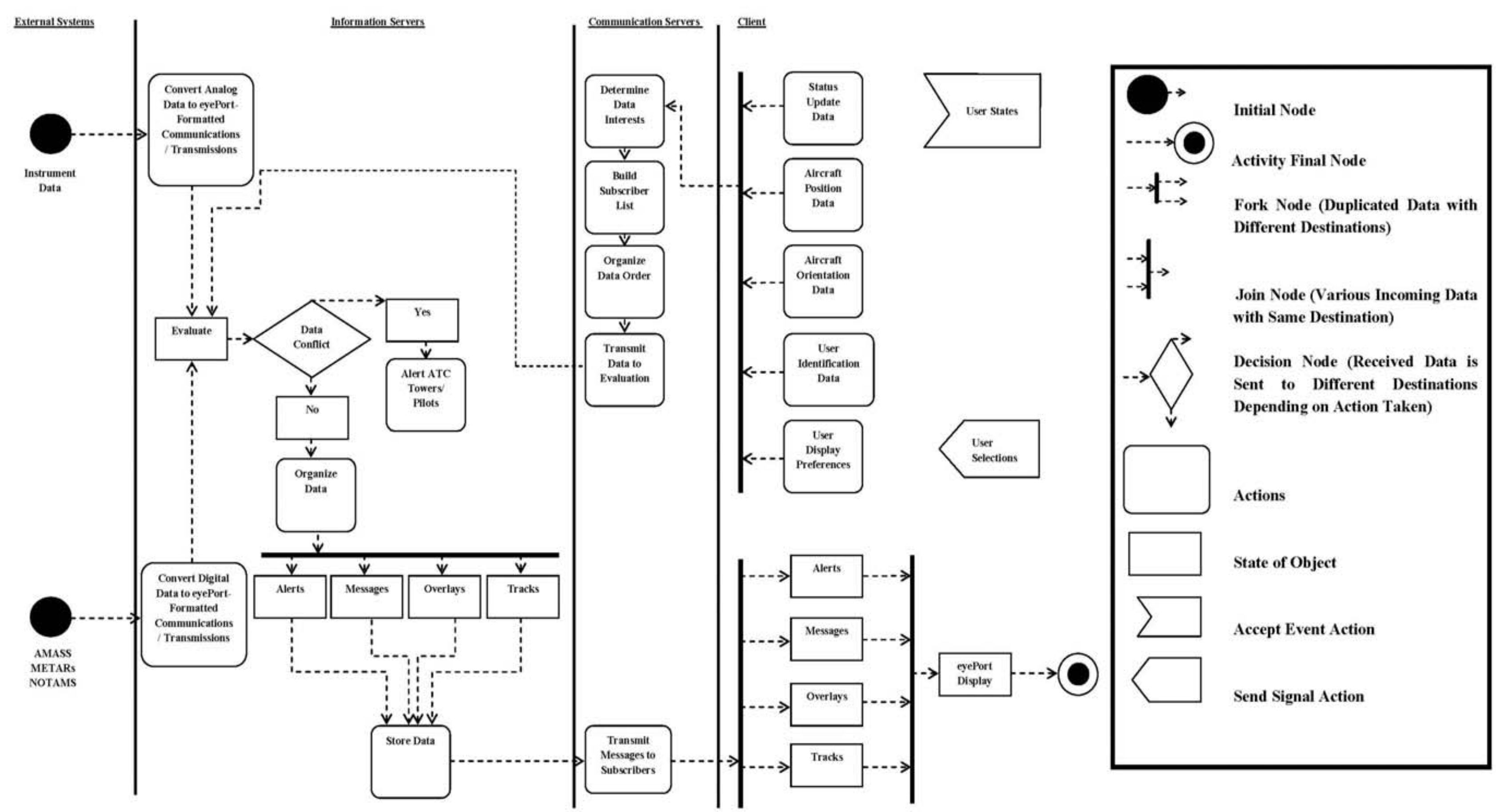


Figure 4.3. Activity diagram of eyePort display system. AMASS = Airport Movement Area Safety Systems; METARs = Meteorological Air Reports; NOTAMS = Notices to Airmen; ATC = air traffic control.

4.2.1.2 eyePort Applications

The ATC is provided a client device with ATC exclusive apps, so controllers can see, in the same format, what the pilots and other ground personnel see. The ATC app provides the capability to graphically enter requests for ground movement, adding to the data present in the system, providing additional opportunities for the system to detect conflicts, and improving the shared SA of other controllers, pilots and ground personnel. Other ground personnel, who require access to airport ground resources (taxiways, containment areas, runways, etc), may be equipped with an eyePort client to maintain their own SA and make reports on their intentions that can be relayed to the entire network of pilots, controllers and ground personnel. The operational overview is depicted in Figure 4-4.

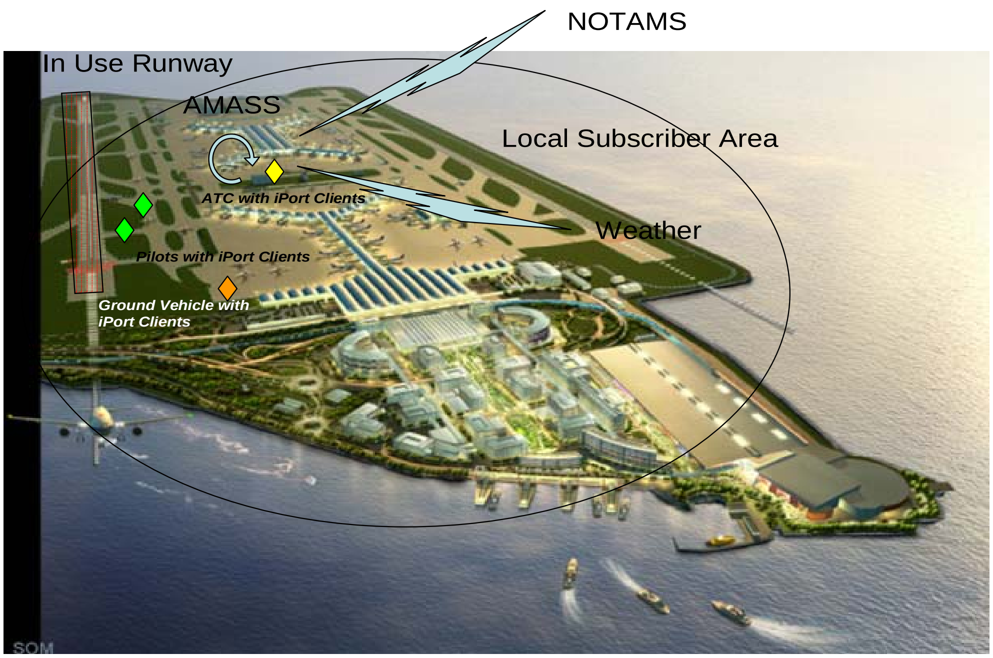


Figure 4-4. EyePort operational overview

Each app must be FAA registered and conform to the FAA managed data interface and toolkit standards. The public is capable of building and selling approved apps and making requests to modify the data interface, contingent on FAA approval, allowing a market driven system for users to suggest changes to data standards based on the continuous evolution of the aviation community. Apps that have been evaluated as dangerous can be delisted. Only FAA registered apps will handle data requests. The FAA maintains control for configuration management, human factors engineering and overall safety. They also offer significant benefit to the NextGen program as they use the data standard requests and app development approval requests as a rapid prototyping and evaluation "laboratory" for concepts that will ultimately get deployed in the NextGen system.

