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Title of Design: Runway Operation Counter

Design Challenge addressed: Airport Operations and Maintenance

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Number of Undergraduates: 4

Number of Graduates: 0

Advisor(s) name: Professor Bahram Nassersharif, Professor Carl-Ernst Rousseau

Executive Summary

The determination of the number and type of operations occurring at the nation's roughly 3000 uncontrolled general aviation airports is a daunting task for airport inspectors to undertake. The fulfillment of the operations portion of the FAA 5010 inspection form requires that the exact number of operations and the type of the operations are known. At uncontrolled airports this is the responsibility of the airport manager and their log book, however with federal funding relying upon these numbers and the trend of simply estimating these numbers, an improved method of determining the number of operations occurring at an uncontrolled airport could be designed. According to officials at the Rhode Island Airport Corporation it is estimated that 60 percent of the operations occurring at local uncontrolled airports are estimated and not actually recorded. If these estimations are false it can lead to airports with insufficient funding, which in turn would lead to safety issues. The Runway Operations Counter is an integrated system that would over the course of a sample time period be put into place near the runway and record, analyze and store operations data occurring at these airports. The final product at the end of the sample time is a complete count of aircraft operations over this period of time as well as the type of aircraft. The system was designed and a prototype was tested over the course of the year. The results will be presented to the Rhode Island Airport Corporation for further assessment. The system was designed by using an intense design process. Many design tools were incorporated to improve the quality and efficiency of the design process. At the end of the spring semester the prototype system was completed and in the testing phase. The system functions as needed and could be developed into a fully operating system in the coming months.

The design team from the University of Rhode Island is comprised of three mechanical engineering students, one of which is a French exchange student, and one industrial engineer. The team was assigned to the project as a part of the year long Senior Capstone Design Course at the mechanical engineering department at the University of Rhode Island. The faculty advisors for the team are the professors of the course, Professor Bahram Nassersharif and Professor Carl-Ernst Rousseau. The University of Rhode Island is located in Kingston, Rhode Island and has over 15,000 students.

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List of Acronyms

FAA	Federal Aviation Administration
ROC	Runway Operations Counter
RIAC	Rhode Island Airport Corporation
QFD	Quality Function Diagram
D-Spec	Design Specification
FAR	Federal Aviation Administration Regulation
OCR	Optical Character Recognition

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Problem Statement and Background

To begin the process of defining the problem meetings were held in October 2009 with the Rhode Island Airport Corporation (RIAC). These meetings were specifically designed to, first, determine the exact problem area RIAC saw as the most important, second, identify the problems that are most important to solve in this area and, finally, determine which issue would be addressed by the team's design. Immediately the Airport Operations and Maintenance area was determined to be extremely important with many issues that need to be solved. The four following topics were discussed in detail with the airport inspector and two engineers from RIAC.

Runway Snow and Ice Removal

One of the main concerns of all airports located in areas affected by winter weather, the removal of snow and ice is a significant cost in terms of time and money. On average T.F. Green Airport spends approximate $15,000 per hour for snow removal. This includes the chemicals that must be applied to the runway. The chemicals, Sodium Formate and Potassium Acetate, cost $8.00 per gallon. During a winter storm or during adverse conditions that affect the condition of the runway a coefficient of friction of 40μ must be maintained for the runway to be safe. Any value below 40μ results in the closure of the runway. RIAC would like to develop methods that would help bring down this cost, as well as improve the speed and efficiency at which the snow and ice are removed.

Runway Obstruction Measurement

The approach paths of every runway must meet specific FAA regulations in order to be certified as safe. The runways primary surface, or no obstruction zone, extends 200 ft past the end of the runway and must not have any object within. After the primary surface the allowed height of objects is defined by a specific slope. Each type of approach has a different slope. For example an ILS approach has a slope of 20:1, or for every 20 feet from the end of the primary surface, 1 foot in elevation is allowed. For purely visual approaches, a slope of 50:1 is allowed. An important aspect in the inspection and measurement process for this slope is the controlling obstruction. The controlling obstruction is the highest point of an object on the horizon when viewed from the end of the runway. It is essential to measure this obstruction and assure that it is within FAA regulation. Current methods are either not accurate enough or too expensive. RIAC felt it was possible to develop a measurement device that would be able to gather data about the controlling obstruction with repeatable accuracy and speed.

De-Icing Fluid Containment and Clean-up

A major concern of not only RIAC but also the FAA and environmental activists deals with the use of De-Icing Fluid, or more specifically glycol. Glycol is used a part of the

De-Icing fluid to ensure that in icing conditions an aircraft is ice free prior to take-off. This is essential to passenger safety. The major drawback is that glycol is harmful to the environment and extensive measures must be taken in order to ensure that it is contained and cleaned up properly. The Environmental Protection Agency has declared that airports should try to reduce the amount of glycol that is released into the environment by 22%. Thus, the usage, containment and clean-up of glycol are major concerns for RIAC. RIAC would like to implement methods and designs that would suppress the amount of glycol released to the environment.

Airport Operations Data

The number of operations, number of aircraft departing and landing, at an airport is essential information in determining FAA funding for an airport as well as necessary upgrades, such as a tower. The information is the responsibility of the airport management to gather and present to the inspector from RIAC. From experience the RIAC inspector has indicated that the current method of gathering this data is inaccurate and plague by a high error percentage. Estimates show that the error is up to 60%. In the opinion of RIAC and the FAA accurate data about the number and type of operations occurring at the nation's airports that do not have a tower is essential. Current methods consist of using the airports log books and simple estimation, however the inaccuracies have a great affect on how funding is dispersed. RIAC would like to see instrumentation that would improve the accuracy of the operations data.

After much deliberation and discussion the team decided to focus on the airport operations data problem area. This is an area that not too much focus has been placed on by those wishing to improve airport operations; however it is viewed as essential information by the FAA. The problem is officially defined as follows:

> "The exact number of operations per year at uncontrolled airports is for the most part an estimate by the airport management or inspector. This data controls most of the funding and upgrades that the airport will receive from the FAA. It is estimated that the error percentage of these estimates could be in the 60% range and thus funding maybe incorrectly dispersed. A device is to be developed that operated for a period of one month and gathers information about the number and type of operations. This data gathered over the course of the month can then be extrapolated to be an estimate for the year. The device should also be able to record the identification number of the aircraft N-number, in order to obtain specifics for the various operations. The system should result in a more accurate count of aircraft operations as well as give a greater detail in the data for the aircraft for the aircraft that are operating at the airport."

Summary of Literature Review

The main sources of literature to be reviewed to aid in designing such a device are the FAA regulations that affect the placement and operation. After review with RIAC, Federal Aviation Regulations 77 and 45 were determined to be the most significant regulations to be reviewed by the team. FAR 77 regulates any objects or obstructions that are located in proximity of the runway and FAR 45 regulates the requirements of identification on the aircraft.

An examination of a report prepared for the Statistics and Forecast Branch Office of the Aviation Policy and Plans Federal Aviation Administration titled "Model for Estimating General Aviation Operations at Non-Towered Airports Using Towered and Non-Towered Airport Data" was used by the team as a reference to help determine some of the design specifications for the system. The report gives maximum and minimum general aviation operations on an annual basis for each state. This data was used specifically to design the system to handle such numbers of operations.

Other Literature that was used in the process of designing the system was the required text book for the Capstone Design Course. "Engineering Design 4th Ed." by George E. Dieter and Linda C. Schmidt was used to help procure design tools that would aid the team over the course of the year. The text provided detailed knowledge for various topics, such as concept generation, and helped the team produce detailed design specifications, a House of Quality, and various evaluations of the design.

As the design took shape a Siemens' handbook on Photoelectric Sensors and Theory of Operation became very important for the team. It provided detailed information on the workings of photoelectric beam sensors and their applications. This source was useful in determining the appropriate sensor to use.

Problem Solving Approach

Over the course of the year the team met weekly to complete the design process and monthly with the faculty advisors to discuss team progress. Meetings were held often with RIAC to help develop the design into an effective product. There was also interdisciplinary interaction over the course of the design. An industrial engineering student was assigned to the group to study the manufacturability of the design as well as a financial analysis of the design. There was also much interaction with the electrical engineering department as much of the design involves the wiring of electrical components. The electrical design was developed by the mechanical engineering students in the group with the aid of electrical engineering teaching assistants.

The team approach to solving this problem involved identifying the design requirements from RIAC and the FARs and creating design specifications for these requirements. The team then used the design specification to generate various concepts that would meet all specifications. These concepts were then analyzed using a House of Quality and the concept that had the best potential to meet the design specifications was chosen. From this point the design of the system was undertaken and a prototype was constructed. This prototype is to be tested to see if it meets the requirements of the design specification.

Rhode Island Airport Corporation Requirements

The team approached solving the airport operations data problem by first inquiring RIAC what they required from a designed Runway Operations Counting system. The Rhode Island Airport Corporation gave the following design requirements to be met in order for the design to be acceptable.

- A portable system to count the number of aircraft operations at uncontrolled airports
- Collects required operations information stated in the FAA 5010-1 inspection form, which can be found in appendix A.
- Records the identification number of the aircraft
- Will not damage the aircraft in a collision
- Does not require an operator
- Operates for a one month sample period
- Final Cost < $3000

Before a design specification could be created, a detailed analysis of all FAA regulations that would affect such a device was undertaken. Federal Aviation Regulation 77 and 45 were determined by the team and RIAC to be the most important regulations to be studied.

FAA Regulation Analysis

To ensure that the design meets the legal parameters set by the FAA, the FAA regulatory documents have been consulted in particular. These are FAR 77.25, FAR 45.25 and FAR 45.29. FAR 77.25 is incredibly important in terms of defining the physical parameters of the design, as it pertains to the allowable size of objects near the primary surface. It also sets parameters for position of the device and its capacity so that it can operate to the desired level while still being within the allowable margins.

While FAR 77.25 gives a broad range of parameters for allowable limits for objects within the airport airspace, the specific parameters are found in FAR 77.25 C.1.i, which gives the distance of 500 feet being the primary surface. That is within this 500 foot wide zone (which extends the length of the runway plus 200 feet) there can be absolutely no obstructions. What is permissible beyond this range is handled in FAR 77.25 E, which sets a 1:7 feet slope limit for any objects. With these two parameters taken into account, it is necessary to design the triggering mechanism to have a range of 500-600 feet so that the whole breadth of the primary surface is crossed only by the triggering mechanism's light beam, with further allowance for the triggering sensors to be mounted up two or three feet high. Likewise, these parameters give the requirements for the optical recording device. Ideally, all aircraft will be landing on the centerline of the runway, so any such device will have to be at least 250 feet removed from that centerline, and if it is to be mounted above the ground it must be seven feet further still for every foot in height.

Therefore the FAA Regulations require a designed system with an operational sensor range of five hundred to six hundred feet, and an optical range of up to 300 feet. The height of these objects must also be less than five feet tall, if mounted fifty feet beyond the primary surface, which is accounted for in the desired height of less than three feet.

FAR 45.25 and 45.29 deal with further parameters for the optical recording system. As it is one of the design goals to not only capture an image of the aircraft, but also a clear image of its N-Number to be analyzed through ideally an Optical Character Recognition System (OCR), documented along with a time-stamp so that far more information about the aircraft can be readily accessed beyond that which can be at the time of operation recorded.

FAR 45.25 A (And B.1 and B.2, which clarify the allowed positioning relative to aircraft type and configuration) states that the N-Number must be positioned on either the vertical tail surface or upon the side of the fuselage behind the main wing. This means that the design must take these positions into account and in fact we must treat them as the primary target areas. These are relatively large components of the aircraft and will not be blocked by the propeller, the cab, the wings, or any of the forward structures.

FAR 45.29 B.1, C, D, and E all set the target parameters of the size of the characters in the N-Number, by which the quality of optical capture can be set. Considering that fixed wing aircraft are the primary users of airports, they are the primary targets for optical capture. FAR 45.29 B.1 states that the characters must be at least 12 inches high, while FAR 45.29 C states that the width must be two-thirds as wide as they are high, except for special cases for the number "1", and the letters M and W. "1" is allowed to be one-sixth as wide as it is high, while M and W can be equally as wide as high. The capture quality of the camera has to be able to discern characters of approximately 2 by 12 inches minimum up to the standard of 8 by 12, and the maximum of 12 by 12. If characters of this size cannot be clearly recorded, then OCR is not possible through a computer set up (though perhaps it can be done manually, which while acceptable as it is the current method, is unacceptable for the purposes of the product being designed here.

Other specifications dictate that each character must be at least two inches thick and spaced by a distance no less than one fourth the width of the preceding character. This will typify as three inches.

So long as all of these parameters are met within the design the designed product will meet the required limitations set by the FAA and the product will be legally able to exist and operate.

Design Specifications

The design specifications were then developed after determining RIAC's requirements and the Federal Aviation Regulation requirements. Initial plans were to test the system at Westerly State Airport in Westerly, RI; as a result some of the design specifications, such as number of operations, are directly related to this airport. The design specification for the Runway Operations Counter is as follows:

> The Runway Operations Counter is a device that will gather data about airport operations at uncontrolled airports. The device is to gather this data as aircraft are taking off and landing from the airport. The system will be comprised of a sensory device to detect aircraft presence, a device to record the presence of the aircraft, a device to identify the aircraft and a device to store this data so that it may be gathered by the FAA inspector to complete the FAA 5010-1 inspection form. It is essential that the product meets all FAA regulations for safety concerns. The overall design must:
>
> - comply with all FAA regulations
> - operate in a temperature range of -20°F to 120°F
> - operate for a time period of 30 days
> - be less than 3ft in height
> - weigh less than 15 lbs
> - be portable
> - must structurally fail if struck by an aircraft
> - have less than a 5% failure rate

Due to FAA regulations the sensor to detect the presence of an aircraft will be placed at the ends of the primary surface as shown in figure 6.

