COVER PAGE

Title of Design: iTaxi – Total Runway Awareness

Design Challenge addressed: Runway Safety/Runway Incursions/Runway Excursions

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Increase Situational Awareness,
Reduce Runway Incursion,
Save Lives…

…Total Runway Awareness

By

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Executive Summary

One recurring factor in runway incursions is pilots' occasional error in properly navigating the taxiways of an unfamiliar or familiar airport. To minimize and eradicate RIs, we need to provide the pilot with tools to strengthen his situational awareness (SA) on the ground. To that end, we propose iTaxi: a navigational aid with the intent of informing the pilot about his current position on the airport. This system would also inform the pilot about the location of "hot spots," where accidents are more likely to occur, and other airport features relevant to the safe taxi of the aircraft.

iTaxi was developed using human factors and system engineering tools and methods. Our team talked to multiple subject matter experts (SME), including FAA officials, airport operators, a commercial aircraft pilot, and aviation maintenance technicians (AMTs). This enabled us to create a system that should be easy to operate, using existing FAA-certified hardware that is already used in aircraft cockpits: the Apple iPad.

iTaxi has been designed as a versatile system capable of being used in both commercial aviation and general aviation (GA). Its low implementation cost makes it an affordable option for GA pilots looking for added safety while on the ground. The financial cost to implement the system in a commercial aviation setting is greatly offset by the low routine maintenance costs, as well as the expected financial benefits yielded from equipping a full fleet of aircraft with iTaxi. As with any technologically related product the risk of obsolescence is omnipresent. To combat this, iTaxi was developed to be fully upgradable using over-the-air software updates. iTaxi will give peace of mind to pilots while on the ground and help to ensure the safety of individuals using air travel.

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List of Acronyms

A7: Alpha Seven

AC: Advisory Circular

ALoS: Acceptable Level of Safety

AMT: Aviation Maintenance Technician

ATC: Air Traffic Control

CRJ: Canadair Regional Jet

EFB: Electronic Flight Bag

ERAU: Embry-Riddle Aeronautical University

FAA: Federal Aviation Administration

FSDO: Flight Standards District Office

GA: General Aviation

GPS: Global Positioning System

ICAO: International Civil Aviation Organization

NTSB: National Transport Safety Board

OTA: Over-The-Air

RI: Runway Incursion

SA: Situation Awareness

SMS: Safety Management System

SRM: Safety Risk Management

TRACON: Terminal Radar Approach Control

1 Problem Statement and Background on Problem Area

According to the Federal Aviation Administration (FAA) "Runway Safety is a significant challenge and a top priority for everyone in aviation" (FAA, n.d., p. 2); among those challenges are runway incursions. In 2007, the FAA adopted the International Civil Aviation Organization (ICAO) definition for runway incursion which is "any occurrence at an aerodrome involving the incorrect presence of an aircraft, vehicle or person on the protected area of a surface designated for the landing and take-off of aircraft" (ICAO, 2007, p. 11). Runway incursions are classified by their severity and type. Severity ranges from category A to category D. Category A, the most serious kind of incident, is when a collision was narrowly avoided. Category D, the least serious kind of incident, is where there is little or no chance of collision. Figure 1-1 provides a definition of the different categories. According to the FAA (2011) the number of category A and B incidents has seen a steady decrease in the past years (see Figure 1-2). The FAA uses specific criteria to properly classify each incident, such as:

- Proximity of the aircraft and/or vehicle
- Geometry of the encounter
- Evasive or corrective action
- Available reaction time
- Environmental conditions, weather, visibility and surface conditions
- Factors that affect system performance

Severity classification scheme

Severity	Classification Description
A	A serious incident in which a collision is narrowly avoided.
B	An incident in which separation decreases and there is 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	An incident that meets the definition of runway incursion such as the incorrect presence of a single vehicle, person or aircraft on the protected area of a surface designated for the landing and take-off of aircraft but with no immediate safety consequences.
E	Insufficient information or inconclusive or conflicting evidence precludes a severity assessment.

Figure 1-1. Runway Incursion Severity Classification
Adapted *from Manual on the Prevention of Runway Incursions* by ICAO (2007, p. 33)

Runway incursions are also described on the basis of the person who causes the error. They are divided into three main responsibility-based categories: pilot deviations; operational error deviation, which are attributed to air traffic control (ATC); and vehicle/pedestrian deviations. According to the FAA (2011), pilots are responsible for the majority of runway incursions. From Fiscal Year (FY) 2008 through FY 2010 they accounted for 63.25 percent of all runway incursion. This trend continued for FY 2011 and up to June of this year, with pilots responsible for 62 percent (436 out of 708) of the incursions. Of those 436 incidents, GA pilots were

Fiscal Year	Category A	Category B	Yearly Total
2000	24	43	67
2001	20	33	53
2002	10	27	37
2003	10	22	32
2004	12	16	28
2005	14	15	29
2006	24	7	31
2007	17	7	34
2008	12	13	25
2009	9	3	12
2010	4	2	6

Figure 1-2. Number of Runway Incursions A and B FY 2000 through FY 2010 Adapted *from National Safety Runway Plan* by the FAA (2011, p. 14)

responsible for 343 (78 percent), followed by commercial pilots with 56 incidents (13 percent).

According to ICAO's (2007) Manual on the Prevention of Runway Incursions, one of the factors that cause pilot deviations is the loss of SA. When loss of SA occurs, pilots may wrongly believe they are at a specific taxiway or intersection when in fact they are somewhere else on the airport. Some of the reasons that contribute to a pilot's loss of SA include environmental factors such as:

- Poor or inadequate signage/markings

  and/or

- Having to navigate through a complex airport in which the pilot has to cross one or more runways (ICAO, 2007).

Other factors affecting SA include performing mandatory head-down piloting tasks and time pressure (ICAO, 2007).

The increase in runway incursions and excursions at aerodromes are partly a result of heavier flight traffic and ground congestion. When coupled with other common risk factors, such as, low visibility conditions, poor flight crew coordination, worker fatigue and lack of clear runway signage, these incidents become ever more common (Honeywell, 2009).

The Flight Safety Foundation has collected runway safety accident data for both commercial jets and turboprop aircraft. As Figure 1-3 shows, even though there are not a lot of accidents, there are a plethora of Category A and B incidents. Federal Aviation Administration Order 8020.11B defines an incident as, "an occurrence, other than an accident, associated with the operation of an aircraft that affects or could affect the safety of operations" (FAA, 2000). The FAA takes the definition of an accident from the National Transportation Safety Board (NTSB), which defines it as and event in which the aircraft receives substantial damage or any person, inside or outside the aircraft, is seriously or fatally injured. The FAA then divides all accidents into four sub-categories: major, serious, damage and injury.

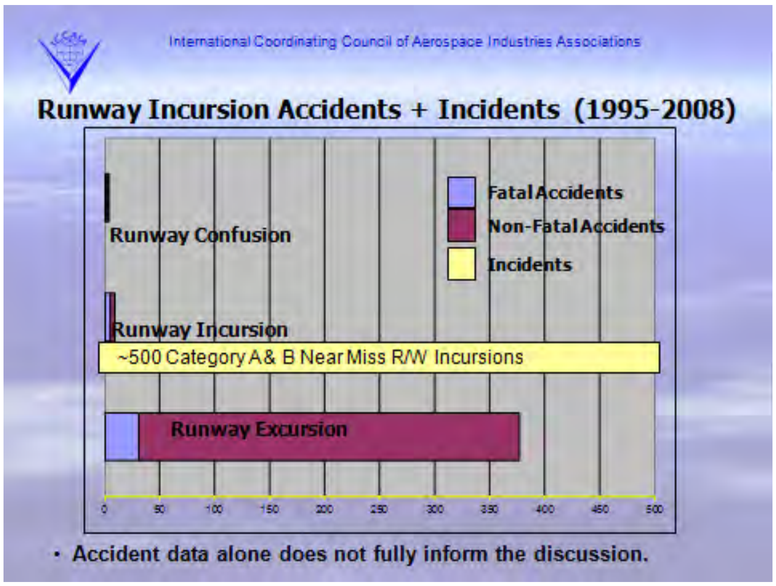

Figure 1-3. Runway Incursion Accidents & Incidents (Adapted from Johnson, 2011)

Data collected over a 13-year period by the Flight Safety Foundation (2011) reveals that of 1,429 total accidents, 10 account for incursions (see Figure 1-4). This equates to 10 per year or .6% of total accidents. However, if you include the category of Runway Confusion (e.g. using the wrong runway for take-off and landing), the numbers increase to 14 per year, or .9% of total accidents a year. These two categories have claimed the lives of 261 people in 7 fatal accidents over the 13 years of data collected (see Figure 1-5). Unfortunately, there are no requirements to report incidents regarding confusion, so these numbers are conservative.