Users may purchase different apps depending on their needs. Active apps on a client will dictate the subscription list to the central servers. All client devices are registered, along with the authorize app types that users can access. Privileges tied to device ID are maintained and updated by the FAA to communication servers. App types also dictate the types of interactions the user may perform through the interface, as listed in Table 4-4. Additional configuration information (such as equipment type and designation) is entered when eyePort is started or retrieved from a list of previous configuration settings. This configuration and registration data is used to ensure that eyePort instruments are reported correctly throughout the system.

Table 4-4. User interface interactions by user type.

User Interaction	User Types
Clear a checkpoint	ATC
Schedule a route	ATC
Request a route	ATC, pilot, ground
Approve a route	ATC (master)
Post/ Retrieve a message (NOTAM, METAR, CHAT)	ATC, pilot, ground
Send general emergency alert	ATC, pilot, ground
Report a track (used to inform uninstrumented and undetected aircraft or vehicle)	ATC, pilot, ground
Report a airport control malfunction (light out, sign damage, etc)	ATC, pilot, ground
Clear malfunction, alert or track	ATC

4.2.1.3 eyePort Operations

EyePort includes doctrinal and human organizational components, plus hardware and software, that compose the machine solution operated daily by users and shaped by them over time (via new app submissions and requests). The relationships between the eyePort elements, including the external dependencies, are depicted in Figure 4-5.

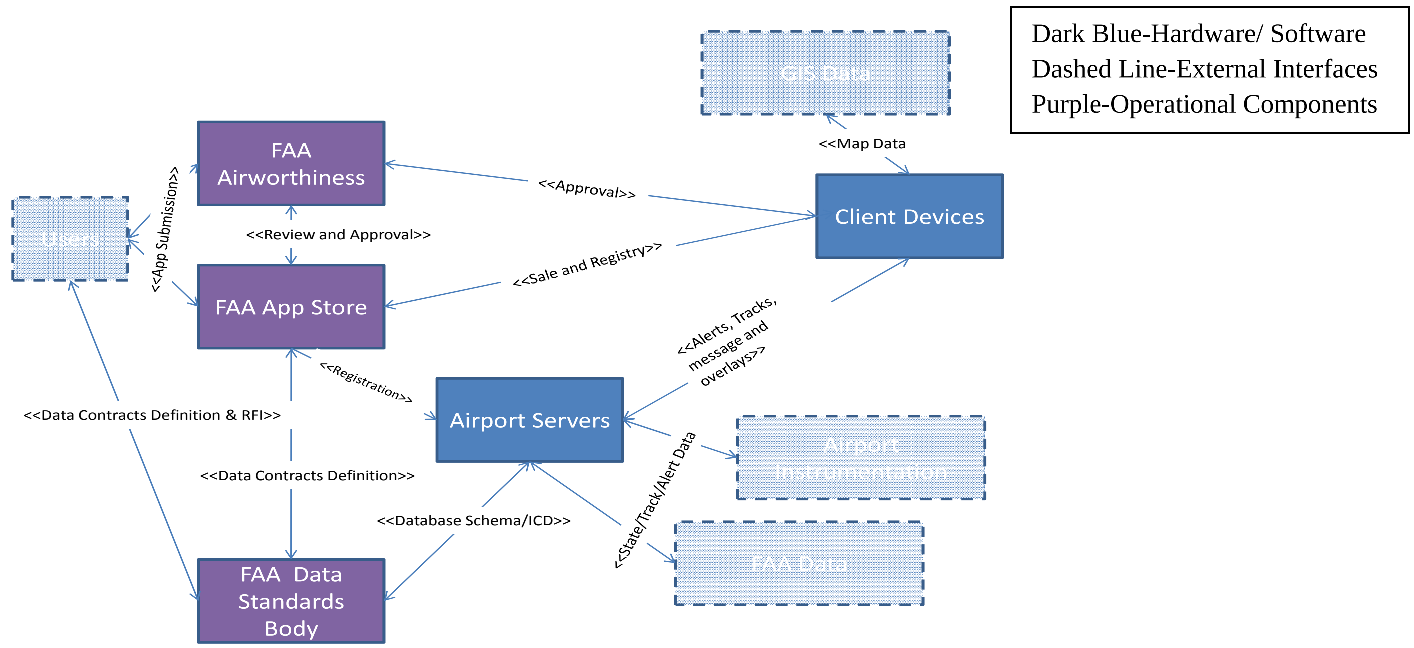


Figure 4-5. EyePort operational node connectivity diagram.
*GIS – Geospatial Information System, RFI – Request for Information

Digital data exchanged via the eyePort Interface Control Document (ICD) are rendered on the client as eyePort information is color coded to convey information specifying the level of attention it requires from the users. The colors are analogous to the colors used by The American National Standards Institute (ANSI) to convey safety related messages in the ANSI 535 Series. A summary of the color codes and their significance in the eyePort system are listed in Table 4-5.

Table 4-5. EyePort color coding

Color	Meaning	Description
Red	Danger	A system alert for a resource or state conflict detected by the system, or relayed by another system (such as AMASS)
Orange	Warning	A resource conflict is possible given the trajectory probability of entities accessing resources in given states
Yellow	Caution	A resource or entity is in an ambiguous state that requires additional alertness
Green	Information	Informational – entities and resources are in normal states which cannot present a conflict (they are too far away, or operating normally)

The eyePort exchanges data of several types defined in the ICD. The application server generates these data from the input/output data sources. Entity collision and resource contention are calculated according to a set of rules maintained within the server. Data are relayed through the communication servers to the clients. Raw data and rule results are compared against the "cognitive coding" in Tables 4-6—4-9. The number of information types is kept small to focus on the "high payoff" capabilities that came out of the stakeholder analysis process. General information types are presented in Table 4-6.

Table 4-6. EyePort output information types

Information Types	Description	Source Data
Tracks	Visual Cue with safety system color coding Provided with uncertainty envelope based on data source	Single prioritized report of ADSB, AMASS, eyePort or operator reported, (in that order of certainty) location and ID of other aircraft or units (such as maintenance vehicles) on the ground
Messages	A retrievable queue of messages indicating type, source, time and sender. Audio and Visual cue for pending messages	Weather, NOTAMs, tower communications from ATC client
Overlays	Color coded translucent shapes over geographic features to show danger, warning or caution areas	Weather, NOTAMS, ATC clients, Pilot clients, airport instrumentation (may include required clearance points as identified by ATC)
Alerts	Audio and Visual cue detecting reportable condition	Pilots, ATC, AMASS, eyePort app server
Icons	Visually coded shapes representing information of airport instrumentation – such as white or blue lights to indicate runway/taxiway instruments and on/off state – audio cue is available for state changes for user selected equipment type	Airport instrumentation (ILS, lights)

4.2.1.4 Display of Information Types

Alerts provide both visual and audio cues and are priority processed and communicated by the system, using quality of service routines available from the communications carrier. Alert types are summarized in Table 4-7.