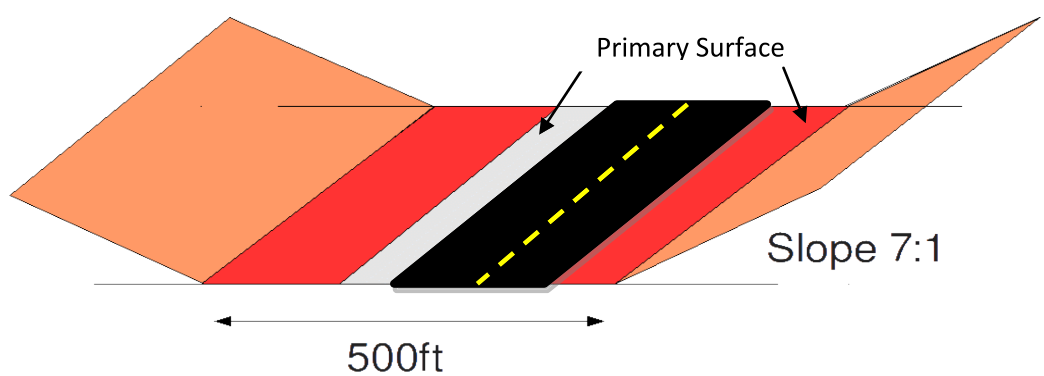


Figure 1: Illustration of Primary Surface Limitations

The sensor will be constant exposed to outside factors and may be triggered by objects other than airplanes. The detecting sensor must:

- operate across a range of 542 feet
- detect an aircraft traveling 120 MPH or less
- operate in all weather conditions that aircraft are allowed to operate in

- operate in a temperature range of -20°F to 120°F
- detect aircraft at all times of the day
- have a response time less than 0.5 seconds
- be able to trigger the recording device
- structurally fail if struck by an aircraft

The recording device is essential to the gathering of the operation data. Like the detecting sensor, the recording device will be exposed to outside elements for the entire duration of the sample period. The recording device does not have to span across the entire width of the primary surface. The recording device must:

- record the aircraft identification number electronically or visually of an aircraft traveling 120 MPH or less
- record the identification number at a range of 300 feet
- operate in all weather conditions that aircraft are allowed to operate in
- operate in a temperature range of -20°F to 120°F
- detect aircraft at all times of the day
- have a response time less than 0.5 seconds
- structurally fail if struck by an aircraft
- be weatherproof / waterproof
- store data to an external data source

A device must also be present that identifies the aircraft, gathers all pertinent data about the aircraft and then stores all information for future use. This device may be a part of the system or may be external to the system and simply used for analysis. This device must:

- Optically read and store the identification number of the aircraft
- scan the FAA n-number data base and identify aircraft in less than 5 seconds
- store the data to a master list

The final component of the design is a storage device to keep aircraft operations data stored for the FAA inspector. The device shall:

- be able to store data for 24,000 operations
- operate using non proprietary software

Concept Generation

A number of concepts were generated by the team to resolve the problem, while meeting the design specifications. The following concepts are a sample of the many generated.

Inductive Sensor System

The inductive sensor system would be used to detect the presence of a large amount a metal and then trigger a camera to take a photo of the aircraft. The sensor would be place under the runway. The main advantage of this concept is that there is no false detection due to the presence of animals. Only aircraft and vehicles on the runway would cause the sensor to operate. The cons of this concept are that the system would require modification to the runway, is permanent, would be expensive, and could have false readings due to vehicles crossing the runway. The concept was abandoned mainly due to the fact that it was not portable.

Pressure Sensor System

The pressure sensor system is a similar concept to the inductive sensor system in that the pressure sensor would be place under the runway. Only heavy vehicles would trigger the sensor and cause the recording device to operate. However, the system is not portable and required construction to be performed on the runway. This system was disregarded as it did not meet all of the design requirements.

Photoelectric Beam Sensor System

The photoelectric beam sensor system would allow for a portable and compact design. The system complies with FAA regulations by not being inside the primary surface and by conforming to the slope regulations. When the beam is broken the sensor would trigger a camera that would take a photograph of the aircraft. This photograph would then be analyzed for the identification number. The identification number would be searched for in the FAA database of identification numbers and the returned data would be stored to future use. The advantages of this concept are that it is compact and portable, as well having the possibility of being relatively inexpensive. The disadvantages of this system are that there are possible false detections due to wildlife or other vehicles. Also, unless a very expensive camera is used night operations will not recorded.

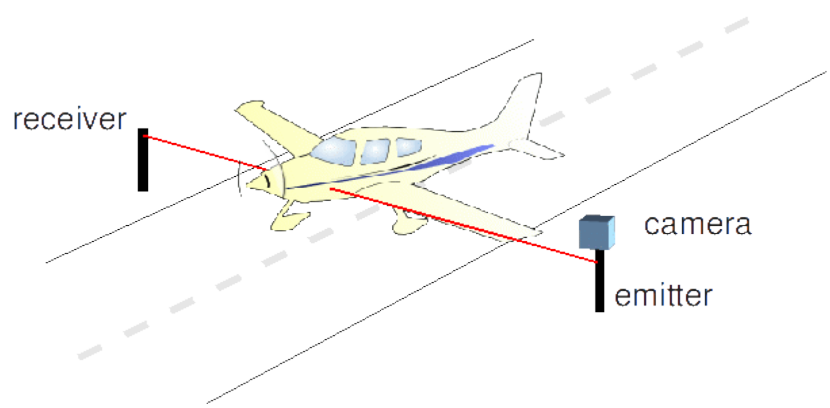


Figure 2: Photoelectric Beam Sensor System

Transponder Detection Unit

The transponder detection unit uses current technology to detect aircraft simply by detecting the aircrafts transponder. The transponder is an identification tag that 95% of aircraft have. The system is similar to the easy pass system found on the nation's interstates highways. The system consists of a reader that would detect the presence of the transponder and record the information. The system is very quick as it is purely electronically based however, the equipment is expensive, limited in range, and transponders are not mandatory nor are they turned on by the pilots all of the time.

Human Counting Method

This is the simplest method of counting the number of operations. An employee at each airport would simply be paid to count and record the number of aircraft operations occurring at the airport, as well as recording the type of aircraft as well. The issue with this method is that someone must be stationed at the airport at all times.

Online Log Books

Similar to the current method, this method would involve the pilot logging online to record their flight. However, it was decided that this method would suffer the fate of the current method since it depends on the pilots to record the operations.

Easy Pass System

This system would require the pilots to place a device similar to those used with Easy Pass into their aircraft. As the aircraft passes a certain point with sensors to detect the device it would record the information and store it into a database. The problem with this system is that it is very similar to the transponder method and relies on the pilots to fly with the easy pass device.

RFID System

This system is another method for detecting aircraft as they pass a sensor used to detect RFID chips. These RFID chips could be implanted into every aircraft at manufacture, or be placed in at service visits. The system would very similarly to the transponder system. The problem with this system is that all current aircraft would have to be fitted with the RFID chip.

Estimation Formula

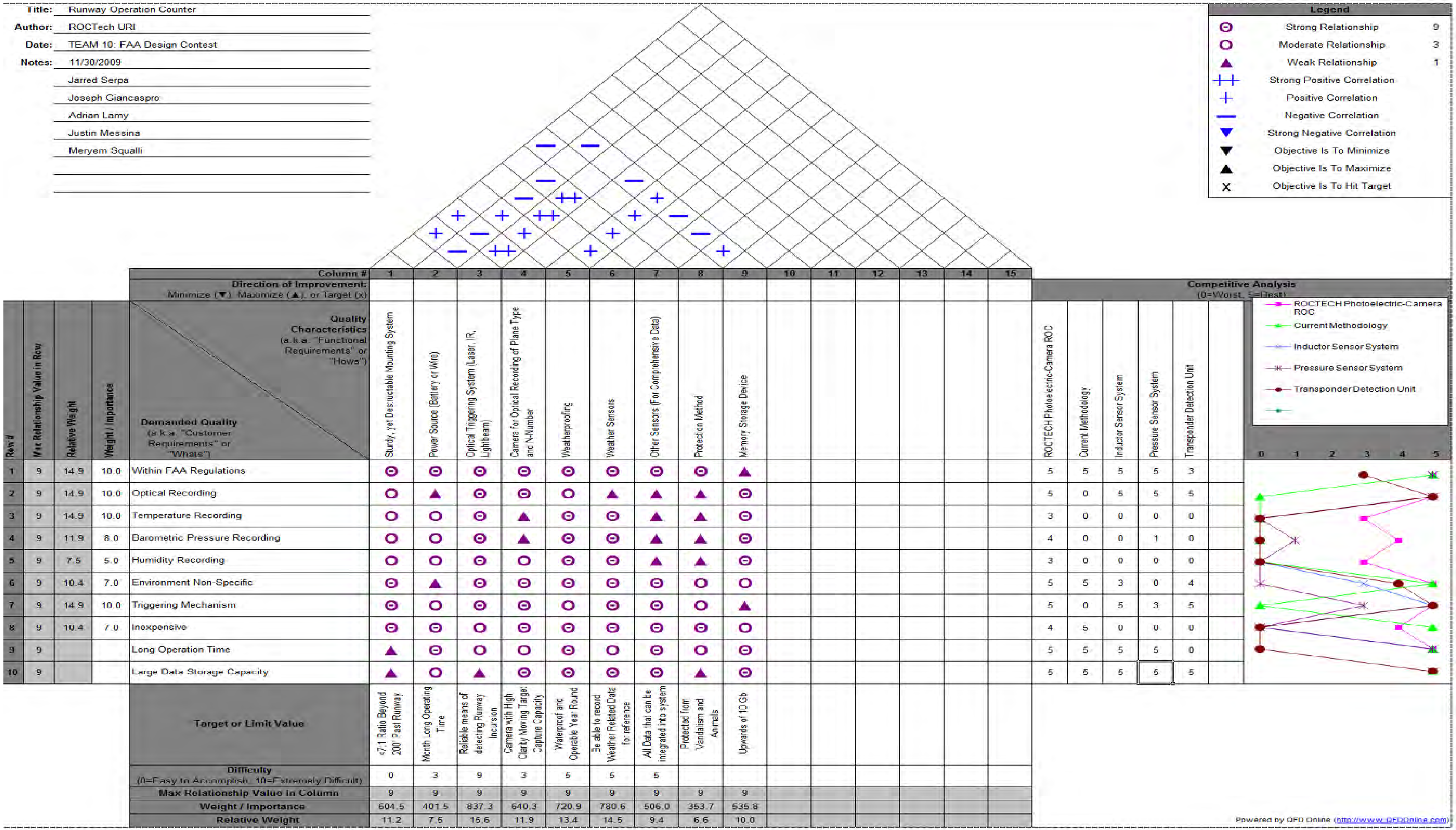
An estimation formula could be developed and used to determine the number of operations occurring at different airports. This formula would take into account different variables that could affect the number of operations. The downfall of this system is that it would require months upon months of observation at an airport to model the number of operations at an airport properly.

From these concepts it was determined that the photoelectric beam system would be the most feasible and cost effective to produce. The majority of the other concepts involved runway modification, incorporation of a sensor into all aircraft, or incredibly expensive components. The following House of Quality diagram helps illustrate the method that was used to pick the concept to be developed into a full design.

When performing a competitive analysis between the best of the proposed concepts it can be seen that the photoelectric beam-camera system produces the best overall system. It outperforms the current methodology of logbook by a large margin and has significant advantages over the other systems. The main advantage of such a system is the low cost of the required components. The transponder detection unit requires expensive, hard to obtain equipment and the pressure sensor system requires modification of the runway. The modification of the runway is expensive and may not even be feasible due to FAA regulations. An induction sensing system that would detect large amounts of metal could also be feasible; however the distance the sensor must be form the runway to meet FAA regulations makes the possibility of such a system very remote.

The photoelectric beam sensor system was chosen because the technology for such a system is proven and is readily available. The cost of such a system is low and can be modified relatively simply if a problem occurs or if an expanded capability is needed, such as weather sensors. After the photograph of the aircraft is taken, it would be analyzed by and optical character recognition program to find the n-number. The advantage of using such a system is that many OCR programs are readily available and are used in very similar applications, such as license plate recognition software. Finally the database analysis can be easily performed using commercially available database software, such as Microsoft access. The FAA N-number database is downloadable in the Microsoft access format and can be analyzed very quickly and inexpensively. While many of the other proposed concepts could achieve the intended goal, the photoelectric beam system would achieve these goals more efficiently and at a lower cost.

House of Quality



Row #	Max Relationship Value in Row	Relative Weight	Weight / Importance	Demanded Quality	ROCTECH Photoelectric-Camera ROC	Current Methodology	Inductor Sensor System	Pressure Sensor System	Transponder Detection Unit
1	9	14.9	10.0	Within FAA Regulations	5	5	5	5	3
2	9	14.9	10.0	Optical Recording	5	0	5	5	5
3	9	14.9	10.0	Temperature Recording	3	0	0	0	0
4	9	11.9	8.0	Barometric Pressure Recording	4	0	0	1	0
5	9	7.5	5.0	Humidity Recording	3	0	0	0	0
6	9	10.4	7.0	Environment Non-Specific	5	5	3	0	4
7	9	14.9	10.0	Triggering Mechanism	5	0	5	3	5
8	9	10.4	7.0	Inexpensive	4	5	0	0	0
9	9			Long Operation Time	5	5	5	5	0
10	9			Large Data Storage Capacity	5	5	5	5	5

Column #	1	2	3	4	5	6	7	8	9
Difficulty (0=Easy to Accomplish, 10=Extremely Difficult)	0	3	9	3	5	5	5		
Max Relationship Value in Column	9	9	9	9	9	9	9	9	9
Weight / Importance	604.5	401.5	837.3	640.3	720.9	780.6	506.0	353.7	535.8
Relative Weight	11.2	7.5	15.6	11.9	13.4	14.5	9.4	6.6	10.0

Figure 3: House of Quality

Detailed System Design

System Function

The complete function of the system is defined by the figures 4, 5 and 6. Figure 4 depicts the overall schematic of the system, figure 5 depicts the components that will be placed near the runway and figure 6 shows the basic operation of the entire system.

