ENGINEERING SENIOR DESIGN CAPSTONE PROJECT:

MOBILE SECURITY SURVEILLANCE UNIT

By

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In Partial Fulfillment of the Bachelor's degree
With Honors in

Optical Sciences and Engineering

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Approved by:

Martha Ostheimer
Electrical and Computer Engineering

STATEMENT BY AUTHOR

Statement of Roles and Responsibilities

This group project is the work of Team 3614 for the College of Engineering's Senior Design capstone project. This project was undertaken for the ENGR 498A and ENGR 498B courses. There were five members on the team: Nicole Ernst, Thomas Flake, Stephen Klein (myself), Sean Marshall, and Adam Ngo. The project had an industry sponsor, CAID, a local manufacturing company. An industry mentor, Fred Highton, was also utilized to review and help facilitate the project. The team corroborated to design, prototype, test, and build our project over the two semesters to be shown during the Design Day held May 5th, 2009.

I personally was in charge of the optics portion of the project and the electronic notebook for the project. The optical engineering work included work on the following components: the cameras, the video server, the solar panels, and the video monitoring software/GUI. Purchase, verification and validation, integration testing, and final assembly of the above parts was undertaken as part of the project. The electronic notebook was a website that contained all relevant documents for the project. Tasks for the notebook included writing project summaries and descriptions, editing documents, managing versions of documents, submitting materials to the project industry sponsor and the faculty advisor, and distributing materials to team members. Additionally, since I have completed a minor in electrical engineering, I utilized my limited knowledge of electrical systems to assist our electrical engineer whenever possible.

Nicole Ernst, an industrial engineer, was the team leader given that she had the most experience with entire-system level management. She was the primary contact for the faculty mentor. She was also tasked with planning and maintaining progress on our project schedule by means of a Gantt chart.

Thomas Flake was the asset manager for the project. His knowledge of mechanical engineering was put to use by charging him with the safekeeping of the unit, subsystems, and all connecting parts. He was also the primary contact for representatives of our industry sponsor. He also assisted with the video monitoring software/GUI.

Sean Marshall was the primary mechanical engineer and financial coordinator for the project. He was responsible for the drawings and the fabrication of all parts within the mechanical subsystem. He also tracked the spending of the team and ensured budget compliance for the duration of the project.

Adam Ngo was the electrical engineer and paper notebook coordinator for the project. He was responsible for the electrical subsystem and ensuring safe operation of the unit while powered. He was also tasked with maintaining all reference documentation in hard copy form, to be submitted to our industry sponsor upon conclusion of the project.

The team composition was specifically chosen for us with input from the college of engineering and our sponsor, so as to give the project the best chance of success. Our team worked together exceptionally well and completed our project on time, under budget, and to the satisfaction of our industry sponsor.

Interdisciplinary Engineering Design Program
University of Arizona

Submitted By: Team 3614 - Mobile Security-Surveillance Unit
Nicole Ernst
Thomas Flake
Stephen Klein
Adam Ngo
Sean Marshall

Submitted To:
CAID Sponsor: Robert Assenmacher
Mentor: Fred Highton


CAID
adidas

Abstract: This is the Final Design Technical Report for Team 3614, Mobile Security Surveillance Unit. This report outlines the final design for the MSSU as designed by 3614 and its sponsor, CAID Industries. Due to downturn in the world economies and the rising price of construction materials, theft and vandalism of construction and mining sites are on the rise. CAID would like to produce a product that would meet the demand of mobile security for these remote areas. The design was made to fit on a generic trailer skid and be easily moved from place to place by the customer. One of the key aspects of the system is that it is solar powered with batteries as a backup power supply so it can last in the field for an extended duration. As a prototype system, CAID is happy with the direction of the project and the results so far. Their biggest concerns were the electronics and video server running off solar power, but we were able to power and integrate everything into the system. The design meets all functional requirements and fits within the constraints.