Table 4-7. EyePort alert types

Alert	Description	Visual Cue
Runway active	eyePort user is approaching a runway which is considered in use (ILS or other runway request system indicates it in use). Also for emergency divert request from ATC app.	Blinking red overlay on runway
Collision possible	eyePort user has a constant bearing decreasing range (CBDR) trajectory to another entity, or to an airport obstruction located in the database	Threat entity or obstruction turns red – arrow points relative heading of threat
Missed checkpoint	A controller prescribed clearance point or hold short line has been crossed without being cleared by the tower or pilot	Red blinking checkpoint
Runway State mismatch	Aircraft is entering from a direction inconsistent with the runway alignment reported from aircraft light controls	Blinking red overlay on runway
Runway Incursion (class IV)	Aircraft has passed hold short line without being released	Blinking yellow overlay on runway- turns red after 10 seconds if not cleared
Environment	A pop-up adverse weather event other emergency intrusion (aircraft emergency, collision detected from another aircraft, animals on the runway , ground emergency reported by other user)	Blinking yellow polygon over affected area – blinks red if user is located in or travelling towards the area

EyePort's tracks and icons are coded and defined as listed in Table 4-8. The state behavior of each icon determines its color.

Table 4-8. EyePort icon and track types

ICON	Shape	Behavior
Runway Light	circle	White is on, Black interior means light is off
Taxiway Light	circle	Blue is on, Black interior means light is off
Tower Checkpoint	diamond	Green means pending, yellow means user is approaching, red means it was missed
Runway end usage light	circle	Green for approach, red for end – black if lights are off
Airport obstruction	cross	Yellow indicates obstruction. Red is user is in danger of collision
Aircraft Track	Aircraft shape (indicating GA or wide body)	Green if no danger, yellow if aircraft is scheduled to use same resources, orange if currently using same resource, red if collision alert is detected
Ground Operations Track	Truck shape	Green if no danger, yellow if vehicle is scheduled to use same resources as user, orange if currently using same resource, red if collision alert is detected

Lastly, the eyePort renders icons and overlays onto GPS referenced graphical database of the airfield. The database is downloaded and maintained locally on the client. Users can download the database definition at any time, even as part of preflight. Any updates will be verified immediately at startup and relayed to any devices registering their geographic interest through the communication server. Overlays are translucent polygons that are placed over features in the airfield database to convey that the feature is exhibiting a behavior that is of interest, and potentially of hazard to the particular user, shown in Figure 4-9. Not every user will see the same color coding, as the significance is dictated by the relationship of a particular user to the underlying data and preserved through the communication interest management.

Table 4-9. EyePort overlay types

Overlay	Description and Meaning
Runway in use	Red over Runway when requested or has a resource on it
Weather system active	Green if user not scheduled to enter rain, yellow if wind, red if thunderstorm or icing - mapped to METAR
Ground operations Resource request	Yellow if non standard (i.e. not taxiing) activity is using a resource but user is not scheduled for using a resource. Orange if user is scheduled or if a resource is temporarily unavailable (as for maintenance). Red if resource is engaged in emergency (crash, fire, medical, etc) –may be mapped to ATC message
Ordered Traffic route	Green route as planned by the tower for taxing aircraft (i.e. that pilot or ground personnel’s route) turns yellow if another is scheduled to use same resources. Orange if a checkpoint is missed, red if an alert is received,- may be mapped to ATC message
Non standard configuration	Yellow for temporary assignment of taxi as runway, long term runway closure – mapped to NOTAMS
Special check in procedures required	Green over tower if special reporting procedures are required – mapped to system message

4.3 System Concept

4.3.1 Human System Integration

Human-System Interaction (HSI) allows for human considerations to be taken into account when developing a human-centered, safe, and effective system, which, based on SME feedback, is especially vital to eyePort,. The human aspect encompasses all users affected by the system.

HSI challenges will be discussed in terms of how they were addressed by the eyePort team. In order to ensure safe and effective functionality of the eyePort interface, it is necessary that the device dos not add a significant amount of user workload. The main goal of the eyePort is to *assist* ATC and pilots with ground traffic movement, not increase the complexity of the workflow. One way to reduce the level of user workload is to minimize the number of significant states, which are system states that require user input and increased cognitive demand. Minimization of significant states can be achieved by decreasing task complexity and reducing the number of steps needed to achieve a desired output.

In order to rate the level of user workload, a Bedford Rating Scale, shown in Figure 4-6, was used to assign a workload rating based on an operator demand level. Although subjective, the demand level was matched to the Bedford criteria as accurately as possible through the input of SMEs. A maximum rating of 3 was selected as a goal to maintain safe operation of the airplane and out-of-window SA.

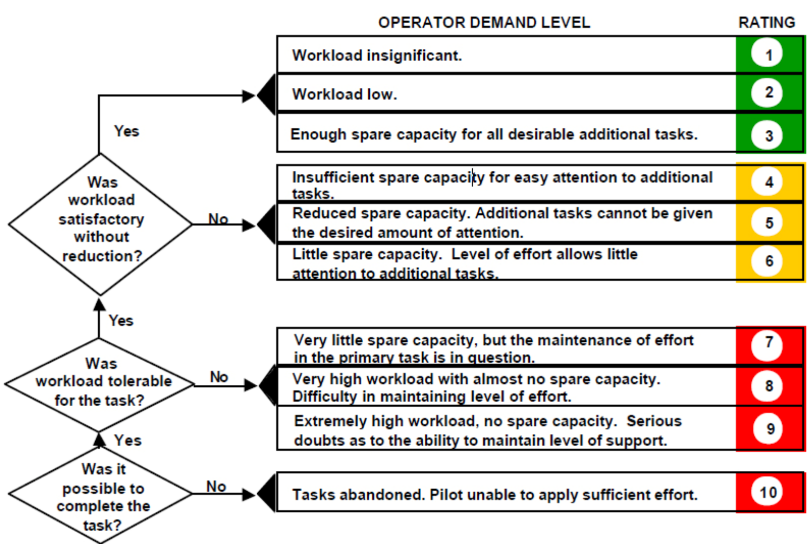


Figure 4-6. Bedford Rating Scale (Adapted from Roscoe, 1984)

Tables 4-10 and 4-11 display a high-level task analysis, conducted with the assistance of Embry-

Riddle pilots, to assess the levels of user workload, with and without eyePort assistance in two ground movement situations: take-off and landing.

