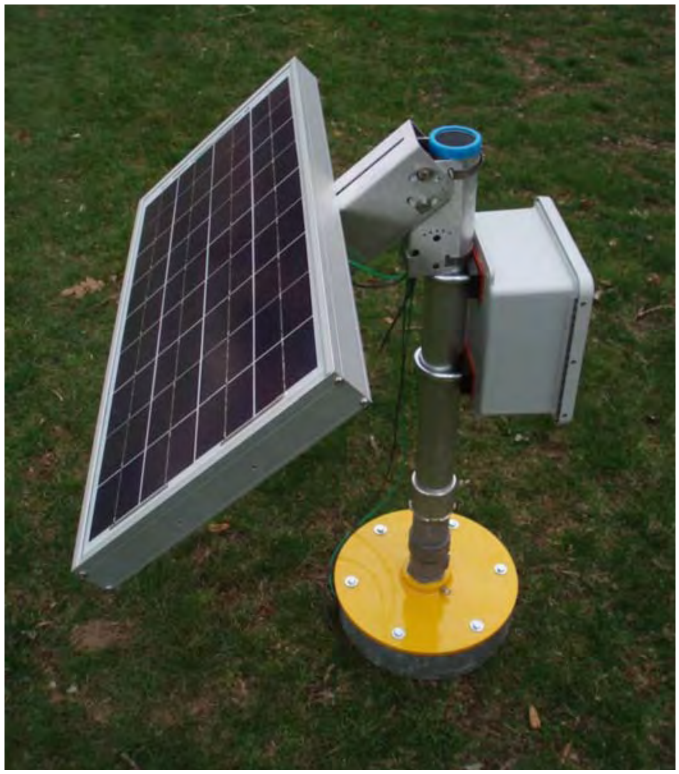
Aviation Operations Monitoring System



University of Rhode Island

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EXECUTIVE SUMMARY

Airports throughout the country are required to track the number of aviation operations occurring on their runways and submit this data to the Federal Aviation Administration (FAA). Currently, the primary data collection method for runway operations at non-towered airports involves airport personnel manually counting the daily operations. Considering the fact that FAA funding is appropriated based on the runway operations data, the inherent errors involved in this method are unacceptable. Therefore, there is a need for an effective automated system that would minimize human error and improve the overall accuracy of the submitted data. Improvements in the accuracy and documentation of operations will prove to be essential to the future progressive development of local non-towered airports.

The objective of this design project was to develop an automated system to improve the accuracy of runway operations data while abiding by all FAA safety requirements and Rhode Island Airport Corporation (RIAC) customer requirements. After extensive research and engineering analysis, the team elected to design a system that utilized Radio Frequency Identification (RFID) technology to perform the task of tracking and storing airport aviation operations data. The selected systems were chosen based on FAA regulations, customer requirements, and the dimensional data of Westerly Airport in Rhode Island that was acquired while surveying the airport with RIAC officials. The final design involves an assembly of separate parts that include an RFID reader mounted inside a protective housing that is attached to a frangible coupling. The RFID reader is powered by a photovoltaic solar panel charged battery, and it detects RF tags placed inside aircraft that transmit signal once they penetrate the range of the reader. Overall, the designed RFID system represents a cost effective approach to runway operations counting that yields data with significantly improved accuracy.

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PROBLEM STATEMENT AND BACKGROUND

The FAA holds an annual competition that challenges students to devise creative and unique solutions to current problems existing at airports throughout the country. The FAA competition design team from the University of Rhode Island includes four mechanical engineering students and one industrial engineering student. The team took on this project as part of a year-long Senior Capstone Design course taught by Professors Bahram Nassersharif and Carl-Ernst Rousseau. The team worked with the Rhode Island Airport Corporation (RIAC) as well as several industry experts in the fields of electronics and radio frequency technology.

An initial meeting with the RIAC was conducted to investigate the problems facing airports in the local area. These issues included:

Runway Snow and Ice Removal

Snow and ice removal is a pressing issue facing all airports that experience severe winter weather. The state of Rhode Island experiences an average total snow fall of 50-60 inches per year. Snow accumulation at this level can lead to dangerous runway surface conditions as well as visual hazards due to plowed snow mounds. The current resolutions for these issues involve costly snow melting machines and deicing chemical compounds that can be harmful to the surrounding environment. The RIAC is currently seeking solutions with increased safety and effectiveness for the problems involving runway snow and ice removal.

Wildlife Runway Incursions

Many of the non-towered airports in RI exist in the more rural regions of the state and experience excessive wildlife populations. Deer, coyote, and rabbits are just a few of the species commonly found roaming the airfields day and night. These animals can pose grave threats to aircraft pilots who risk serious damage and injury in the event of a collision. Airports throughout the country have attempted many solutions to this issue which include different types of fencing, scarecrows, sound disturbances, and pyrotechnics.

Runway Operations Data

Currently, there is a need for a tracking system that yields an accurate approximation of the number of aviation operations taking place at uncontrolled airports. Many non-towered airports presently use a data collection method that involves airport personnel manually counting the daily operations. The RIAC is currently seeking an automated system that eliminates the need for ineffective manual labor and improves the accuracy of the data for runway operations counting.

The final problem selection was based on current demand from local airports and the feasibility of proposed design concepts. After much deliberation, the team decided to address the issue of airport aviation operations counting and the lack of an effective automated system that produces accurate statistics. Upon reaching a conclusion for the design problem selection, the team began the design process with a systematic problem solving approach Figure 1.

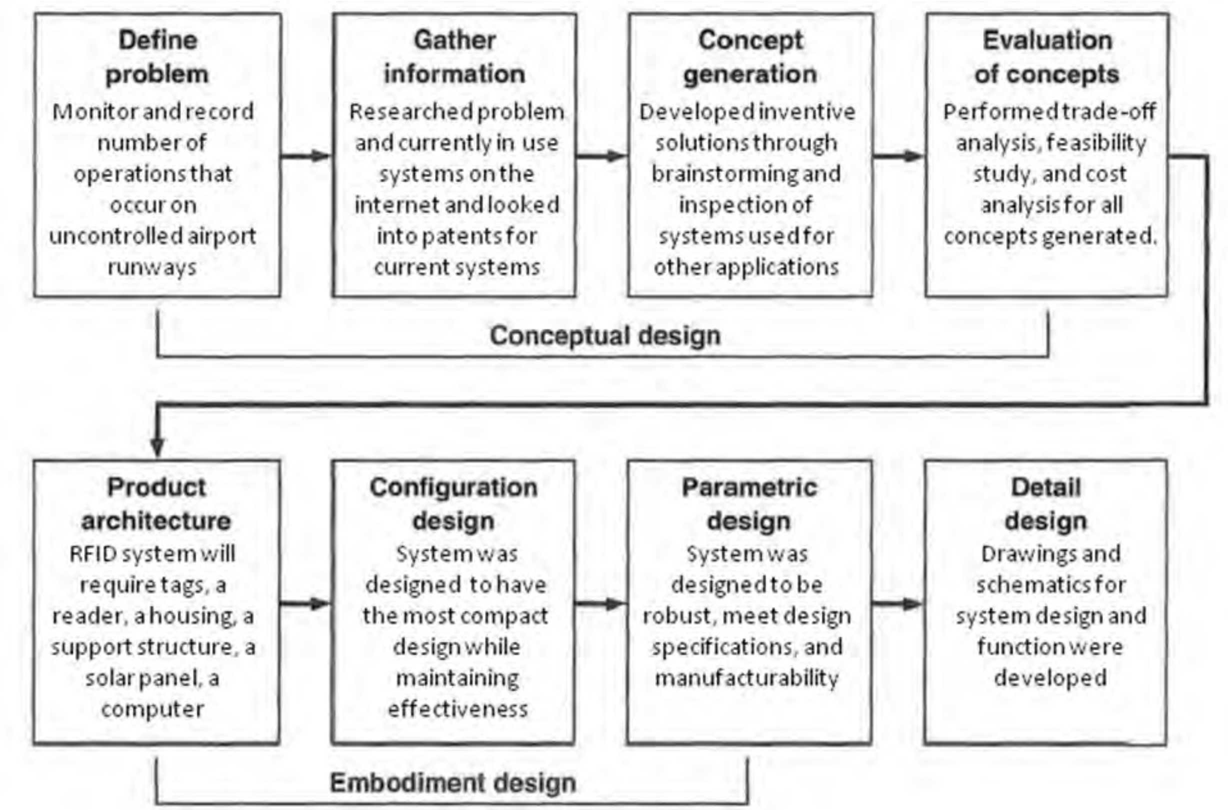


Figure 1: Roadmap to Engineering Design

The plan was to develop an automated system that tracks the number of aviation operations and transmits the data to a computer storage system that reads and records the aircraft identification information. The initial design concepts included a video surveillance system, a still shot camera with sensor trigger system, a beam breaking sensor system, a runway pressure sensor system, a runway imbedded RFID signal detection system, and a mounted RFID signal detection system. Overall, the system is intended to deliver accurate aviation operations statistics while minimizing the need for ineffective manual operations.

Work in the area of airport operations counting has involved the development of several systems that track aviation operations with varying degrees of accuracy. Hanscom Airfield in

Bedford, MA uses still shot cameras with motion detectors, but the effectiveness of this system is greatly reduced at night and in adverse weather conditions. Another system employed at Hanscom Airfield is a Noise Operations Management System (NOMS), which is a multilateral noise monitoring system that tracks airport operations using radar technology. This is an expensive system that is only capable of detecting aircraft carrying Mode F transponders. Automatic Dependent Surveillance Broadcast (ADSB) is a system that uses radar technology to detect signals transmitted from individual aircrafts. This system is expensive and designed for aircraft transmitting signals while in flight. Along with these automated systems, the most common method used for airport operations tracking at non-towered airports involves airport personnel manually counting the daily operations. Overall, work done in the field of airport operations counting is inadequate, and the need for an efficient, cost effective, and reliable system is still in high demand.

The team gathered several customer requirements from the RIAC and considered the primary competition in order to develop a set of design specification. The team sought to develop a system that would prove effective and affordable for non-towered airports in the local area. The team selected Westerly Airport to test and demonstrate the effectiveness of the proposed system. Several aspects of the system were designed specifically for the dimensional layout of Westerly Airport, but overall the system is intended for easy adaptability to non-towered airports in the local area and throughout the country.

SUMMARY OF LITERATURE REVIEW

When designing the device for operations counting, several literature sources were used during the design process. Most importantly, FAA Regulations formed the backbone of the design specifications. The design team and RIAC jointly decided that the FAA regulations involving radio frequencies on the airfield, and FAR 77, which regulates objects located in proximity of the runway would be the main focal point of the project. FAR 77, lead to the team's decision of implementing a frangible structure at a height no greater than three inches. Along with the FAA regulations, the team used a number of texts to aid in the design and analysis of the system.