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Introduction:

CAID is an engineering, design and metal fabricator located in Tucson, Arizona. They have been in business since 1947. They are sponsoring the interdisciplinary engineering design program because they would like to enter into the market of mobile surveillance units. CAID requires a product that will assist many industries by monitoring construction sites, storage yards, parking lots and special events. This is an alternative to manual surveillance. It will lower costs and increase accuracy and integrity of security. The product will also help prevent theft and vandalism for their clients.

CAID will have competition with their mobile security surveillance unit. There are multiple companies that provide similar products. The competition includes produces from Pro-vigil, Smarter Sentry, and Skyway Security. It is our goal to produce the next generation security-surveillance unit so that CAID will be able to competitively compete within the mobile security surveillance market.

This technical report will provide the information covering the design of this project. The design process section will include information on the design, manufacturing and implementation phase. The design phase portion will focus on the system requirements, design concepts, analysis of concepts and the final design. The manufacturing phase segment will include information on the system build and testing. The implementation phase section will discuss the design results and conclusions. Altogether, this report will explain how the project went from customer needs to final prototype delivered to the customer.

System Requirements:

The technical requirements for the project are explained by our Functions, Attributes, and Measurables, shown in the section below. The requirements fell into three major categories: mobility/size, surveillance capabilities, and financial. The functional requirements are shown in Table 1. Our requirements were provided to us from our sponsor. Each requirement was weighted by what requirement was the most important for CAID. These requirements were determined by analyzing the competition and determining which requirements would produce a product that would have a better competitive edge. CAID also included constraints for the project which limited our design options, as shown below.

FAMs: Functions, Attributes, and Measurables:

Mobility/Size:

Must be no bigger than 90’’ by 55’’ wide
Must be able to be transported by an average vehicle
Must incorporate theft prevention of the unit itself

Surveillance Capabilities:

At least 50 feet of vision space
Must have 24/7 surveillance
Able to record in low-light environments
System must have human interface
Capable of 360 degree vision

Financial:

Parts must be able to be replaced by clients and sold through CAID

Constraints

1) Total costs must not exceed $15,000
2) Comply with government privacy policies
3) Must have rechargeable power source that lasts for 5 to 10 days
4) Parts must be able to be warranted for a year
5) Must withstand temperatures from 10 °F to 150 °F

Top Level Functional Requirements

Table 1. Functional Requirements with CIR, Relevant CTQ variable, Target and Tolerance

Top Level Functional Requirement	Customer Importance	CTQ (metric)	Target Value & Tolerance
Capture video surveillance of client’s property	5	Range	360 degrees for 50+ feet
Retrieve video via human interface	5	Access time	Access in less than one minute
Moves surveillance	5	Setup time	Setup time in 10 +/-5 minutes
Operate in a remote environment	4	Operation time	5-10 days

Design Concepts and Analysis:

Concept Generation

The concept generation process began with brainstorming ideas to meet each functional requirement. The brainstorming notes can be found in Appendix B. After brainstorming, our team developed three concepts to meet the constraints and requirements of the project. The design matrix for each concept can be found in Appendices C-E.

The main components of each of our design concepts are as follows:

Concept A:

- 360 Degree Camera
- Flash-drive
- WI-FI
- Trailer
- Solar Panels

Concept B:

- Multiple Cameras
- CD/DVD
- Cell Phone
- Briefcase
- Generator

Concept C:

- Strobe Cameras
- Monitor
- Human Interface
- RC Cars
- Turbine

Decision Analysis

To determine our final design we completed a Pugh Diagram to help in our selection for the final design. We determined five selection criteria that are most important to our design and gave a weight for each one. Then we scored each of the concepts based on how well they met the criteria. The overall score showed that all three concepts meet the demands of the project.

