R.I.P.S.

Hampton University
School of Engineering & Technology
Department of Aviation
Team Members

Griffin Weathers, B.S. Flight Education
Raha Maxwell, B.S. Aviation Management: Admin
Cameron Ray, B.S. Aviation Management: Admin
Ellis Woodyard, B.S. Flight Education
Jordan Williams, B.S. Aviation Management: A.T.C.
Julian Payne-Dillard, M.S. Aviation & Aerospace Management
Kailyn Hyman, B.S. Aviation Management: Admin
Kiuma Muchira, B.S. Flight Education
Montá Williams Jr., B.S. Aviation Management: Admin
Myles Divinity, B.S. Flight Education

Faculty Advisor
Professor Andrew Smith, AT-CTI Program Director/Assistant Professor
Department of Aviation

Industry Partners
Rick Aviation
IFly

HAMPTON UNIVERSITY

R.I.P.S Hampton University

FAA Challenge
Smart Airport Student Competition

Objective and Description of Effort:

- The objective of our project is to create an app to help reduce runway incursions and taxi mishaps

Technical Approach:

- Discovered the need for a general aviation taxiing aid

Image:

Team & Management Approach:

- Team lead: Griffin Weathers
  Team co-lead: Raha Maxwell
- Griffin - Summary/Concept
- Raha - Summary/Concept
- Jordan - Impact statement
- Kailyn - Research/ Problem Statement & Background
- Montá - Research
- Cam - Research/Problem Statement & Background
- Myles - Risk Assessments
- Ellis - App/Demonstration Materials
- Julian - App/Demonstration Materials
- Kiuma - Problem Solving Approach

Schedule:

- October 31st: Expression of interest
- November 15-23: Brainstorming ideas
- December 8- January 17: Researching and writing project plan proposal
- March 3: Became finalist
- March 7- May 8th: More research and outreach to companies to help design our app
- April-May: Finish Technical paper

Cost:

- Total estimated cost $30,300
  - Amazon Web Service
  - Database
  - Security
  - App Store fee
  - Domain Name

2 Executive Summary

The aviation industry is the safest mode of transportation today. Our well-trained pilots and air traffic controllers ensure that the aviation industry is withheld to its prize safety standard every day. One problem the industry constantly faces is runway incursions. The Federal Aviation Administration (F.A.A.) defines a runway incursion as "any occurrence in the airport runway environment involving an aircraft, vehicle, person or object on the ground that creates a collision hazard or results in a loss of required separation with an aircraft taking off, intending to take off, landing, or intending to land."(FAA ,2021). The primary factor in runway incursions is general aviation pilot deviation or communication errors with air traffic control (A.T.C.) and the Pilot in Command (P.I.C.). More than 90% of the roughly 210,000 civil aircraft registered in the United States are general aviation aircraft. And of the nation's approximately 600,000 pilots, an estimated 500,000 or more fly general aviation airplanes. (A.O.P.A., 2021) General aviation (G.A.) pilots are 80 percent of all aviation and are responsible for approximately 74 percent of runway incursions during the four years from fiscal year (F.Y.) 2001 through F.Y. 2004. As air transportation increases, so will the amount of planes increase which means safety needs to improve in aviation.

Hampton University Aviation Department's team consists of student pilots, airport administration, and A.T.C. students who discovered the high prevalence of runway incursions. General aviation accounts for yearly runway incursions at an alarming rate. With many team members being student pilots who are a part of the G.A. community, runway incursions directly impact us. As a result, we came up with the Runway Incursion Prevention System or R.I.P.S.

R.I.P.S. is an application that utilizes augmented reality (A.R.) to help direct pilots to their respective runways, taxiways, and terminals/ramps. The application will ask for the taxiing route then it will give pilots audible instructions in the cockpit, such as when to make turns, what taxiway they're currently on, and how long they must go before their next turn. This operational guidance would mitigate problems and reduce the number of runway incursions. This application will work with and enhance the procedures already implemented in A.T.C. and pilot communication.

This project aims to reduce the number of runway incursions at airports across the globe. Taxiways and runways are crucial parts of aviation and must be safe and efficient. We acknowledge some current companies and programs are developing solutions to runway incursions in general aviation.

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4 Problem Statement and Background

Aviation is a highly used method of transportation. Therefore, air travel needs to be safe and efficient. The risk of an aircraft collision increases when aircraft are on the ground. With that in mind, planes need to be extra cautious from the departure terminal to the destination terminal. Therefore, the safety of runways and taxiways is a crucial part of every flight. Smooth navigating from the taxiways to the runway is necessary for a smooth flight for the crew, passengers, and air traffic control.

As many know, piloting is very difficult, and much training is needed for safe operation. In addition to the flying portion, each pilot needs to be cognizant of the runways and oncoming air traffic. While taxiing to the runway, there are many signs that the pilot in command needs to be aware of to follow the air traffic controller's instructions. These signs include taxiway markings, runway markings, holding position markings, and many others(A.I.M., 2021). Every pilot, especially in general aviation, needs to have updated knowledge on all of the above to keep the runways safe. When pilots aren't entirely aware and knowledgeable, it could lead to runway incursions.