In order to insure the team was following a proper engineering design approach, the required text book of the Capstone Design Course, "Engineering Design 4 Ed," was frequently referenced. The text written by George E. Dieter and Linda C. Schmidt proved to be a helpful tool to aid in the development of an effective design. The team used the text to enhance specific aspects of the design such as the problem definition, design specifications, cost analysis and several others.

A very important aspect of the design is to insure reliability and proper functionality. A number of engineering text books were referenced to aid the teams analysis. The analysis was used in accordance with the design process to help the team develop an effective system. "Shigley's Mechanical Engineering Design" was used to evaluate forces required to shear the frangible coupling. To evaluate the structures ability to withstand high winds, Frank White's, "Fluid Mechanics" was used to find the drag forces on the system. To find the force during a collision with an aircraft, the team referred to Tipler's, "Physics, for Scientists and Engineers." The analysis insured the design would structurally fail during a collision with an aircraft and would also be structurally sound during high winds.

PROBLEM SOLVING APPROACH

Throughout the year, the team followed a scheduled project plan which had an organized and normal regimen laid out by a Gantt chart. The Gantt chart for the first semester contains three main sections; conceptual design, design definition, and engineering analysis, which are marked in red. Within each of these segments many specific tasks took place, several of which were mandatory while others were supplementary. The main tasks required for the project are marked in blue and follow a systematic path. The additional tasks are broken into weekly meetings, highlighted in purple and other meetings and duties are colored in green.

Within the conceptual design segment of the Gantt chart the team met with the RIAC to discuss the concepts approved by the professors and further narrow the designs being considered. After meeting with the RIAC and the professors, the team decided to focus on runway operations counting and worked together to generate more concepts in that area. By the end of the conceptual phase, the team had many concepts to consider but had developed a clear problem definition. The next stage of the first semester was design definition and the discussion of the need for extra funding. Here, the team met again with the professors as well as with the RIAC to discuss the concepts generated regarding operations counting. Some of the best concepts generated by the team are described below as they were presented to professors and the RIAC.

Camera with Sensor System

This system (see Figure 2) would consist of a high resolution high speed camera, two beam sensors, a storage device for the photos, as well as a computer with Optical Character Recognition software, and a software program to create a database of recorded data and images. The camera and one of the sensors would be mounted on one of the tripods. A protective housing will surround the camera and sensors to improve weatherization and reliability. The camera would then be placed next to the runway, positioned so that the camera lens is oriented toward the runway. The other sensor would be mounted on the second tripod and would be placed on the opposite side of the runway, in alignment with the sensor mounted with the camera. As a plane lands or takes off, it will pass through the area where the camera is placed. When the plane passes by the system, the sensor's beam is broken which triggers the camera to snap a photo. The photo would then be stored on an external hard drive which would be removed at regular intervals for processing of the data. The storage device would be plugged into a computer and an OCR program that would evaluate the photos and extract the N-Number from the aircraft in the photo. The N-Numbers recognized by the OCR program would then be added into a modifiable, searchable database for easy access by airport officials. Advantages and disadvantages of this concept are listed in Table 1.

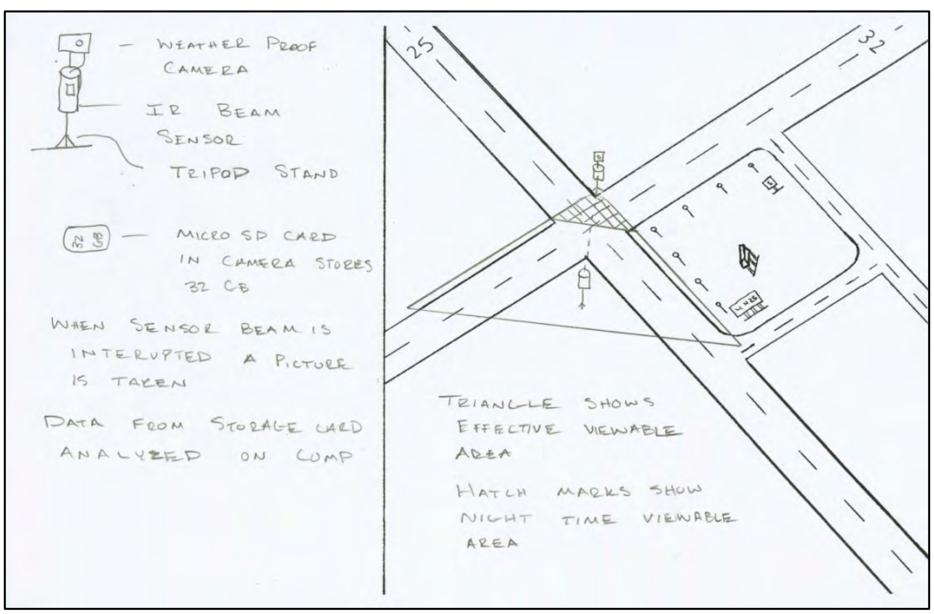


Figure 2: Camera with System Sensor Layout

Table 1: Camera with System Sensor Advantages and Disadvantages

Advantages	Disadvantage
Allows for documented N-Number identification	Does not record at night
Reliable capturing of N-Number	Does not record during inclement weather
Ability to capture clear photos with high resolution	Relies on aircraft breaking beam
Does not exceed 3' in height	Relies on OCR program to identify N-Numbers
System is inexpensive	

Video Surveillance System

This system (see Figure 3) would consist of a high resolution video camera, a support structure, a data storage system, a video optical recognition program and a software database. The video camera would be mounted on top of the support structure and then placed on the side of the runway. The system would be enclosed in a housing to protect it from environmental effects such as dirt or inclement weather. The camera would run continuously with power provided by an external source such as a large battery bank or power from the runway lighting system. When a plane lands or takes off in the section of the runway where the camera is placed, a video will be recorded of the event. This video would be saved to a data storage device which would be removed at regular intervals and then synced to a computer inside of the airport. The video clips would then be analyzed by the video OCR program and the N-Numbers would be identified. These N-Numbers would then be compiled into a database program which would allow the data to be easily viewed and manipulated by the airport staff. Advantages and disadvantages of this concept are listed in Table 2.

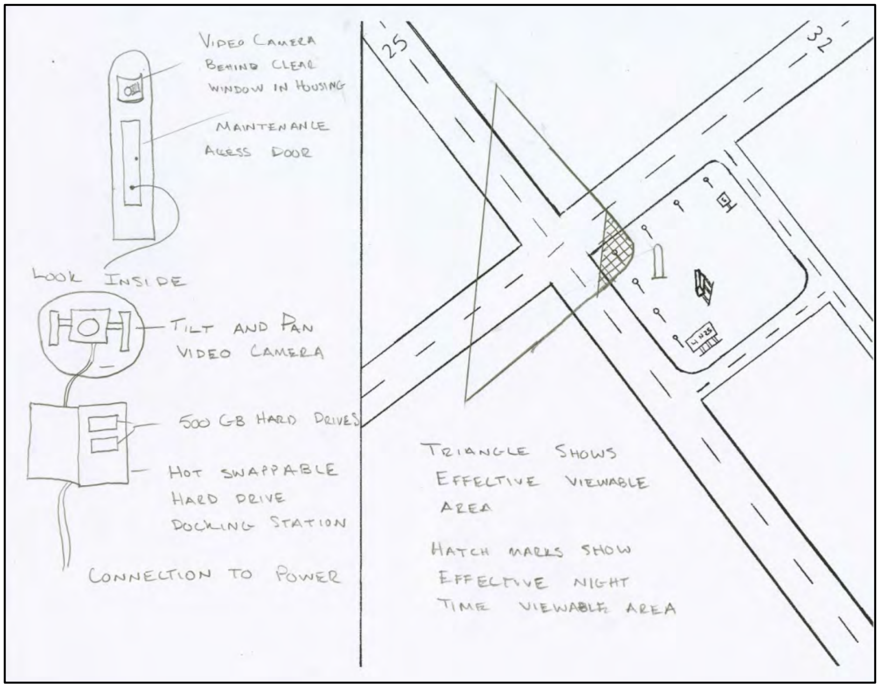


Figure 3: Video Surveillance System Layout

Table 2: Video Surveillance System Advantages and Disadvantages

Advantages	Disadvantages
Allows for documented N-Number identification	Does not record at night
Reliable capturing of operations	Does not record during inclement weather
Ability to capture clear video with high resolution	Relies on OCR program to identify N-Numbers
Does not exceed 3’ in height	
Continuously running	
System is inexpensive	

Beam Breaking System

The system (see Figure 4) contains two beam sensors, two support structures to hold the sensors, and a mechanism to record the count. Each sensor would be attached to an individual support structure which would be protected by a ruggedized housing. The two sensors would be placed on opposite sides of the runway from each other, but oriented so that their sensors are facing each other, allowing for a continuous beam to span the runway. A mechanism such as a manual or digital counter will be integrated into the system to record the count. When an aircraft breaks the plane of the beam, the circuit of the beam sensor would be closed and would activate the counter. The counter would then increase by one increment. This count would then be checked periodically, once the value was recorded, the count could be reset to zero, thus beginning a new count. Advantages and disadvantages of this concept are listed in Table 3.

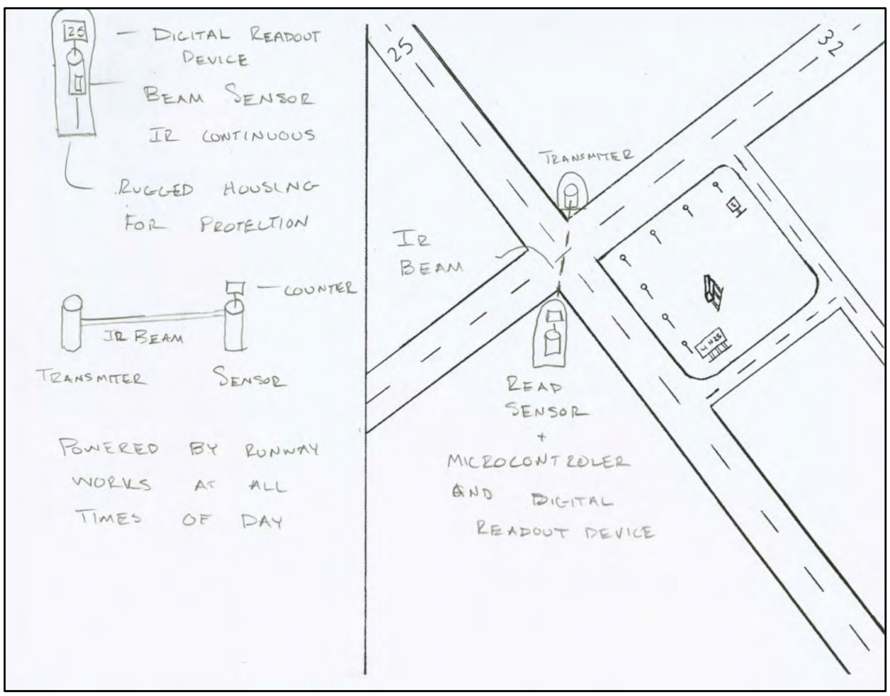


Figure 4: Beam Breaking System Layout

Table 3: Beam Breaking System Advantages and Disadvantages

Advantages	Disadvantages
Documentation of number of operations on runways	Does not record specific airplane N-Numbers
Does not exceed 3’ in height	Records a count for every time the beam is broken regardless of the object was a plane or not
System is inexpensive	Relies on aircraft breaking beam
	Airport staff member must reset count

Pressure Sensor in Runway System

This system (see Figure 5) would consist of a pressure sensor that is embedded in the runway surface and a counter to record the count. The sensor would be buried just below the runway surface and would span the width of the runway. As the aircraft moved over the pressure sensor read area, the adjustment in pressure on that area would be detected, causing the pressure sensor to increase the counter by one. This counter would keep a running count either manually, like an odometer does, or with a digital read out. An airport staff member would then have to come out and manually record the count on the reader. Advantages and disadvantages of this concept are listed in Table 5.