Table 2. Pugh Diagram

	Weight	A	B	C
Functionality	5	5	4	3
Cost	4	2	3	3
Manufacture	3	3	4	4
Ease of use	2	4	3	2
Durability	1	5	3	1
Overall score (/75)		55	53	44

Design:

Our final design incorporates the best aspects of the three conceptual designs into a single product that meets or exceeds all requirements and falls within the constraints provided by our sponsor. The design starts with a trailer to give the system the desired mobility, while at the same time allowing it to be locked in place to prevent theft. Atop the trailer is a housing that contains and protects the internal components (batteries, solar power controller and converter, video server, and wireless electronics). It is a sturdy and rugged container that will allow it to function in harsh environments and for extended durations. Attached to the housing is a telescoping pole that can be lowered for transport and extended prior to use. The pole holds four cameras that have infrared imaging capabilities to provide surveillance during the day, night, and all hours in between. The system transmits the video data to an offsite server/website via a router and broadband card. The input from the video server is stored in an FTP web page for remote access to the surveillance.

System Build:

The housing was fabricated by CAID in their machine shop, but all other components are off-the-shelf. We ordered our parts from different stores based on pricing and availability.

The cameras are mounted to the pole. The cameras are connected to the baluns, which provide power to the camera and converts the BNC cable to a CAT-5 cable. The cables go down the pole and into the housing where they are connected to the 4 to 1 ethernet box. The 4 to 1 ethernet box is connected to the Axis video server by the BNC cables. A CAT-5 cable connects the video server to the D-Link router.

The solar panels are connected in parallel to the Prostar meter controller with the MC connectors. The controller is connected to the batteries and a terminal block with 14 gauge wire. The terminal block is connected to the power supplies for the router, the video server and the 4 to 1 ethernet box.

Before integrating all of the components we tested them individually. This testing verified all of the components were functional in a standalone environment and would meet our requirements. No major problems were found and all minor problems were corrected. We then integrated all of the components, except the housing and power, and tested to verify compatibility. After this we integrated the power supply to the system by connecting all components to the DC power and running them. The video server required the most amount of time for set up and testing. We set up the server to detect motion at a certain threshold. When motion is detected, the video server then uploads video to an ftp site.

The acceptance testing was done on April 18. This involved successfully powering all components directly off of the DC power from the batteries, viewing the video date both by local LAN connection and via the website. All components and systems worked and met or exceeded the expectations.

Testing:

Testing was completed in three main stages. The three main stages are for purchased parts, subsystems, and the final design as a whole.

The first stage was testing each purchased part. The purchased parts needed to be tested before being integrated into the subsystem. If the purchased parts were not tested before being integrated it would have been difficult to determine where errors in the system were coming from. For example, to test the cameras we made sure each camera had acceptable video quality and met the requirements for low-light detection. After all of the purchased parts were tested we moved to the second stage.

The second stage of testing focused on the subsystems. The main subsystems of our system are the wireless, surveillance, mechanical and power subsystems. Each subsystem was tested as it was completed. The wireless system was the most difficult to pass testing. There was a software based bug that reset options and caused confusion, but it has been addressed and resolved satisfactorily. All subsystems have completed testing and have been proven acceptable.

The final test stage was the final proof of the entire system. In this stage each of the functional requirements are tested. Due to time constraints, the evaluation of the complete model was not performed. The housing was not ready in time to undertake an endurance test to determine battery life/recharge rates for the entire system. The unit, however, has been tested extensively in a semi-complete (excluding the housing) setup and has met all requirements. The video feed has been transmitted and accessed for several days, without power issues. Because of this, our team is confident that the prototype unit would have been successfully tested had the housing been ready at an earlier date.

Design Results:

Current Status

We have completed test phase one and two entirely—preliminary testing and integration of the unit's power, wireless, and surveillance systems—but were unable to complete final testing. Results for each system are broken down below:

- **Power**

The unit has been powered entirely from the batteries. All electrical components are working properly and are communicating with one another. The voltages and currents are as expected per the battery specifications. Only two of the six batteries were used since this provided adequate power and was simpler to manage. Both solar panels have been connected and provide reasonable recharge rates to the two batteries. It was noted that the panels' recharge rate suffers greatly when a portion of the solar collecting cells is blocked.

- **Wireless**

The wireless router has been set up and secured appropriately. It is easily accessible via either wireless or wired connection. Signal range on the router signal has not been tested yet, but has been acceptable within the test buildings. The broadband wireless card is functional and has been integrated into the unit. This allows for both local (router signal) and long distance (broadband) access to the unit. The method of accessing video feed chosen was to use an FTP site, which has been set up and accessed remotely. There currently is an easily accessible user interface that allows the operator to view the live images and to access stored images from specific times.