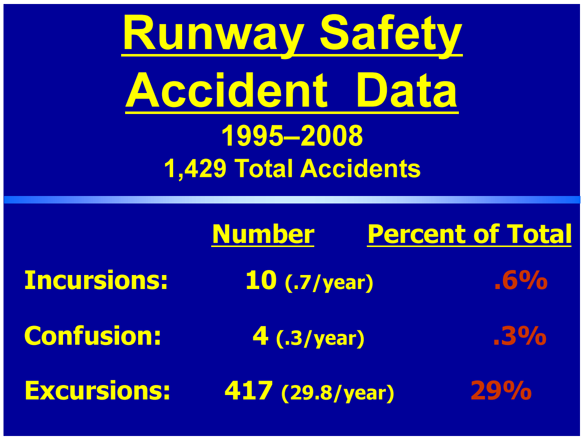

Figure 1-4. Runway Safety Accident Data (Flight Safety Foundation, 2011)

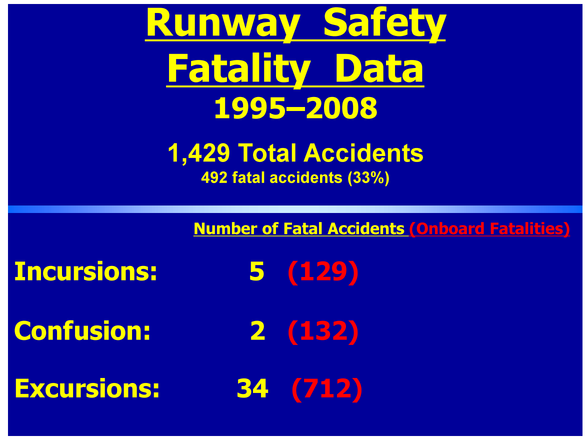

Figure 1-5. Runway Safety Fatality Data (Flight Safety Foundation, 2011)

Honeywell (2010) has released information on common causes of runway incursions and excursions in the form of percentages. According to the graph in Figure 1-6, incursions make up 66% of the incidents; this includes aircraft taking off on the wrong runway or taxiway (9%), aircraft to aircraft near misses (14%), aircraft to aircraft collisions (18%) and aircraft taxiing onto an active runway without clearance (25%).

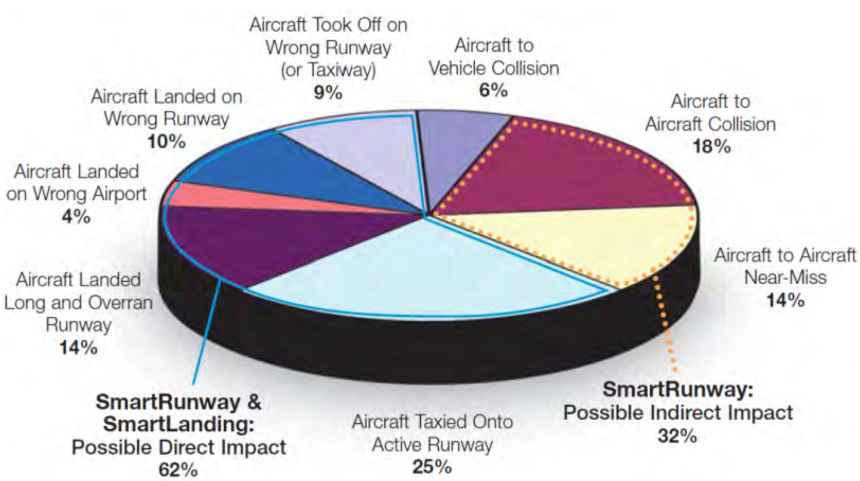

Figure 1-6. Common Causes of Runway Incursions and Excursions (Honeywell, 2010)

The Flight Safety Foundation (2011) admits that even though there aren't many runway incursion accidents, there are many incidents and the risk is still very high. Both the Flight Safety Foundation and the International Coordinating Council of Aerospace

Industries Associations (Johnson, 2011) suggest that a possible solution could be the implementation of a moving map to help flight crews navigate the aerodrome. This is where our team has stepped up to build on this suggestion by developing the iTaxi concept, a moving map application with an aerodrome information overlay.

Because the majority of runway incursions are caused by pilot deviations, iTaxi was developed to help pilots navigate through unfamiliar or difficult-to-navigate airfields. One of the main foci of iTaxi is to increase the pilot's SA while assisting the pilot with attentional management. A risk that comes with navigational aids is that they will draw the pilot's attention away from the out-the-window view and the dynamics of the real world runway environment. We address this risk in the design of iTaxi to achieve an end result of improved attention to external dynamics and cues. By minimizing heads-down requirements while informing pilots of the landmarks and cues to look for and reducing the cognitive load iTaxi was designed to provide pilots with turn-by-turn directions and other critical information such as hold-short lines and airport hotspots. By delivering this navigational information, iTaxi will lower the amount of time and effort a pilot has to spend trying to find and comprehend signage and markings on an unfamiliar or complex airport and provide a viable alternative to progressive taxiing which may, in turn, reduce ATC workload and increase pilot SA. By providing critical information, iTaxi can free a pilot's attention for pursuing other important tasks such as meteorological conditions, verifying location of other aircraft, and monitoring radio communications.

The remainder of this report describes the iTaxi design and its development. First, we contrast the goals of iTaxi with the capabilities of similar technologies. Then, we describe ways the iTaxi design benefited from a literature review and our interactions with SMEs. The technical portion of our report follows; in this portion, we present a concept of operation for the iTaxi design and mitigation strategies for potential safety risks. Next, we report our assessment of iTaxi's commercialization potential and conclude with potential real world impacts.

2 Existing Technology

Companies including Garmin, Honeywell and Thales have developed systems that try to reduce the cognitive demand and potential for confusion for ground navigation. The following sections will provide information about the design of their systems. Ways in which each system differs from the iTaxi concept will be noted.

2.1 Garmin: SafeNav GPS

Powered by Garmin in partnership with I.D. Systems, SafeNav was designed to help support vehicles avoid accidental runway incursions. This GPS-based navigation device has a 4.3-inch wide-format touchscreen color display and incorporates automatic, audible and visual alarms to prevent runway incursions before they happen (see Figure 2-1 & 2-2). The user of the device can further prevent incidents by inputting waypoints to identify "hot spot" locations at the aerodrome.

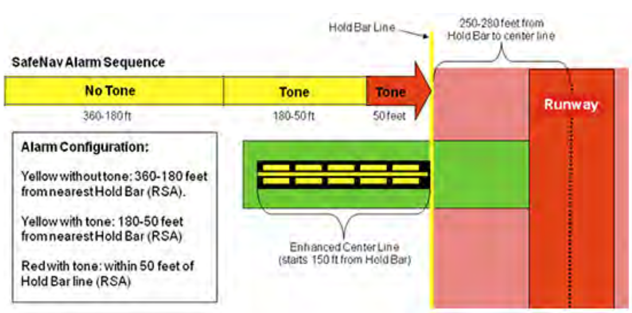

Figure 2-1. Garmin SafeNav (Garmin, 2008)

Figure 2-2. Garmin SafeNav Alarm Sequence (Garmin, 2008)

Some of the benefits of this system include the automatically prioritized multimodal warnings, color-coding of the runway (red) and taxiway (green), and real-time vehicle location tracking for low visibility conditions.

A weakness of this device is its small screen size and which likely requires the use of focused attention such that external visual information cannot be easily monitored while information is being extracted from the device. Garmin says their device increases SA, but there is no data to back this claim. Further, this Garmin device is tailored for use by support vehicles and so does not support the pilot population.

2.2 Honeywell: SmartRunway and SmartLanding

SmartRunway, Honeywell's solution to ground navigational challenges, alerts the flight crew when approaching a runway while taxiing and gives constant situational updates while on the runway tarmac. The benefit of this technology is that it supports heads-up operations by combining both visual and auditory alerts. Since 2004, the Boeing Company has integrated SmartRunway in various 737, 747-8 and 777 aircraft.