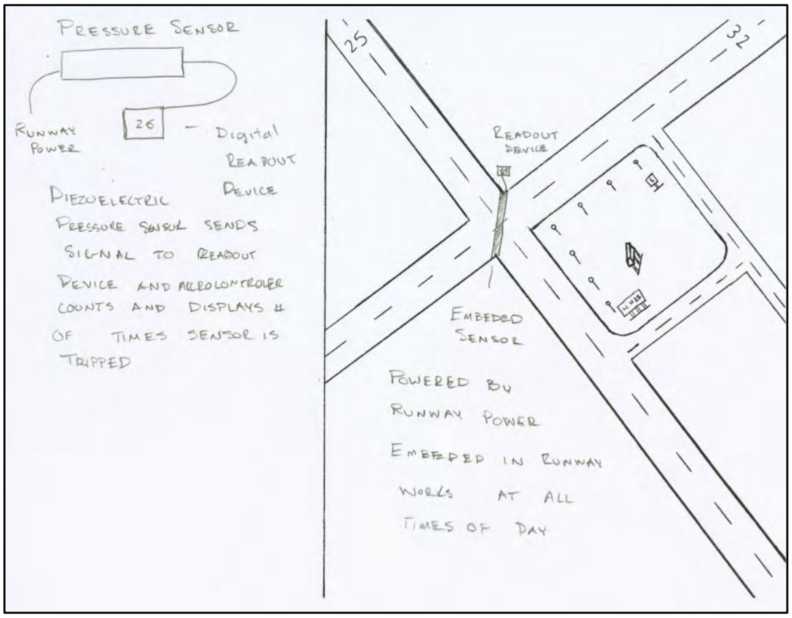


Figure 5: Pressure Sensor in Runway System Layout

Table 4: Pressure Sensor in Runway System Advantages and Disadvantages

Advantages	Disadvantages
Documentation of number of operations on runways	Does not record specific airplane N-Numbers
Eliminate wildlife counting	Records a count for every time the beam is broken regardless of the object being a plane or not
	System needs to be embedded in runway
	To install would be costly
	Requires Airport Staff to check count

RFID system on side of runway

This system (see Figure 6) would be comprised of RFID tags, an RFID antenna, a support structure, an RFID reader, a housing for the reader, a computer and a database software. The RFID tags would be placed on the side of the aircraft, most likely on the tail or in the windows. The antenna would be mounted onto the support structure and placed next to the runway. The antenna would be oriented to face the runway so that the RF field is projected across the runway. As an aircraft passes through the RF field, the tag would transmit its ID data back to the reader. The antenna will pass that info along to the reader which will interpret and confirm the ID data. The indentified ID data will then be passed along to the predetermined computer, either wirelessly or with an Ethernet cable. The computer will then take in the data and compile it into a database created by a software program such as excel. Advantages and disadvantages of this concept are listed in Table 5.

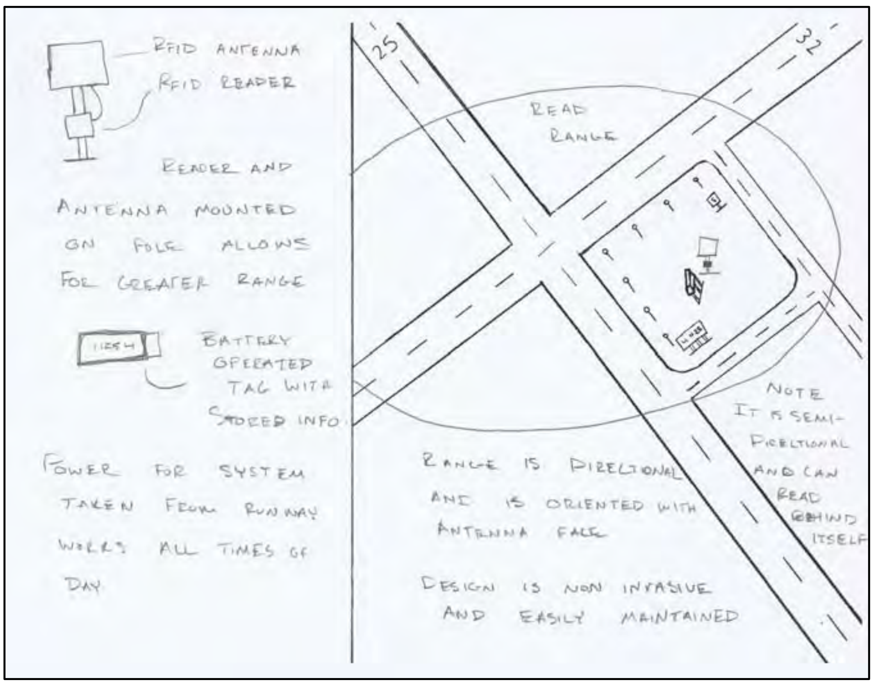


Figure 6: RFID System on side of Runway Layout

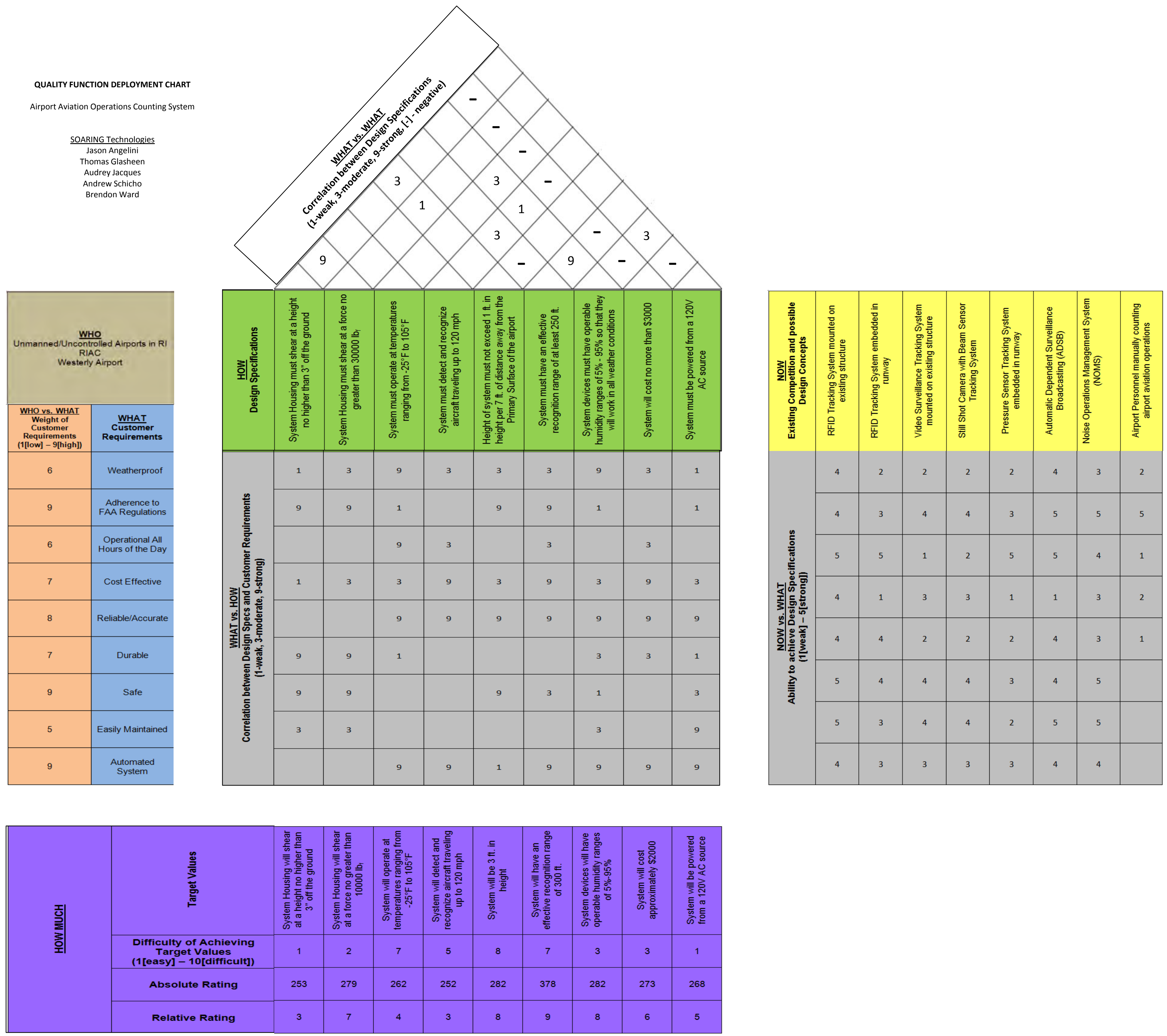
Table 5: RFID System on side of Runway Advantages and Disadvantages

Advantages	Disadvantages
Allows for documented N-Number identification	Less effective during heavy rain, snow or ice
Reliable counting on operations	Requires owners to install tags in planes
Record N-numbers at all times of the day	
Works during most weather conditions	
Does not exceed 3' in height	

In the meeting with the RIAC, the team was able to receive the input of airport officials on the various concepts and collaborate together to develop an innovative design that catered to the RIAC's needs. After this meeting, the team was able to determine design specifications based on the RIAC's list of requirements for a runway operations counting device. Eventually, the team decided on a final concept which was most effective in meeting all the requirements set forth by the RIAC. The design the team chose which was most effective for counting airport operations was the RFID tag reader system.

The final segment of the first semester was the analysis period where the final design concept was reviewed. In this section the team prepared Solid Works™ drawings, executed a second patent search, developed a Quality Function Deployment (QFD) assessment, prepared a cost analysis, researched competition, and performed engineering analysis. The QFD chart can be viewed in Figure 7.