- **Surveillance**

All four cameras have been tested and verified individually. Individual distance/clarity tests are in progress to categorize the four different cameras to determine under which scenarios each camera would be best suited. Low-light testing has given image quality beyond expectations. The cameras are connected to and communicate with the video server and the router to deliver the surveillance feed to the user.

Functional Requirement Analysis

- **Capture video surveillance of client's property**
  The unit, as implemented currently, is capable of viewing and capturing the surveillance feed. The range and coverage were not able to be verified because of the delays in the mechanical system being completed. Based on analysis of images taken at ground level, the system is expected to meet this requirement.
- **Retrieve video via human interface**
  The live video is easily accessible from the unit in the required time. Stored video is accessible via the FTP setup and a GUI has been implemented, which makes it easy for the user to access the video. It is noteworthy that the card chosen for broadband access is not capable of transmitting video data, only still images. The refresh rates for transmission are, however, capable of achieving several images per second, which imitates live video but is not quite up to what would be considered quality video.
- **Moves surveillance**
  The mechanical housing has been fabricated, and the trailer has been verified as acceptable and in working condition. The housing design meets the requirements, but due to time constraints has not been thoroughly tested. Locking mechanisms have not yet been implemented, so care must be taken to protect the unit.
- **Operate in a remote environment**
  Testing of the unit has been done both indoors and outdoors, under various temperature and weather conditions. The unit has been autonomously powered for several days without any problems. Stress testing to verify compliance with requirements was not completed due to time limitations, but the unit is expected to meet requirements without difficulty.

Conclusions:

The unit has been shown to meet all of its functional requirements. Results of preliminary testing under phase one have demonstrated the capabilities of our design concept. Phase two testing has further proven the capabilities of the unit. Phase three testing, the final whole-system level testing, was not completed in time but the initial testing has show the units capabilities and functionality.

The most critical conclusions are listed below. The metric of analysis is listed in parenthesis and the expected/required result listed below in brackets. System results as tested are listed in bold.

- Range of coverage of the four cameras (field of view)
  [360 degrees] **360 degrees**
- Accessibility of a specific time interval of video surveillance, remotely (access time)
  [1 minute] **1 minute**
- Accessibility of a specific time interval of video surveillance, locally (access time)
  [1 minute] **1 minute**
- Successful setup of the unit (time required)
  [5 minutes] **5 minutes**
- Successful take-down of the unit (time required)
  [5 minutes] **5 minute**
- Remote operation, low solar recharge (hours)
  [24 hours] 2**4 hours**
- Cost effectiveness of design (dollars)
  [$12,000] **$10,000**
- Video camera detection and recognition (range)
  [50 feet] **30 feet ***
- Remote operation, high solar recharge (hours)
  [72 hours] **48 hours ****

* The cameras have not been tested for distance when mounted at the correct height/angle. This figure is based on ground-level testing and is expected to increase significantly when the cameras are mounted to specification.

** The unit has never been running autonomously for longer than 48 hours. The limited duration of the project and production schedules made this unrealistic to test.

Recommendations:

Current recommendations, listed below, are based on preliminary testing and may change significantly. More detailed and more thorough recommendations will be reported after all testing has commenced and reliable data has been obtained and analyzed.

- Orientation of the unit
  The orientation of the unit so that it obtains a maximum level of sunlight is obviously crucial. Even small shaded areas on the solar panels decrease efficiency of recharge significantly.

- Auto-focus on cameras
  One of the cameras is a fixed focus with manual adjustment for zoom and focus. This is severely limiting on the system since the depth of focus is very low. The other three have an auto-focus which helps with recognizing targets as they approach.