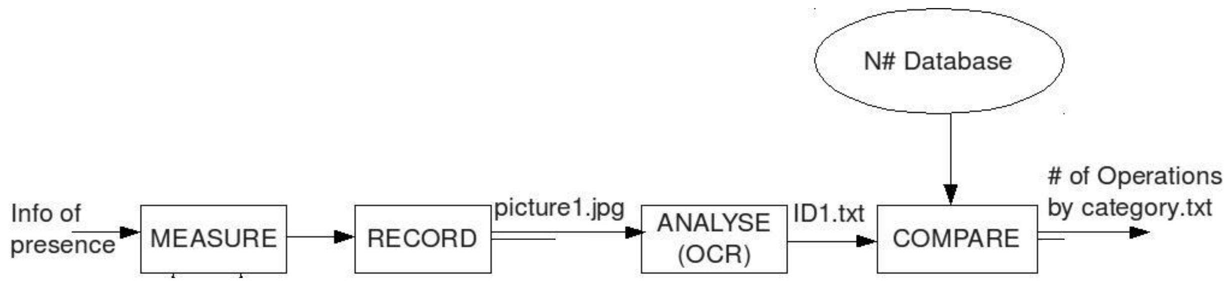


Figure 4: System Overview Schematic

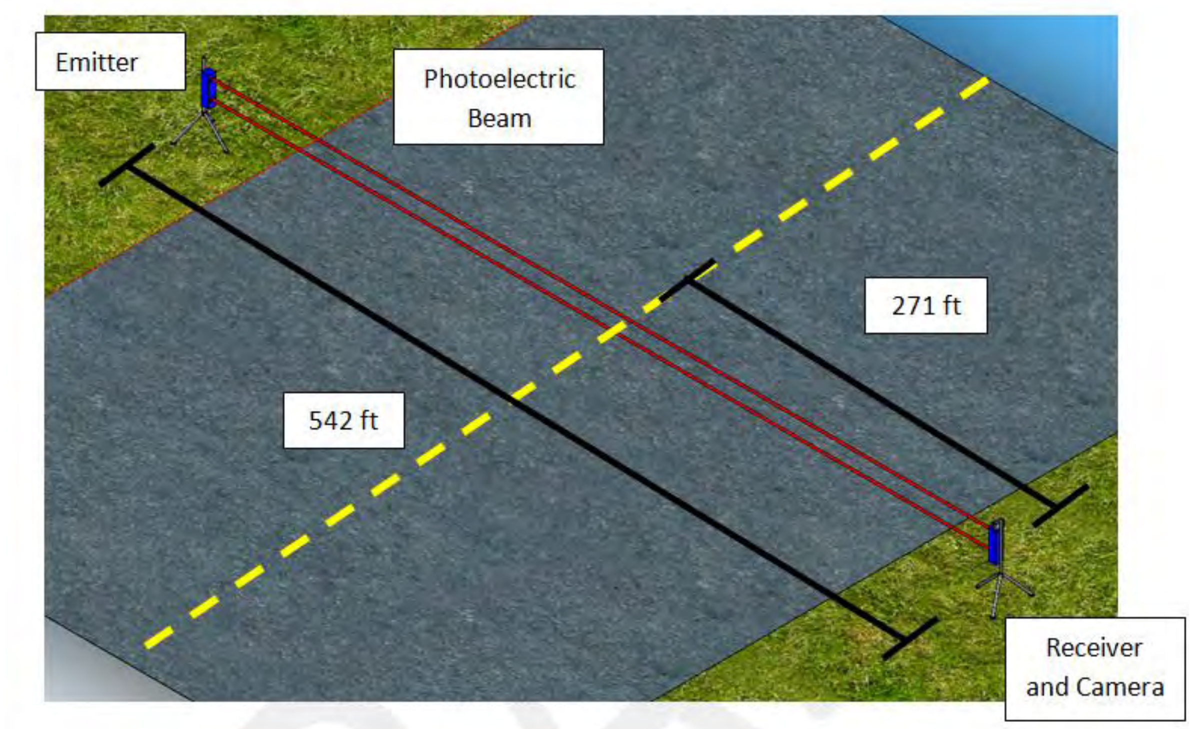


Figure 5: System Placement

Two photoelectric beams are mounted to bases that are placed 250 plus the height of the base multiplied by 7 feet from the center of the runway on each side. The output of receiver sensor is wired to a camera that takes a photograph of the aircraft as it passes by.

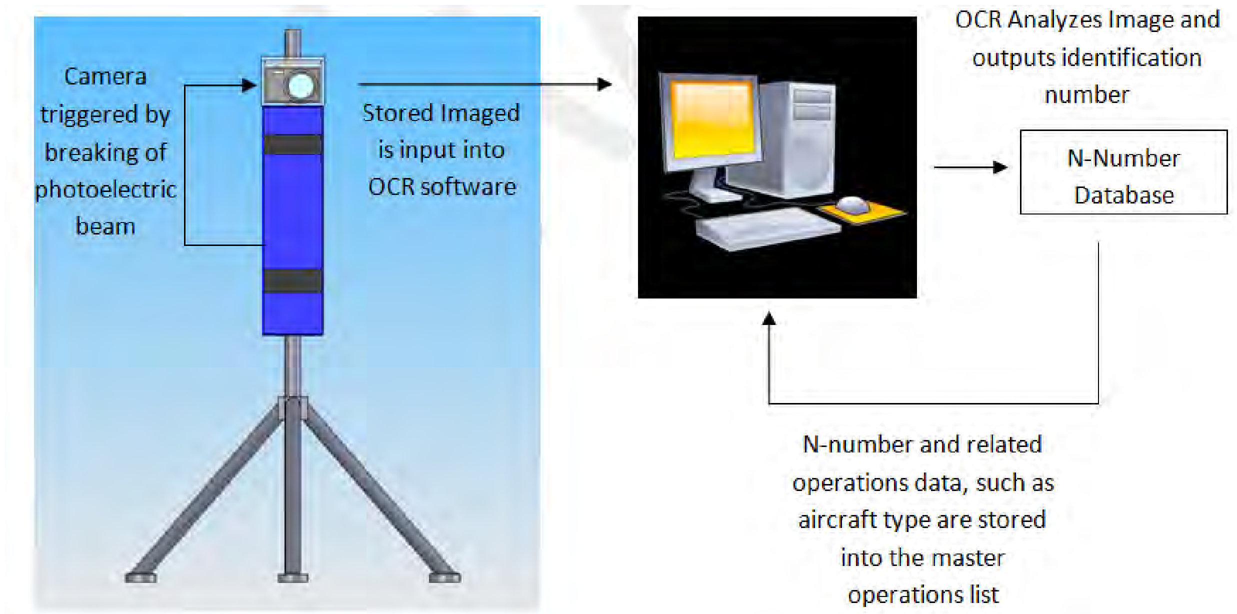


Figure 6: System Function

The images are then processed by an optical character recognition program to convert and store the tail numbers into a text file. This text file is then created into a database and compared to the FAA N-number database online, where all the required information for the FAA 5010 inspection form can be found. If the system is in place for the duration of the year, then the operations data can be presented directly to the airport inspector. If the system is used on a monthly basis, then the data can be extrapolated to cover the entire year.

Component Identification

The following table identifies the necessary components that need to be incorporated into the design and the design specifications they must meet. From this list a buy or produce decision will be made. This decision is based off several factors. The ability of the team to design and produce the component, the cost of commercially available components, and the amount of modification needed to make an "off the shelf" component fit into the design.

Component	Design Specifications
Photo Electric Beam Sensor	- operate across a range of 542 feet - detect an aircraft traveling 90 MPH or less - operate in all weather conditions that aircraft are allowed to operate in - operate in a temperature range of -20°F to 120°F - detect aircraft at all times of the day - have a response time less than 0.5 seconds - be able to trigger the recording device - structurally fail if struck by an aircraft
Camera	- record the aircraft identification number electronically or visually of an aircraft traveling 120 MPH or less - record the identification number at a range of 300 feet - operate in all weather conditions that aircraft are allowed to operate in - operate in a temperature range of -20°F to 120°F - detect aircraft at all times of the day - have a response time less than 0.5 seconds - structurally fail if struck by an aircraft - be weatherproof / waterproof - store data to an external data source
Optical Character Recognition	- Optically read and store the identification number of the aircraft - scan the FAA n-number data base and identify aircraft in less than 5 seconds - store the data to a master list
Storage Device	- be able to store data for 24,000 operations - operate using non proprietary software
Camera Housing	- weather- and waterproof the camera
Sensor and Camera Mounting	- secure and keep alignment of the sensors and camera - structurally fail if struck by an aircraft
Electrical Components	- wiring camera to sensor

Table 1: Required Components

The majority of the components exist commercially and can be easily modified to meet the designs requirements. Thus, it was decided that the majority of the components would be "off the shelf," meaning that they would be purchased and modified as needed. The main component that would be designed by the team was the base, and the mounting mechanism for the camera and sensors. It was decided that these components should be created by the team to ensure that in the case of an accident of an aircraft the entire mechanism would be destructible and cause minimal damage to the aircraft.

Photoelectric Beam Sensor

The analysis of the existing photoelectric beam sensors that meet the design specifications reveals that the required range of the design is at the outer limits of current sensors. The majority of outdoor photoelectric beam sensors have a range between 100ft to 300ft. Also, most beam sensors that contain the emitter and receiver in the same housing and use a reflector at the other end only have a range of up 200ft. A thorough search reveals that only a few sensors meet the design specifications. Two of these sensors are manufactured by the same company, OPTEX. The application of these sensors ranges from industrial applications in a production line to security applications where the sensor is used to trigger an alarm. The two sensors produce by OPTEX that meet the design specifications are the OPTEX AX-650TF and OPTEX AX-500PLUS. Table 2 summarizes the features of each sensor and the realization of the design specifications.

Photo Electric Beam Sensors		
Component	**Features**	**Realized Design Specification**
Optex AX-650TF 	- Effective Range: 650ft - Protective Housing - -31°F to 151°F - 0.05 to 0.7 s response time - Selectable contact relay (N/O, N/C)	- operate across a range of 542 feet - operate in all weather conditions - operate in a temperature range of -20°F to 120°F - have a response time less than 0.5s - be able to trigger the recording device
Optex AX-500PLUS 	- Effective Range: 500 - Protective Housing - -31°F to 151°F - 0.05 to 0.7 s response time - Selectable contact relay (N/O, N/C)	- operate across a range of 500 feet - operate in all weather conditions - operate in a temperature range of -20°F to 120°F - have a response time less than 0.5s - be able to trigger the recording device

Table 2: Photoelectric Beam Sensors

The AX-650TF sensor has been chosen to be the sensor used for the design as it meets the major design specifications needed to fulfill the system requirements. While the AX-500PLUS covers over 500ft, it is at the outer limit of the device.

Camera

Various digital cameras are available to be used for this design. After researching and testing the requirements needed to photograph a fast moving object with a still camera, the main requirement outside of those stated in the design specifications, is the number of megapixels. 8 megapixels or greater is ideal for capturing a fast moving vehicle clearly with a stationary camera from a great distance. This differs from the preliminary design in which shutter speed was the priority. It was discovered during testing that the distance of over 250ft is so great that the shutter speed has little effect, and the resolution of the image is much more important for the clarity of the image. Current research has shown that the majority of digital cameras have this capability. The other main priority is response time. The camera must quickly take the image or else the moving aircraft will be completely out of the frame. A camera that can rapidly take photographs is ideal for this design. The Sony DSC-W170 meets all of the specifications. The following table shows the DSC-W170 specifications and the design specifications that are met.

Camera		
Component	**Features**	**Realized Design Requirements**
Sony DSC-W170 	- 10.1 Megapixels - 1/1600 Shutter Speed - 5X Optical Zoom	- 8 Megapixels or greater - 1/1200 Shutter Speed or Greater - 4X Optical Zoom or Greater

Table 3: Camera Specifications

Camera Housing

It was decided to purchase the camera housing as there are many commercially available housings and if there is ever a need to change cameras, it is simpler to purchase the correct housing rather than redesign the current one. The camera housing that will be used is designed to be used with the Sony DSC-W170. It is manufactured by IkeLite and is waterproof up to a depth of 200 feet. This housing meets all of the requirements of the design specification.

Figure 7: Camera Housing

Sensor and Camera Mounting

The essential factor for the base for mounting the sensor and camera is that it is the component that structurally fails first in the rare case of an accident with an aircraft. The is achieved by designing a base with a tripod that is fixed to it. The base is secured to the ground with stakes and the tripod is affixed to the base using ¼" nylon bolts. These bolts are designed to fail in the case of an accident. Both the tripod and base are made of 6061 aluminum and is assembled using ¼" stainless steel bolts of various lengths. Only the center tube of the tripod is welded in place.

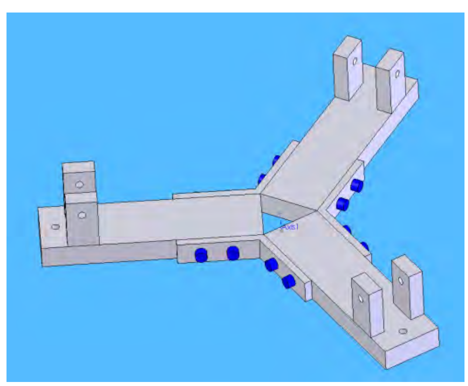


Figure 8: Base Assembly

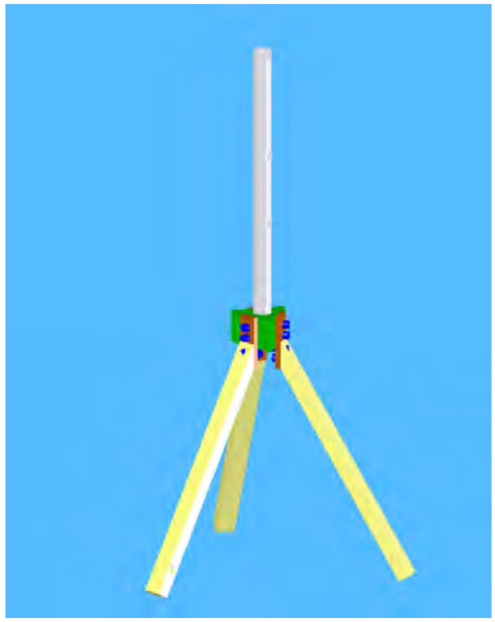


Figure 9: Tripod Design

Dimensional drawings for the base and tripod design can be found in the appendix C. The following materials are needed to construct the base and tripod designs.