From Figure 8, the team's first semester plan, each task was assigned to a team specialist and respective analyses were completed and reviewed by a second member of the team. Field experts from the electrical engineering department and physics department were contacted to help the team ensure that the system would operate as planned barring any outside issues. During this time the team applied for external funding in the form of research grants while looking into potential vendors and commencing communication with them. The team also accompanied the RIAC in a visit to the Westerly State Airport for a surveying objective. This helped the team to better understand the current method of operations counting, determine potential locations for the system, and expand collaboration with the RIAC on this project.

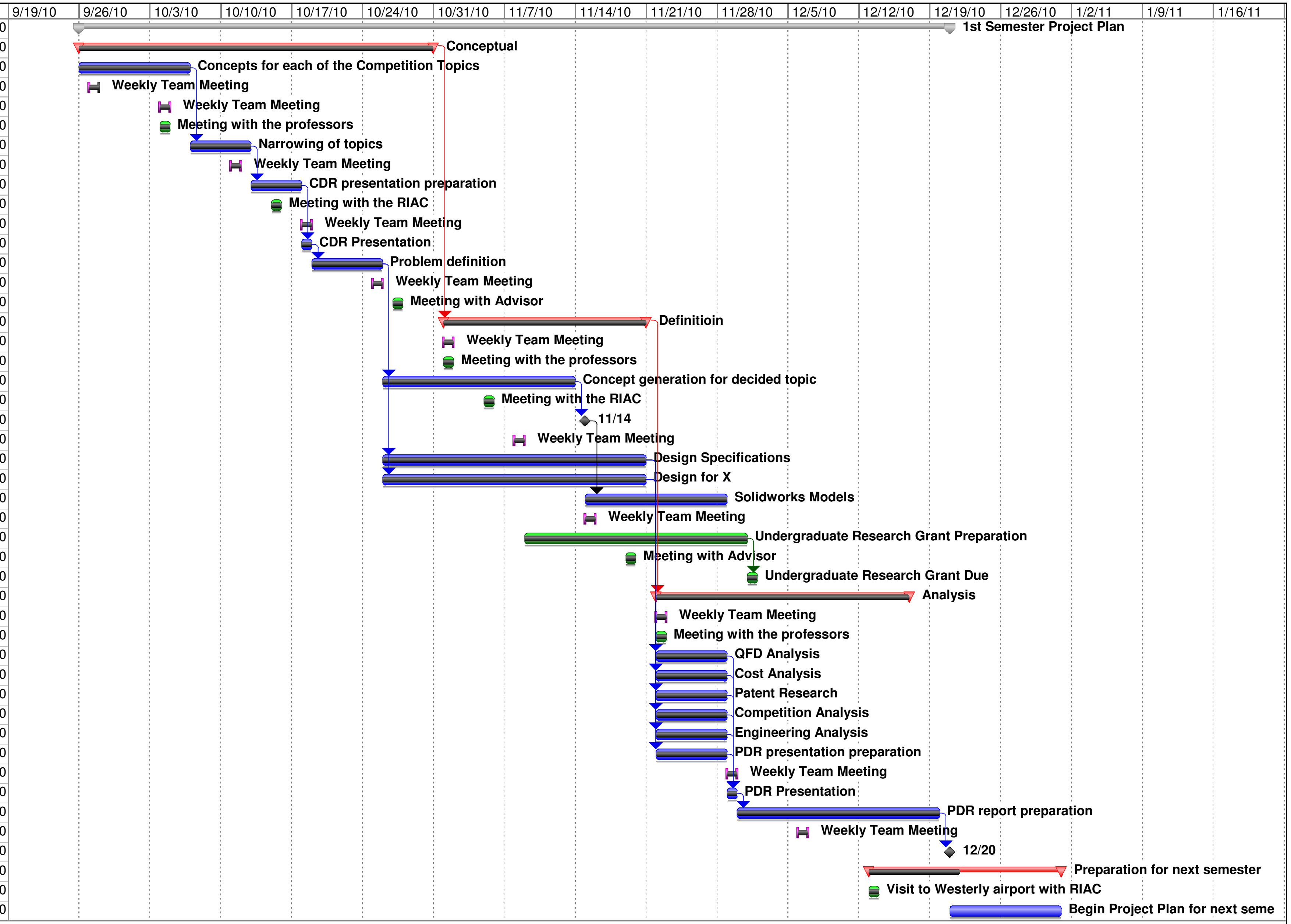


Weight	Customer Requirement	Housing shear height	Housing shear force	Temperature	Detect 120 mph	Height limit	Recognition range	Humidity	Cost	Power
6	Weatherproof	1	3	9	3	3	3	9	3	1
9	Adherence to FAA Regulations	9	9	1		9	9	1		1
6	Operational All Hours of the Day			9	3		3		3	
7	Cost Effective	1	3	3	9	3	9	3	9	3
8	Reliable/Accurate			9	9	9	9	9	9	9
7	Durable	9	9	1				3	3	1
9	Safe	9	9			9	3	1		3
5	Easily Maintained	3	3					3		9
9	Automated System			9	9	1	9	9	9	9
	Difficulty of Achieving Target Values	1	2	7	5	8	7	3	3	1
	Absolute Rating	253	279	262	252	282	378	282	273	268
	Relative Rating	3	7	4	3	8	9	8	6	5

Customer Requirement	RFID on structure	RFID in runway	Video Surveillance	Still Shot Camera	Pressure Sensor	ADSB	NOMS	Manual counting
Weatherproof	4	2	2	2	2	4	3	2
Adherence to FAA Regulations	4	3	4	4	3	5	5	5
Operational All Hours of the Day	5	5	1	2	5	5	4	1
Cost Effective	4	1	3	3	1	1	3	2
Reliable/Accurate	4	4	2	2	2	4	3	1
Durable	5	4	4	4	3	4	5	
Safe	5	3	4	4	2	5	5	
Easily Maintained	4	3	3	3	3	4	4	

Figure 7: Quality Function Deployment Chart

ID		Task Name	Duration	Start	Finish
1		Project Plan	74 days?	Sun 9/26/10	Mon 12/20/10
2		Conceptual	30 days	Sun 9/26/10	Sat 10/30/10
3		Concepts for each topic	9 days?	Sun 9/26/10	Wed 10/6/10
4		Weekly Team Meeting	1 day?	Mon 9/27/10	Mon 9/27/10
5		Weekly Team Meeting	1 day?	Mon 10/4/10	Mon 10/4/10
6		Meeting with the professors	1 day?	Mon 10/4/10	Mon 10/4/10
7		Narrowing of topics	5 days?	Thu 10/7/10	Tue 10/12/10
8		Weekly Team Meeting	1 day?	Mon 10/11/10	Mon 10/11/10
9		CDR presesntation preparation	5 days?	Wed 10/13/10	Sun 10/17/10
10		Meetin with the RIAC	1 day?	Fri 10/15/10	Fri 10/15/10
11		Weekly Team Meeting	1 day?	Mon 10/18/10	Mon 10/18/10
12		CDR Presentation	1 day?	Mon 10/18/10	Mon 10/18/10
13		Problem Definition	5 days?	Tue 10/19/10	Mon 10/25/10
14		Weekly Team Meeting	1 day?	Mon 10/25/10	Mon 10/25/10
15		Meeting with Advisor	1 day?	Wed 10/27/10	Wed 10/27/10
16		Definition	19 days	Mon 11/1/10	Sat 11/20/10
17		Weekly Team Meeting	1 day?	Mon 11/1/10	Mon 11/1/10
18		Meeting with the professors	1 day?	Mon 11/1/10	Mon 11/1/10
19		Concept Generation for decide t	18 days?	Tue 10/26/10	Sat 11/13/10
20		Meeting with the RIAC	1 day?	Fri 11/5/10	Fri 11/5/10
21		Concept Selection	1 day?	Sun 11/14/10	Sun 11/14/10
22		Weekly Team Meetin	1 day?	Mon 11/8/10	Mon 11/8/10
23		Design Specifications	25 days	Tue 10/26/10	Sat 11/20/10
24		Design for X	25 days	Tue 10/26/10	Sat 11/20/10
25		Solidworks Models	13 days	Mon 11/15/10	Sun 11/28/10
26		Weekly Team Meeting	1 day?	Mon 11/15/10	Mon 11/15/10
27		Undergraduate Research Grant	21 days?	Tue 11/9/10	Tue 11/30/10
28		Meeting with Advisor	1 day?	Fri 11/19/10	Fri 11/19/10
29		Undergraduate Research Grant	1 day?	Wed 12/1/10	Wed 12/1/10
30		Analysis	20 days	Mon 11/22/10	Thu 12/16/10
31		Weekly Team Meeting	1 day?	Mon 11/22/10	Mon 11/22/10
32		Meeting with the professors	1 day?	Mon 11/22/10	Mon 11/22/10
33		QFD Analysis	6 days?	Mon 11/22/10	Sun 11/28/10
34		Cost Analysis	6 days?	Mon 11/22/10	Sun 11/28/10
35		Patent Research	6 days?	Mon 11/22/10	Sun 11/28/10
36		Competition Analysis	6 days?	Mon 11/22/10	Sun 11/28/10
37		Engineering Analysis	6 days	Mon 11/22/10	Sun 11/28/10
38		PDR presentation preparatio	6 days?	Mon 11/22/10	Sun 11/28/10
39		Weekly Team Meeting	1 day?	Mon 11/29/10	Mon 11/29/10
40		PDR Presentation	1 day?	Mon 11/29/10	Mon 11/29/10
41		PDR report preparation	15 days?	Tue 11/30/10	Sun 12/19/10
42		Weekly Team Meeting	1 day?	Mon 12/6/10	Mon 12/6/10
43		PDR Report	1 day?	Mon 12/20/10	Mon 12/20/10
44		Preparation for next semester	16 days?	Mon 12/13/10	Fri 12/31/10
45		Visit to Westerly airport with RIA	1 day?	Mon 12/13/10	Mon 12/13/10
46		Begin Project Plan for next sem	9 days?	Tue 12/21/10	Fri 12/31/10



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Task	Progress	Summary	External Tasks
Split	Milestone	Project Summary	External Milestone
Deadline			