Acknowledgement:

Project 3614 would like to thank:

CAID Industries for sponsoring our project.
Rob Assenmacher for providing the necessary support at CAID
Dennis Messer for providing IT support for our project
Fred Highton for providing mentorship for the project

Appendices:

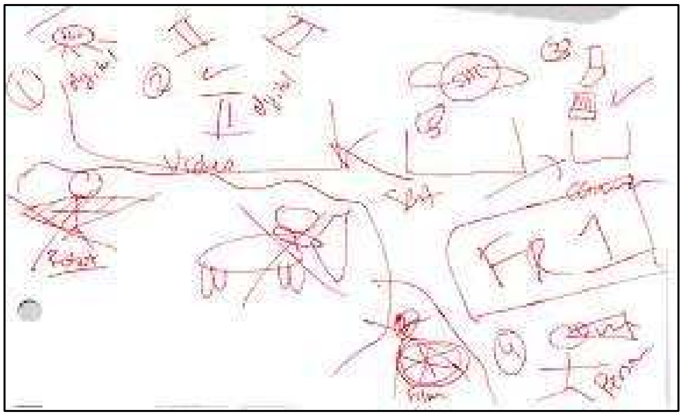
Appendix A: References

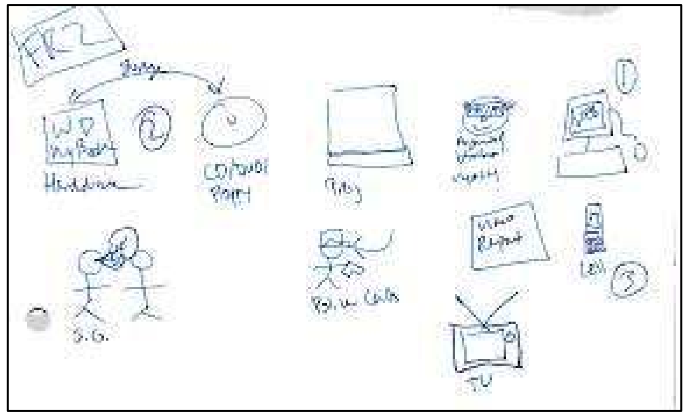
Competition Research:
http://www.smartersecurity.com/outdoor/smartersentry/

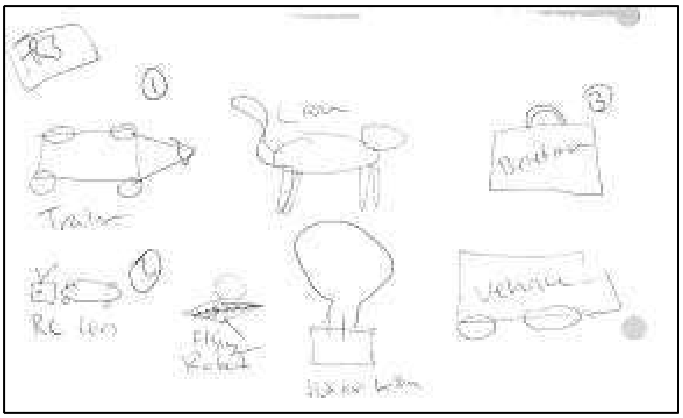
http://www.skywaysecurity.com/mobile_security.cfm

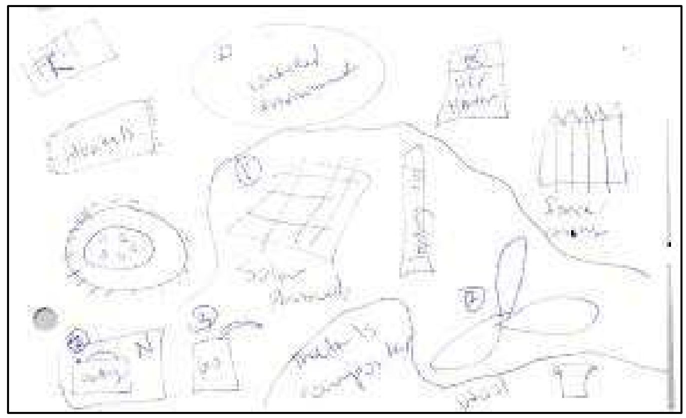
http://www.pro-vigil.com/mobile-video-surveillance/