Material	Dimensions	Quantity
6061 Aluminum	7/8" X 7/8"	12'
6061 Aluminum	3" X 3" X 1-1/2"	1
6061 Aluminum	1" X 1/4"	36"
6061 Aluminum	7/8" OD	36"
6061 Aluminum	1-1/2" X 1/2"	12"
6061 Aluminum	2" x 3/4"	6'
6061 Aluminum	3/4" X 1/4"	48"
6061 Aluminum	1" X 1/2"	36"

Figure 10: Base and Tripod Materials

Figure 11 shows the complete base and tripod assembly with the transmitter sensor attached while figure 12 shows the base and tripod assembly with the receiver sensor and camera attached. Two of these are to be produced per system, one for the receiver sensor and one for the transmitter.

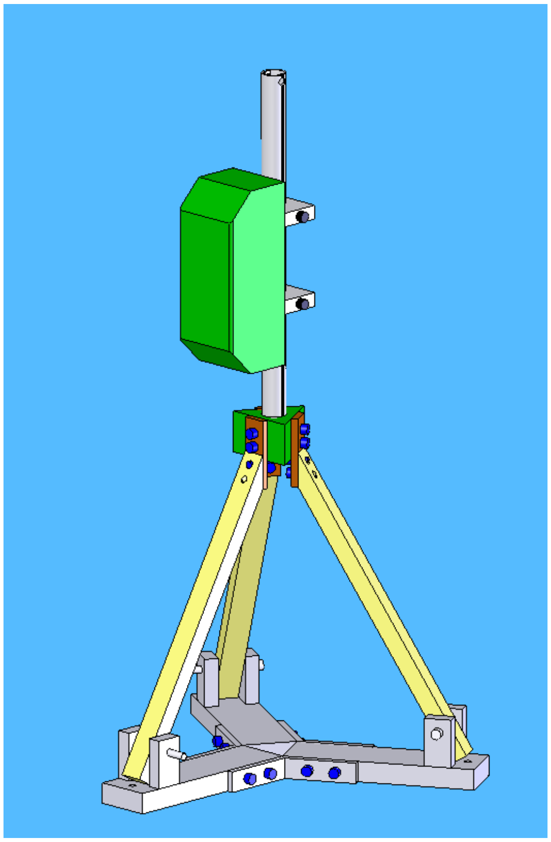
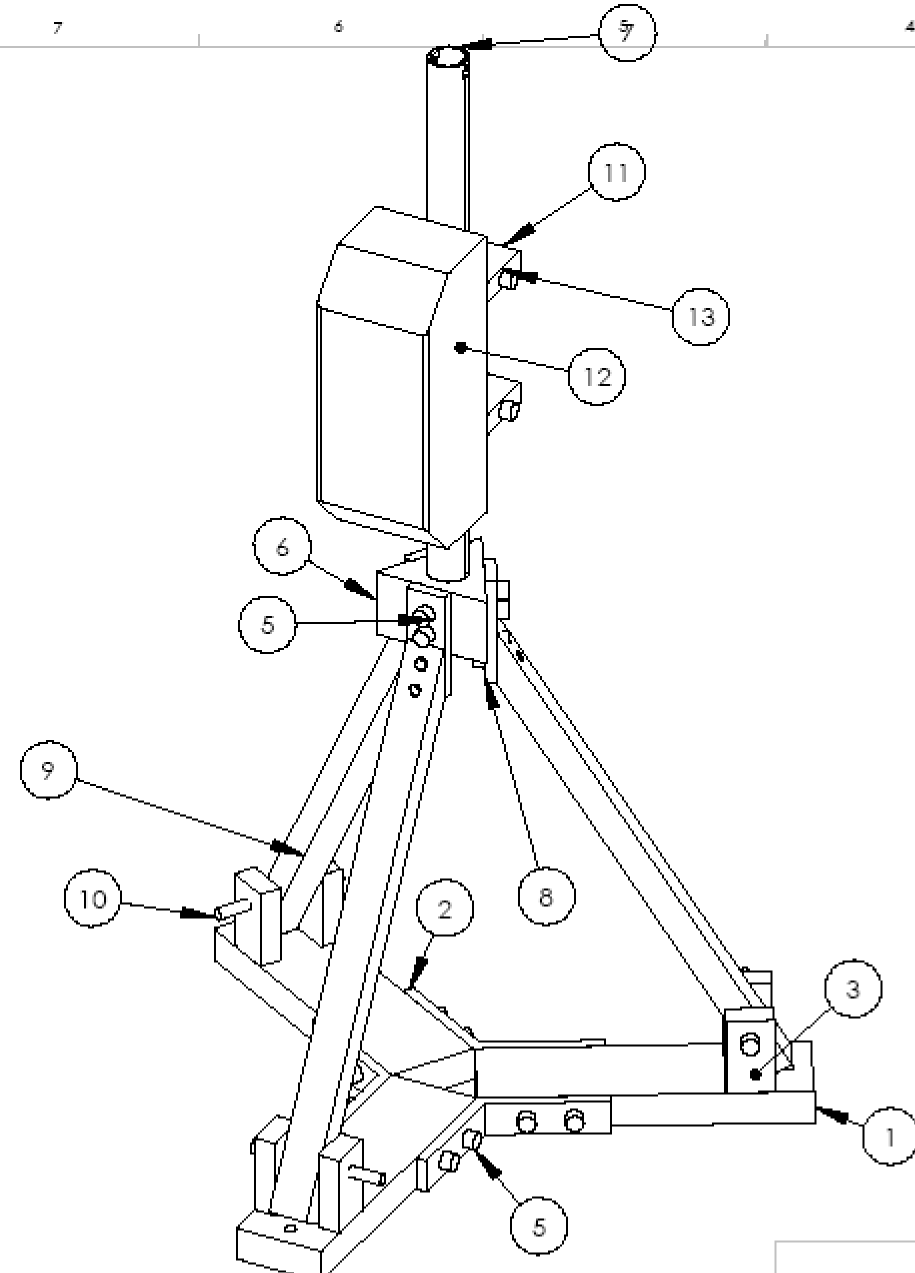


Figure 11: ROC Assembly

The camera is attached to the tripod design using an already existing tripod head that can be affixed to the 7/8" OD diameter tubing. The following drawings encompass the complete design of the base, tripod, camera mounting and sensor mounting



ITEM NO.	PART NUMBER	QTY.
1	Base Foundation	3
2	Base Foundation BRKT	3
3	Verticle Leg Block	6
4	#10-32 1" SS Socket Head Cap Screw	12
5	.25-20 3/4" SS Socket Head Cap Screw	24
6	Joiner Block	1
7	Tripod Top	1
8	Tripod Leg Joiner BRKT	3
9	Tripod Leg	3
10	1/4"-20 3" Nylon Socket Head Cap Screw	3
11	Sensor Mount	2
12	SENSOR	1
13	1/4"-20 3" SS Socket Head Cap Screw	2

UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN INCHES
TOLERANCES:
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ANGULAR: MACH ± BEND ±
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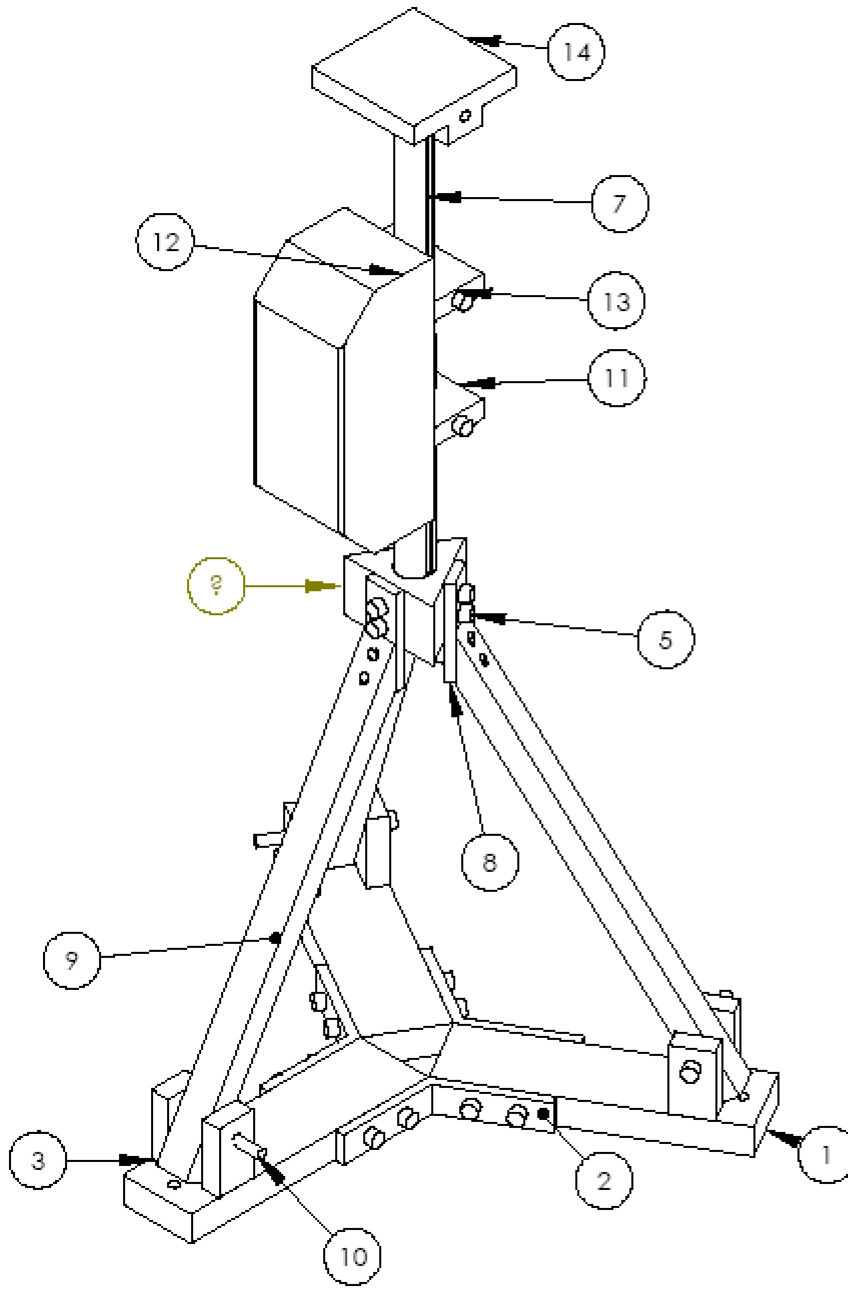

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4	#10-32 1" SS Socket Head Cap Screw	12
5	1/4"-20 3/4" SS Socket Head Cap Screw	24
6	Joiner Block	1
7	Tripod Top	1
8	Tripod Leg Joiner BRKT	3
9	Tripod Leg	3
10	1/4"-20 3" Nylon Socket Head Cap Screw	3
11	SENSOR MOUNT	2
12	SENSOR	1
13	1/4"-20 3" SS Socket Head Cap Screw	2
14	Camera Mount	1