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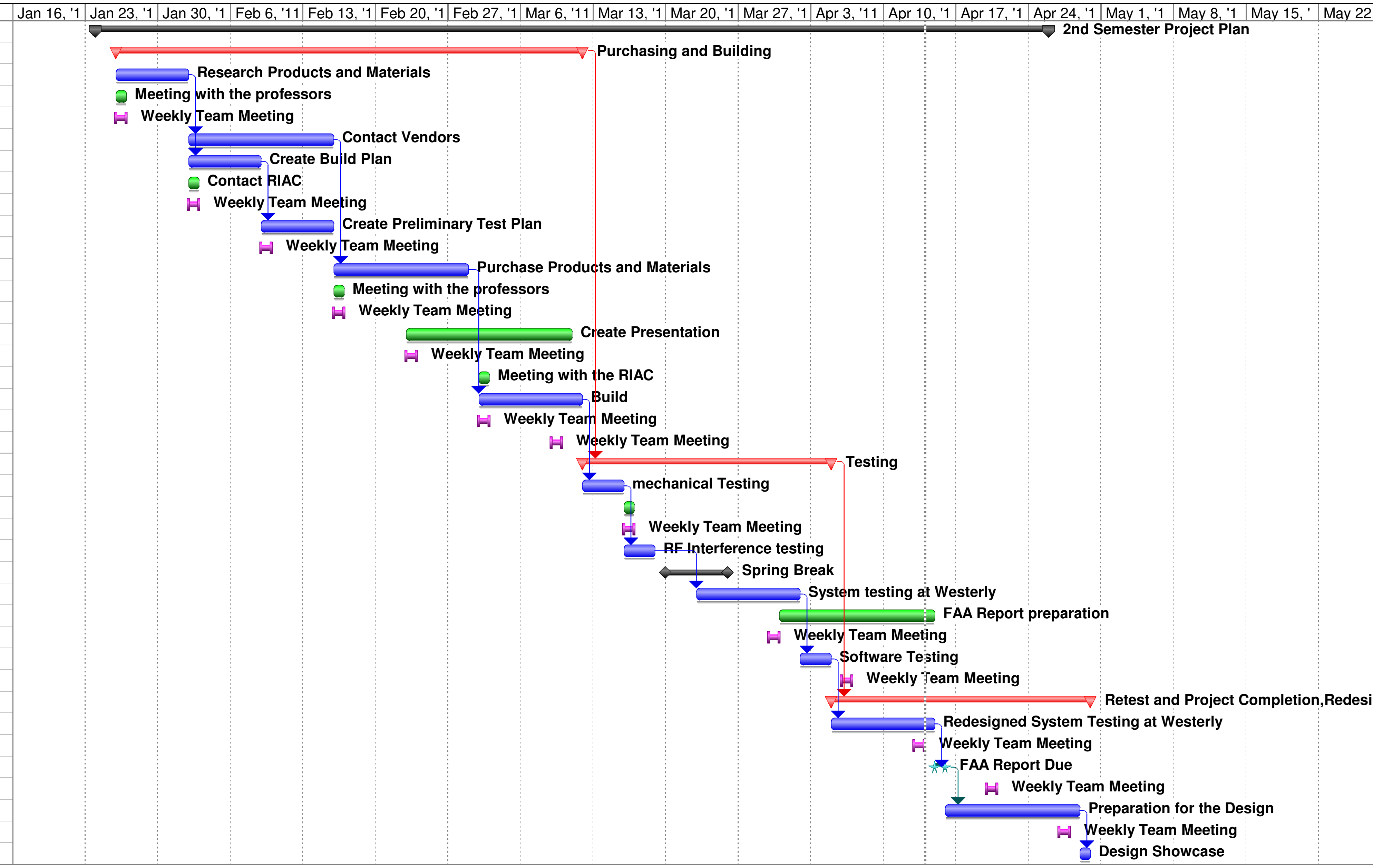
Figure 8: First Semester Project Plan

ID	Task Name	Duration	Start	Finish	Predecessors
1	Project Plan	74 days	Mon 1/24/11	Mon 4/25/11	
2	Purchasing and Building	34 days	Wed 1/26/11	Fri 3/11/11	
3	Research Products and Materia	5 days	Wed 1/26/11	Tue 2/1/11	
4	Meeting with the professors	1 day	Wed 1/26/11	Wed 1/26/11	
5	Weekly Team Meeting	1 day	Wed 1/26/11	Wed 1/26/11	
6	Contact Vendors	10 days	Wed 2/2/11	Tue 2/15/11	3
7	Create Build Plan	5 days	Wed 2/2/11	Tue 2/8/11	3
8	Contact RIAC	1 day	Wed 2/2/11	Wed 2/2/11	
9	Weekly Team Meeting	1 day	Wed 2/2/11	Wed 2/2/11	
10	Create Preliminary Test Plan	5 days	Wed 2/9/11	Tue 2/15/11	7
11	Weekly Team Meeting	1 day	Wed 2/9/11	Wed 2/9/11	
12	Purchase Products and Materia	10 days	Wed 2/16/11	Mon 2/28/11	6
13	Meeting with the professors	1 day	Wed 2/16/11	Wed 2/16/11	
14	Weekly Team Meeting	1 day	Wed 2/16/11	Wed 2/16/11	
15	Create Presentation	12 days	Wed 2/23/11	Thu 3/10/11	
16	Weekly Team Meeting	1 day	Wed 2/23/11	Wed 2/23/11	
17	Meeting with the RIAC	1 day	Wed 3/2/11	Wed 3/2/11	
18	Build	8 days	Wed 3/2/11	Fri 3/11/11	12
19	Weekly Team Meeting	1 day	Wed 3/2/11	Wed 3/2/11	
20	Weekly Team Meeting	1 day	Wed 3/9/11	Wed 3/9/11	
21	Testing	21 days	Sat 3/12/11	Mon 4/4/11	2
22	Mechanical Testing	4 days	Sat 3/12/11	Tue 3/15/11	18
23	Presentation	1 day	Wed 3/16/11	Wed 3/16/11	
24	Weekly Team Meeting	1 day	Wed 3/16/11	Wed 3/16/11	
25	RF Interference Testing	3 days	Wed 3/16/11	Fri 3/18/11	22
26	Spring Break	6 days	Sun 3/20/11	Fri 3/25/11	
27	System testing at Westerly Airp	8 days	Wed 3/23/11	Fri 4/1/11	25
28	FAA Report preparation	12 days	Thu 3/31/11	Thu 4/14/11	
29	Weekly Team Meeting	1 day	Wed 3/30/11	Wed 3/30/11	
30	Software Testing	2 days	Sat 4/2/11	Mon 4/4/11	27
31	Weekly Team Meeting	1 day	Wed 4/6/11	Wed 4/6/11	
32	Redesign, Retest, and Project (	21 days	Tue 4/5/11	Fri 4/29/11	21
33	Redesigned System Testing at	8 days	Tue 4/5/11	Thu 4/14/11	30
34	Weekly Team Meeting	1 day	Wed 4/13/11	Wed 4/13/11	
35	FAA Report Due	1 day	Fri 4/15/11	Fri 4/15/11	33
36	Weekly Team Meeting	1 day	Wed 4/20/11	Wed 4/20/11	
37	Preparation for the Design Shov	11 days	Sat 4/16/11	Thu 4/28/11	35
38	Weekly Team Meeting	1 day	Wed 4/27/11	Wed 4/27/11	
39	Design Showcase	1 day	Fri 4/29/11	Fri 4/29/11	37



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Date: Thu 4/14/11

Task		Progress		Summary		External Tasks		Deadline	
Split		Milestone		Project Summary		External Milestone			

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Figure 9: Second Semester Project Plan

For the second semester, a new project plan was implemented and a new Gantt chart was created for the team to follow. The Gantt chart for the second semester contains three main sections; Purchasing and Building, Testing, and Redesign, Retest, and Project Completion, which are marked in red. The other tasks marked in blue and green follow the same color scheme as previously defined for the first semester plan. The team's progress in the second semester was bolstered by additional funding through a University of Rhode Island undergraduate research grant for $1,400. Our project was selected through a competitive URI review process based on our research proposal. This helped the team move forward with purchasing parts and building our design during the Spring semester.

Within the purchasing and building section of the plan the team determined what parts would be necessary to build a fully functional and safe design. The team chose parts based on their functionality and value, weather resistance, and safety for use on airport runways. After purchasing these parts the team worked with the university machine shop techs to assemble the prototype. This process included some redesign and extra purchasing to create a more functional prototype which was powered by solar electricity. This new design is self sufficient and can power itself with solar electricity provided by its newly added panel and battery system.

The second major section of the semester plan was testing during which the team designed tests for the system to measure its functionality in the field. These real life tests included range testing, temperature testing, interference testing, and many mechanical tests to prove the soundness of the support structure. The data from these tests was collected and will be used in the last major section of the semester plan redesign and project completion. A list of tests to be preformed can be seen in Table 6.

Table 6: Project Test Plan

Test Type	Test Procedure
Waterproof Testing - ensure water resistance	Submerge protective housing
Compatibility Test - verify functionality of tag and reader	Place tag in range of reader
Solar Power Test - Confirm ability to power system	Place system outside for full day
Frequency Interference Testing – testing with interference present	Provide artificial interference using similar frequencies
Obstruction Test – test ability to transmit through objects	Place obstructions in front of system and monitor transmission capabilities
Software Testing – ensure software ability to process tags	Use provided software to archive transmitted tag data
Adverse Weather Testing - observe effects of weather	Operate system in adverse weather conditions (wind, rain, ice, and snow)
Range Testing - determine maximum range of the reader	Move tags outward until maximum read range is determined
Speed Testing - determine max speed of tag with successful transmission	Move tag through range at increasing speeds
Placement Testing – test tag placement in aircraft	Place 10 tags in different locations throughout aircraft
Multiple Detection Testing - test ability to read multiple tag signals simultaneously	5 tags will be passed through reader range simultaneously
Real World Testing - field test full system	Tags will be placed in a New England Airlines aircraft

The final section of the project plan specifies that the team will use the data collected in the testing section to improve the quality and functionality of the system. This analyzed data will be used to discover weaknesses in the system and improve them through redesign. The new design will then be retested and this process will be continued as a loop until the team is satisfied with the results and the system is ready for deployment. At this point the project will be completed and presented to interested parties for critique and possible sale.

SAFETY RISK ASSESSMENT

The FAA advocates safety throughout all its functions and operations, and in order to ensure consistency in this field, there are many regulations and procedures set in place. A thorough Safety Management System (SMS) can be implemented at an airport to ensure a safe environment for pilots and airport personnel alike. The FAA has produced documents that outline the procedures for implementing an effective SMS. These documents include the "Introduction to Safety Management Systems for Airport Operators" and the "FAA Safety Management System Manual". These documents provide a detailed approach to maintaining safe operations with the installation of a new system.

The aviation operations counting system designed by the team involves a small structure positioned at key locations throughout an airfield. The positioning of this structure is expected to abide by FAA regulations, but its mere presence on the airfield classifies it as a hazard that poses potential risk to people and equipment. In order to properly manage this risk, the five phases of Safety Risk Management (SRM) are followed accordingly. During the design of the system, the hazards were identified and the risk of these hazards was determined. These risks included RF interference, aircraft collision, maintenance vehicle collision, and obstruction of view. In order to control or mitigate these risks, the team integrated specific safety factors into the design of the system. One of these design factors includes a shearing collar that would allow the mounting column to break at an appropriate applied force in order to minimize damage to aircraft and maintenance vehicles. In the event that the collar does shear, a durable wire lanyard is connected between the column and the secured base so that the column is not be free to roll into the runway and cause another collision. The system is designed to stand at a height of 3 ft. and positioned at designated locations in order to prevent obstruction of view for aircraft pilots and maintenance workers. The system also employs RF technology that uses a specific frequency intended to minimize interference and abide by FAA restrictions and regulations. Overall the system is specifically designed to minimize risk and abide by FAA regulations, allowing it to be categorized as a medium-low risk hazard.