There were 1573 runway incursions in 2021 (F.A.A., 2021). Of these incursions, 65 percent were caused by pilot deviation. These numbers have consistently hovered around 1500 since 2012. The airport is tied with the most incursions, John Wayne Airport and L.A.X., California. Most runway incursions happen at towered airports, and 40 percent occur with general aviation pilots. The primary factor in runway incursions is general aviation pilot deviation or communication errors with A.T.C. and the pilot. Within that communication, the error tends to be the pilot's failure to hold short of the runway as instructed, accounting for 61.6 percent of all incursions (Brary, 2021). Other causes of runway incursions are the wrong entry of aircraft or vehicles on the runway and incorrect spacing between departing and arriving aircraft. Pilots are unfamiliar with the airport or phraseology. Many general aviation incursions are caused by failure to comply with signs or getting lost/confused. When incursions happen, they are categorized by their seriousness. The categories are as follows:

- Category A - a severe incident in which a collision was narrowly avoided.
- Category B - an incident in which separation decreases, and there is a significant potential for collision, resulting in a time-critical corrective/evasive response to avoid a collision.
- Category C - an incident characterized by ample time and distance to avoid a collision.
- Category D - an incident that meets the definition of runway incursion, such as the 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.

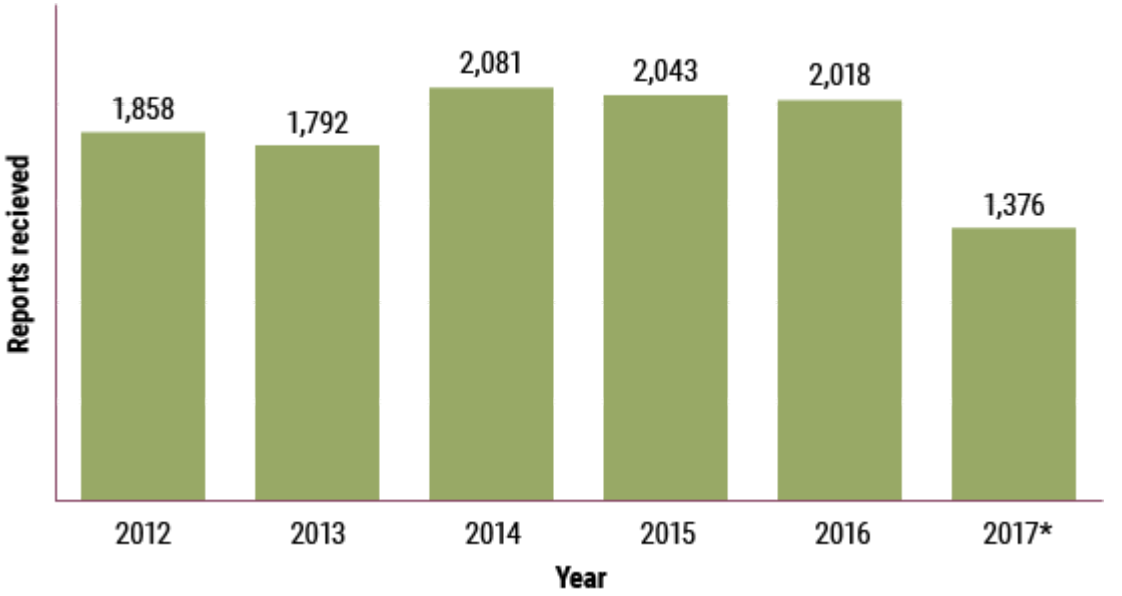
Most incursions are Class D with no significant consequences. However, this does not negate the seriousness of runway incursions. Runway incursions occur at all airports, therefore impacting safety in aviation. Runway incursions are severe and occasionally deadly, as proved in numerous incidents. The most infamous runway incursion was the Tenerife Airport disaster. The incursion happened when two Boeing 747 collided on the runway due to many factors; however, poor crew resource management issues with A.T.C. clearance. The result of this runway incursion was 583 fatalities. The last fatal runway incursion happened in 2006 at Blue Grass Airport in Lexington, Kentucky, which resulted in only one survivor among the 50 passengers.