Table 4-10. Take-off navigational procedure for unfamiliar airports

Steps	Take-off using standard navigation	SME Rating	Take-off navigation using eyePort	SME Rating
1	Check ATIS weather report (Radio)	2	Read ATIS report from eyePort	2
2	Contact ATC and request taxi clearance (Radio)	3	Contact ATC and request taxi clearance (Radio)	3
3	Receive Clearance (Radio)	1	Receive clearance visually on eyePort display	1
4	Contact Ground Control for taxi ways (Radio)	3	Contact Ground Control for taxi ways (Radio)	3
5	Receive runway and taxi way directions (Radio)	3	Receive taxi way directions visually on eyePort	2
6	Write down taxi way information on knee pad	6	Follow eyePort navigation	3
7	Check Airport Facility Directory for airport diagram	6	Proceed to hold short line	3
8	Proceed to hold short line	3	Receive visual and radio take-off clearance	1
9	Contact tower for take-off clearance (Radio)	3		
10	Receive take-off clearance (Radio)	1		
	Average Rating:	3.1	Average Rating:	2.25

Table 4-11. Landing navigational procedure for unfamiliar airports

Steps	Landing using standard navigation	SME Rating	Landing navigation using eyePort	SME Rating
1	Contact tower for landing clearance (Radio)	3	Contact tower for landing clearance (Radio)	3
2	Receive clearance (Radio)	1	Receive clearance (Radio)	1
3	Proceed to hold short line	3	Proceed to hold short line	3
4	Contact ground control for taxi ways to specified destination (Radio	3	Contact ground control for taxi ways to specified destination (Radio)	3
5	Receive taxi way directions (Radio)	3	Receive taxi way directions visually on eyePort	2
6	Write down directions on knee pad	6	Follow eyePort navigation to destination	3
7	Check Airport Facility Directory for airport diagram	6		
8	Navigate to destination	3		
	Average Rating:	3.5	Average Rating:	2.5

According to the task analyses, the two tasks, when conducted using eyePort are within the 1-3 operator demand level on the Bedford Scale and improves over the current standard navigation methods in terms of workload and efficiency. The average demand level was estimated at 2.25 for take-off navigation using an eyePort unit versus 3.1 using standard methods. The demand level for landing navigation was also lower with use of the eyePort at 2.5 versus 3.5. In both tasks, demand level was assessed as high as ‘6’ without eyePort versus as high as ‘3’ with eyePort

One of the main eyePort features, which aids in the reduction of user workload and improvement of SA, is the visual representation of airport diagrams and taxi way directions. Under unfamiliar conditions a pilot would have to pull out a printed airport diagram usually found in the Airport Facility Directory. Careful analysis of the diagram is required to identify current location and specified taxi ways. The eyePort automatically locates the map from an internal database and loads it according to position and ground proximity. Step by step directions to the specified airport destination are provided with the ability to view ATC taxiway directions in a written format for future reference.

4.3.1.1 Training

Training for proper operation of the eyePort should be minimal and low-cost. A benefit of the device is that it can be incorporated into standard training simulators. Instructors can load the current simulated ground traffic data into the device and operate it as they would in real situations. Warnings, taxi directions, map diagrams, and other features of the eyePort could be utilized during a training session. Also, due to the simple nature of the user interface, the eyePort will not require a significant learning curve. A pilot unfamiliar with the system can always rely on the standard navigation methods as the eyePort does not interfere with normal operational procedures; it only adds redundancy to the safety aspect of ground navigation.

4.3.1.2 User Interface

In order to adhere to FAA regulations and to provide an optimal visual display field, the eyePort software module can be implemented into a certified third party in-dash GPS device. Because ground navigation is not an immediate need when the airplane is off the ground, the eyePort will only be actively displayed once the ground proximity sensors detect an airplane is at or approaching ground level. During flight, eyePort will display standard operation data.

To illustrate the eyePort interface, a model was created and fitted into a Garmin G1000 device as depicted in Figure 4-7. Figure 4-7 shows the designated taxi way, which is highlighted for easy path visualization. ATC directions are displayed at the top left corner. Runway short stop lines display a flashing red alert circle indicating that the pilot does not have clearance to cross. Once authorized by ATC, the circle changes to green. A data screen will display other relevant information such as NOTAMS and past ATC taxi way directions.

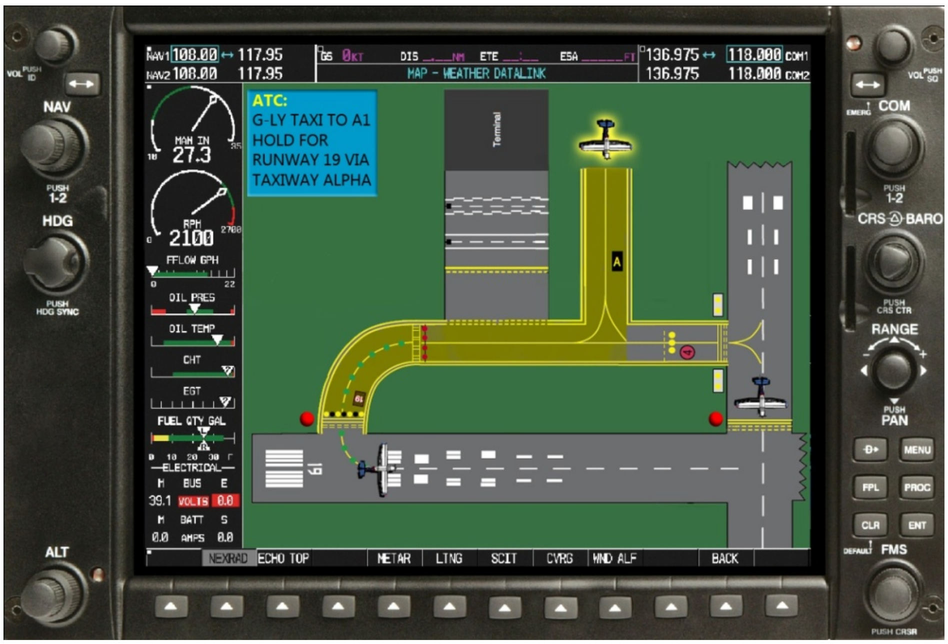


Figure 4-7. EyePort interface model (Adapted from G1000, 2010 and U.S. Department of Transportation, 2008)

The eyePort provides innovative visual display capabilities that greatly enhance SA. It relays information about the critical ground operation components and organizes them in a comprehensive and easy to understand manner.

4.3.2. Safety and Risk Management

The safety and risk management aspects of the eyePort were designed to follow the guidelines in the FAA Safety Management System (SMS) manual (FAA, 2008), with the goal of making the system more tolerant to error. This is done through the implementation of multiple safety layers which are redundant to each other. This greatly increases the likelihood that if one barrier fails, another will be able to detect a hazardous situation.

The eyePort adds to standard methods of ground navigation. The amount of variability in navigational situations at airports is enormous and ample testing will be required. One of the advantages is that the system does not eliminate any of the current navigation methods, it simply provides another alternative.

After developing clear CONOPs for the eyePort, hazard identification techniques were used to locate possible faults within the system. SMEs discussed situations that could pose risks, and the eyePort team held "what-if" brainstorming sessions. Due to the complexity of the system and the variability of the environment, the main hazards identified were placed into three main categories: technology malfunctions, pilot error, and controller error, which are displayed in Tables 4-12, 4-13, and 4-14 respectively.