Along with safety design factors, a proper SMS would prove to be essential in maintaining a continuously safe environment. This system would need to include training and education for all airport personnel as well as an effective safety communication system for reporting damage or improper functionality of the system. Clear reporting lines, well defined duties, and adequate understanding of the overall system would be crucial to maintaining a sound safety culture.

TECHNICAL ASPECTS OF THE PROPOSED DESIGN SOLUTION

<u>Technical Aspects of the Proposed Design Solution</u>

Figure 10a: Final System Design

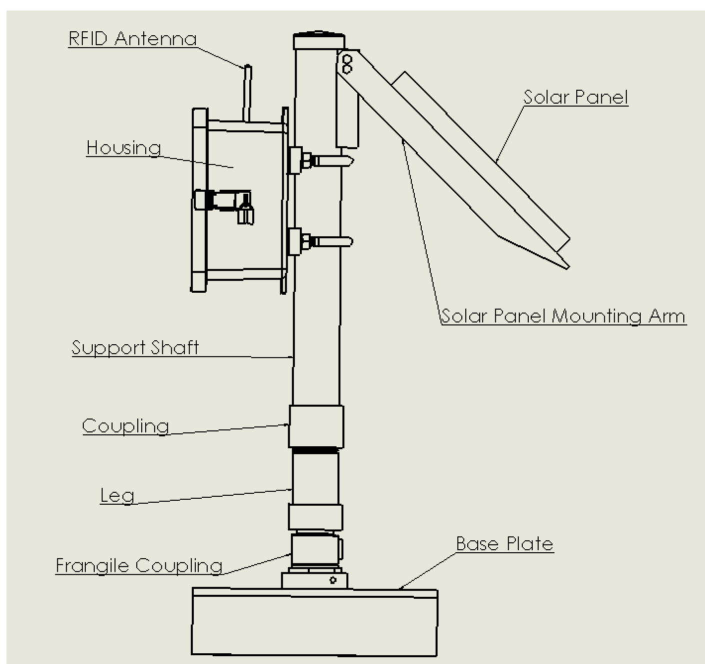

Figure 10b: Skematic of Final system Design

The system proposal that would provide a solution to the problem of inaccurate runways operations counting is an Radio Frequency Identification (RFID) System. The system structure is depicted in Figure 10 and consists of 6 parts: the RFID tags, an RFID reader with antenna, housing, support structure, 30W solar panel system and a computer with database. In order to make sure that the proposed solution would meet basic customer requirements a set of design specifications were developed. Table 7 lists the customer requirement given by RIAC and the design specification established to meet those requirements.

Table 7: Customer Requirements and Design Specifications

Customer Requirements	Design Specifications
1. Operable in all weather conditions	1a. Operations in temperature range (-22 to 104 °F)
	1b. Operation of all weather conditions including precipitation and wind
2. Adheres to all FAA regulations	2a. Reading range will be greater than the size of the runway safety zone (300 feet)
	2b. The system will not interfere with any FAA or RIAC frequencies
	2c. The total height of the system will not exceed 3 feet as per FAA regulation
3. Safe for pilots and airport maintenance workers	3a. The system will fail at a shear point when the force exceeds 16,000 lbs
	3b. The system will not emit frequencies or radiation deemed unsafe by the FAA
4. Reliable and accurate system	4a. The system will acquire data from planes traveling at less than 120 mph
5. Operable 24 hours a day	5a. The system will operate 24 hours a day in any lighting situation or in pitch dark
6. Resistant to environmental factors	6a. The structure will withstand corrosion and elements for up to 20 years
7. A system which is cost effective	7a. The total cost of the system shall not exceed 3000 dollars per installed antenna
8. A system that is easily maintained	8a. The system will only need a scheduled maintenance check twice a year

The Reader with Antenna

The most important aspect of the system is the RFID reader and antenna. A decision on the most effective reader for this application was based on design specifiactions 1a, 2a, 2b, 3b, 4a, 4b, 5a, 7a in Table 7. In order to fulfill the customer requirement of a 300 foot range it was decided that an active RFID system would be employed, which have a range up to 328 feet, per D-Spec 2a.

Frequency	Band Name	Person
190 - 435 & 510 - 535 kHz	Non-directional Beacons	Hinton Ebate
2100 - 28,000 kHz	HF Communications	Pawlowitz
75 MHz	NAVAID (Marker Beacons)	Hinton Ebate
108 - 112 MHz	VOR; ILS Localizer	Hinton Ebate
112 - 118 MHz	VOR; SCAT-I Radionavigation data link	Hinton Ebate
118 - 137 MHz	VHF Air / Ground Communications	Balanga Lafertte Jimenez
138 - 150.8 & 162 - 174 MHz	Fixed, Mobil	Murphy
225 - 328.6 & 335.4 - 400 MHz	UHF Air / Ground Communications (U.S. Military)	Murphy
328.6 - 335.4 MHz	ILS Glide Slope	Hinton Ebate
406.1 - 420 MHz	Fixed, Mobil	Ebate
932 - 935 & 941 - 944 MHz	RMM, LLWAS, LDRCL, etc.	Murphy
960 - 1215 MHz	NAVAID (TACAN / DME, etc.)	Ebate
1030 & 1090 MHz	Air Traffic Control Radar Beacon; Mode S; TCAS	Ebate
1215 - 1390 MHz	Air Route Surveillance Radar; GPS and GLONASS L1	Pawlowitz
1545 - 1559 MHz	Satellite-Based Comm (To Aircraft)	Murphy Cabala
1559 - 1610 MHz	Satellite Navigation; GPS and GLONASS L1	Murphy Cabala
1646.5 - 1660.5 MHz	Satellite-Based Comm (From Aircraft)	Murphy
1710 - 1850 MHz	LDRCL; fixed links	Ebate
2700 - 3000 MHz	Airport Surveillance and Weather Radar	Pawlowitz
5000 - 5250 MHz	Microwave Landing System	Hinton Ebate
5600 - 5650 MHz	TDWR	Pawlowitz
7125 - 8500 MHz	RCL	Murphy
9000 - 9200 MHz	Military Precision Approach Radar	Pawlowitz
14.4 - 15.35 GHz	Microwave Link	Ebate
15.7 - 16.2 GHz	Radar (ASDE-3)	Pawlowitz
21.2 - 23.6 GHz	Microwave Link	Ebate

Table 8: FAA list of Currently Used Frequencies

Two different systems were considered that would fulfill the requirements, the Wavetrend 433 MHz reader and the GAO RFID 2.45 GHz reader. One of the most important considerations that was researched prior to making a decision was the allowed frequencies to be used on an airfield, D-Spec 2b and 3b. Table 8 shows the list of all currently in use frequencies according to the FAA, and neither system conflicts with any of these frequencies.

Ultimately the GAO RFID reader (see Figure 11) was decided upon because it offered a 328 foot omnidirectional RF field as opposed to the Wavetrend system that provided a 328 foot directed field. The GAO reader has an operating temperature of -40 °F to 176 °F which fulfilled D-Spec 1a. The omni-directional read range will allow the system to be placed at the confluence of multiple runways or taxiways or a combination of the two which will maximize the number of reader points while minimizing the number of readers to be installed. The GAO system was also purchased at a significantly smaller price ($595) than the Wavetrend system ($995), which will contribute to keeping the entire system under $3000, meeting D-Spec 7a. The reader comes with a small detachable stub antenna that provides the omni-directional signal. The antenna will be extended using a cable and will be run outside of the housing and will be mounted to the top of the structure to allow for the highest placement and least obstructed coverage of the airfield. This system will be operational at all times of the day, as well in all but the most severe weather situations, fulfilling D-Spec 5a. Since the system communicates through RF signals, it will work regardless of the light level of the surrounding environment, meeting D-Spec 5a. The reader has the ability to read 100 tags per second, satisfying D-Spec 4a.

Figure 11: GAO RFID Reader

The Tags

The system would consist of RFID tags (see Figure 12) being placed in aircrafts as part of the registration process. Each tag would have a unique serial number assigned to it which would correspond to information in a State or FAA database. The tags will be attached to the inside window of the plane which will allow for maximum line of sight transmission of the RF signal. The two different readers that were considered for this project each have an associated tag that is required for the system to operate. The tags for the Wavetrend system would have cost $78, the GAO tags cost $22 each (see Figure 12). The tag would be placed in the window of the aircraft in order to provide unobstructed access to the RF field.

Figure 12: GAO RFID Tag

The Support Structure

The entire system height does not exceed 3', meeting D-Spec 2c in Table 7, which was the height provided by the customer so that the system does not stand taller than the runway signs of the airfield. The support structure (see Figure 13) consists of 5 parts: the baseplate, the frangile coupling, the leg, the pipe coupling and the pipe shaft. All of the parts for the proposed design are made by Crouse-Hinds Airport Lighting and were provided by the RIAC for use in the prototype. All of the parts used meet airport standards, which ensures that our design will comply with all FAA regulations, specifically those set for signage placed around an airfield. All of the parts used in the system are made from aluminum, fullfilling D-Specs 6a and 8a from Table 7. The most critical specification that needed to be met by the

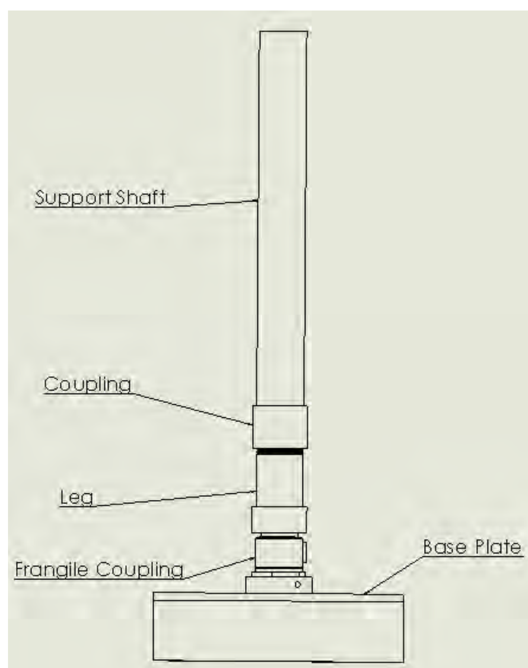

Figure 13: Support Structure

support structure was that it must shear when struck by an aircraft, D-Spec 3a Table 7. This FAA and customer requirement is met through the use of a frangile coupling (see Figure 14). The coupling provided is rated to shear at a force of 1065 – 1540 pounds at 1 ft above the frange point which meets the customers specification of shearing below a force of 16,000 lbs-ft.