Based on Honeywell's literature, this system only alerts the flight crew when the aircraft is near or on an active runway. It does not help the flight crew navigate from the gate to the active runway via taxiways nor does it highlight key interest areas or hot spots at the aerodrome. The system only notifies the flight crew as they approach the preset warning areas.

Honeywell claims their SmartRunway system, coupled with their Airborne Traffic Situational Awareness (ATSAW) system, "is estimated to save more than $100,000 per aircraft per year" (Crabtree, 2010). No data are offered to back this claim.

2.3 Thales: Onboard Airport Navigation System (OANS)

In 2010, the Thales Group designed OANS to increase flight crew SA. Using an Airport Mapping Database (AMDB), OANS dynamically presents the aircraft position over a georeferenced airport moving map (Thales Group, 2011). The system allows the flight crew to build their SA by providing comprehensive taxiing information, as well as appropriate alerts, along the way to and from the aircraft's gate. Already installed on the Airbus A320, A330, A340 and A380, Thales hopes to decrease runway incursions and minimize position loss.

Benefits to this system are the visual and audio alerts to points of interest. With its worldwide airport database it has the potential to reduce navigation error during ground operations. The potential problems of this system include the relative high cost, the installation time and the large size, all of which point to this system being developed for commercial aviation only. Thales' website offers no data to show OANS lowers runway incursion rates.

3 Summary of literature review

One of the most important activities contributing to the development of iTaxi was the review of current literature to help us clarify concepts, identify current and future technologies, and understand relevant FAA requirements. The team primarily used a variety of journal articles and FAA publications.

The first step we took during our literature review was to review the different categories and types of runway incursions as well as the factors that play a role in these types of incidents. We found valuable information in ICAO's (2007) Manual on the Prevention of Runway Incursions and the FAA's (2010) Annual Runway Report. These documents introduced us to the complexity of the problem and provided us with a wealth of statistical data. For instance we learned that 78 percent of runway incursions involve GA pilots. This gave us a clear indication that there is a need to develop a system that can be implemented for both commercial and GA, as GA pilots are responsible for the majority of runway incursions.

We decided to consult the FAA's (n.d.) Runway Safety- A Best Practices Guide to Operations and Communications brochure to learn about possible recommendations for pilots to increase their situation awareness during taxi operations. Recommendations included in this document advise pilots to have a current airport diagram while taxiing, pay attention to any complex intersections and hotspots, verify the assigned route on the airport diagram and write down taxi instructions. After gathering and analyzing this information, the team decided to develop a system to aid pilots during taxi operations. To support our idea of providing pilots with an interactive software tool, we reviewed the literature on the subject. We found the results of an experiment done by Prinzel and Jones (2004) showing that the use of an Electronic Flight Bag (EFB) displaying a surface map with own-ship position was an effective way to prevent runway incursions. Finally, we consulted different FAA documents to become familiar with the certification requirements for software and to understand the difference between EFB classes. The following documents were crucial to our understanding of software types and hardware requirements: FAA (2007) Advisory Circular (AC) No: 120-76A "Guidelines for the Certification Airworthiness, Operational Approval of Electronic Flight Bag Computing Devices" and FAA (2003) AC No: 91-78 "Use of Class 1 or Class 2 Electronic Flight Bag (EFB)." With the knowledge about software as well as hardware requirements and the background information on runway incursions, our team acquired the necessary foundation to design iTaxi.

4 Interactions with Subject-Matter Experts

To narrow in on the scope of iTaxi we knew we would need the help of SMEs. In-depth interactions with three SMEs will be discussed in the paragraphs that follow. Interactions with six other experts will be discussed in a subsequent paragraph. All experts were contacted in order to determine how iTaxi could be used, its implementation, and the technological and software feasibility of the program. The first three rows of Table 4-1 list the experts with which in-depth interactions were carried out. In addition to the experts listed in Table 4-1, the team attempted to reach Apple engineers; however our phone calls and emails were not returned.

Table 4-1. iTaxi Subject-Matter Experts

Subject Matter Expert (SME)	Position	Contact Information
John Murray	Director of Operations, Daytona Beach Airport	jmurray@co.volusia.fl.us
Joe Gambino	Air Traffic Controlller, Daytona Beach Tower and TRACON	(386) 226-3900
Mitch Huffman	Aerospace Engineer, Atlanta Aircraft Certification Office	Mitch.huffman@faa.gov
Pete Faller	Captain, United Airlines	pjfaller@aol.com
Clark Badie	Senior Technical Manager, Honeywell	(480) 353-3020
Ratan Khatwa	Senior Chief Engineer, Honeywell	(480) 353-3020
Paul Cox	Engineer Director, Honeywell	(480) 353-3020
Rose Mae Richardson	Senior Technology Manager, Honeywell	(480) 353-3020
Bill Warren	Aviation Maintenance Technician	(904) 364-9192

In order to correctly identify the type certification that iTaxi will need, we turned to Mitch Huffman, an FAA Aerospace Engineer at the Atlanta Aircraft Certification

Office. Through our interview with Mr. Huffman we were able to determine that our product, when used as a handheld device (i.e. not mounted), will be a Class I product. This, according to AC 120-76A, means that the product would be considered a loose object and would have to be stowed during the critical phases of flight. He was able to explain to our group that certification of iTaxi as a Class I device could be handled through the local Flight District Standards Office (FDSO). Secondly, with Mr. Huffman's assistance, we were also able to classify our software application as Type A, meaning that the content being displayed matches what already exists in paper format (i.e. airport diagrams). Mr. Huffman clarified that for ease of certification, keeping the hardware to Class 1 and the software application to Type A would be our best option.

Mr. Joe Gambino, an Air Traffic Controller at Daytona Beach International Airport, is certified in both Daytona TRACON and the Daytona Tower. We consulted with him in order to better understand how taxiing works. After an in-depth tour of Daytona's control tower we were able to discuss our idea with Mr. Gambino, including the concept that once the pilot had obtained their initial clearance, iTaxi could serve as a backup by providing more detailed instructions. During our discussion, we sought his inputs regarding potential benefits to stress and workload management. Mr. Gambino felt that iTaxi would assist with reducing the stress of the workload although, in the end, would not completely alleviate the responsibility of a controller monitoring an aircraft using iTaxi. His reasoning was that, as a controller, it is instinctual to keep an eye on all traffic no matter what kind of aids are present in the cockpit. Therefore, the product could reduce workload associated with talking to pilots needing extra guidance, but controllers would still maintain visual awareness of the aircraft's location. He did state that he would feel relief knowing iTaxi was at the disposition of the pilot and that it is not “his word against their ears”. He encouraged us by indicating iTaxi would be a huge assistance in addressing certain safety concerns on runways and taxiways.

We were also able to view presentations and engage in a question and answer session with staff members from Daytona Beach International Airport. Through their presentations, we were able to narrow down the scope of what our product would do in addition to making sure it addresses real issues. The Director of Operations, John Murray, was able to shed light on the issues that the staff feels are contributing to runway incursions. The most prevalent issue discussed were “hot spots”. Our product design was modified to provide visual cueing to the pilot as to the location of "hot spots” on the airfield. In addition, Mr. Murray was able to share with us that the airport (speaking specifically for Daytona Beach airport) was looking into ways to prevent runway incursions. Due to the high amount of student traffic, this particular airport has a higher rate of pilot deviations and runway incursions.

The additional six experts contacted were extremely helpful in answering simple questions and directing our group. These experts were contacted for quick questions about feasibility and not necessarily to alter our product. The Honeywell experts identified current technologies and software that are being used which are similar to iTaxi. This helped our group to not accidentally replicate a current technology. Lastly, the aviation maintenance technician and airline captain addressed feasibility and need, respectively, for a technology like iTaxi both gave positive and encouraging feedback.

5 Problem Solving Approach and Technical Design

The iTaxi design concept emerged and progressed over the months of this project as we learned from SMEs and literature. The research described above allowed us to adapt the design to better meet the needs of the target population. In the four sections that follow, the design analysis conducted during its development will be described.