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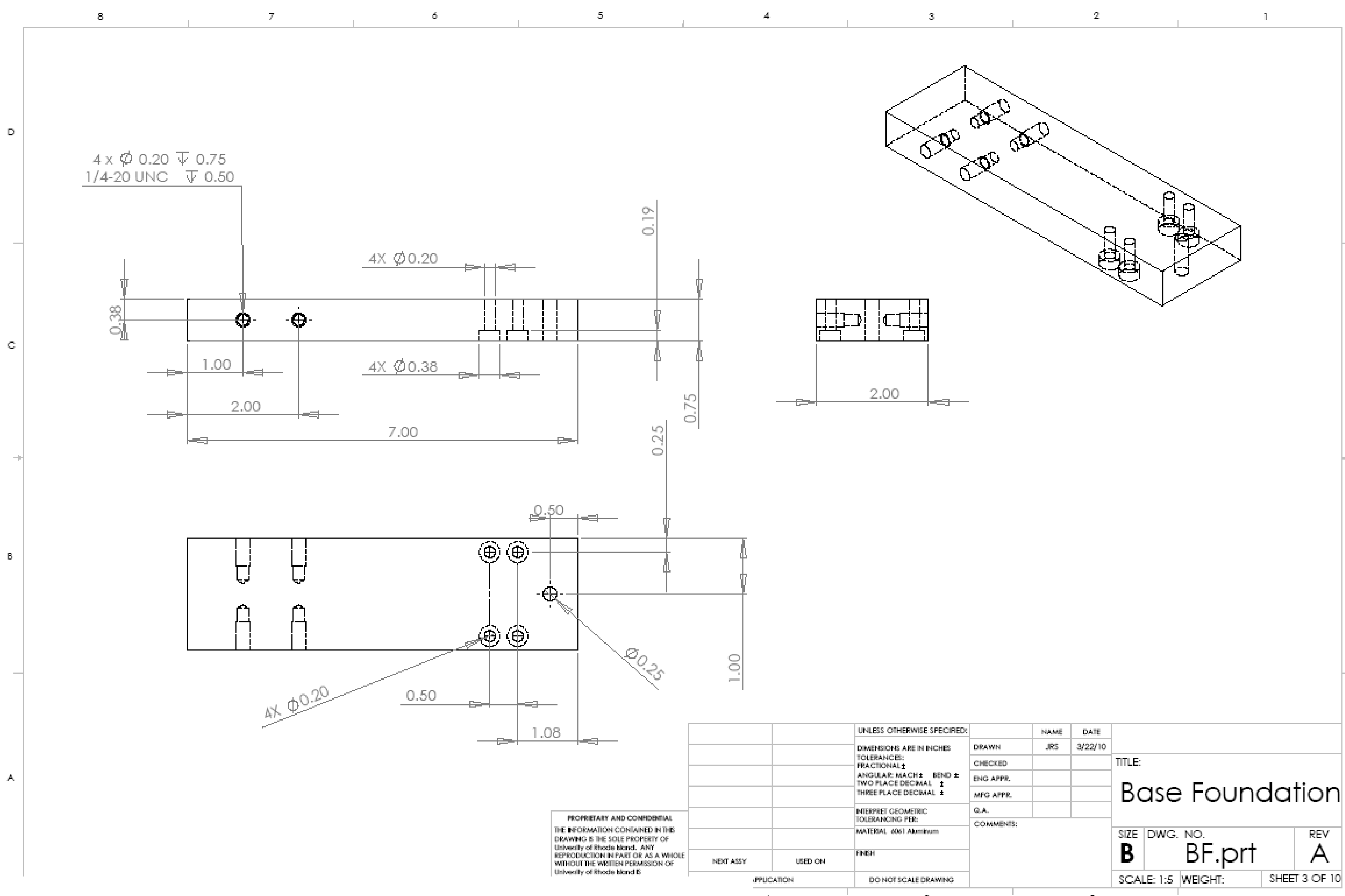
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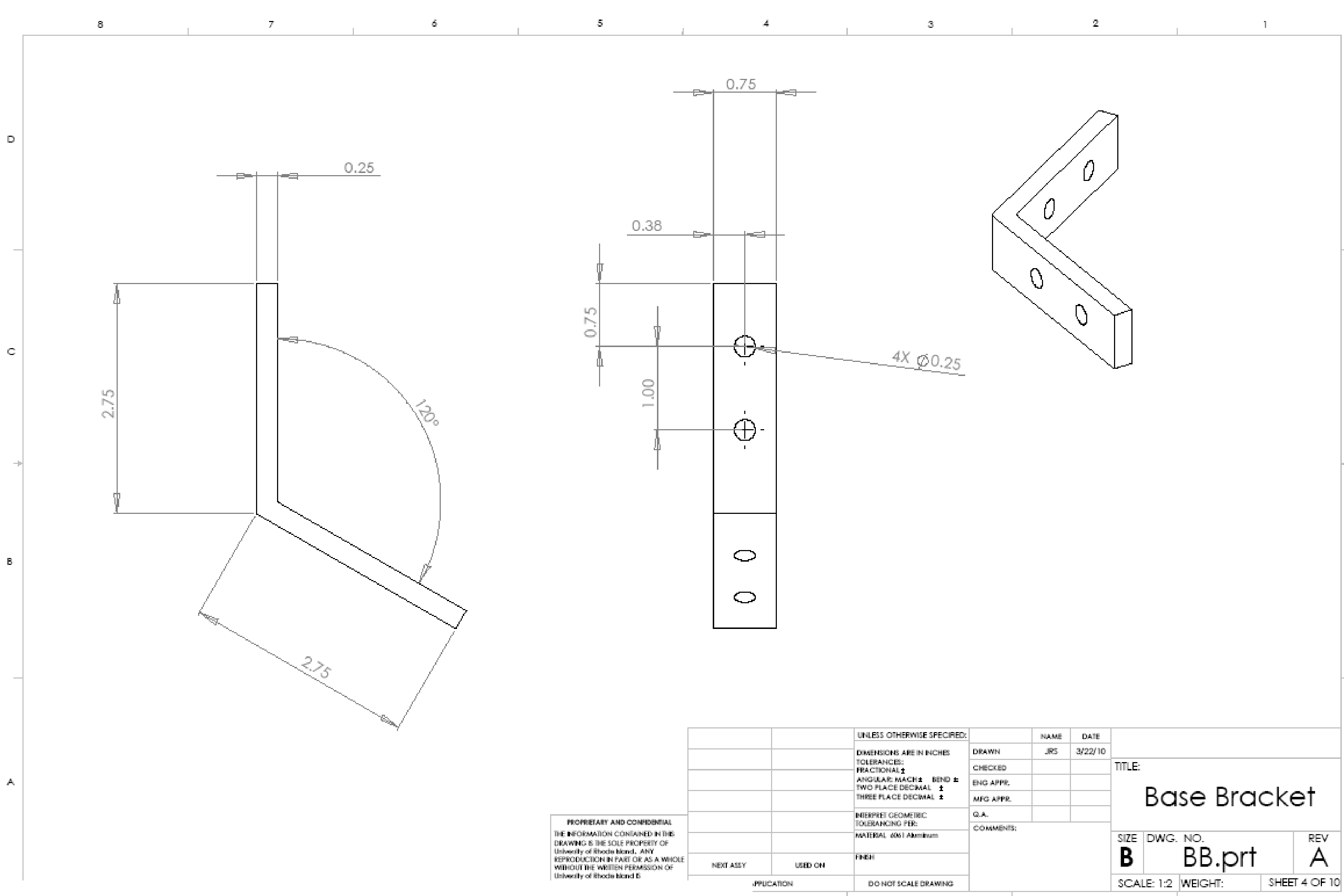
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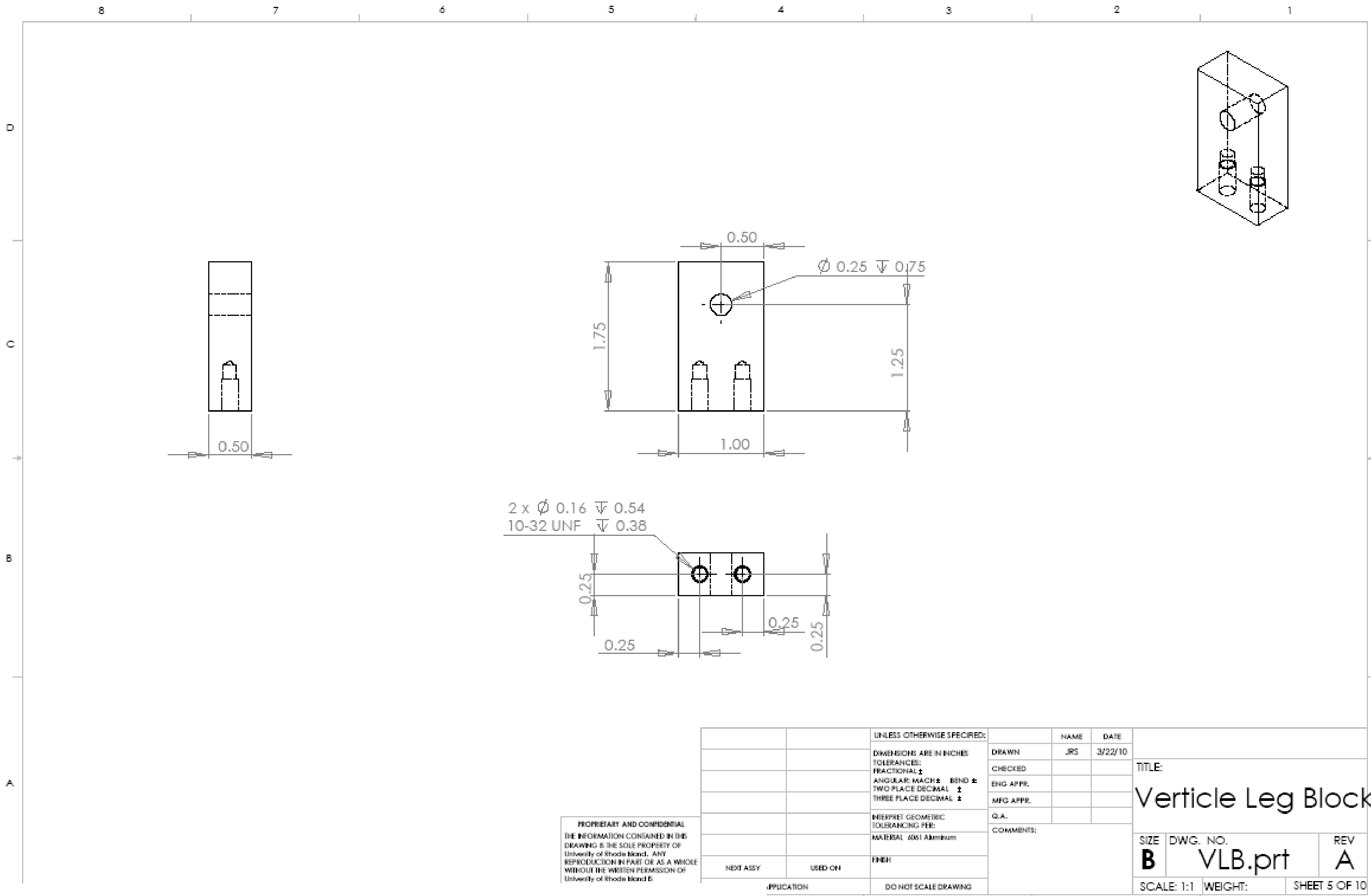
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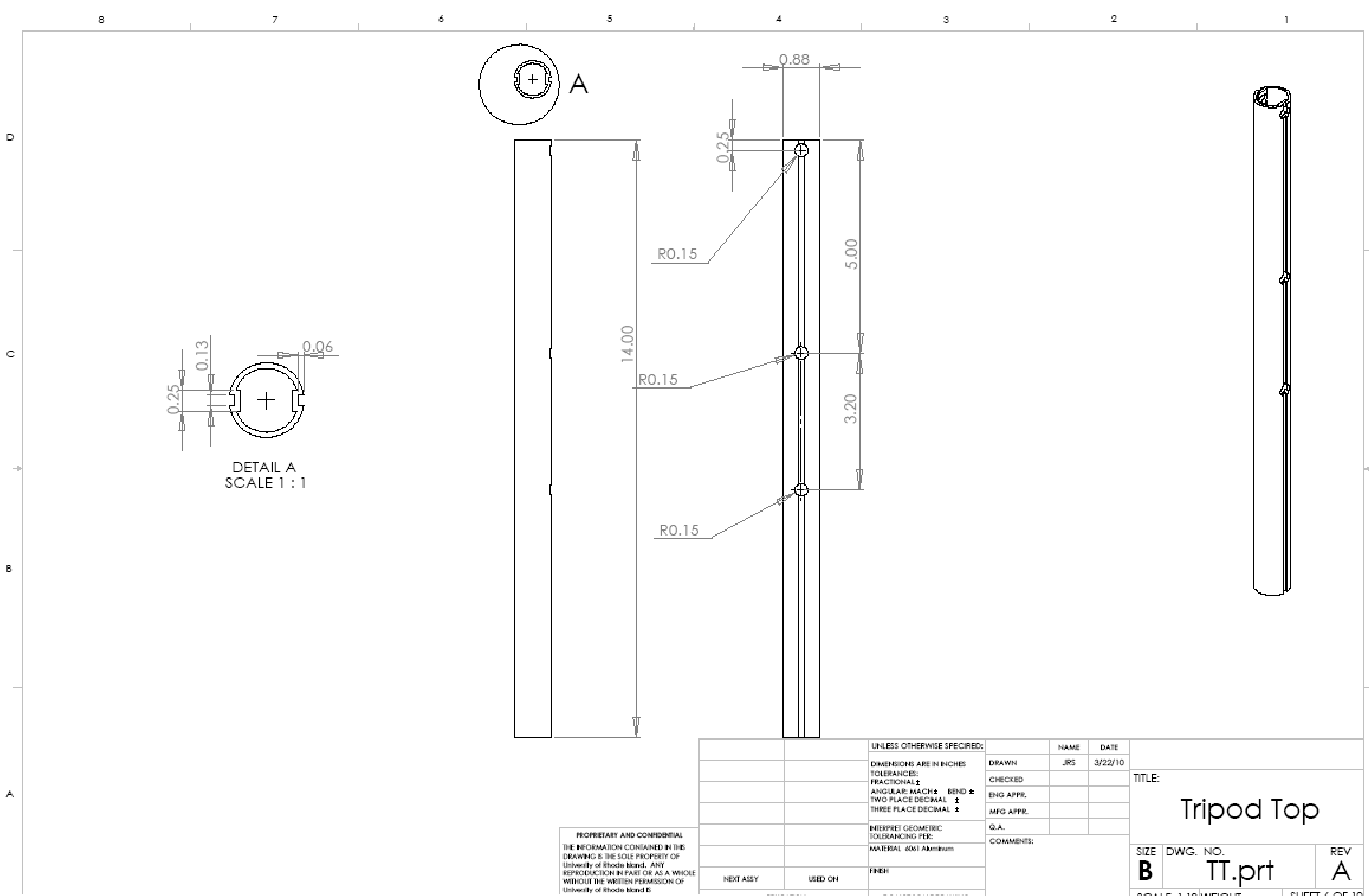
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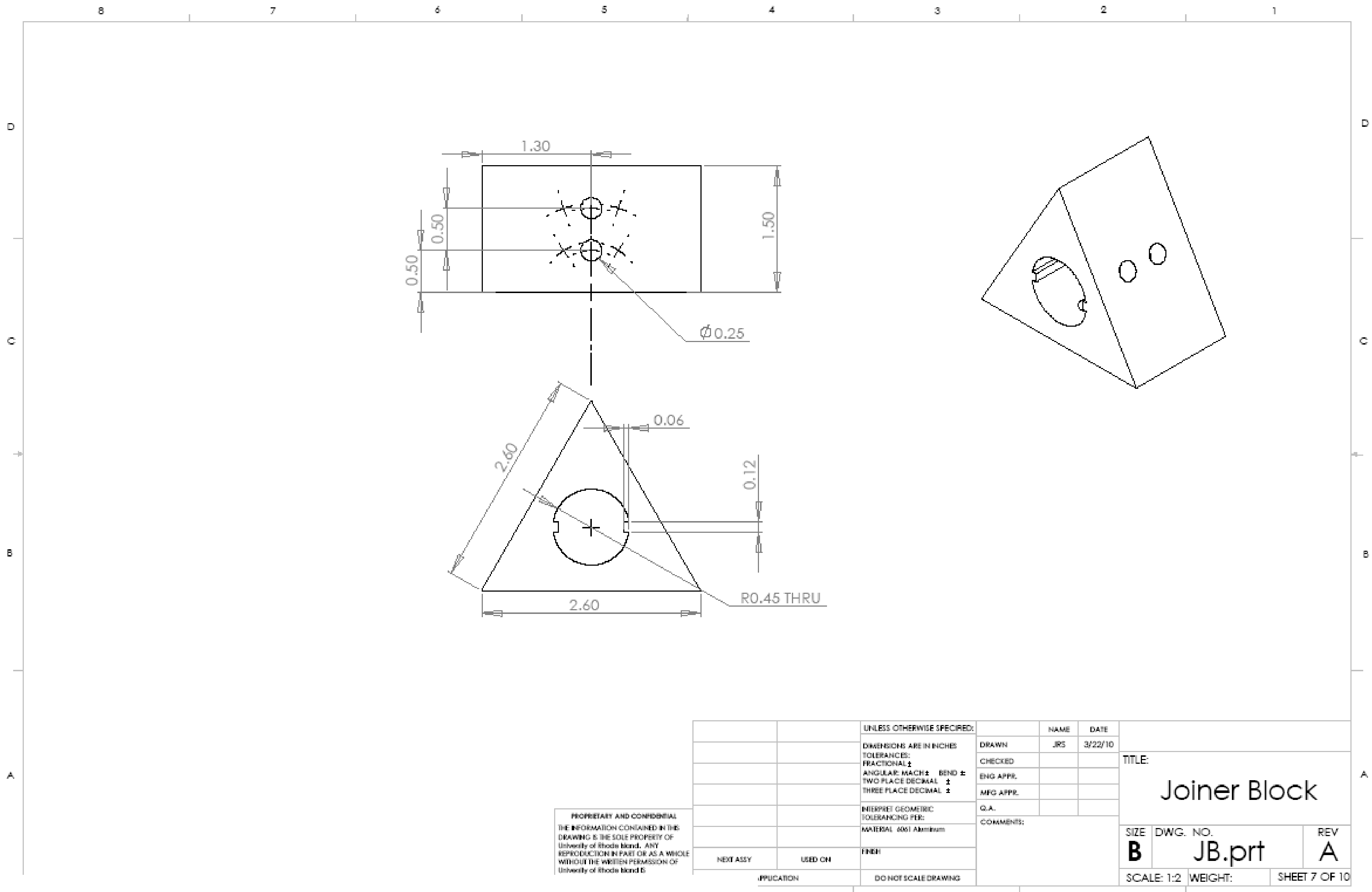