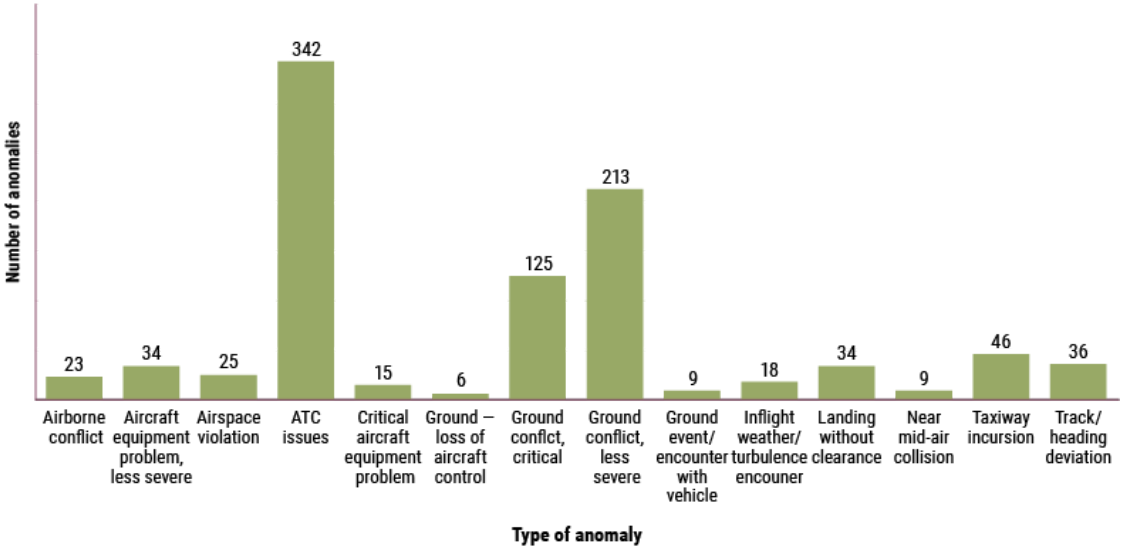
The F.A.A. also prioritizes runway safety and is always working to help runways be safer. For example, they are currently working on a standardized hotspot symbol. Hotspots are runways with a heightened risk and a history of many incursions. By making a standardized symbol, pilots and others using runways can be informed, plan for, and pay extra attention to the runway. The

F.A.A. states, "Proper planning helps avoid confusion by eliminating last-minute questions and building familiarity with known problem areas." In addition to the standardized hot spot symbol, the F.A.A. is also releasing an Arrival Alert Notice to many airports with a history of misalignment risk. Arrival Alert Notices (A.A.N.) are graphics visually depicting the approach to a particular airport with a history of misalignment risk and language describing the misalignment risk (F.A.A., 2022). With these new developments, pilots and other runway users should be more prepared and aware of the runways to lessen the incursion rate.

In addition to the F.A.A. taking measures for safer runways, aerospace companies such as Honeywell have applications to prevent runway incursions for airliners and jets. The application, Runway Awareness and Advisory System, allow the pilot to have timely information regarding the landing and runway, which is very helpful for the final approach stage of landings. Compatible aircraft include, but are not limited to, Airbus 380, Boeing 737, and Citation X. Although this application has helped decrease runway incursion, it does not help the majority of general aviation, which is who causes the most runway incursions.

In summary, taxiway and runway knowledge a crucial to pilot information and essential to the industry's safety. Taxiing is difficult due to the amount of knowledge a pilot must be up to date on and follow the instructions given by A.T.C. perfectly. Although the F.A.A. is already working to improve runway safety by notifying pilots of areas with a high incursion rate, it is vital to enhance taxiing to and from the runway. Incursions tend to happen due to communication errors, primarily between general aviation pilots and A.T.C. So, it is pertinent that the communication and instruction aspect is enhanced. The F.A.A. keeps a running total of runway incursions, and as of April 19, there have been 859 in 2022. The majority of runway incursions are class D; however, the number of runway incursions has not improved, which has led us to develop the concept of R.I.P.S. to rectify the safety problem of runway incursions.





5 Project Description

5.1 Design Overview

Our project concept is an app that utilizes augmented reality to aid general aviation pilots in taxiing. It will achieve this by using G.P.S. location and pre-downloaded airport diagrams to show real-time directions. As soon as the pilot is ready to taxi, they will open the app and select their departing and arrival airport. After they receive their taxiing instructions, they will proceed to select their departing runway. Once they have selected their runway, they can either quickly select nearby taxiways or enter it manually and press "G.O.." The app will calculate the distance and directions needed for the provided taxi routes and provide live A.R. directions similar to other G.P.S. mobile apps. If the pilot makes the wrong turn or approaches a hold short line or an active runway, the app will alert the pilot.

5.2 Concept

5.2.1 Concept of R.I.P.S App

R.I.P.S. is an application that utilizes augmented reality (A.R.) to help direct pilots to their respective runways, taxiways, and terminals/ramps. The application will ask for the taxiing route then it will give pilots audible instructions in the cockpit, such as when to make turns, what taxiway they're currently on, and how long they must go before their next turn. This operational guidance would mitigate problems and observe the airport's taxiways and runways. This application will work with and enhance the procedures already implemented in A.T.C. and pilot communication.

5.3 Concept of Operation

5.3.1 Concept of R.I.P.S. Operations

Many of the processes this app uses are conducted by the user's device. Once the user selects the two different airports that will be utilized during the flight, the app will download both of the airport diagrams so that they may be utilized even in the event of a lost internet connection. The app can also store the last two airports that have been used. This will save the user data by not having to download the different airport data if they may be returning to their home airport. Once the user is ready to start their flight, they input the runway from which they would like to depart. The app will set a waypoint from where the pilot is to the active runway. The app will then use a sorting algorithm, such as Dijkstra's algorithm. This will plot the shortest path and most likely course to the active runway. The app will then pull the taxiways that give the shortest path onto the screen so that the pilot may select them with ease if given taxi instructions. This process will be reversed when the pilot lands the aircraft. The user will tap the appropriate gate or hanger they will park at, and the app will show the shortest path and give suggestions on what direction the user might take. They input the path, and the pilot will follow the path.