5.1 Concept of Operations

The targeted population for use of iTaxi is pilots, both commercial and GA, who fly to airports with which they are unfamiliar. Our product would eliminate the requirement for these pilots to request progressive taxi instructions from ATC. It would provide detailed taxi instructions to the aircrew and display a visual representation of ATC's directions using a moving map. Once an aircraft has landed, the control tower will pass control of the aircraft to the ground controller who will provide the pilot with their taxi clearance. The pilot (or copilot as appropriate) will input this information into iTaxi. iTaxi will combine the inputted instructions with a Global Positioning Satellite (GPS) signal and the aerodrome map to provide a visual representation of the assigned route. A similar procedure would occur when pilots are ready to taxi from the gate to their assigned point of departure. The components and component relationships that enable this scenario are presented in a system overview diagram (formally, an OV-1 diagram), shown in Figure 5-1.

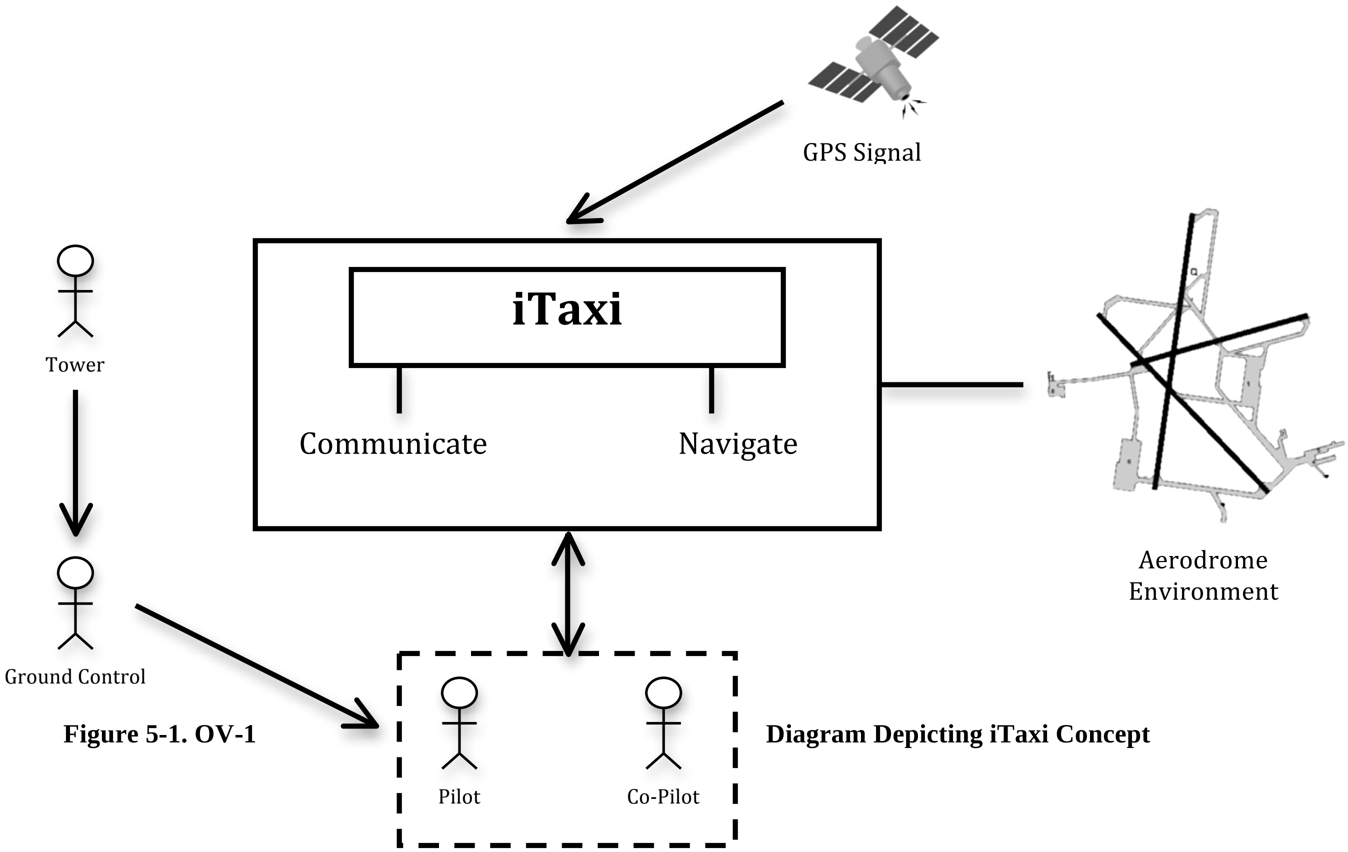

Figure 5-1. OV-1 Diagram Depicting iTaxi Concept

5.2 Design Diagrams

An iPad template is used to illustrate the proposed iTaxi interface. Upon startup of the application, a screen containing the airport diagram and option to "Input Route" is displayed. As shown in Figure 5-2, the GPS in the iPad will automatically determine the airport at which the aircraft is located and display its position on the airport as a green dot. The following interface examples will portray a pilot navigating from 7R to Embry-Riddle Aeronautical University Ramp at Daytona Beach International Airport. An FAA airport diagram will be used for navigation purposes as that is what the pilot is the most familiar with.

Figure 5-2. iTaxi Application Startup Screen

Upon selecting “Input Route”, the airport diagram moves to the upper right corner to allow room for the keyboard which the pilot then uses to input the given taxi directions. The user first inputs the end point (e.g. Gate 2) and if there is only one available route, iTaxi will automatically display the option. Otherwise, the user will continue on and input taxi directions, which typically consists of a series of alphanumeric instructions (eg. N6 -> N -> B-> Gate 2). As shown in Figure 5-3, as the user inputs directions, the route highlights on the screen for verification. The green, yellow, and red variations agree with the color standardization guidance in AC 23.1311-1B. Green represents safe operating conditions, yellow means caution, and red signifies that immediate action is required. The yellow caution color highlights hotspots where pilots should take extra care. The red color indicates to pilots to immediately contact ATC before continuing onto the runway. A back button on the bottom right allows the user to go to the previous field to edit. The

"Done" button completes the input process.

Figure 5-3. iTaxi Input Screen

After inputting the taxi instruction, the route is displayed for verification purposes as shown in Figure 5-4. The destination, route, and warnings associated with the route are displayed. The pilot presses the "Verify" button to continue.

Figure 5-4. iTaxi Input Route Verification

Located on the bottom right of every screen is a "Settings" button represented by the default iPad settings icon. In the settings menu, shown in Figure 5-5, the user has the option to create or edit the route, adjust the screen brightness, and toggle between a north up and track up display of the map during navigation.

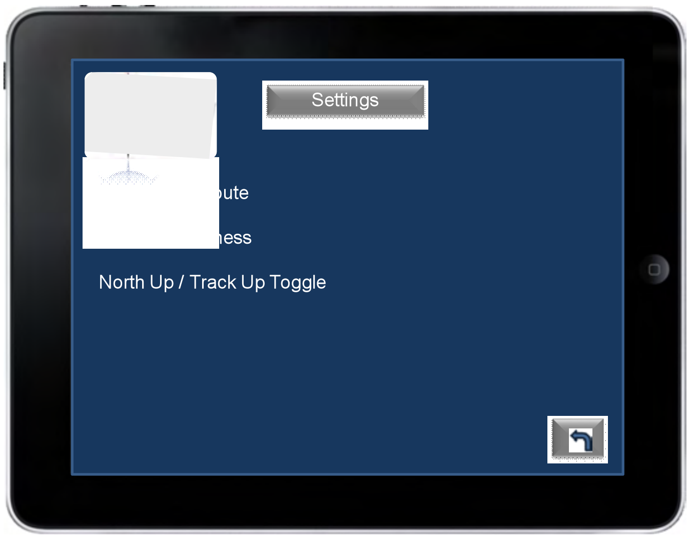

Figure 5-5. iTaxi Settings

An example of a navigation screen is illustrated in Figure 5-6. An arrow designates the current location of the aircraft on the map. The map in this view has been automatically zoomed in to the area of the airport where the aircraft is located. The grey box indicates the upcoming action and to the right is a more detailed description including the distance until the action.