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REV A
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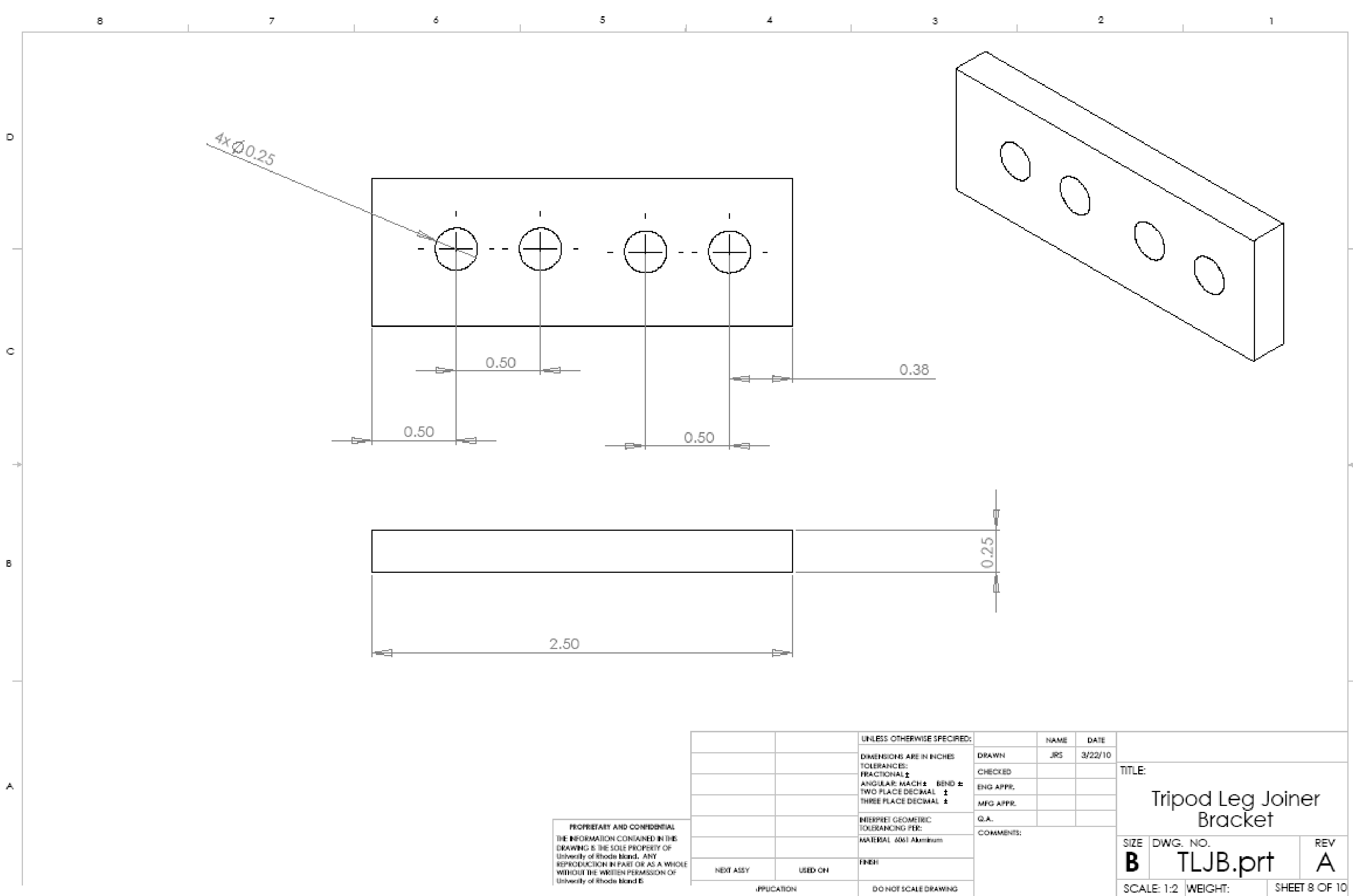
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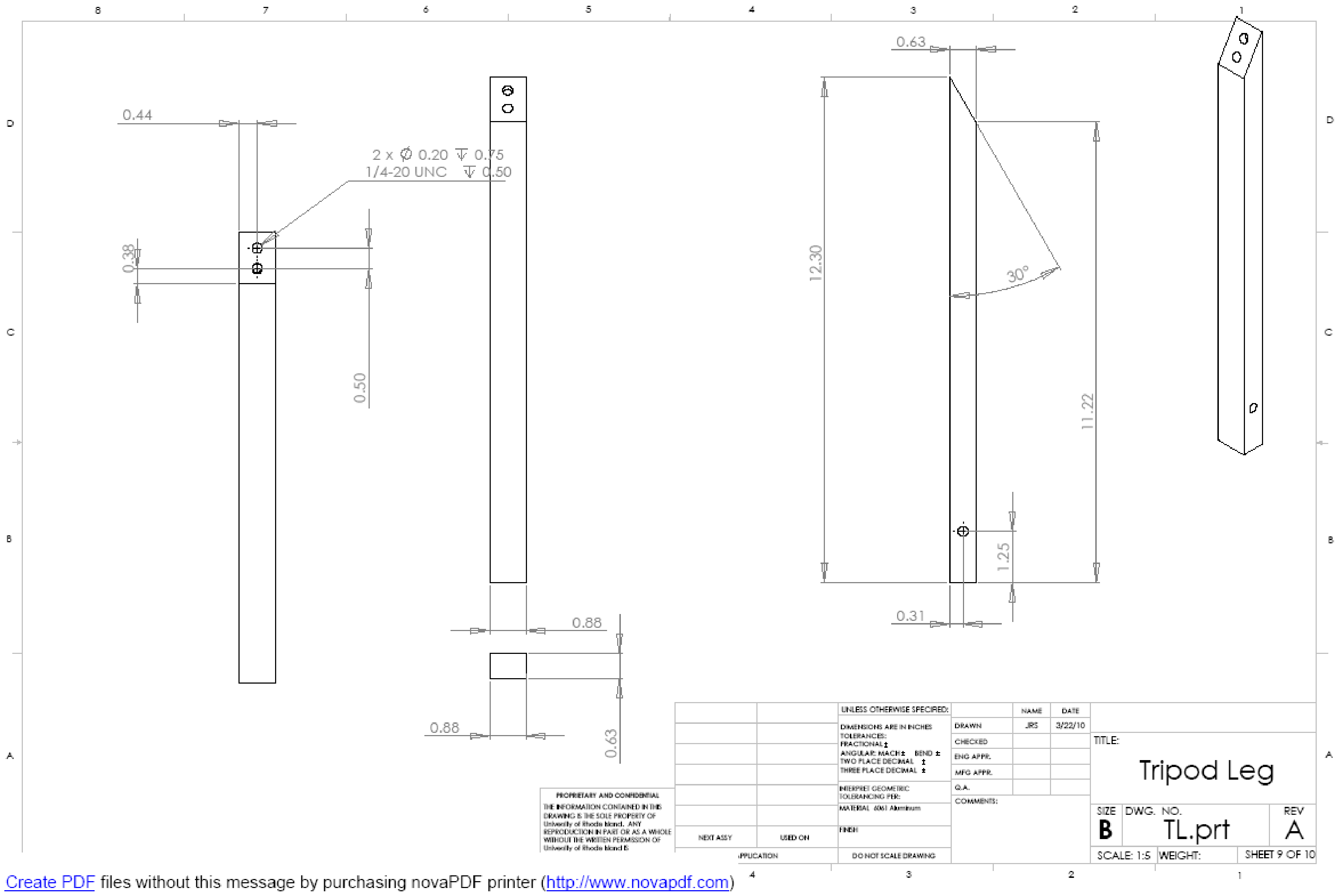
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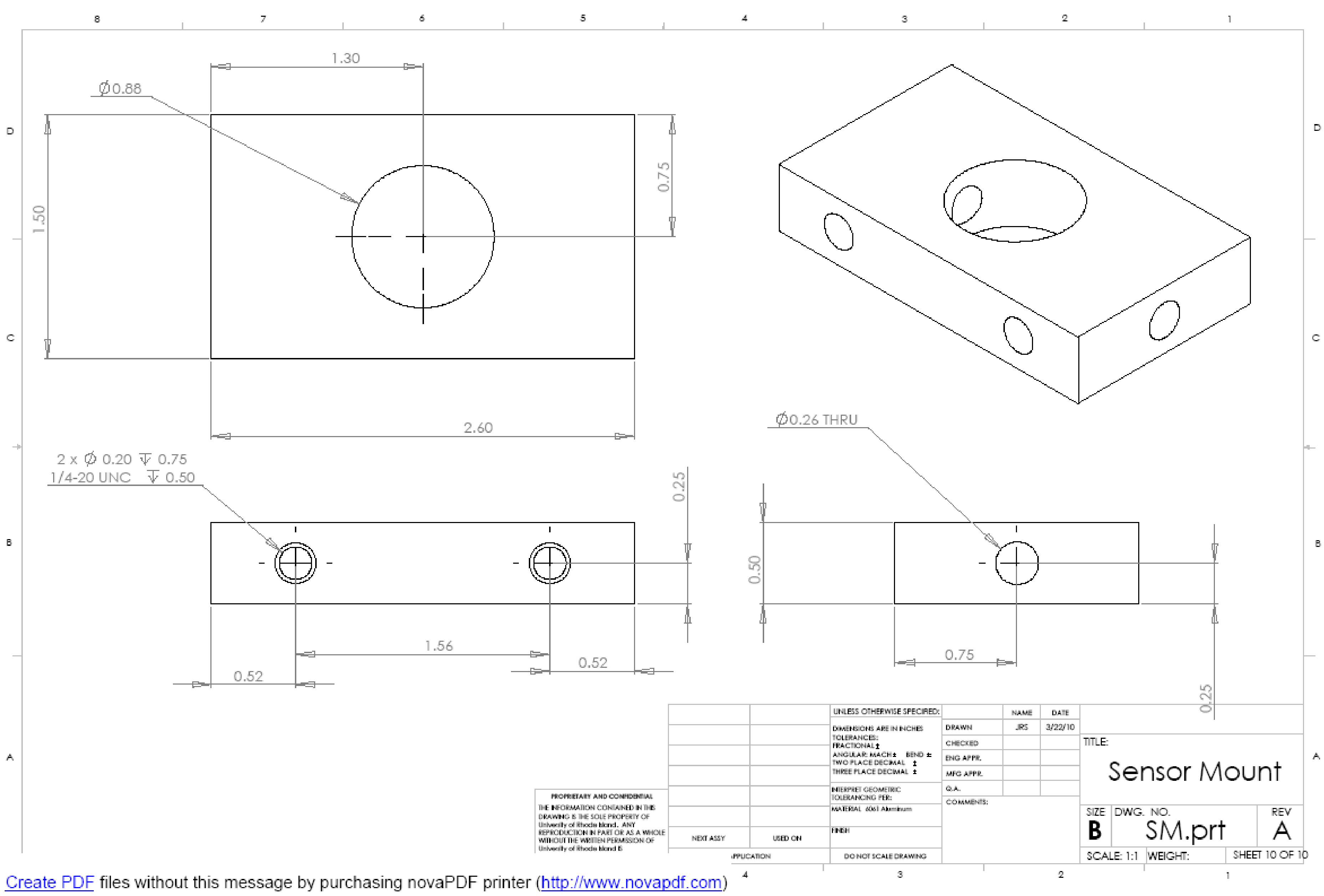
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Sensor Mount
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SHEET 10 OF 10