During taxi, the app will use G.P.S. location first to assess where the pilot is. The app will then set and use waypoints on each taxi to determine what directions will be used. Like the basic G.P.S. for car navigation, the app will use the distance formula:

And give the user tips on how far they may be from the end of the taxi, how much longer to go straight, and how much closer they are to turning left or right. The app will also note the different movement areas and alert the pilot of upcoming stops and when to advise Air Traffic Control.

Coding Language/Device Applications

The following describes and visually depicts how the application will operate. The coding language of choice will be Apple's swift software. It works best with the IOS operating system found on Apple products, which most general aviation Electronic flight Bag (E.F.B.) users prefer. The base code written in one language can also be translated/converted to other coding languages such as C and AVA/SPARK, which are all common languages for avionics found in most general aviation aircraft.

Acquiring Position

Getting the full benefits of the application will require a G.P.S. input that can be provided by the device or external through an ADS-B feed. Considering the G.P.S. requirement and the possibility of a G.P.S. outage, and intermittent or even incorrect position readings, a non-location-dependent coding string will be written. In addition, the app will display the connection reliability in the corner, providing the user with a constant status report of the app.

$$d = \sqrt{(x_1 - x_2)^2 + (y_1 - y_2)^2}$$

5.3.2 Concept of User Operation

Upon opening the app, the user will be greeted with a few different options. The main options screen consists of two bars. The first bar is a drop-down menu of what airport the pilot is at, and the second bar is the destination the pilot will be landing at. Once the selection is complete, the pilot presses “Ready” and is ready for their flight. The screen will then change to the options menu for the departure airport. The pilot will first select the active runway they are departing from. This will then bring up adjacent runways to which the user will be able to quickly choose taxiway instructions from the controller or manually input the selection. Next, this will bring up an overhead view of the airport and the pilot's intended route. Once verified, the pilot presses "G.O.' and is ready for their flight. The device will then show an augmented reality of where the pilot is relative to the ground with directional instructions on when and where to turn.

5.4 Expected Potential

With this app, we envision it being used by many different pilots in the industry's general aviation side, ranging from student pilots to business pilots to recreational pilots. With our app being used, we also expect to see a decrease in runway incursions per year, especially on the G.A. side of aviation. With our research, we will be able to determine how we can make the app more useful and palatable to pilots in hopes of it being used as much as IFly and Foreflight.

5.5 Risk Assessment

5.5.1 The importance of risk mitigation

Risk mitigation is significant in aviation and is possibly what aviation is known for. Therefore, it is equally important to consider the different risks that may affect our desired goals. Therefore, risk mitigation must be looked at and thoroughly thought of. Consequently, the app developing team has created a list of possible risks that could occur with this app. The list also comes with potential solutions and possible causes of said risks.

5.5.2 NEW RISKS

Distracting or disoriented users	● To mitigate distractions, pilots/users shall only insert taxi instructions as they are received, not meant to be used during taxi, only before. ● R.I.P.S. will make it easy for pilots to follow by notifying users visually and aurally if they are going away from the designated route, as well as approaching the runway
How will R.I.P.S. prevent incursions?	● The user will be alerted of directions visually and/or aurally and nearby aircraft via ADS-B.
How will R.I.P.S. notify the user of upcoming runways/taxiways/hot spots etc?	● R.I.P.S. will notify the user when approaching hot spots, taxiways, runways, etc., visually and/or aurally.
How will R.I.P.S. be useful for directions and preventing distractions	● If the user makes an incorrect turn or approaches a hold short line, other aircraft, etc. R.I.P.S. will inform the user of the situation visually and/or aurally.

5.5.3 Social Risks

What is the attainability of R.I.P.S?	● R.I.P.S. will be downloadable from not only the google play store but the apple app store as well.

Taxing at a towered vs. non-towered field	● When taxing at non-towered fields, R.I.P.S. will allow you the option to select your final destination, and R.I.P.S. will create the best route to get there. ● Taxing at towered fields will allow you to turn off automatic route generation, where you will manually insert your route.
The user wants to change features, making R.I.P.S. how they want it.	● All features can be turned on or off; thus, if one feature is not working correctly and becomes disabled.

5.5.4 Cyber Risks

Keeping airport diagrams up to date.	● R.I.P.S. will notify the user through the device's notification system and receive over-the-air updates. ● If built into other apps, this will be done based on their procedures, databases, and ours. ● R.I.P.S. will be receiving live NOTAMs to keep airport diagrams up to date ○ The user must have an internet connection for this feature to work.
Ensuring that the correct airport diagram comes up upon landing.	● Upon landing, the airport you've landed at will be chosen for you automatically; R.I.P.S. will know which airport you're at via G.P.S. As well as the fact that you will be able to choose which airport diagram you want to be shown.
A lack of G.P.S. connectivity issues	● If the G.P.S. fails, the user will no longer see themself on the map, but the route may still be drawn out, making it easier to follow. ● R.I.P.S. will alert the user of a lack of G.P.S. connection.