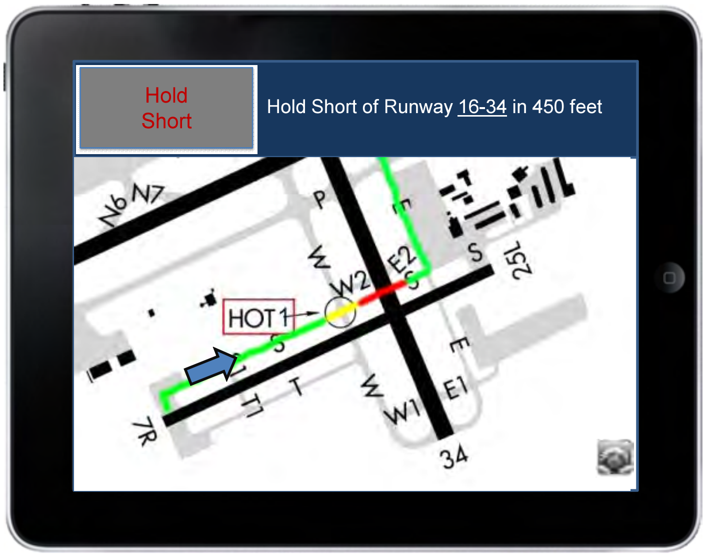

Figure 5-6. iTaxi Navigation to Hold Short

As a hold short action approaches, the grey box expands into a larger grey button as shown in Figure 5-7. The user must acknowledge the hold short notification by pressing the grey button. The next step in the navigation route will not display until the button is pressed. As previously mentioned, the route across the runway is colored red to indicate immediate action and contact air traffic control before proceeding.

Figure 5-7. iTaxi Approaching Hold Short

A typical navigation screen is shown in Figure 5-8. The next action is to turn left and is shown as a left turning arrow with the more detailed instructions to the right.

Figure 5-8. iTaxi Navigation

In the event of a deviation from the route, the airport diagram grays out and the button to input a new route appears as shown in Figure 5-9. The lettering is red to again represent immediate action and contact tower for new route instructions.

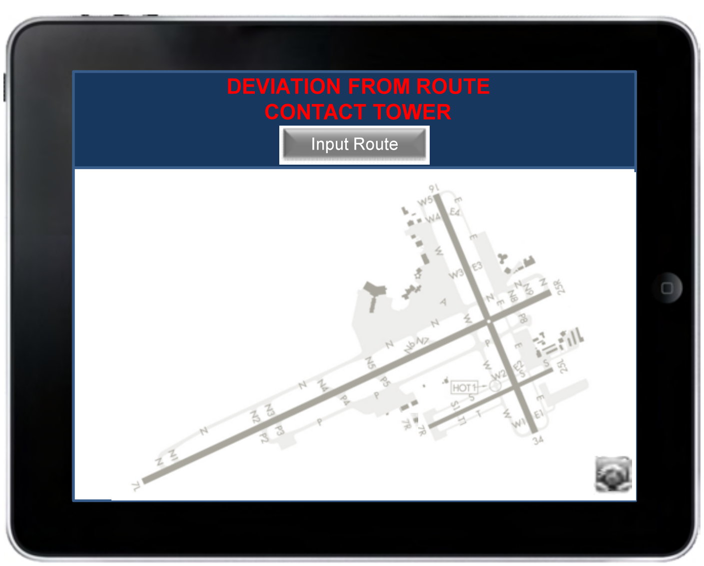

Figure 5-9. iTaxi Deviation Notification

5.3 Safety Risk Management

For this project we used the FAA's Safety Management System (SMS) (FAA, 2004 and FAA, 2007) to conduct our hazard identification and risk assessments. This follows the process captured by the five phases of the FAA's Safety Risk Management Analysis (see Figure 5-10). This section identifies some of the hazards that may need to be addressed as part of iTaxi's continued development and testing.

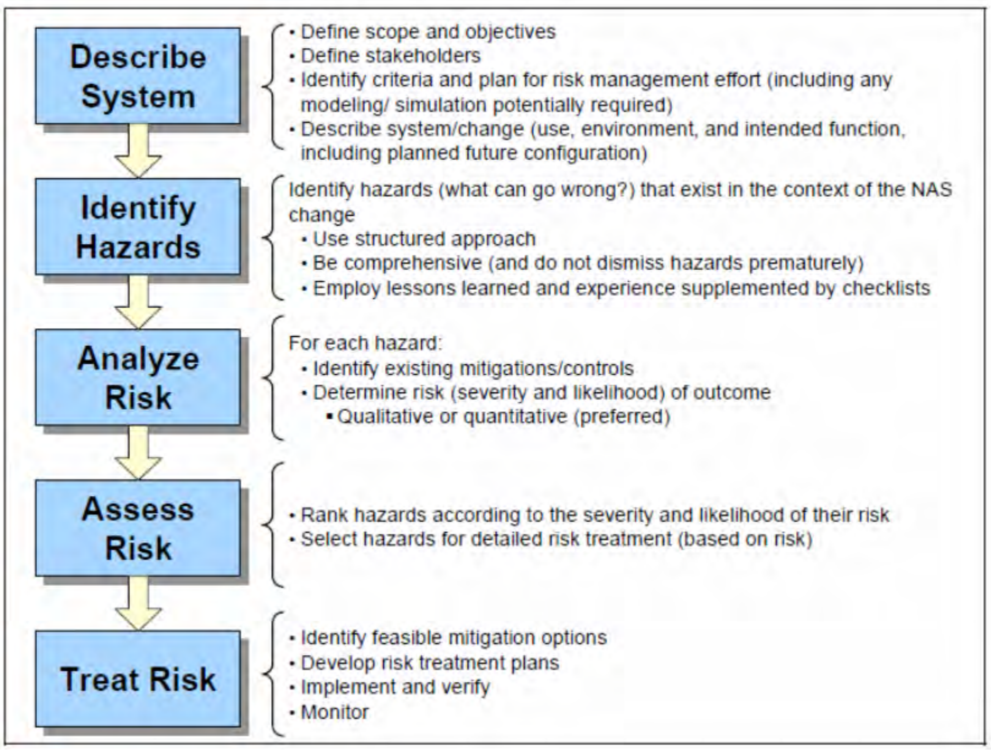

Figure 5-10. FAA's Safety Risk Management Process (adapted from FAA, 2004, p. 26)

5.3.1 Summary of FAA's Safety Risk Management Process

In order to complete an SRM analysis it is first important to understand the FAA's SRM phases in detail.

Describe system: The scope of the problem and the proposed change are clearly detailed to allow the hazards to be identified. The proceeding two sections present the details of this system and its operational challenges faced in the operating environment are presented in Section 1.

Identify Hazards: The level of detail in this phase is dependent on the complexity of the proposed change and sets the level of depth for the remainder of the SRM. In identifying the hazards, the worst credible outcomes and their potential causes are identified and documented. The main hazards we identified are presented in Table 5-1.

Analyze Risk: Each identified hazard is analyzed with respect to the system-states in which they could potentially exist. This is done in order to determine what factors exist to reduce the severity or likelihood of the risk progressing to its worst credible state. The level of risk for each hazard is determined by a combination of the likelihood of its occurrence and the severity of the outcome.

Assess Risk: Each hazard's risk is plotted on a risk acceptability matrix (see Figure 5-11). The priority for risk treatment is then determined by each risk's placement on the matrix.

HAZARD			CATEGORY				
Severity / Probability			A Catastrophic	B Hazardous	C Major	D Minor	E Negligible
LEVEL	1	Frequent	A1 Extremely High	B1 Extremely High	C1 Medium	D1 Low	E1
	2	Probable	A2 Extremely High	B2 High	C2 Low	D2	E2
	3	Remote	A3 High	B3 Medium	C3	D3	E3
	4	Extremely Remote	A4 Medium	B4	C4	D4	E4
	5	Extremely Improbable	A5	B5	C5	D5	E5

Acceptable Level of Safety

Figure 5-11. Risk Matrix (adapted from Department of National Defense, Government of Canada, 2010, p. 5-14).

Treat Risk: The risk matrix indicates the priority for the treatment of risks, with the highest risks being given the most consideration. Risk management identifies feasible options for mitigating the identified risks. Mitigation strategies may include: avoidance by selecting another approach, transfer of the risk, assumption of the risk or developing training and techniques to mitigate the effects.

5.3.2 iTaxi Safety and Risk Management

The hazards identified for the iTaxi system are believed to be fairly consistent from airport to airport and between commercial and GA. Following the guidelines of the FAA SMS for Airport Operators (2007) and using the Risk Matrix from Figure 5-11 our team identified hazards relating to the implementation, operation and maintenance of our system. Within these categories, we considered iTaxi's interface with potential users, within the aerodrome environment and with existing systems. Postulated hazards, ordered by priority, and the results of our hazard analyses are shown in

Table 5-1.

Note: ALoS - Acceptable Level of Safety.