Table 4-12. Potential technology malfunctions

Hazard	Severity	Likelihood	Mitigations	Adjusted Severity
Total system failure resulting in system shut-down	Minimal	Extremely Remote	The effect on ground navigation would be negligible. Because the eyePort simply enhances current navigation methods, the pilots would only have to revert to standard radio communication and airport diagrams.	Minimal
Display error of false visual clearance due to software glitches	Major	Extremely Improbable	All runway clearances must given both visually AND through radio communication. Pilots should be trained to react once they have received both confirmations. If only one is received, the pilot should contact ATC for clarification.	Minor

Table 4-13. Potential controller error

Hazard	Severity	Likelihood	Mitigations	Adjusted Severity
Controller who grants a pilot clearance for a runway already in use	Catastrophic	Extremely Improbable	If a controller authorized an aircraft into an active runway, eyePort would automatically detect that the runway is in use by another aircraft. Before displaying the clearance, eyePort would notify the pilot of the conflict. The pilot would then contact ATC and ask to confirm the clearance.	Minimal

Table 4-14. Potential pilot error

Hazard	Severity	Likelihood	Mitigations	Adjusted Severity
Pilot loses situational awareness and takes a turn into the wrong taxi way	Major	Extremely Remote	EyePort would detect a deviation from the established route and display a clear visual warning sign alerting the pilot. ATC would also receive an alert on the pilot deviation. At this point the pilot should be notified by both the eyePort and ATC to return back to the established taxi way.	Minimal
A pilot tries to cross a runway hold short line without clearance	Catastrophic	Extremely Improbable	EyePort would detect unauthorized movement into an active runway. Immediately the pilot would see a “STOP” warning sign on the screen and receive a short yet loud auditory alert. ATC would also receive a warning indicating the violation, allowing him to quickly contact the pilot. The airplane authorized to use the runway at the time, if equipped with an eyePort device, would receive a warning indicating that the runway has been compromised.	Major

The strength of eyePort relies on the distribution of data and the increased level of pilot SA. Because the eyePort is integrating all the ground operations information, the user is able to evaluate ground traffic more effectively. Although absolute safety is unattainable, the risk analysis shows that the eyePort has sufficient safety barriers, which minimize the occurrence of an RI under multiple situations.

4.3.3 Scenarios

4.3.3.1 Scenario1: Updated Airport Diagrams

Through SME interviews, the eyePort team realized that continually updated airport diagrams, especially during construction, are unavailable in a consolidated form. Figure 4-8 shows how the eyePort consolidates NOTAMS into airport diagrams, so pilot and ground operators may refer to an up-to-date, comprehensive, and visual display of the airport's current condition. As shown, users are able to see the closed portion of the runway because the eyePort can incorporate airport modifications into the visual display. Any taxiing pilot or ground operator can distinguish which parts of the airport have been closed.

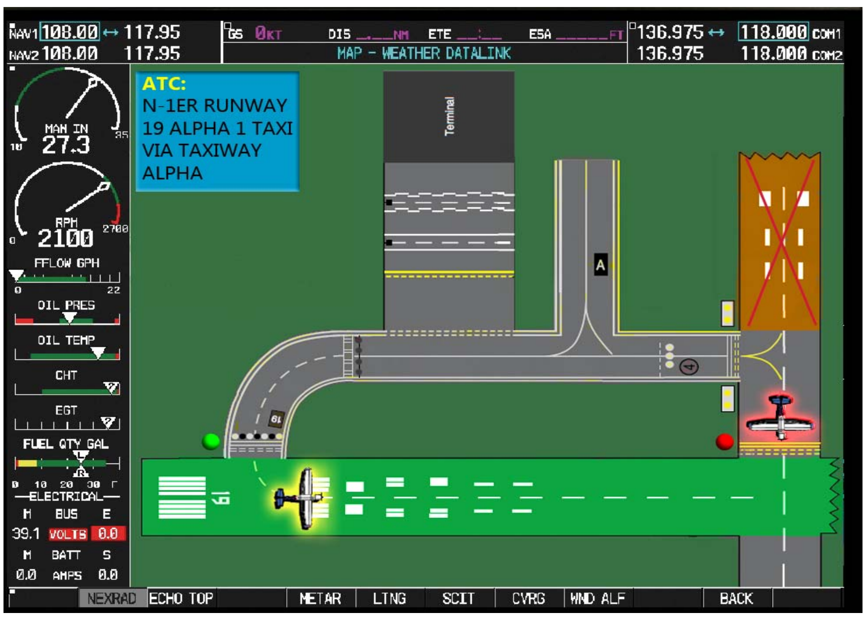


Figure 4-8. EyePort displaying closed runway section and runway clearance

4.3.3.2 Scenario 2: Lost Aircraft

SMEs discussed several past RIs caused by loss of SA of the pilot and air traffic controller. Figure 4-8 shows how the eyePort would use GPS coordinates of airplanes placed on airport diagrams to show an up to date location of all aircrafts and personal on the airport grounds. In this particular scenario, the ability of the eyePort to target specific planes on the runway enables the user (in yellow) to see a potential hazard (the red plane). If a plane were lost, it could target itself (making it appear red on the general eyePort display) so that any traffic at the airport could be notified of its current location and any risks the lost plane may cause to other plane's safety. Here, the user (in yellow) knows to take caution on takeoff because there is a lost plane at the active runway intersection. For the user that has lost SA due to low visibility or unfamiliarity with the airport, the eyePort reorients the user via continuous updates of aircraft positions, resource availability, and airport control states in context.

4.4 Financial Analysis

Cost is a key factor in every product's development. EyePort has some initial developmental costs, but only in updating existing systems to interact and become comparable with eyePort. The systems utilized all already transmit data, which is already being received by other devices. The aim of eyePort is to meld all those data sources into one device. This melding of data will require new software, which will be the largest single cost. Another bonus of eyePort is the cost of development is placed solely on the company developing it. Therefore, the cost of development will result in a slight increase in unit cost for the device (Garmin G1000 or smartphone) that utilizes this new software. As this analysis shows, the benefits of eyePort will drive a desire to have this software. This increased demand will lead to increased sales of the devices that are equipped with it, leading to profit for the developing company.

The Garmin G1000 cost is incorporated into the price of the aircraft, so the cost of eyePort will be extended to the user. In order to justify the increased cost, a hypothetical scenario was created based on eyePort's use in a Boeing 747 wide body airliner. These jets cost anywhere from $234 million to $308 million depending on chosen specifications ("Jet Prices," 2008.). The increased unit cost of the GPS would be minimal in a purchase of this size. The eyePort team has claimed that the device will increase SA and ground efficiency. Pilots will be able to navigate airports quicker, with less confusion, by utilizing eyePort. If this increased efficiency leads to one more Boeing747 taking off per week, across an entire airline, the increased profit for that airline will quickly cover the initial cost of this updated system. In 2007, the average net profit per passenger was roughly $82.10 ("Factbox: fuel eats," 2008). A Boeing 747 set can accommodate 524 passengers ("747 technical characteristics," 2010), making the net profit of a fully loaded Boeing 747 roughly $43,000. At a potential net gain of $43,000 per week, the yearly profit increase is roughly $2.23 million. In other words, if a single airline gains a one-flight increase with the assistance of eyePort, they will have more than justified the cost of eyePort.