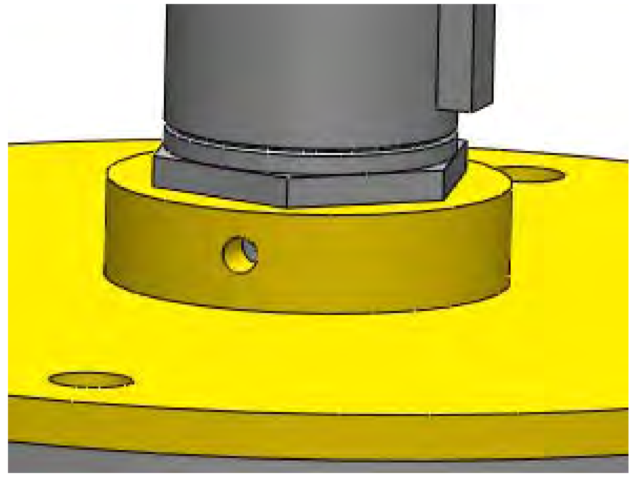

Figure 14: Frangible Coupling

The Housing

The housing used is a fiberglass waterproof, dustproof, fireproof, uv-resistent enclosure purchased from McMaster-Carr. The enclosure also has a padlockable latch attached to the outside to ensure that only airport personal will have access to the reader inside. The fiberglass housing is being used to ensure that it will not cause interference with the reader. The reader is mounted to the pole by the use of clamping U-bolts. The U-Bolts are secured inside of the housing to prevent tampering and gaskets are used around the U-Bolt entrance to keep the housing waterproof.

The Computer with Database

In order for the tag data to be stored, the reader needs to have a direct connection to a computer. The reader is connected via a Crossover Ethernet cable. The ethernet cable will need to be directly buried into the ground and run to where the reader is positioned. When the software that is provided with the reader is running on the PC, it will collect and organize every occurance of an RFID tag passing though the RF field. The software records the Unique Serial number of the tag, the time and date at which it passes through the field, the duration the tag was in the field, as well as keeping a count of the number of times the tag passes through the field (see Figure 15). The software also has the capability of saving the data and exporting it to a text file which would be then imported into a spreadsheet software, such as Excel, to form a database. If an FAA managed database were created, the serial numbers of the tags could be linked to the N-Numbers of the specific plane containing that tag which would provide the FAA and State airports with a great knowlegde of aircraft travel patterns, along with keeping a count of the operations of the airports on a day to day basis.

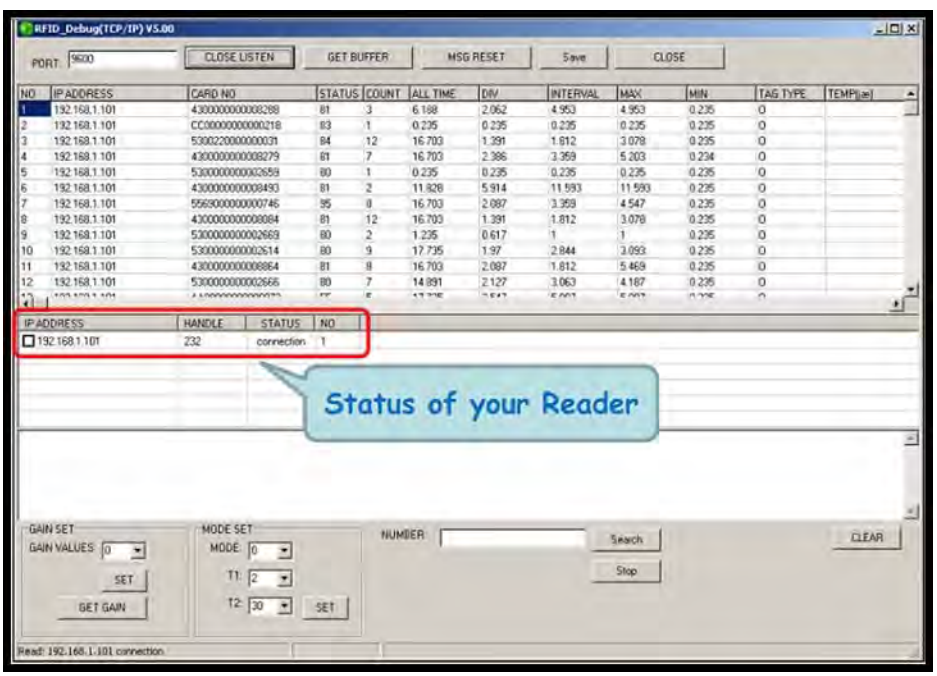

Figure 15: Image of Software Records

The Solar Panel

Two methods of continuosly powering the reader were considered. One method was to access the power grid currently laid out on the airfield and the second method was through the use of a solar panel and battery system. The solar panel system was decided upon because the system would become more portable and enviromentally friendly. A 30W BP solar system was chosen to provide power to the system (see Figure 16). A 12 volt battery is used to store the charge of the power panels and will provide energy to the reader. As the current system is set up the battery can provide the reader with a full 24 hours of power in the absence of sunlight. A charge controller is used to regulate and equilize the amount of charge flowing to the battery in order to keep it from overloading.

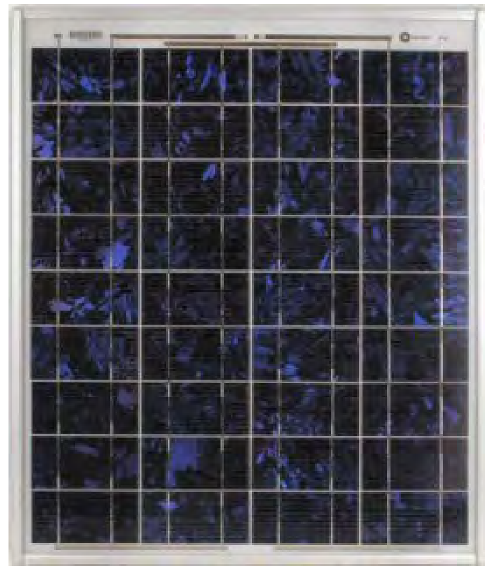

Figure 16: Solar Panel

The Placement

The system is currently designed to be implemented at Westerly Airport in Westerly, Rhode Island. Westerly is a small untowered airport that has significant traffic that occurs daily. The system is being designed to be implemented where two runways intersect and will also cover the area where mulitple taxiways intersect as seen in Figure 17 below. The GAO readers omni-directional RF range provides ample coverage for the airfield. However, since not all aircraft land and take off from the same section of the runway, one RFID receiver may not be sufficient to provide coverage for the entire airfield, so multiple recievers may be required.

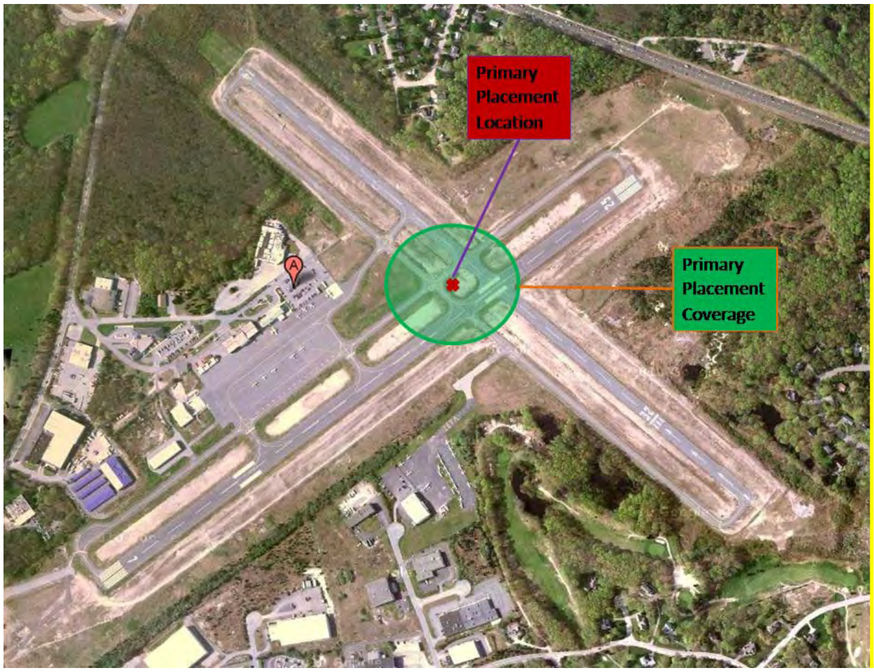

Figure 17: Westerly Airport in Westerly, Rhode Island

INTERACTIONS WITH AIRPORT OPERATORS AND INDUSTRY EXPERTS

After deciding to enter the FAA's design competition in September of 2010 the team met with RIAC officials to discuss the challenges faced by the airport and their importance. The team then created several solutions for each of the categories put forth by the FAA and met to present these solutions to the RIAC for critique. With the guidance of the RIAC, the team chose to pursue a runway operations counter which used Radio Frequency Identification to count and record landing planes. In order to accomplish the goals of our customer the team worked with industry specialists from four different technical fields relating to our project. At the RIAC Mr. Alan Andrade, Mr. Jim Warcup, Mr. Jay Brolin, and Mr. Jim Crowley provided guidance and helped the team to understand FAA regulations and safety requirements. This included the positioning of the system at Westerly airport near the runway, recommendations on frangibility, and frequency interference regulations. Mr. Steve Catanzaro, a master electrician at the RIAC also helped us to understand the runways electrical systems and provided us with advice for weatherproofing. The RIAC has been a major influence and a great supporter of our project through the donation of its time and some materials including the frangible coupling and matching base.

Another important part of completing the project was the selection of the RFID reader and tags which will be attached to the planes. The URI physics department and GAO RFID a leading supplier in the industry helped the team to better understand the differences between active and passive RFID systems and how to choose the best one. GAO's technical specialist Mr. Arif Ali worked with the team to select a reader which met the range goals of the project while not interfering with frequencies already in use at airports.

During meetings with the RIAC the team also decided that in an effort to make the system more sustainable a solar power system would be designed to power the reader. AltE a leading supplier of custom made and small solar systems was very helpful during this design process. The technical staff there helped design a system which would match the needs of the reader while keeping costs low. Mr. Greg Salley at AltE suggested the addition of an in line charge controller to maximize the power captured by the batteries and sized it appropriately for the batteries the team already had.

Finally the team sought to do real life testing with the finished system and contacted local commercial airlines to ask if they would help. Mr. Bill Bendokus at New England Airlines agreed to test the tags in his fleet of small commercial planes. New England Airlines which runs flight service through Westerly to Block Island daily equipped their planes with the RFID tags supplied by the team and landed normally while the team observed the system for proper operation. The contacts the team made in these fields helped to connect all parts of the project seamlessly. The continued cooperation of all these contacts will help the team to observe any problems with the system and improve the design to be a easy to manufacture and implementable system.