Table 5-1. Identified and Assessed iTaxi Risks with Mitigation Priority

Hazard	Probability	Severity	Assessed Risk Category	Mitigation Priority
Interference with safe egress during emergency	Extremely Remote	Hazardous	B4 - ALoS	High
Increased heads down time	Probable	Minor	D2 - ALoS	Medium
Errors during input affecting route accuracy	Extremely Remote	Minor	D4 - ALoS	Medium
Lost GPS signal	Remote	Negligible	E3 - ALoS	Low
Loss of power	Remote	Minor	D3 - ALoS	Low
Inaccurate maps	Extremely Remote	Minor	D4 - ALoS	Low
Over reliance on system	Remote	Minor	D3 - ALoS	Low

Hazards occur when the proposed system has a negative interaction with the existing FAA approved system. The majority of these hazards; for example, mechanical or electrical interference, can be addressed in the prototyping and testing phases of development. As seen above, all our identified hazards for the iTaxi system have been identified as falling within the Acceptable Level of Safety in accordance with Figure 5-11. Regardless, some of these risks require mitigation prior to iTaxi's implementation.

The highest priority hazard for mitigation, as determined by the risk analysis, is the potential for interference with safe aircrew egress under emergency conditions. The team's design decision is to implement the iTaxi application on an electronic kneeboard device, such as an Apple iPad. The tablet computer could also be mounted using a quick release device. With either of these approaches, the impact of this hazard has been significantly reduced bringing the hazard within an ALoS.

The next hazard identified for treatment is the potential for increased heads-down time as the pilot looks at the iTaxi system rather than at their surroundings. As our prime goal is to increase safety by improving pilots' SA in an unfamiliar terminal setting, it is important to consider the impact of iTaxi on the pilot's SA. Iterative prototyping and testing to ensure ease of use will help to mitigate this hazard. As a further step, in multi-crew aircraft the non-flying pilot would be responsible for entering the required information into the system and monitoring the iTaxi display. It is also strongly recommended that taxi information not be entered while the aircraft is in motion.

The team has recognized that there is potential for the pilot to make errors during the input of their taxi instructions. This will be mitigated through the use of prototyping to ensure the error potential is minimized and that when committed, errors are easily recognized and remedied before they are transmitted into the system. To further aid in increasing SA and decrease the impact of operator error, the iTaxi system will provide a confirmation readback screen prior to giving the display of the mapped route.

iTaxi is designed to be a SA aid in the crew cabin and is not intended to replace the requirement for diligent attention on the part of the pilot and the crew to their surroundings. The ultimate goal of iTaxi is to increase flight crew's SA and reduce the possibility of runway incursions resulting from a deviation of approved taxi instructions.

5.4 Human-System Interaction

The strength of a system comes from its ability to communicate with its user in an effective and useful way, and our system does just that. When it comes to interacting with displays in an aircraft cockpit environment, a large screen display and touch-control have been recommended (Chengqi, Cen, & Yan, 2009). For the iTaxi information display, we had to choose a platform that would be adequate for the environment it will be used in: an aircraft cockpit. Because the screen needs to display map information, it needs to have a high resolution as well as good viewing angles (Karwowski, 2001). In a cockpit environment, glare can be a serious problem when reading information off an LCD display. By offering a wide variety of viewing angles, the adjustable display makes it possible for the pilot to use our system in a multitude of lighting conditions. The Apple iPad 2 fits these requirements with a 9.7”, 1024x600 resolution touch-screen display (Apple Inc, 2011). The iPad’s touch screen only requires the touch of a finger; no stylus is required.

Another important factor to consider is that more and more people are using Apple products, including pilots. We all know how much we use these devices in our everyday life and how easy they are to operate. By choosing the Apple iPad, we are giving iTaxi a hardware platform that is already in use and that currently accounts for 50% of the mobile web traffic in the United States (AdMob, 2009). More importantly, it is not something totally new. Pilots already use the iPad for charts and checklists; we are only adding software and a mounting system.

6 Installation and Deployment

6.1 Installation

As this system is based on existing products, implementation time and cost should be rather low. As previously mentioned, this system would be purely optional so the following implementation plan should be interpreted as guidelines more than requirements. One of the strengths of iTaxi is its customizability and capacity to adapt to the pilot's preferences. The least integrated solution would be a kneepad setup where the pilot uses the device as he would a regular kneepad. This method is easy, simple and pretty much free of installation costs but requires the pilot to look down to view navigation progress and guidance and hence may reduce SA while taxiing.

The preferable way of using the system is via a mounting device. After a review of multiple mounts, two types stood out. The first type is a yoke mount (see Figures 6-1 and 6-2), designed to be implemented in a GA setting. This has the advantage of being simple to install and easy to use. The mount rotates independently from the controls, which results in the device being constantly upright even when the pilot is correcting for crosswind while taxing. This type of mounting system is comparable to Boeing's Class 1 Electronic Flight Bag (EFB) architecture.

After consulting with our aviation maintenance technician (AMT) subject matter expert, we established that this particular model takes about an hour of installation time (Personal communications W. Warren, certified aviation maintenance technician, 11/14/2011). Then the unit can be removed and replaced in matter of seconds. This mount can also support a 28 volt DC power unit that would keep the unit fully charged at all times.

Figure 6-1. Yoke Mont: Front and Back

Figure 6-2. Yoke Mount Fully Installed

The second type of mounting system would place our system to the side of the pilot, making it easy to use while taxiing. In this position only a sideways glance would be required to establish one's position and destination on the airport diagram (see Figure 6-3). This type of mounting system is comparable to Boeing's Class 2 EFB architecture. To optimize our iTaxi's performance, and for redundancy reasons, we recommend that two units be installed: one to the left of the captain and the other to the right of the first officer. A 28-volt DC power unit will come standard with this type of installation.

Figure 6-3. Mounting Solution for Commercial Aircraft

This particular installation could be adapted to different kinds of aircraft so the placement does not hinder the operation of key systems. After consulting our AMT SME, we established that about three hours would be required to complete the installation of the two units in one cockpit.

The installation of iTaxi can be done simultaneously while routine maintenance is performed on the aircraft to minimize the cost of grounding an aircraft. In some cases the company will already have outfitted their flight deck with iPads to be used as an EFB; in those cases, only an application upgrade would be necessary. (Training would be required for anyone who has never used the system or application before.)

Future upgrades to the system will be delivered via an over-the-air update capability, meaning that it would be fully wireless. Upgrades could possibly include live representation of other aircraft around the taxi route, enhanced warning systems when going off track and other necessary modifications that would be discovered by obtaining user feedback.

6.1.1 Estimated Deployment Timeline

Months 0-3: As every company is going to have different regulations and aircraft, the first three months will be used to determine company-specific requirements. We suggest forming an iTaxi deployment team consisting of pilots and company administrators, which will meet every week during the deployment period. Following the meetings, the pilots and administrators would respectfully gather feedback from their peers and discuss results in following meetings. User testing will be performed in various situations and aircraft types to achieve those ends. During this period, all pilots should still be apprised of system-critical decisions and encouraged to add input if they so desire. In addition to achieving a safer and better product, including the users (pilots), in design and modification development should facilitate acceptance later when the system is operational.

*Months 3-11***:** The airline company retrofits all airplanes in their fleet with the system. Realistically, this depends on the timetable of the company in question, as well as if they are willing to ground aircraft just for the installation of the system.

*Months 11-12***:** All pilots using the new system undergo an online training seminar to familiarize themselves with our system. This training program would be formulated by the company with the pilots involved from the start of iTaxi's deployment process. The purpose of this approach is to ensure acceptance by the pilot population.

6.2 Financial Analysis

Like any new product, the cost of implementation, usage and maintenance are key factors in deciding the viability of our proposed product. To this end, we conducted a cost-benefit analysis of iTaxi, which is described below (see Table 6-1 for analysis results).

The main component of iTaxi is an Apple iPad 3G with a hard drive size of 16Gb which currently has a consumer retail price of $629.00. It is worth noting that this price might be lower pending possible agreements between the FAA and Apple Incorporated. The application is based on a yearly subscription that will cost $500 for full coverage of the continental United States, and $900 for full worldwide coverage. This price scheme is per-system not per-device. This means that for a commercial application where 2 iPads are required in one cockpit, the yearly subscription for both devices is $500 (for the continental United States). After talking to a certified AMT, we expect the installation cost of implementing our system in a flight deck to be around $7,500 per commercial airplane. This includes the cost of the mounts, which average $3,000, and labor. From a GA standpoint, the mounts cost from $50 up to $2,000. Most GA pilots would not want to spend much so we will use $200 for the cost of a mount. This makes the installation cost for a GA airplane around $300, after adding $100 for tools needed to install the mount.