Other costs for eyePort include the hardware such as Industrial Organization buses and server networks to handle the influx of data. It is estimated that these networks will cost roughly $80,000. This would be paid for by the airport that wishes to be eyePort capable. If an airline gains a $2.23 million profit by flying into eyePort capable airports, it would allow the airport to better sell itself. By providing this system, airlines will want to fly into these equipped airports; this increased desire translates to new business and revenue for the airport. The $80,000 dollar cost of hardware would quickly be recovered.

The cost to General Aviation (GA) pilots is minimal. Eventually, the eyePort team hopes to port our system to GPS capable Smartphone. Smart phones capable of using eyePort cost roughly $200. This cheaper option would be for pilots that cannot afford the new eyePort ready Garmin G1000 GPS. For GA pilots purchasing new planes with glass cockpit systems, eyePort would be included in the price. Another cost to GA pilots would be the installation of an ADS-B transponder. These transponders can cost several thousand dollars. EyePort can use the phone as transponder, whose signal is only received by other eyePort devices, so the ADS-B transponder is not mandatory for eyePort to function. However, the FAA will mandate these transponders in the future, so this is not an eyePort specific cost. GA also stands to gain by using this system. For GA the profit is found in their safety. As eyePort is used more frequently, there will likely be a reduction in RIs. On airports with GA and commercial airliners, eyePort could increase the commercial airliners SA of the GA pilots' positions and movements. By increasing users' SA, RIs will be reduced. By increasing the safety and efficiency of GA pilots, the low cost of a $200 Smartphone will be justified.

Once the benefits for pilots and airlines has been demonstrated, the air traffic controllers, pilots, and ground operators may pressure the FAA to mandate airports with eyePort; in that case the FAA may pay for extending the system and cover the cost of upgrades and maintenance to the airports.

5.0 Future Impact

EyePort will assist the user by providing a means to collect, store, and reference critical information during flight operations, minimizing voice communication and hardcopy references. EyePort may modify the workload of a pilot or ATC, but not to the point it will disrupt or slow down flight operations. On the contrary, it will increase safety during flight operations by giving the user additional SA, especially during heightened periods of operation.

There are valid questions about the potential impact eyePort will have on general and commercial aviation. In multiple discussions with SMEs, concerns arose about the introduction of an interactive situational tool. Would there be an increase in workload of a pilot or air traffic controller? Will this merely add onto existing systems or replace specific systems over time? Are we reducing the workload for ATC so much it starts to eliminate jobs? Initially it will be an extra system to implement, but with the potential to be a stand-alone system that incorporates today's systems and provides pilots and ATC a consolidated reference for real time data. Also, it adds an additional safety layer. EyePort reduces the workload of ATC, but not to the point of reducing human interaction with pilots. On the contrary, we will be providing ATC the means to manage more aircraft on the ground and in the air by providing them with a means to constantly monitor aircraft operations under their control and make needed adjustments with the help of the application decision model.

5.1 eyePort Benefits

Airports are busy, and with general and commercial aviation increasing every year, it was inevitable that a situational tool would arise to assist pilots and air traffic controllers with increasing demands. EyePort is merely taking existing technology, software and hardware, and incorporating it into a more useful, condensed tool that can be referenced during flight operations. More specifically, it will allow ATC, pilots, and ground operators to view the information communicated over the radio for approach, take-offs, traversing controlled airspace, and taxiing with the added abilities to provide information to other aircraft within the immediate vicinity and to provide a graphical representation of the aforementioned scenarios. Additionally, it will provide ATC with the added awareness of weather that could affect airport operations and will provide options to successfully navigate aircraft to their desired destinations or provide ATC with corrective actions to communicate to pilots prior to take-offs, landings, and taxiing. Finally, it will incorporate the existing NOTAMs and AMASS systems and communicate to users the real time data about the current situation at desired airports, advisories, and graphical layout of a desired airport with pertinent NOTAMs due to construction, accidents, or runway closures.

5.2 eyePort Growth Potential

As this product becomes a staple in flight operations, it will grow to include ATC, pilots, and airport operations. Personnel such as those in emergency services will be provided real time data to safely negotiate ongoing flight operations with no loss to response time. Wildlife Management will be able to depict graphically where certain species of birds and other potential flight hazard animals congregate and access the systems to disperse them safely and ecologically. The system will be able to provide airport maintenance with graphical locations and descriptions via text of runway hazards or runway lighting requiring maintenance or replacement.

5.3 eyePort Marketability

History has shown that as aviation has increased, more technology and tools have been required to assist pilots, ATC, and ground operators. When pilots wanted to fly at night, there was a need for runway and navigational lights, as was started in 1920's. From there, aviation needed to communicate with those on the ground and in the air, and by the late 1930's we were including voice communications in flight operations. By the 1960's we started incorporating satellite technology to provide real time data on an aircraft's exact position and communicating the information to controllers on the ground to increase safety and awareness. As seen with the growth of general and commercial aviation, there has always been a need for technology to contribute to the safety and awareness needed to navigate short or long distances, allowing pilots to freely roam the skies with ease. The eyePort will only increase that technology development, as well as provide a more convenient means to safely navigate on the ground, in the sky, and avoid potential hazards. Technology developers already have the means to produce an application and distribute it based on the current technologies such as GPS, smart phone applications, and the standard computer technology that is used today. In the long run, this system looks to further develop the ease and enjoyment associated with air travel and recreation.

6.0 Conclusions

EyePort provides real time information to pilots, controllers and other ground personnel for conducting flight operations in and around airports. EyePort will be able to present to users, current status information for runways, taxiways and airports instrumentation, as modified by active weather and NOTAM messages. This information is overlaid with track status information as relayed through the ADS-B, AMASS, or other eyePort devices. EyePort will allow the pilot to receive or request instruction from ATC, have it stored for future reference, and displayed graphically in context when applicable. During the eyePort design process, multiple subject matter experts stated that retaining and recalling taxiing and layout information at unfamiliar or busy airports proved to be difficult and potentially dangerous. Additionally, message passing for state updates, clarification and getting up to date weather and NOTAMS was a significant source of ATC workload, detracting from their ability to plan and supervise safe, efficient ground movement. By eliminating some of this communication workload, and providing access to this information, in context, and in real time to all interested users, it facilitates increased safety and efficiency of ground movement by allowing controllers to focus on those tasks. EyePort is designed to be modular and extensible, allowing the integration of newer “apps”, displays and interfaces, as the need or value of them becomes apparent. The display formats, information coding and access rights for eyePort users are maintained centrally by the FAA and handled automatically as part of the communication process – ensuring that the FAA has control over the whole system as it matures – but enabling it to expand rapidly in response to demand. It provides a market driven solution for enabling a rapid capability to enhance ground movement safety and efficiency, while providing feedback to the FAA for integration into the overall NextGen vision.

Appendix A- Contact Information

A-1 Faculty Advisors

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Appendix B-Description of University

The Embry-Riddle Aeronautical University homepage presents a description of ERAU (http://www.erau.edu/about/story.html).

Embry-Riddle Aeronautical University prides itself in the world's source for innovation and excellence in aerospace education and applied research.

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

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. The following spring the company opened the Embry-Riddle School of Aviation.