Optical Character Recognition Software

A main feature in the design of the Runway Operations Counter is the ability for the images to be automatically processed. This involves a way of reading the images for the identification number. Optical Character Recognition software is in common use today. While the is no specific OCR software that has been designated for use in this design, it is possible to use one of the many license plate recognition software that currently exist with some modification. One existing software package is SeeWay, which is produced by Advanced Imaging Processing Products. SeeWay is able to identify the license plate number of fast moving vehicles on the highway. The product would fit well into the Runway Operations Counter design.

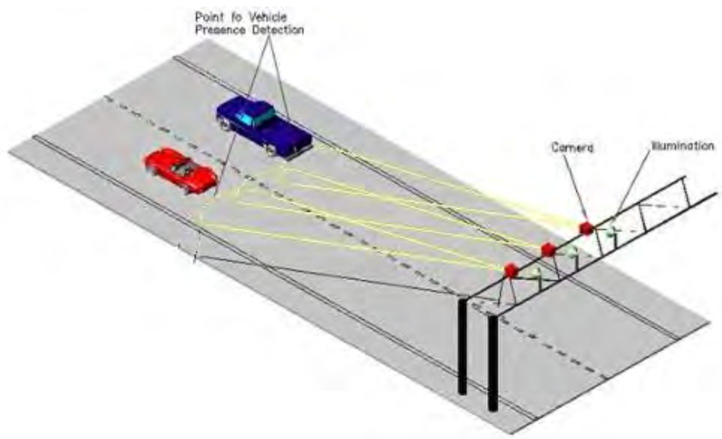

Figure 12: SeeWay Concept

The cost of such an OCR programs range is $1000.00. Each program has specific capabilities; however they could not be explored by the team due to cost limitations. A program such as SeeWay could be modified to meet the needs of the Runway Operations Counter. However, due to the cost limitations this option could not be explored further.

Database Analysis

The analysis of the N-numbers the OCR program will create a database that contains all N-numbers that were captured over the sample period. This N-number can be compared with the FAA database of N-numbers using Microsoft Access. The process is relatively simple and Microsoft access is found on any computer with Microsoft Office. The process involves downloading and opening the master database from the FAA, which is updated weekly, and opening the N-number database from the OCR program and comparing the two to find all matches. The required information can then be displayed and saved into a separate database. The detailed process for this step can be found in the operations manual included in the appendix.

Power Supply

Due to the sufficient power grid that exists at the majority of airports due to the wiring for the runway lights, power will be provided for by this system. The direct current systems that currently exist at all airports will be adequate to run the entire system for an extended period of time. The system is designed to operate on 12 volts and most power systems can be modified to fulfill this power requirement.

Wiring Configuration

It is important that the system is wired correctly for proper operation. The following diagram shows the schematic of how the system is to be wired together. The numbers shown represent the corresponding terminal on the sensor. Terminals 3 and 4 are connected to a normally open relay which will close and complete the loop when the beam is interrupted and the receiver no longer is activated. This results in the solenoid in the relay to no longer be energized and a spring causes the mechanical switch in the relay to close. Terminal 3 and 4 are directly wired in to the triggering switch of the camera.

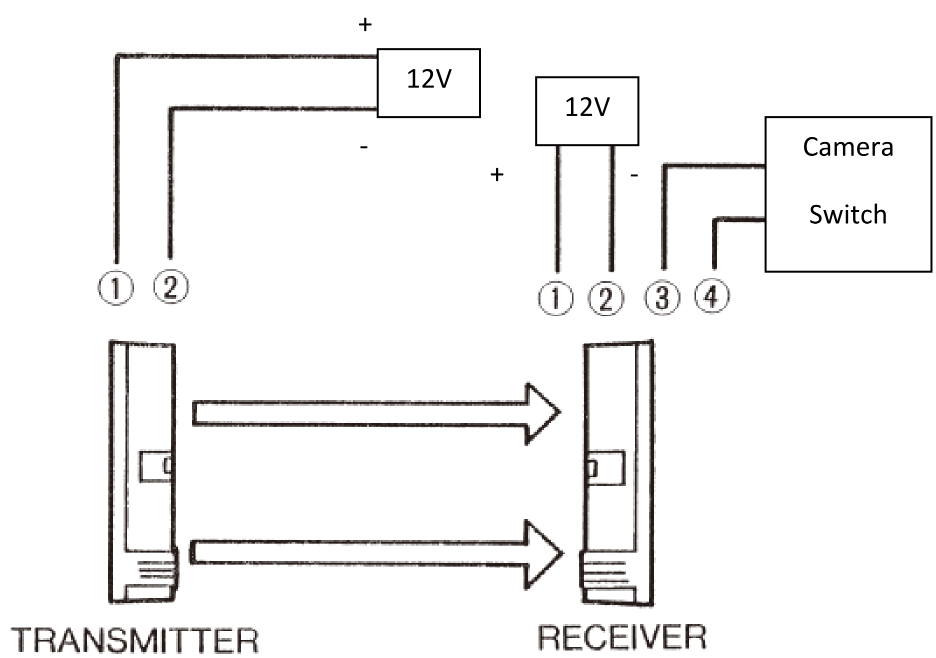

Figure 13: Sensor Wiring Diagram

The following figure also shows the wiring configuration for the camera. The schematic shows the switch used for triggering the camera. The switch has 4 terminals, 2 on each side. The terminals on the same sides are connected while the terminals opposite of each other are not connected. When this switch is activated it completes the circuit and the camera takes the photograph. The wiring for the camera must bypass this switch and connect to the sensor relay which in turn will act as the switch to activate the camera.

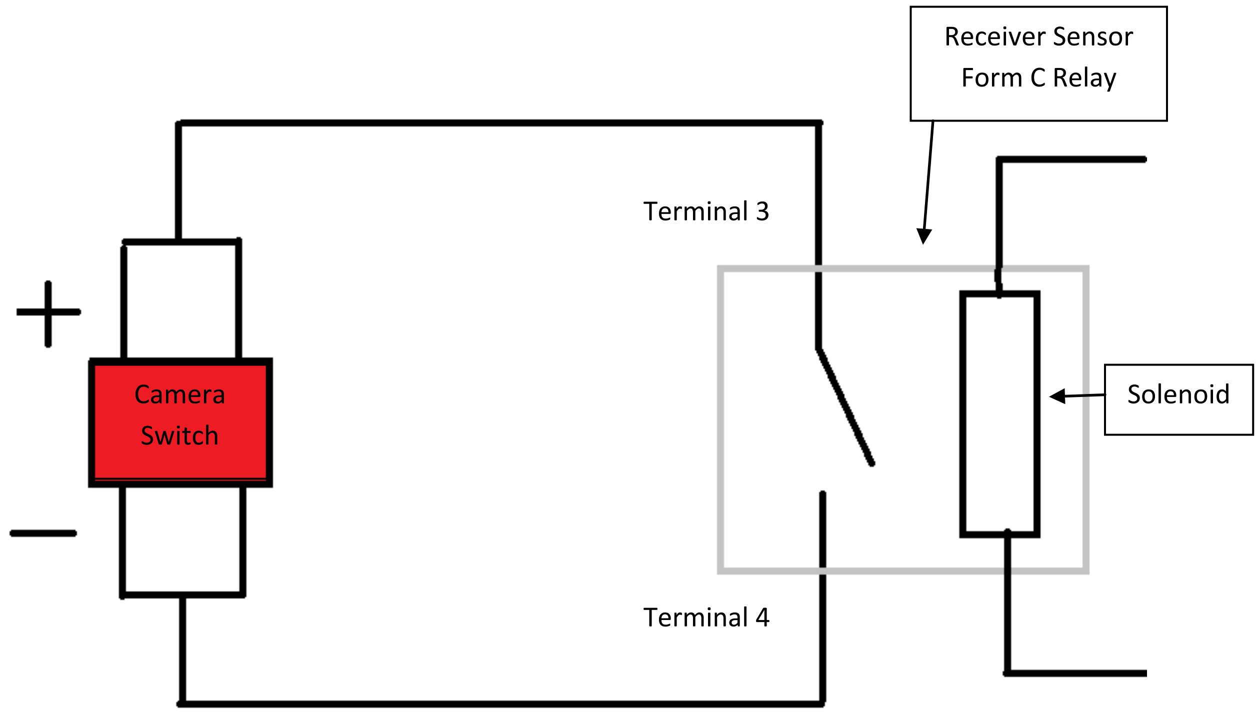

Figure 14: Camera Wiring Schematic

Interaction with Airport Operators and Industry Experts

Over the course of the design the team was in constant contact with airport operators and industry experts. Specifically, the team was in contact with Jim Crawley, the airport manager at Westerly State Airport, Jay Brolin, engineer at RIAC, James Warcup, airport inspector at RIAC, and Alan Andrade, head of RIAC.

The interaction with Jim Crawley of Westerly State Airport consisted of interviews to first determine what the biggest problems the airport faces and then sessions to help develop this design. Specifically the amount of time and effort he was willing to place into such a system in terms of set up and maintenance.

The interaction with RIAC was more involved and consisted of 3 meetings per semester to evolve the design process. The first meetings help narrow the scope of the project with rest of the meetings evolving the design to something that was acceptable and discussing testing and redesign of the system.

Design Impacts and Findings

Economic Analysis

The fully function design is slated to cost no more than $3000.00. Below the projected cost for the full design is shown.

Full Design Projected Costs			
Component	Model / Part	Distributor	Amount ($)
Photoelectric Beam Sensor	Optex 650 Dual Photoelectric Beam Sensor	Home Security Store	$405.00
Camera	Sony DSC-W170	BHPhoto	$299.99
Memory Card	8 gb	BHPhoto	$30.00
Camera Housing	Ikelite 6210.15	BHPhoto	246.95
Sensor and Camera Mounts	6061 12' X 7/8" X 7/8" Bar Stock	McMaster – Carr	$70.82
	6061 3" X 3" X 1.5" Stock	McMaster – Carr	$17.10
	6061 ¼" X 1" X 36"	McMaster – Carr	$17.48
"Modified Tripod design"	6061 36" X 7/8" OD Tubing	McMaster – Carr	$22.25
	6061 1.50" X 0.50" X 12"	McMaster – Carr	$15.92
	6061 6' X 2" X 0.75"	McMaster – Carr	$49.74
	6061 48" X 0.75" X 0.25"	McMaster – Carr	$23.66
	6061 36" X 1" X 0.50"	McMaster - Carr	$24.36
OCR Software	Modified License Plate Recognition System	-	$1000.00
Electrical Components	50' 20 AWG Wire	McMaster - Carr	$6.27
Hardware	#10 – 32 X 1" SS Socket Cap Screw (24)	McMaster – Carr	$8.87
	0.25" – 20 X 0.75" SS Socket Cap Screw (48)	McMaster – Carr	$6.76
	0.25 – 20 X 3" Nylon Socket Cap Screw (6)	McMaster – Carr	$6.53
	0.25 – 20 X 3" SS Socket Cap Screw (4)	McMaster – Carr	$4.24
	0.25 – 20 SS Lock Nut (10)	McMaster - Carr	$8.67
		Total	**$2264.92**

Table 4: Design Project Costs

The projected total cost of the full design of the Runway Operations Counter is estimated to be $2264.92. This cost analysis does not incorporate the manufacturing costs for the design. The major investment that needs to be made in this design is for the photoelectric beam sensors. The cost of a sensor that has an effective range over 500ft, is weather proofed, and adjusts sensitivity in adverse weather conditions is very high. Another major investment is the OCR program which must be modified to work properly with the system. The majority of OCR programs for license plate recognition cost approximate $1000.00, however the modification of such a program could increase the costs. The final major investment is the camera.

For roughly $2300.00 uncontrolled airports and consulting firms would receive a device capable of recording a month's worth of typical operations without any intervention beyond a simple maintenance inspection once a week or as weather conditions dictate. The resultant data would then be able to be analyzed with software without occupying several hours' worth of airport or consulting employee time. At the end of the process, a searchable database with all relevant FAA information would be available to airport staff and any consultants.

Subsequent operation, testing, and analysis would streamline and further automate the process without significantly affecting the estimated price.

The final design is designed specifically with improving efficiency at uncontrolled airports within the United States and potentially worldwide. Any attempt at marketing would be aimed primarily at consulting firms as for a small investment they would be able to provide a service to airports and reap a substantial profit. The specific market for the final design is currently limited only to airports, and more specifically uncontrolled airports. However, upon the proving of the viability of the design, it stands to reason that that market could grow to encompass even controlled airports.

Taking into consideration the availability of supporting infrastructure at airports, other aspects of the design, for example power supplies, would seem to be able to be eliminated. Through the development of data interpretation software by consulting firms very little in the way of operations cost will be incurred. As a simple, wholly automated data collecting and recording system, the only requirement for human interaction will be in setup, dismantling, and final data presentation.

Manufacturability Analysis

Machining of Parts

Using aluminum for the parts makes manufacturing the parts quite simpler than it could have been. Many pieces in the shape of rectangular or triangular prisms can be cut to specifications with ease. Other operations include: drilling, often for the placement of unthreaded bolts;

tapping, for threaded bolts; and rolling, for the cylindrical section. Below is the detailed description of the machining jobs.