To provide a more detailed picture of the costs associated with our system, we decided to arbitrarily outfit a modern day airline company with our system. This company currently has 560 planes in service, which would represent an initial installation investment of $5,399,480. Other costs would include: (1) online training development: $50,000 during the first year, and $25,000 in each subsequent year; (2) fact sheet creation: $15,000; and (3) test and evaluation: $150,000. These costs are presented in Table 6-1.

The main danger of runway incursions is possible collisions resulting in multiple fatalities. Our team searched the NTSB database from January 2005 to January 2011 for accidents involving runway incursions resulting in fatalities or serious injury. We found a total of fifty-one deaths and three serious injuries corresponding to our search criteria. We proceeded by dividing those figures by six to get an annual estimate of deaths and injuries. We gave the financial value of $5.8 million to a human life and $333,500 for a serious injury, based on the values given by FAA (2008b); GRA, 2007.

No system can completely eradicate runway incursion. For this reason we estimated an 80 percent improvement in the runway incursion rate prevention with the use of our system. To account for unforeseen factors we use a more conservative figure and predict that our system will have a prevention rate of 70%. If every company in the

U.S. uses iTaxi this, would result in 5.95 lives saved and 0.35 serious injuries avoided per year. Even with such figures, as Table 6-1 shows, the system will be highly profitable. The estimates shown in Table 6-1 assume daily use of our system on a fleet of 560 aircraft. 7,771 aircraft are in use as of 2009 in the National Airspace System (Research and Innovative Technology Administration: Bureau of Transportation Statistics, 2009), the proposed retrofit only affects 560 of these airplanes, which accounts for 7.2% of all aircraft operating the US. Hence we revised our life saved estimate by using 7.2% of 5.95, which gives us 0.43 lives saved and 7.2% of 0.35 which gives us 0.0252 serious injury avoided per year and a financial benefit of nearly $2 million after Year 1.

Table 6-1. Estimated/Projected Annual Costs of iTaxi

Item	Estimated Costs	Estimated Benefits	Total Benefits
2 Apple iPad 2 3G 32 GB	$1,258		
Continental United States Coverage	$500		
Installation Cost for 1 Plane	$7,500		
Total Retrofit Cost (per airplane)	$9,258		
Total for a current airline company (560 planes)	$5,184,480		
Training/Testing	$215,000		
First Year Total	$5,399,480		
Yearly Subscription Continental United States Coverage (per airplane)	$500		
Maintenance (per airplane)	$500		
Annual Cost	$560,000		
0.43 Lives saved/year		**$2,494,000**	
0.0252 Serious Injury avoided/year		**$8,404**	
Total Benefit		**$2,502,404**	
1-Year (B - C)	$5,399,480	$2,502,404	**-$2,897,076**
2-Year (B - C)	$560,000	$2,510,808	**$1,950,808**
3-Year (B - C)	$560,000	$2,510,808	**$1,950,808**
4-Year (B - C)	$560,000	$2,510,808	**$1,950,808**
5-Year (B - C)	$560,000	$2,510,808	**$1,950,808**

6.3 Commercialization

Consistent with a target customer base of GA pilots, iTaxi's affordability and usability costs are relatively low. Given the popularity of the iPad and SME feedback regarding the usefulness of iTaxi, we anticipate significant sales. iTaxi's ease of use means few to no barriers to an immediate acceptance by pilots and, hence, an immediate surge in sales. The role of aviation is expected to continue expanding. With that expansion, comes more iTaxi users and greater complexity, which will also increase demands for iTaxi.

A potential market for the iTaxi does exist outside the United States. The taxi diagrams for each international airport would need to be uploaded into the device. The software could be adapted to incorporate different languages for different air carriers, as well as GA pilots.

7 Real World Impact and Conclusion

One of the deadliest crashes related to runway safety in modern times is the tragic accident that took place in Lexington, Kentucky in 2006. Comair 5191 has since been in the spotlight when improving runway safety, mainly because the accident was highly preventable. As the Bombardier Canadair Regional Jet (CRJ) lined up with the wrong runway, many preventative measures could have served to prevent such an accident from happening. However, due to the lack of these measures, forty-nine human lives were lost.

Our iTaxi design would have helped increase the Comair pilots' SA during many different phases of the aircraft's taxi to the assigned runway, Runway 22. Initially, the flight crew was given instructions to taxi from the terminal to Runway 22. Given the aircraft's position on the ground, taxiing to Runway 22 would only be possible via taxiway A7. Upon the pilot choosing his end destination for his taxi (Runway 22), the software would have presented the pilots with A7 as the only available taxi route that permits successful completion of the taxi. Furthermore, the highlighted taxi route would have alerted the pilots of any approaching runway hold short lines. As the pilots were taxiing and approaching the hold-short line for Runway 22, the software would have visually alerted them, via a pop-up screen, of the approaching hold-short line. This would have increased both pilots' SA with regard to the aircraft's position on the field. By periodically checking the visual display of position along the taxi route, relevant hot spots, and landmarks, the pilots would have been alerted that the runway assigned for takeoff was fast approaching. If all this was missed and the pilots still decided to line up with the wrong runway, the system would have alerted the pilots using another warning that indicated the deviation from the assigned routing via another pop-up screen. As with the previous alerts, this would have remained active until its successful acknowledgement by the pilot via touch. Thus, iTaxi could have prevented the tragic accident of Comair 5191 by increasing the pilots' SA via map-based position information and a series of alerts.

Although the example above depicts a regional carrier as an operator of the software, it is important to note that this is not a limitation on a specific type of operation. For instance, GA pilots, and airline crews alike can benefit from enhanced SA during ground operations. Many GA airports have taxiways leading to multiple runways. Furthermore, the taxiway markings, signage, and runway hold-short markings are difficult to view due to the paint wearing off. This is a danger at night because it is next to impossible to view these faded markings. However, with itaxi on board, GA pilots at unfamiliar airports can get a highlighted taxi route, with alerts to approaching hold-short lines, depictions of the runway hot spots and alerts to deviations from selected routes. Similarly, with air carriers operating out of busy and complex airports, the highlighted taxi-routes and visual alerts will increase SA of the crewmembers, helping them to safely execute their taxi. As demonstrated with Comair 5191, the iTaxi software could be used to save dozens, if not hundreds, of lives.

Appendix A

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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: Team Evaluation

Martin Lauth and Kelly Neville, Team Advisors

iTaxi team members came from diverse backgrounds—civilian piloting, air traffic control, aerospace engineering, psychology, US military aviation, Canadian military engineering, and human factors. Initially, non-aviation team members were concerned that they might end up playing minimal roles in the design competition project. As it turned out, everyone on the team participated fully. Each team member contributed and everyone learned from one another. Those team members who had initially been concerned about their lack of aviation knowledge reported a rewarding experience and are now more knowledgeable about aviation and much more.

This competition provided an exceptional and rare learning opportunity. In Dr. Neville's ongoing memory and cognition class, students wrote last week about learning research and theory. At least a couple essays pointed to the FAA design competition as a learning experience that is consistent with strategies advocated by research and theory, citing, for example, the facts that the competition encourages deep, meaningful processing of new information, the formation of multiple complex interconnections, and the use and integration of information across multiple settings.

We find it difficult to imagine a project that could be better suited for or do a better job of preparing our students for careers involving research, problem solving, design, and engineering. The students learn to work as a team over an extended period of time, experience multiple phases of a project, and importantly, don't just develop a solution that's been handed to them. They must gain an understanding of the *problem space*—the problem, constraints and opportunities, resources, stakeholders, stakeholder concerns and priorities, and much more. Then, using all that information, they must figure out and 'grow' a solution over time.

The iTaxi team considered multiple options and spent weeks running ideas by pilots and controllers and trying to understand the constraints, opportunities, and other problem space elements. All that work gave them a sense of pride and ownership in their work and now, after deciding upon and developing a solution that could truly be of value in aviation, they know they are able to make a difference in the world.

Interacting with aviation and engineering professionals was one of the highlights of this project. Not only did the students appreciate the assistance of these seasoned professionals; they also came to recognize the value of their interactions with them. Through this part of the FAA design project work, the students learned that successful engineering depends on frequent and rich interactions with a range of subject matter experts, future users, and other stakeholders.