No internet Connectivity in general	• A lack of internet connectivity will not allow R.I.P.S. to be updated; therefore, you will not have the most up-to-date airport diagrams. • A lack of internet will also prevent the user from searching for non-downloaded airport diagrams, making the only accessible diagrams the ones which are already downloaded.
The user's device lacks G.P.S. connectivity entirely	• If the user's device lacks G.P.S. connectivity entirely, R.I.P.S. will alert the user of a lack of G.P.S.; however, the user will still be able to map out their route.
The user cannot insert taxi instructions/draw taxiways	• Even if the user can not insert taxi instructions or R.I.P.S. does not draw out a taxiway, the user will still be able to see themselves in the airport diagram and have the airport diagram out and accessible.

6 Research

Upon completion of the app, we plan to utilize a survey during the beta stages of the app to modify any discrepancies that negatively affect app usage. Unfortunately, our application is still pre-alpha, meaning that the app is still being coded to conduct the proper functions of the app.

6.1 Research Methods

As aforementioned, all data would be collected via a survey directly after using the application during taxiing/flight. The app itself will not use data collection methods in its early stages, so that we will rely on the input of a select few willing participants.

6.2 Data Collected

Data will be collected via the survey given post-flight and have an array of questions such as "how accurate was the mapping," "how distracting was this app to use while operating the aircraft," and "how easy was the application to use." These questions will be given a range of 1-5 for numeric values when it is time to plot data points and conduct a statistical analysis. We will emphasize the importance of including how many total flight hours a tester has within the survey to ensure we get all levels of pilots' input. During the apps testing stages, we will be recording which took the survey and would expect the study to be completed multiple times throughout a specific time period; this way, we are given more accurate data points and can cross-reference dates/times for any potential weather complications. For example, if a tester uses the app between 1400 and 1500 on a given day and the application's G.P.S. is off slightly, we can cross-reference weather conditions and find a way to account for this issue. As the application progresses, we plan to constantly update the app with accurate airport graphics (to include closures, etc.) specific to your location. In addition to this, we will keep a close eye on how the application handles the automated route generation for untowered airports, as this is where the app's capabilities will truly shine. As of now, we have no hard date for the completion of the application, and as mentioned, it is currently in pre-alpha being coded while also going through the proper channels to roll out the app for public use.

6.3 Data Determinations

From the information gathered through the survey, we plan to showcase what the application is capable of and what changes can be made in the future. These determinations will help us improve on the application and, with specific user input, what can make the application more appealing, both technically and aesthetically.

7 Conclusion

With our app in development, we are still waiting to experience its helpfulness and ability in full effect. While waiting for the app to be developed, we have brainstormed some ideas that we believe will also help improve the app and its safety. Some of these features include using ADS-B to see incoming traffic while holding short of a runway, especially at non-towered airports. Another feature we had thought about was a 3D rendering of your taxi route so you can visualize it before departing.

7.1 Impact Statement

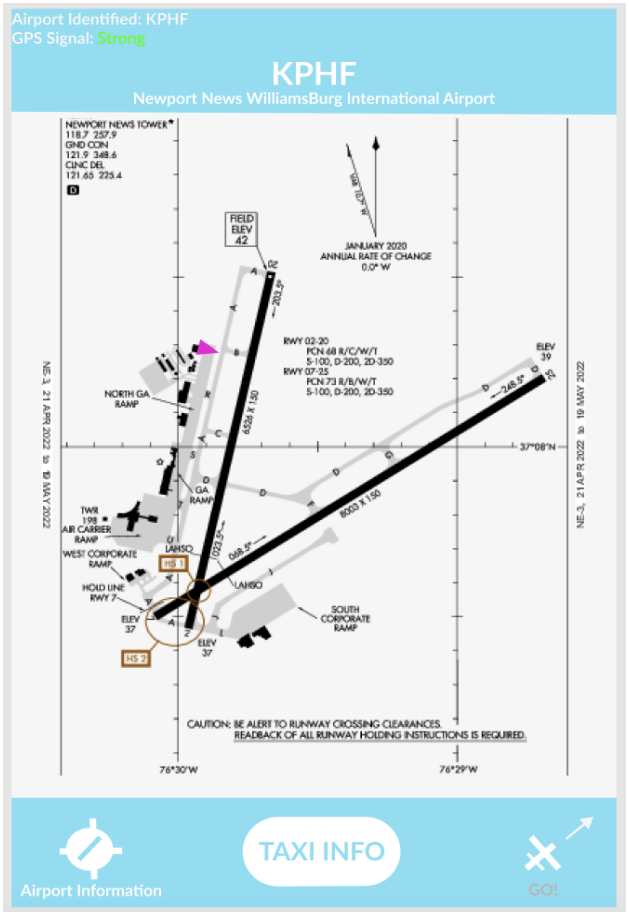
The aviation community prides itself on the focus on efficiency and, most importantly, safety. We plan to utilize augmented reality (A.R.) with our new application to help direct pilots to their respective runways, taxiways, and terminals/ramps. This app will create a seamless and immersive track and voice commands on whichever mobile device or table the pilot has onboard. Our mission is to reduce and mitigate the frequency of incursions that occur during all ground