At Embry-Riddle, our mission is to teach the science, practice and business of aviation and aerospace, preparing students for productive careers and leadership roles in service around the world.

Our technologically enriched, student-centered environment emphasizes learning through collaboration and teamwork, concern for ethical and responsible behavior, cultivation of analytical and management abilities, and a focus on the development of the professional skills needed for participation in a global community. We believe a vibrant future for aviation and aerospace rests in the success of our students. Toward this end, Embry-Riddle is committed to providing a climate that facilitates the highest standards of academic achievement and knowledge discovery, in an interpersonal environment that supports the unique needs of each individual. Embry-Riddle Aeronautical University is the world's leader in aviation and aerospace education. The University is an independent, non-profit, culturally diverse institution providing quality education and research in aviation, aerospace, engineering and related fields leading to associate's, baccalaureate's, master's and doctoral degrees.

Though it began as a school for pilots and aircraft mechanics, the University now offers more than 30 undergraduate and graduate degrees and provides the ideal environment for learning. It combines an impressive faculty with state-of-the-art buildings, laboratories, classrooms, and a diverse student population. Embry-Riddle enrolls more than 34,000 students annually. Undergraduate enrollment for the fall term is more than 4,450 at the Daytona Beach campus and more than 1,600 at the Prescott campus. Additionally, more than 550 graduate students are enrolled at the Daytona Beach and Prescott campuses during the fall term. The programs of the Worldwide Campus enroll almost 20,000 undergraduates annually, while Worldwide graduate enrollment is more than 6,800. Embry-Riddle's students represent all 50 states and 98 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 C- Description of Non-University Partners

Not applicable.

Appendix E-Team Reflections

Dr. Kelly Neville- Faculty Advisor

Not only did the eyePort team face the basic competition challenges of learning new domains and solving problems they did not initially understand; they also took on the challenge of designing a sophisticated solution with extensive implications for almost all aspects of airport operations. The level of difficulty meant that even the most experienced team members were in some way challenged but it also meant that the less experienced members were especially challenged. They faced the challenge, and, impressively, held themselves to high standards while doing so.

The more experienced team members made themselves available to both assist and encourage the less experienced team members with their responsibilities. In the end, every member of the eyePort team had a firm grasp of the technical details of the design, every team member was able to conduct the appropriately sophisticated analyses, and every team member shared in the sense of ownership. Throughout the semester, I was continuously impressed with the work produced by this team, including its youngest members. I credit their accomplishments to both the generosity and patience of the more experienced team members and to the hard work every team member put into both understanding and designing all that was involved in this complex solution.

Early on, this team faced the challenge of discarding a chosen idea and restarting. This extended the already time-consuming domain and problem research, but the team took on the challenge with open arms. They simply reworked their plan of action and dug back into their research. Later, they became concerned about similarity with an existing technology development effort. To their great credit, the team sought out this information about possible competing solutions, proactively strategized on how to adjust their solution, and went back to work. Discoveries that impact design work after it is well under way are a common problem in real world systems development. Experiencing these sorts of discoveries during their project work made this competition even more of a valuable learning experience for the eyePort team.

We were all grateful to find that subject matter experts were so willing to share their time and knowledge with this team. The manager at Daytona Beach International Airport, for example, was extremely generous with his time when approached by my students. He and some of his staff allowed members of the eyePort team to interview them, and they additionally visited our classroom. He said payback would be the development of future aviation professionals, and I think many of the students now have a much deeper understanding of ways in which they can one day contribute.

The thought of producing a 40-page document is incredibly intimidating for students. In her reflections, team member Maggie Hart wrote, “ I was terrified…and stayed that way until I finished…and realized I had gained a lot...”. But the team actually ended up producing a document that was much longer than 40 pages and discovered the unexpected challenge of whittling it down. Once a team of students does something like this—produces a 50- to 60-page design document that needs to be whittled down *and* produces a meaningful data-based design that could make a real-world difference, I believe they are never the same.

Daniel Antolos

Utilizing the FAA design competition as a class project was very beneficial. I feel it is not often students at Embry-Riddle Aeronautical University; specifically Human Factors students get to participate in National Events such as this. On the flipside I like having the opportunity to be involved or contribute to the FAA and help develop tomorrow's aviation world. It is very satisfying to know you will have some form of impact upon aviation in the future, moreover knowing you may contribute to a company in the same respects to project research and design. Being a military officer, I have not been able to be involved with the realm of Human Factors as much as I would like have over the past eight years. To have the opportunity to be focused on a system design project that would allow me to apply my undergraduate as well as my experience in the military to a focused solution was well worth it. On the other side of the coin it was interesting to work with others that came from all walks of life. Sharing knowledge and understanding others viewpoints and contributions has been a very educational experience. Overall this was a good experience as well as real glimpse into the world of systems design. Even though this was a small scale project, I grasped a huge understanding to how long, detailed, and correct the system design process needs to be in order to meet the stakeholders' expectations. This experience will definitely benefit me in the future after I progress from the US Army.

William Dructor

At day one of group eyePort, I knew only common knowledge details of aircraft, airports, and airport operations. Three months later I can now say I feel confident in my understanding of operations, and procedures on an advanced novice level. Also, it was a great experience working on a team of fellow human factors believers. Working with a team sharing the same goals and deadlines was valuable in retrospect as it is noticeable that some emerge as leaders, social loafers, and everywhere in between. Although we strived for a team which delegated equality, situational roles inevitably developed. This is seemingly unavoidable, however, all members still worked diligently on individual portions outside of group meetings.

Challenge 1 was selecting a topic. Challenge 2 was that the competition picked the same topic. We chose a new one, and we stuck with our new found topic which appeared to appeal more to our team. Challenge three was when we found similar emerging technology due to develop in 2025. Since the production date was still 15 years away and slightly more complex than our idea we choose to claim foundation and prototype to the similar technology. This approach seems justified because it is different enough yet where there is room for overlap it is also likely to provide guidance for a better design in the future.

Industry participation was extremely beneficial. Several Daytona Beach aircrew members came to class and prepared slideshows, lectures, and presentations which provoked Q and A along with excellent discussion. They were extremely generous with their time spent assisting our development process and, for me at least (I knew practically nothing), extremely informative. Receiving information 1st hand rather than research, I find to be more beneficial because experience always surpasses even the best of research.

This process is auspicious in workforce preparation. I gained a greater understanding of writing flow directed towards product proposal, design, and development. Also, working in a large group, I was exposed to many different qualities and personalities which were all assets to the team in their own way. Fitting in and finding my role in the group proved to be beneficial, as roles will change and develop from group to group and within the same ever-evolving group (situational roles).

Augusto Espinosa

The project was a great learning experience. Although it seemed overwhelming at first, it was task which we tackled with great effectiveness. I gained a ton of knowledge in my respective sections, specifically Human System Interaction and Safety Risk Management. It helped me see the “big picture” as far as learning how all the components of a system work together to accomplish a main goal.

As a team, we encountered numerous challenges. We went through different system designs before settling with our current concept. We started with what we thought was a good solid idea but a few weeks into the project we discovered limitations which sent us back to drawing board. It was a bit frustrating knowing that we had wasted so much time on a failed design but we picked up quickly with a new and better idea.