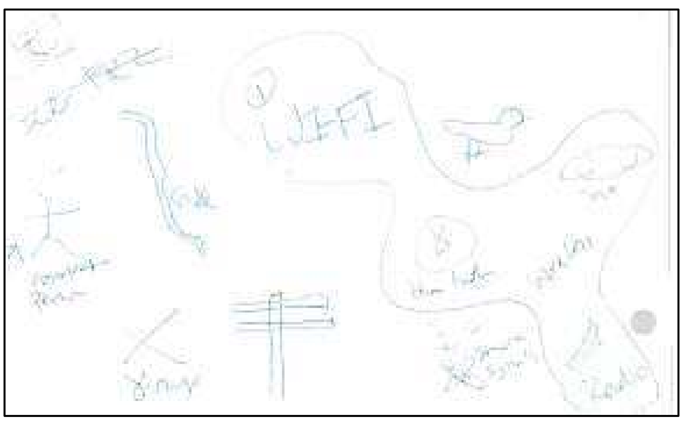
Appendix B: Design Brainstorming







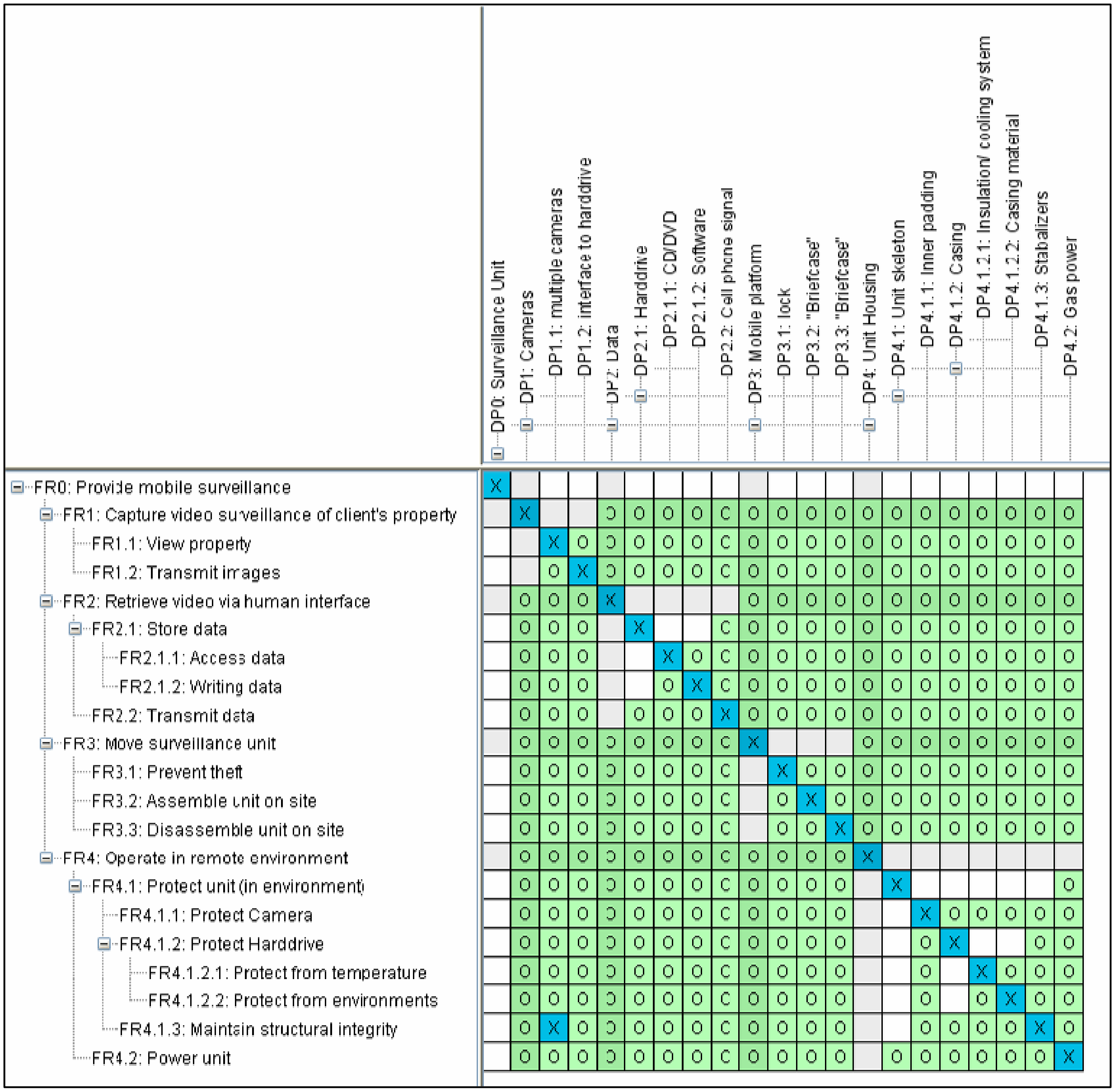




Appendix C: Concept A Design Matrix

	DP0: Surveillance Unit	DP1: Cameras	DP1.1: 360 degree camera	DP1.2: interface to harddrive	DP2: Data	DP2.1: Harddrive	DP2.1.1: Jump drive	DP2.1.2: Software	DP2.2: WI-FI	DP3: Mobile platform	DP3.1: lock	DP3.2: Trailer	DP3.3: Trailer	DP4: Unit Housing	DP4.1: Unit skeleton	DP4.1.1: Shield	DP4.1.2: Casing	DP4.1.2.1: Insulator/ Cooling system	DP4.1.2.2: Casing material	DP4.1.3: Stabalizers	DP4.2: Solar panels with battery
FR0: Provide mobile surveillance	X																				
FR1: Capture video surveillance of client's property		X			O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O
FR1.1: View property			X	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O
FR1.2: Transmit images			O	X	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O
FR2: Retrieve video via human interface		O	O	O	X					O	O	O	O	O	O	O	O	O	O	O	O
FR2.1: Store data		O	O	O		X			O	O	O	O	O	O	O	O	O	O	O	O	O
FR2.1.1: Access data		O	O	O			X	O	O	O	O	O	O	O	O	O	O	O	O	O	O