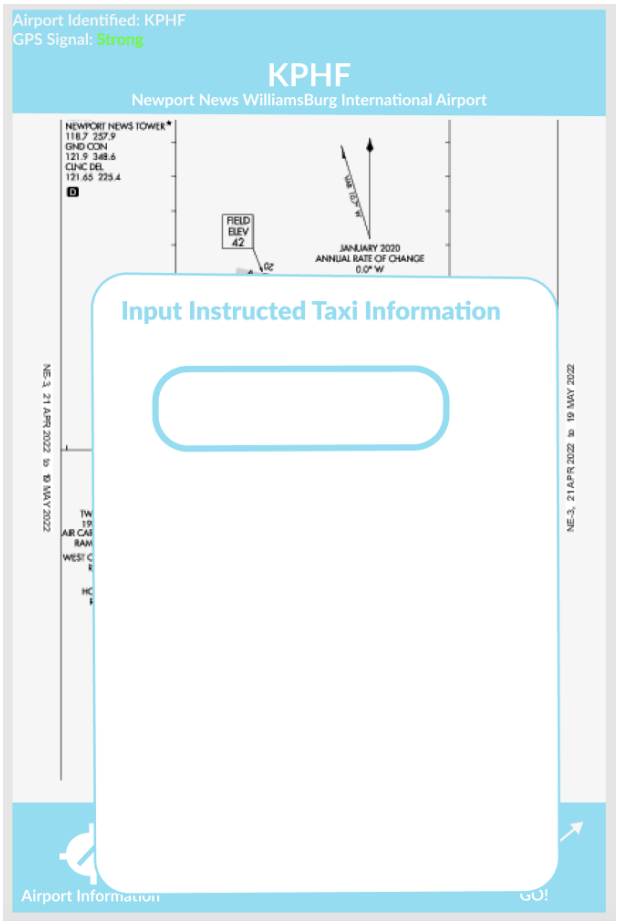
operations.

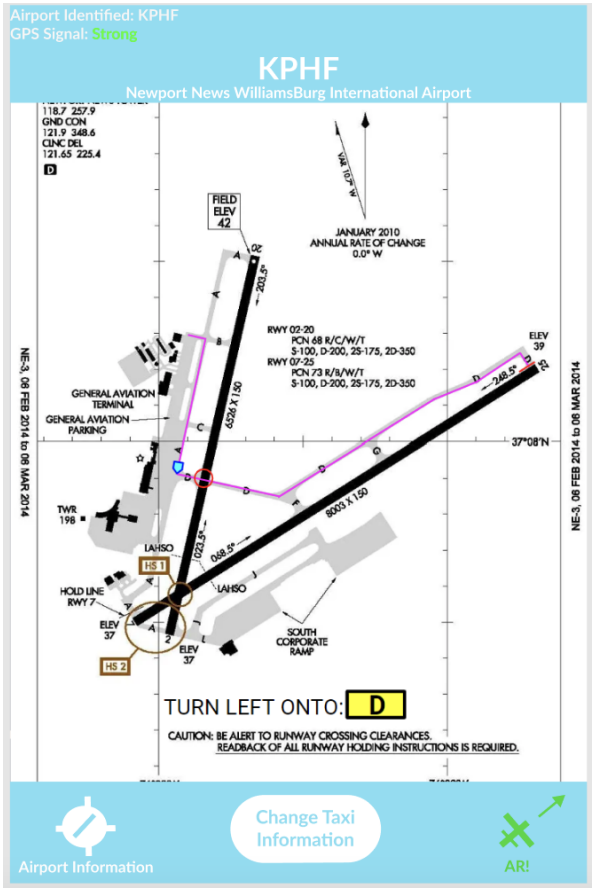
General aviation accounts for the majority of the recorded incursions to date; with this app, we hope that pilots can streamline their ground operations in a more efficient and focused manner. However, it is essential to note that this application is not an alternative to air traffic controllers and is not an effort to replace them; this app is to be used in conjunction with the standard operating procedures and commands given by A.T.C.

Our application will significantly benefit student pilots, private pilots, and general aviation. As stated previously, most incursions happen within this population of the aviation community. This app, accessible to the public, gives beginners a way to easily learn about the airport and the best way to navigate it. Even for some of the more seasoned pilots, this app will be able to orally notify them when/if there is another airplane on the route, which essentially acts as a “traffic” call you would receive from a live controller, and be able to cover any blind spots or complete lapses. Ultimately we want to create a safer environment for operating aircraft on the ground by utilizing G.P.S., augmented reality, and onboard transponders to collect data on plans in immediate surroundings. Finding a way to link transponder feedback to our app seamlessly is critical as this will give pilots with this application an actual "live look" at what is going on around them. With all of these factors in place, our goal is to reduce the number of runway incursions significantly nationally and globally because safety is imperative.