PROJECTED IMPACTS

The overall goal of the proposed design is to provide non-towered airports with a more accurate and reliable method of counting airport operations. Recent data states that there are approximately 20,000 non-towered airports in the United States, which is forty times the amount of airports that have an air traffic control tower (AOPA Air Safety Foundation, 2008). Since the level of airport traffic determines airport funding, having an accurate count is of great importance. Currently, the data collection method for runway operations at small airports involves airport personnel manually counting the daily operations and recording them, which leads to many errors. Our designed automated system will read and record the aircraft identification information, delivering accurate aviation operation statistics while minimizing the need for ineffective manual operations.

Financial Analysis

The proposed design consists of four parts: the RFID system, the solar power system, the support structure and the software package. The RFID system was purchased from GAO RFID Inc. and consists of the RFID reader purchased for $527.00 as well as RFID active tags costing $22.00 each (the minimum order quantity of ten was purchased). The solar power system was obtained from AltE Store, which consisted of a 12V panel, a pole mount and a 12V PWM charge converter, which costs $229.80, $50.49 and $26.00 respectively. The support structure consisted of several components listed in Table 9.

Table 9: Breakdown of Support Structure Components

Component	Cost	Component	Cost	Component	Cost
Enclosure w/ Back plate	$81.68	U-bolts (Qty:2)	$17.60	Frangible Coupling	$90.00
2" Aluminum Pipe	$67.64	Gasket (12"X12")	$22.76	Leg	$36.00
2" Aluminum Coupling	$16.08	Base plate	$140.00	Base Extension	$35.00
Ethernet (Crossover) Cable	$14.99	Hardware/Misc.	$121.35	Mini-coaxial Cable	$5.09

The software system, purchase from GAO RFID Inc. with the RFID reader, costs $1,500.00 but there is potential for this to be a one-time cost since the software will be able to read data from any system. Since the system is solar powered, the only cost incurred is the initial purchase of the system, which can be seen in Table 10.

Table 10: Total System

RFID System Cost	Support System Cost	Solar Power System Cost	Software Cost	Shipping Costs	Total Cost
$747.00	$612.19	$306.29	$1,500.00	$85.00	$3,250.48

Cost/Benefit Analysis

For this analysis, the total cost of the design will be compared to the cost of having the airport manager recording airport operations for a year. Assuming that the manager in question works a total of 48 weeks out of the year (this allows for 2 weeks vacation time and 2 weeks government recognized holidays) and spends on average 2.5 hours a week on logging airport operations, that person would work a total of 120 hours in a year. The hourly wage of an airport manager for an un-towered airport is on average $26.00 per hour, therefore the yearly cost of counting the airport’s operations manually would be $3,120. Comparing this to the total cost of the system stated above, it would take just over a year to recoup the initial cost of the system. It is clear that with the reliability advantages and the short payback period, the proposed design far exceeds the current method in use.

CONCLUSION

Monitoring of aviation operations monitoring is of great interest to small airports and State airport corporations. The current manual methods are not very effective and it is error prone. The accuracy of this data is crucial for the proper appropriation of FAA funding and the progressive development of non-towered airports throughout the country. During the design process, the proposed automated RFID system was designed and proven to provide data with significantly improved accuracy, efficiency, and reliability. Along with improved accuracy, the system provides a method for storing, analyzing, and sending information to an airport database that can use the data to properly determine need-based funding and development. Overall, this system represents an innovative approach to improving airport operations management systems.

APPENDIX A

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APPENDIX B

The University of Rhode Island

The University of Rhode Island, founded in 1892, is the State's public learner-centered research university, holding accreditation from the New England Association of Schools and Colleges (NEASC). It is the only public institution in Rhode Island offering undergraduate, graduate, and professional students the distinctive educational opportunities of a major research university. The main campus lies on 1,200 acres in Kingston, Rhode Island with three satellite campuses: the Feinstein Providence campus, the Narragansett Bay campus, and the W. Alton Jones campus. As of this fall, there are 13,094 undergraduates, 1,781 full-time graduates, and 1,419 part-time graduates and of those students 10,182 are in state while 6,112 are from out of state. There are over 80 majors offered at the university from seven degree granting colleges: Arts & Sciences, Human Science & Services, Environmental & Life Sciences, Business, Nursing, Pharmacy, and Engineering.

The College of Engineering

The College of Engineering at the University of Rhode Island has the vision to be "a global leader in engineering education and research." Their diverse community of scholars, students and professional staff is devoted to the development and application of advanced methods and technologies. The college offers eight Baccalaureate degrees to its 1,211 undergraduates: biomedical, chemical, civil, computer, electrical, industrial and systems, mechanical and ocean. The college, accredited by ABET (Accreditation Board for Engineering and Technology) educates all focuses to be creative problem solvers, innovators, inventors and entrepreneurs and to utilize those skills in the advancement of our society's knowledge.

APPENDIX C

The Rhode Island Airport Corporation

The Rhode Island Airport Corporation was formed on December 9, 1992 as a semiautonomous subsidiary of the then Rhode Island Port Authority, now the Rhode Island Economic Development Corporation to operate and maintain the state's airport system. The powers of the corporation are vested in its seven-member board of directors, six of whom are appointed by the governor, and one member appointed by the mayor of the City of Warwick. The Rhode Island Airport Corporation is responsible for the design, construction, operation and maintenance of the six state-owned airports; and the supervision of all civil airports, landing areas, navigation facilities, air schools and flying clubs. In addition to T. F. Green Airport, the Rhode Island Airport Corporation is responsible for five general aviation airports throughout the state: Block Island, Newport, North Central, Quonset and Westerly.

New England Airlines

New England Airlines has been providing daily scheduled air service between Block Island and Westerly airport as a certificated Commuter Airline since 1970. New England Airlines also has a private charter division which will take you to Block Island from any one of the nearby major airports such as Providence, Hartford, Boston, or New York. Charter flights are not only to or from Block Island. New England Airlines is certificated to operate between any points in the continental United States.

GAO Group Radio Frequency Identification Incorporated

GAO RFID Incorporated has established itself as one of world's most influential suppliers of RFID products, including RFID tags, readers and software, as well as integrated solutions for various vertical markets. GAO RFID places its emphasis on product quality and support. The company not only provides exceptional products and services for its standard off-the-shelf RFID products, but also offers customized solutions in innovative, economical and efficient ways. The company's projects have ranged from specialty pilots in giant parking complexes to national rollouts of customized modulation readers.

AltE Incorporated Alternative Energy Solutions

AltE® was founded in 1999 by three impassioned engineers focused on bringing renewable energy to the web and to the DIY enthusiast by reducing the costs of green energy systems and revealing the truths of how home based solar and wind energy systems can be designed and installed. They set out to build an online community and support that community with extensive, free educational materials, competitive pricing, knowledgeable staff and unbounded enthusiasm. Today, we at AltE are achieving that vision. We provide our customers with a select choice of renewable energy brands encompassing solar and wind energy systems, as well as quality renewable energy training. Our retail arm services Do-It-Yourselfers, hobbyists, and students with superb knowledge and friendliness, while our wholesale division provides personal service and expertise to professional installers and system integrators.

APPENDIX E

Student Assessment

The FAA Design competition provided the members of our team with an extremely valuable educational experience. Working on an open ended project in which the team defined its own problem and solution was a great change in pace from our typical assignments. It also provided valuable experience in how each team member will be using his/her engineering skills in the work force upon graduation. The design project proved to be a valuable tool in improving each member's abilities to work productively and successfully within a group. It also provided valuable experience in overcoming challenges the team had encountered during the design process.

There were a number of challenges the team had to overcome while designing and constructing the device. An RFID system required a great deal of electrical and circuitry knowledge. With the team being constructed of four Mechanical Engineers and one Industrial Engineer, there was little knowledge of how electrical systems work. In order to overcome this obstacle the team consistently consulted a knowledgeable Electrical Engineering Student at the University of Rhode Island. When the team was in the design phase, we found it difficult to insure that the design met FAA Regulations. The members of the team had very little or no knowledge of airport regulations, so we found ourselves frequently consulting with the RIAC and searching the online database of FAA Regulations. Another obstacle which significantly slowed the progress of the group was choosing which solution the team wanted to adopt. The team had a number of different preliminary designs in mind and did not decide on the RFID solution until about two months into the first semester. This put the team behind schedule and required a significant amount of work towards the end of the first semester to catch up. Once the team had decided on a solution approach, we began developing our design.

To develop our hypothesis we began meeting with the RIAC to discuss a number of issues it was having with its airports, one of the most pressing being tracking and counting the number of operations on non-towered airfields. So the group decided to design a solution to this problem. After intensive internet and patent research, the team decided RFID technology would be the best solution.

After the team decided on an RFID system, communication with industry leaders in this field proved to be extremely valuable. Due to the lack of RFID knowledge of the team members, communication with technicians from a number of RFID companies strengthened the team's ability to design the best possible system. Also, communication with a renewable energy company helped to guide the team in the assembly and circuitry of the photo voltaic solar panel and battery. This proved to be extremely valuable because the team's lack of electrical knowledge.

Each member of the team learned a significant amount during the duration of our design for the FAA Competition. One of the most important techniques each of us has gained skills in is the development of a project from start to finish. We have also learned a great deal about RFID technologies and circuitry. The FAA Design Competition provided the members of our team with an open ended, independent project. A project like this has provided great real world experience that each member of our team will use in the work force or in the pursuit in further studies.

Faculty Assessment

This was the second year that our university and engineering program participated in the FAA design competition. I slected this competition as one of the projects for my senior capstone design course in mechanical, industrial, and systems engineering because the program description and particularly timeline was an excellent match for my project requirements. Our senior capstone design sequence starts in the fall of the senior year and concludes in the following spring semester.

The value of the educational experience for students participating was excellent. In particular, interactions with our local Rhode Island Airport Corporation (RIAC) were outstanding and we received tremendous support from the engineering staff there. The students conducted a broad and comprehensive search through the problem outlined by the FAA design competition and identified a problem of significance to RIAC that is also of significant interest nationally (and perhaps internationally).

The most significant challenge for the students at the beginning was to identify, define, and research the problem(s) of interest. This search was conducted over a period of two months which delayed them somewhat during the fall semester. I feel that part of the issue with this delay was the broad nature of the FAA design competition announcement. However, because this was our second year experience with RIAC, we knew the people and this made the contacts and interactions much smoother. They provided tremendous support to the team.

The student team has done an excellent job in thoroughly exploring their problem (recording aircraft operations at uncontrolled airports). They have designed a practical and economical solution. They have prototyped their solution and have obtained reasonable results to pursue the creation of an engineered product. This is exactly the type of process and experience that we expect for our students on design projects. I am very pleased with the competition process, project solicitation, and organization of the FAA design competition. I will definitely use this competition again in the future if it will be continued.

If you have any questions or need additional information, please contact me.

Sincerely,

Bahram Nassersharif, Ph.D.

Distinguished University Professor

APPENDIX F

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