MANUFACTURING OF PARTS	
Job	**Description**
A	Machining of tripod legs
B	Machining of center brackets
C	Machining of center triangle
D	Machining of top tube (cylinder)
E	Machining of sensor mounts
F	Machining of camera mounting platform
G	Machining of base plates
H	Machining of base brackets
I	Machining of leg blocks
J	Welding top tube and center triangle

Table 5: Manufacturing of Parts

Job A: Machining of Tripod Legs

There are three legs per tripod, six for the complete design. For each part, aluminum will be cut to form rectangular prism at the specifications. A second cutting operation will follow to cut one end of the piece at a 30° angle, forming a new face. This face will then be tapped to created two vertical holes for threaded bolts at 0.25-20 .75". Finally, at the other end of the leg, a hole is drilled through the perpendicular faces at 0.25-20 .3".

Job B: Machining of Center Brackets

The center brackets are affixed to both the tripod legs and center triangle structure. The plates are 0.25" thick sheet metal cut to 2.5x7/8". Two sets of two holes each are drilled to fit 0.25-20 .75" threaded bolts, which will screw into both the legs and center triangle.

Job C: Machining of Center Triangle

The center triangle reinforces the base and stabilizes the design. Aluminum is cut into a triangular prism, and then a 7/8" diameter hole is drilled through the center of the triangular face.

Lastly, two holes are tapped vertically at the center of each rectangular face, aligning with the center brackets.

Job D: Machining of Top Tube

This piece undergoes rolling to achieve its cylindrical shape. The part is then drilled at two locations for 0.25-20 .3" bolts used for the sensor mounts, and then tapped near one end for the camera mount.

Job E: Machining of Sensor Mounts

There are two sensor mounts per tripod structure, four for the complete design. The sensor mounts are cut to form small rectangular prisms, and then drilled through the center of the large face at 7/8" diameter. A smaller hole is drilled through the center of the small face for a .25-20 .3in bolt, and then two holes are tapped on the adjacent small face, perpendicular to the most recent drilling operation.

Job F: Machining of Camera Mounting Platform

The platform is manufactured through a cutting operation into its specified dimensions, then drilled to fit a longer bolt, at 0.5-20 4".

Job G: Machining of base plates

The six total base plates are first cut into rectangular prisms. At the largest face, two sets of two holes are tapped for .25-20 .75" threaded bolts. Two holes on each medium-sized face are tapped to fit .25-20 .75" threaded bolts for the base brackets. One additional hole on the large face is drilled to fit the bolt that affixes the structure to the ground.

Job H: Machining of Base Brackets

There are an equal number of base plates and base brackets needed in manufacture. The base brackets are cut sheet metal parts, drilled at points to align with the base plates (see base plates tapping).

Job I: Machining of Leg Blocks

There are 12 total leg blocks for the design, cut into small, rectangular parts. Two holes are tapped through one smallest face to affix a threaded bolt to the base plates, and an additional hole is drilled through the largest face to fit the nylon bolt (.25-20 .3").

Assembly of the Design

The following tables present the amount of time it would take to completely assemble the ROC design. Table 13 describes the smallest portions of the assembly process. Table 14 presents the total times required to perform each task the total number of times necessary and table 15 shows the overview of the entire assembly process.

Time Required for Assembly Tasks		
Task #	**Description**	**Avg. Time Required (min:sec)**
1	Alignment of two given parts	0:10
2	Place unthreaded bolt and screw in a nut on each end	0:25
3	Place unthreaded bolt and screw in nut on reverse side	0:20
4	Screw in a threaded bolt	0:20

Table 6: Time Requirement for Assembly Tasks

Assembly Times for One Structure					**For Complete Design**	
Job	**Task #**	**Task Time**	**Replications of Task**	**Time/Task**	**Time/Task**	
a	1	0:10	3	0:30	1:00	
	4	0:20	12	4:00	8:00	**9:00**
b	1	0:10	6	1:00	2:00	
	4	0:20	12	4:00	8:00	**10:00**
c	1	0:10	3	0:30	1:00	
	4	0:20	6	2:00	4:00	**5:00**
d	1	0:10	3	0:30	1:00	
	2	0:25	3	1:15	2:30	**3:30**
e	1	0:10	3	0:30	1:00	
	4	0:20	6	2:00	4:00	**5:00**
f	1	0:10	2	0:20	0:40	
	3	0:20	2	0:40	1:20	**2:00**
g	1	0:10	2	0:20	0:40	
	4	0:20	4	1:20	2:40	**3:20**
h*	1	0:10	2	0:20	0:20	
	3	0:20	1	0:20	0:20	
	4	0:20	1	0:20	0:20	**1:00**
i	Not used due to variability, specific to location				**Total Assembly Time = 38:30**	

Table 7: Assembly Times for One Tripod and Base

After analyzing the assembly process it was determined that it would take roughly 38 minutes of work to assemble each structure. There are two of these structures in the system so a total assembly time of 76 minutes is achieved.

Commercial Potential

The commercial potential of the Runway Operations Counter design s limited to the number of general aviation airports throughout the country. This product is intended to be used by a consulting firm over a sample period of a month to help better characterize the number of operations occurring at an airport over the course of a year. The product could be developed further to be used at an airport year round, and thus the commercial use of such a product increases greatly. Instead of one company using one system at various airports, multiple systems could be in use at every uncontrolled general aviation airport in the country. The commercial potential also depends on the willingness of airport manager to try a new system.

Additional Considerations

Environmental impact

Considering that this design is intended to be built from already produced items, it won't add a significant burden upon the environment by its construction. However, by allowing airport operators a better understanding of how the airport is running, they will be able to make more accurate and relevant decisions. For example, should there be more operations that previously thought, and subsequently expansion is required, construction would directly affect the environment. The opposite also holds true, as perhaps some airports would not require further attention and instead of directing funds towards construction, wildlife management could benefit. The device is temporary and enclosed, so it itself won't affect or pollute the operating environment, and even in the event of a collision that damages the device it will be a simple matter to clean up afterwards.

Societal impact

Having a means by which to better run small airports will facilitate the use of these airports. Small towns that utilize them would better be able to market the airport as a viable port of call, so as to bring business and tourism into the town. There would be less uncounted operations at any airport that used this device, so those events that are not observed (potential theft and unpaid use of runway, for example) would be minimized. Subsequently these better run airports would generate more revenue for relevant companies which could then be taxed at the state or federal level to provide more funding for other programs that could use financial support.

Political impact

The current process for acquiring funding utilizes calculations to show merit for receiving federal funding. As it is up to the local operators, such data gathering could be stigmatized and thus be not wholly accurate. This would lead to incorrect application of funds which would lead to inefficient operation of the airports. By removing the human element here, and by offering a definitive quantifiable number, the FAA and other funding organizations will be able to award funds to those that need it without any lobbying for grants.

Ethical consideration

This device is stationary, and only photographs when triggered. There is no violation of as its very operation requires the pilot of an airplane to voluntarily land at the airport. It only stores data relative to the time of landing and the airplane, and while that information could then be theoretically connected to the owner of the plane, so long as the pilot abides the law there would be no reason to look into the landing beyond the type of plane and whom to bill.

Health

By itself there is no direct health impact. In the event of an accident the device is designed to break first before any damage or harm might come to a plane and its crew.

Ergonomics

This is designed to be automated, so all that is required for operation is for it to be brought out to the runway and secured to the ground. Its weight is limited, so transportation will be with ease.

Safety Issues

The design takes into account FAA regulations for safety margins and it is also designed to be destroyable. This was done so that in case of an unlikely collision, it would break before the far more expensive aircraft would.

Achievement of FAA Goals

The design of the Runway operation counter succeeds in achieving the FAA goals for this competition. The system takes an outdated process, the use of log books, and turns it into an almost automated system that with further development could increase the efficiency and safety of uncontrolled general aviation airports.

The system will help distribute federal funding more effectively, as the increased accuracy of the operation numbers on the FAA 5010 Inspection form will allow for funding to be dispersed to the airports that need it the most. This means if an airport is seeing an increased amount of activity and needs a tower it is possible for this system to identify the increased activity more effectively than the outdated log books. This also increases the safety at the airports as a system is in place that has the potential to quickly identify when the airport has become over congested with traffic and needs to be controlled.

Furthermore the goals of the FAA were met by raising awareness of issues occurring at the nation's airports. Traditionally the University of Rhode Island does not have much involvement in the aeronautical field. This design competition has allowed for professors to introduce many aspects of the aeronautical field into the class room.

Appendix A

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Appendix B

University of Rhode Island

The University of Rhode Island, and more specifically the College of Engineering, is a facility dedicated to the advancement of knowledge, potential, and its graduates. By providing a means for eager students to attain a Bachelor's of Science degree in several accredited fields (Mechanical and Industrial Systems, Chemical, Electrical, Ocean, Civil, and Biomedical) with options for Bachelor's of Arts in languages representing major engineering cultures (German, French, Spanish, Chinese) or other degrees in conjunction with the University's other Colleges, the University of Rhode Island has provided for this particular group to participate in this FAA Competition with competency. This Engineering Design group brings together students from not just the University of Rhode Island but also a French (formerly two) engineering students, representing a diverse assembly of scholars from various nations and states of approximately 1100 undergraduate students studying with and under 200 graduate students and 65 faculty members.

This Design team in particular has benefited greatly from the dynamic engineering programs through collaborative learning. In addition the University has provided means by which we students have been able to gain valuable professional experience through internships, seminars, and job fairs featuring representatives of many of the major local engineering and scientific corporations. Also, the International Engineering Program (IEP) is a leader in international engineering education and has provided through excellent faculty the professional experience to members of this design team in the relevant field of aerospace engineering.

The IEP program, founded at the University of Rhode Island, has, in addition to relevant engineering skills, provided means for us as students to grow and experience other cultures and other ways of solving problems. This has served as an excellent ancillary to our design progress in this FAA competition, as well as the core values of the University's College of Engineering to produce intelligent and capable innovators today to solve the problems of tomorrow.

Appendix C

RI Airport Corporation

Founded on December 9, 1992 as a semiautonomous subsidiary of the then Rhode Island Port Authority (now the Rhode Island Economic Development Corporation), the Rhode Island Airport 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 of the state of Rhode Island and one by the Mayor of the City of Warwick

As a result of its overarching structure, the Rhode Island Airport Corporation was made to be 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.

The Rhode Island Airport Corporation is responsible for five general aviation airports throughout the state: Block Island, Newport, North Central, Quonset and Westerly, in addition to the major airport in Warwick (T. F. Green Airport)

Block Island State Airport provides essential access to the offshore vacation retreat through small commercial passenger service between Westerly and Block Island. In Smithfield is North Central State Airport, which provides services for corporations and recreational flyers in the Providence metropolitan area. This airport also serves as an auxiliary to T.F. Green, so that general aviation activity need not interfere (or be interfered with) by the larger activity T.F. Green sees.

In Quonset is the Quonset State Airport which is a public use facility that combines port, rail, road and air transportation facilities, with immediate access to an extensive industrial park. It is home to both the Air and Army National Guard, who use the facility for training and aviation operations. Across Narragansett Bay is the Newport State Airport which is used by local flyers, visitors to the area, and the Army National Guard for training purposes. The year-round festivals in Newport are serviced by this airport, and all of the nearby marinas have quick and ready access to this flight service.

Westerly State Airport fulfills several roles for the South County area, including corporate aviation service, extensive aircraft maintenance and repair and regularly scheduled air passenger service to Block Island.

The Rhode Island State Division of Purchases is the central contracting authority responsible for all State departments and agencies - with the exception of certain quasi-public authorities, which solicit their own bids and RFP's. The Rhode Island Airport Corporation is a Quasi-Public Agency, and as such all Quasi-Public bid notices for the Rhode Island Airport Corporation can be viewed at bid notices.

http://www.pvdairport.com/main.aspx?sec_id=15

Appendix E

Student Assessment

This design project allowed us as a team to come together and simultaneously assess and utilize our respective skills. As we analyzed the problem and began to conceptualize potential solutions we were able to discover exactly what remained for us to learn for us to complete this project. The process of conceptualizing made clear our strong points, specifically in the realm of mechanical systems, electronic hardware construction, mechanical analysis, systems design and testing. It also illuminated our deficits in some areas of electrical engineering that initially we attempted to avoid but could not in the end but involve them. These problems in particular showed us well the need for interdisciplinary teams in solving problems, and that no one person will have all the skills necessary in the modern world to solve a modern problem. We were able to apply our studies in Finite Element Analysis towards our design of the purely mechanical systems. In addition, the mechanical systems gave us an opportunity to physically comprehend some of the theories learned in the past several years.

However, much like professional engineers, there was no single action in this project that could typify our education outside of the core tenant of being problem solvers. We utilized the experiences of our international team and faculty to bring our concept from sketches on paper and words spoken to proper schematics, testing procedures, results, and interpretation, and the final prototype of our project.

Faculty Assessment

THE
UNIVERSITY
OF RHODE ISLAND
COLLEGE OF
ENGINEERING

THINK BIG WE DO™

DEPARTMENT OF MECHANICAL, INDUSTRIAL AND SYSTEMS ENGINEERING
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April 15, 2010

To: FAA Design Competition

This was the first 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 participaing was excellent. In particular, interactions with our local Rhode Island Airpoirt Corporation (RIAC) was outstading and we received tremendous support from the engineering staff there. The students conducted a broad and comprehensive search through the problem soace outlined by the FAA design competition and identified a problem of signficance to RIAC that is also of significant interest nationally (and perhaps internationally).

The most signficant challenge for the students at the beginning was to identify, define, and research the problem(s) of interest. This search was conducted over a peroid of two months which delayed them somewaht during the fall semester. I feel that part of the issue with this delay was the first-time experience for us and RIAC to engage in the FAA design competition. Now that we know the people and have made the contacts, future interactions will be much smoother.

The student team has done an excellent job in thoroughly exploiring 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 solicitaion, 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

Bahram Nassersharif, Ph.D.
Distinguished University Professor

Appendix F

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