8 Technical Demonstration


Airport Identified: KPHF
GPS Signal: Strong
KPHF
Newport News WilliamsBurg International Airport
NEWPORT NEWS TOWER*
118.7 257.9
GND CON
121.9 348.6
CLNC DEL
121.65 225.4
FIELD ELEV 42
JANUARY 2020
ANNUAL RATE OF CHANGE
0.0° W
RWY 02-20
PCN 68 R/C/W/T
S-100, D-200, 2D-350
RWY 07-25
PCN 73 R/B/W/T
S-100, D-200, 2D-350
6552 X 150
8003 X 150
NORTH GA RAMP
GA RAMP
TWR
AIR CARRIER RAMP
WEST CORPORATE RAMP
LAHSO
HS 1
HS 2
HOLD LINE RWY 7
ELEV 37
SOUTH CORPORATE RAMP
ELEV 39
37°08'N
76°30'W
76°29'W
NE-3, 21 APR 2022 to 19 MAY 2022
CAUTION: BE ALERT TO RUNWAY CROSSING CLEARANCES.
READBACK OF ALL RUNWAY HOLDING INSTRUCTIONS IS REQUIRED.
Airport Information
TAXI INFO
GO!


Airport Identified: KPHF
GPS Signal: Strong
KPHF
Newport News WilliamsBurg International Airport
Input Instructed Taxi Information
Airport Information
GO!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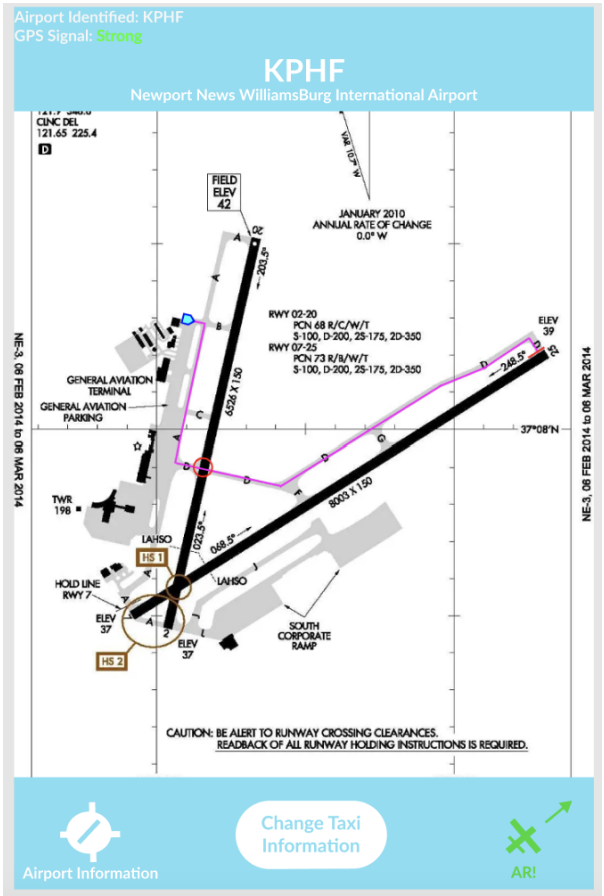
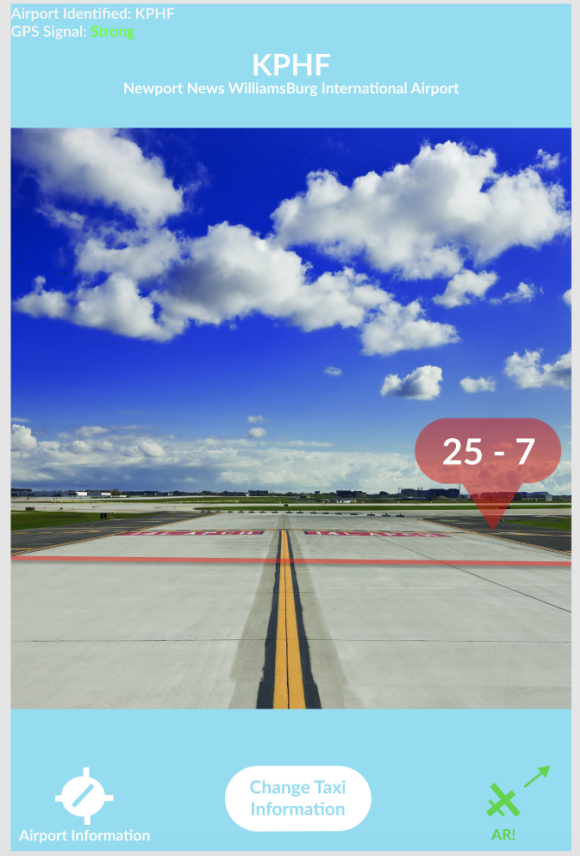
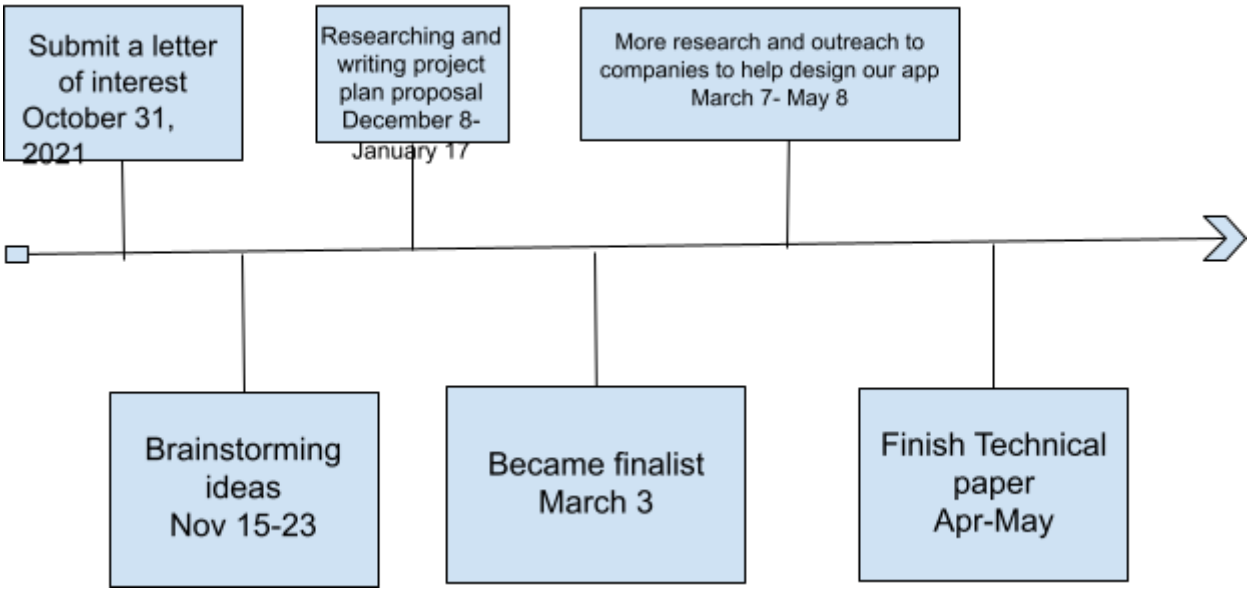
GPS Signal: Strong
KPHF
Newport News WilliamsBurg International Airport
JANUARY 2010
ANNUAL RATE OF CHANGE
0.0° W
FIELD ELEV 42
RWY 02-20
PCN 68 R/C/W/T
S-100, D-200, 2S-175, 2D-350
RWY 07-25
PCN 73 R/B/W/T
S-100, D-200, 2S-175, 2D-350
ELEV 39
GENERAL AVIATION TERMINAL
GENERAL AVIATION PARKING
6526 X 150
8003 X 150
37°08'N
TWR 198
LAHSO
HS 1
HOLD LINE RWY 7
ELEV 37
HS 2
SOUTH CORPORATE RAMP
NE-3, 06 FEB 2014 to 06 MAR 2014
TURN LEFT ONTO: D
CAUTION: BE ALERT TO RUNWAY CROSSING CLEARANCES.
READBACK OF ALL RUNWAY HOLDING INSTRUCTIONS IS REQUIRED.
Airport Information
Change Taxi Information
AR!