Before coming up with a hypothesis, we needed to determine what were the root causes of the problem at hand? What were the human considerations we need to take into account? A lot of research and brainstorming went into the preliminary design and once we felt that we were addressing the main issues, we came up with a hypothesis that brought everything together.

Participation from members in the industry was crucial to the development of our system. The advice and information provided by SMEs helped us come up with the requirements and functions of the eyePort. Furthermore we learned about airport operations from Air Traffic Controllers and also about new technologies which we could integrate into our system.

I was fortunate enough to have a group composed of highly experienced individuals. I think that we all learned from each other. The more knowledgeable members did a great job at explaining and teaching different concepts from systems engineering and how they applied to real life situations. This competition did a great job at simulating what a project in the workplace might be like. It was also a great way to add project experience to my resume.

Jolie Gascon

The FAA Design Competition absolutely provided a meaningful, learning experience for me. I was introduced to and gained valuable insight, knowledge and exposure to Concept of Operations (CONOPS), House of Qualities (HoQ), Use Case and Activity Diagrams, among the many other aspects involved in designing a proposal. I had not heard of these concepts before, and certainly did not know what each aspect entailed.

Our first bump in our project began in its early stages. Essentially, another group had our exact idea. Instead of moping about this event or figuring out who conceived the idea first to claim ownership of the idea, our group relinquished the idea to the other group and moved on to brainstorming another brilliant idea.

I would say another ‘bump’ was one that would occasionally crop up at any given time during the project’s process. This is the feeling of inadequacy, of not knowing how to execute an assigned role, since most of us were completely new to all of these concepts involved in the design competition. However, we all pooled together and supported one another. Support showed itself in both project role assistance and in words of encouragement which is reflective of good team spirit.

A third and major challenge, was the discovery that essentially our project is already in the works via NextGen. Automatic Dependent Surveillance Broadcast (ADS-B) is a NextGen development that encompasses all that our eyePort achieves to do. I discovered this from a telephone interview with one of my SMEs. To bounce back from this unexpected news we continued with our eyePort idea, but this time, to enable it to be used as a way of introducing ADSB in a way that is complimentary to it while incorporating safety and reducing runway incursions.

SMEs from the Daytona Beach Airport and the FAA were all very willing to avail themselves to us, visit, and agree to meeting times for various forms of interview (phone, in person, email). Each gave thoughtful advice, constructive criticism and encouragement.

I am sure learning how to use Activity and Use Case diagrams appropriately and familiarizing myself with processes such as House of Quality and stakeholder analysis will certainly add value to the assets I bring with me to the workforce.

Abigail Gaston

This project was a great learning experience. Not only did I learn about runway incursions, systems engineering methodologies, FAA safety, and existing technologies, but I also learned a great deal about team cohesiveness. When the project first began, the team of 8 discussed a wide variety of ideas before we settled on eyePort. Settling on a design idea was quite daunting because I had never before researched runway incursions or knew what technologies existed. Yet, through extensive research and contact with SMEs, the concept of eyePort seemed to be a great additional to improve safety measures across the aviation community.

While writing my report contribution and reading my teammates' contributions, I was able to get a large grasp of what systems engineering encompasses and how to utilize the multitude of methods. I had one previous project regarding systems engineering, but it did not go into near as much depth as this project was to go.

Our team came from a very diverse experience and backgrounds, which was very beneficial. Those with more experience were able to assist those with little to no experience, while at the same time, those with less experience brought fresh ideas and perspectives to the table. Also, each person had their specialties and brought something new to the table.

Overall, this was a great opportunity, and I look forward to my future in systems engineering.

Jerry Gordon

I have been a professional engineer for almost 20 years, and a systems engineer for over half. The basic design elements are fairly well known to me, However, it is always educational to have a proposal problem to practice my writing and organizational skills. Our team also had the largest number of undergraduates, so I had a lot of opportunities to provide training and mentoring. I also find it interesting that the younger crew was able to quickly understand and contribute to what was a reasonably complex system, as “digital natives” they have an instinctive appreciation for both automation and complex adaptive systems based on social networks.

Initially we had a different approach based on the initial readings of runway incursion reports we did for class. We immediately found out that another team had a very similar proposal and decided to change. About halfway through, we received some critical feedback that NextGen “was already doing this”, so we decided to look more closely at how the NextGen (ADSB) solution interfaced with ours, and decided that we could easily retool the approach slightly to be completely complementary, instead of suggesting competition with, the NextGen plans.

Viewing the “design as hypothesis” we started with trying to precisely define the problem statement. Initially we drew the box “very large” trying to understand the whole ground movement and safety problem. As we discovered more about technology currently in work or available, as well as the true nature of the problems through our interviews, we were able to narrow down our focus. The design evolved from examinations of existing technology elements as our overarching philosophy was “low technical risk, buy and integrate - not make, and speed to market.”

Participation with industry was absolutely essential. In several cases, it confirmed our hunches, but in some cases alerted us to very unintuitive problems, such as animal incursions other than bird strikes. In each case of the three major interview sessions we conducted at different points, we received critical information, got enthusiastic support for our approach and were able to validate or refine our design.

To me, the most value was in the exercise of having to map some “high level” concepts regarding “joint cognitive systems”, functional allocation and information (Shannon) theoretic approaches to understanding system data transformations to human information. This occurred specifically in the writing of the CONOPS section. This is all useful for helping me to frame my thesis topic.

Joshua Hagar

The FAA design project was the first real taste of team work I have experienced in my Graduate education. I have a B.A.in Psychology which did not prepare me for group work of this caliber. I recognized coming into this project that this was going to be a taste of what a future in human factors and systems engineering would hold. It was a great experience to be a part of a team that was well informed and highly motivated. It was exciting to be a part of a team that had diverse backgrounds, levels of experience, and unique skill sets. At eight people, this is by far the largest group that I have worked with on a single project. At times it was difficult to ensure that we were all on the same page and functioning as a single minded unit rather than a confused collection of individuals. This experience has taught me how to operate on teams of this size and the importance of clear directives and goals. As well as the lessons about team work, this project has taught me the importance of a good lit review and in depth research before committing to a design. As a whole this was a very beneficial and encouraging project.

Maggie Hart

Participating in the FAA design competition was definitely a learning experience. I started the competition as an undergraduate in the five year Human Factors bachelors and masters program. The design competition was the first “real world” project I took on, and in my first graduate class. To be honest, I was terrified of the competition, and I stayed that way until I finished my part of the report sometime last week, and I realized that I had gained a lot of knowledge throughout the competition.

This competition allowed me to experience the “systems engineering” process in a way that textbooks have not yet done. As our design team encountered all of the components of the design process, we worked together to fully understand and perform all tasks in order to create the best product possible.

The team, however, was definitely the most beneficial part of the design competition. Our team was comprised of people from all kinds of backgrounds and professions, and experiencing how cohesively and effectively such a diverse group can work taught me a lot about responsibility and teamwork.

Overall, I got way more from the FAA design competition than I ever thought I would. I have gained knowledge that will stay with me throughout my academic career.

Appendix F- References

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