We do not have any changes to suggest for future years. The project guidelines do not impose specific constraints or requirements and this is a great beauty of the competition. The competition guidelines allow teams a wide range of options for how to approach the project. The competition is well-run and perceived as fair, resources are available, and questions are always answered quickly.

James Garvin

There are many lessons to be learned from this project. I had the duty of being project manager. This task would be overwhelming for anyone who does not know how to time manage, be flexible, set milestones, goals or how to recover from a failure. I felt like I could tackle the task of overseeing the progress of our group. The first obstacle that we encountered as a group was the lack of familiarity with each other. While this could have been an obstacle, our team came together with ease after our first meeting. This cohesion and mutual respect among peers lead to a comfortable forum where everyone had the ability to contribute their ideas.

To capitalize on fostering ideas, Joey Jaworski created a Facebook group. This helped our group stay connected and communicate in many ways. We had a forum which was accessible by anyone. It allowed us to post references, ideas, pictures and videos that would not have been discussed during our class meetings. I highly recommend groups establish an on-line group discussion forum after their first meeting.

This project also required the implementation of goals by planning in phases during class meetings. Since we only met once a week, we relied heavily on our Facebook page. As time continued, we accomplished and set new goals, always reviewing what we had completed at subsequent class meetings for continuity reasons. By reviewing the past, it gave us direction on where we needed to go in the future.

Lastly, it is very important for the person undertaking the role of project manager to understand how to draw out timelines, flex with schedule changes and realize the importance of treating everyone with respect.

Anne Gray

This project has given me a new appreciation for working as a member of a team of peers. Coming from a military background I am used to an environment in which the determination of the best way forward is often determined by a single person and the team then works to fulfill the given task. It was interesting to work in a group where everyone's ideas held equal merit and a consensus, or at least a majority, had to agree on a single idea. Even once we had picked a concept it became clear on more than one occasion that we did not all have the same interpretation of that concept, ensuring everyone was on the same page through clear communication became vitally important to our success as a team. To that end, we often met outside of the allotted class time for this project and met in a less formal setting. In fact, some of our most productive work stemmed from casual conversations between team members outside of the classroom environment.

Having the opportunity to interact with industry experts to gain feedback and suggestions for improvement to our concept was extremely beneficial. In the early stages of formulating our idea, conversations with professional pilots and ATCs helped us to narrow the scope of what we wanted to tackle. In the final stages, Mitch Huffman from the Atlanta Flight Standards District Office was enormously accommodating answering our many concepts and carefully explaining the certification process. Aside from the applications to our project, I feel that learning about the airworthiness certification process was one of the most useful things I have learned this semester.

Cassandra Gribbins

Participating in the FAA Design Competition was a meaningful learning experience for me. It was my first professional team experience and happened to be part of my first graduate class. I initially felt overwhelmed by all of the possibilities that our team could focus on and did my best to research runway incursions, excursions, airport maintenance, airport lighting system and many other topics. I enjoyed learning the different aspects of an airport. When we began developing our idea for iTaxi, I was surprised at all of the technology that is in development and currently in use.

Some challenges the team encountered during the process was the many possible ideas and the diversity of the team. Early on in the semester, we were able to agree on Runway Safety/Runway Excursions/Runway Incursions. Everyone researched the field and brought a few suggestions to the table and we narrowed our way down from there. The diversity of our team became beneficial as we were able to hear different perspectives and new ideas.

I learned so much about airports and teamwork during this process. I am also grateful for the Daytona Beach International Airport Personnel for talking to the class. The quick rundown of the many different operations occurring on airports provided clarification and ideas for possible topics. I also appreciated being able to take a tour of Daytona Beach Tower and was able to see the communication that occurs between the air traffic controller and the pilot. In the teamwork aspect, this was my first big research project and I will definitely take this experience to help me in my future classes and projects.

Joey Jaworski

Through this design project I have learned many things, but the one thing that I will take away from this project most is the importance of teamwork. From the beginning it was evident that our team was going to work well together. Our diverse backgrounds helped us find each other strong points and weaknesses. However, through working together we were able to help each teammate out in the areas they struggled in and we utilized everyone's strengths effectively.

The greatest challenge that I think all teams face was the conceptualization of an idea. Our team was no different in that aspect and we struggled for many weeks just to find our idea. However, by working so strongly together we came up with iTaxi. The greatest part about iTaxi was that it did not come to us in a formal group meeting, but rather while our group was sitting down to eat dinner. It was amazing to see how not thinking about it for once helped us to find, what we feel, is a great idea.

I think the greatest accomplishment was within myself. I have never worked with a team this large before, but I feel that having done so has really enhanced my skills at working within a team. Being one of the younger members of the team was one thing that I thought would be difficult, since I didn't have as much "real world" experience as most of my teammates. However, I did not ever feel that I was not taken seriously, or that my ideas were taken for granted.

Finally, I do believe this project, although intimidating at times, is one of the greatest learning experiences and accomplishments of my time in college. The lessons truly did extend outside of the classroom, which made for an exciting, thought provoking, and teambuilding learning experience.

Camilo Jimenez

After the completion of this project I feel that this was a great learning experience not only because I was able to learn about different issues that affect the aviation community, but also because I was able to implement the knowledge I was acquiring in the classroom into this project. This project also gave me the opportunity to work with outstanding individuals (my teammates) that were a valuable source of information in a diversity of areas in which my knowledge was limited. Now, thanks to their help and the help provided by some subject matter experts I have a better understanding of runway safety issues.

At first, since my knowledge on this topic was limited, it was rather difficult as I had to catch up with the rest of the group and had to spend extra time learning about different concepts in aviation. As a team I think our greatest challenge was to come up with an idea that we felt was worth pursuing. We had many meetings brainstorming and discussing the pros and cons of different ideas we had in mind. Finally, thanks to numerous hours of teamwork and interactions with some subject matter experts we were able to come up with an idea we were all comfortable with. As I mentioned before, communicating with subject matter experts was very important in this project. Thanks to these interactions we could learn more about runway safety issues, existing and future technologies, and FAA requirements that iTaxi needed to comply with. Also, feedback provided by subject matter experts helped to shape iTaxi.

What did I learn from this experience? Well, I had never worked with a group so large and diverse before, and that was something new for me. As a future human factors professional, this experience has given me the opportunity to understand how these types of projects need to be approached. I have also learned how important it is to understand everyone's perspective on the topic in order to be able to develop ideas that can be beneficial for the final user.

Antoine Juhel

This has been the first project I have worked on with such a diverse group of individuals. With everyone coming from different academic backgrounds it made for an expectational collaboration of ideas and opinions. Even with a group of seven the bumps in the road were rare and most of the time everything went smoothly.

The hardest part for us was to narrow down are interests, choose a category and then agree on a solution. We spent a lot of time exploring different avenues before finally settling down on one category. What helped us the most was talking with aviation and airport experts and getting their opinions on our ideas. A lot of our design decisions were made with the help of feedback from industry experts as well. This made our project feel more applicable and real that others in the past.

This project also open my eyes on the current problems faced by airports all around the globe. When airport managers from Daytona Beach International came to talk to us and explain what it meant to run an airport, I was fascinated. From day to day operations to wildlife issues, I never realized how much work and manpower was needed to maintain an airport. Even things that might seem trivial can require extensive planning and work. As my first graduate level project this was a great way to start!

Shalinda Perera

This was an intriguing project that brought together individuals of many different educational backgrounds. This in turn created an extremely competent team that allowed for the flow of ideas to be rather natural and logical. Our team especially benefited from the diversity because we had team members from Human Factors, Air Traffic Control, United States Air Force, Royal Canadian Air Force, Psychology, Engineering and Aviation. This helped bring many different perspectives for a better end result.

The biggest challenge we had as a group was brainstorming and coming up with an idea. We overcame this by meeting outside of class and talking about different experiences we had in individual circumstances that pertained to each other. When we had an idea of what needed to be improved in runway safety and where most errors occur we honed in on the idea of iTaxi. We were able to improve our rough idea due to each of our experiences in the aviation field, and were able to find contacts to help us with the design phase as well. However, even with a large group we all put in tremendous effort to complete this project.

Although having a large group risks different opinions to clash, our project overcame this by respecting each other's opinions and having an open mind throughout the entire process. This allowed for a smoother completion of the project and a fun atmosphere. Overall this project was an unbelievable learning experience because it opened my eyes to how things are done in the real world.

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