Airport Identified: KPHF
GPS Signal: Strong
KPHF
Newport News WilliamsBurg International Airport
JANUARY 2010
ANNUAL RATE OF CHANGE
0.0° W
FIELD ELEV 42
RWY 02-20
PCN 68 R/C/W/T
S-100, D-200, 2S-175, 2D-350
RWY 07-25
PCN 73 R/B/W/T
S-100, D-200, 2S-175, 2D-350
ELEV 39
GENERAL AVIATION TERMINAL
GENERAL AVIATION PARKING
6526 X 150
8003 X 150
37°08'N
TWR 198
LAHSO
HS 1
HOLD LINE RWY 7
ELEV 37
HS 2
SOUTH CORPORATE RAMP
NE-3, 06 FEB 2014 to 06 MAR 2014
CAUTION: BE ALERT TO RUNWAY CROSSING CLEARANCES.
READBACK OF ALL RUNWAY HOLDING INSTRUCTIONS IS REQUIRED.
Airport Information
Change Taxi Information
AR!


Airport Identified: KPHF
GPS Signal: Strong
KPHF
Newport News WilliamsBurg International Airport
25 - 7
Change Taxi Information
Airport Information
AR!

9 Project Timeline



10 Budget

As of now, we have not had to pay any money for any research purposes. However, we will have our beta testers use the app on pre-scheduled flights when we start beta testing. This way, they will not be paying out of pocket for research for the project.

We will be sending three team members to represent the Hampton Aviation R.I.P.S. team to Atlantic City for the competition. The total cost will be $1,937.18

11 References

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