FR2.1.2: Writing data		O	O	O			O	X	O	O	O	O	O	O	O	O	O	O	O	O	O
FR2.2: Transmit data		O	O	O		O	O	O	X	O	O	O	O	O	O	O	O	O	O	O	O
FR3: Move surveillance unit		O	O	O	O	O	O	O	O	X				O	O	O	O	O	O	O	O
FR3.1: Prevent theft		O	O	O	O	O	O	O	O		X	O	O	O	O	O	O	O	O	O	O
FR3.2: Assemble unit on site		O	O	O	O	O	O	O	O		O	X	O	O	O	O	O	O	O	O	O
FR3.3: Disassemble unit on site		O	O	O	O	O	O	O	O		O	O	X	O	O	O	O	O	O	O	O
FR4: Operate in remote environment		O	O	O	O	O	O	O	O	O	O	O	O	X							
FR4.1: Protect unit (in environment)		O	O	O	O	O	O	O	O	O	O	O	O		X						O
FR4.1.1: Protect Camera		O	O	O	O	O	O	O	O	O	O	O	O			X	O	O	O	O	O
FR4.1.2: Protect hardware		O	O	O	O	O	O	O	O	O	O	O	O			O	X			O	O
FR4.1.2.1: Protect from temperature		O	O	O	O	O	O	O	O	O	O	O	O			O		X	O	O	O
FR4.1.2.2: Protect from environment		O	O	O	O	O	O	O	O	O	O	O	O			O		O	X	O	O
FR4.1.3: Maintain structural integrity		O	X	O	O	O	O	O	O	O	O	O	O			O	O	O	O	X	O
FR4.2: Power unit		O	O	O	O	O	O	O	O	O	O	O	O		O	O	O	O	O	O	X

Appendix D: Concept B Design Matrix



	DP0: Surveillance Unit	DP1: Cameras	DP1.1: multiple cameras	DP1.2: interface to harddrive	DP2: Data	DP2.1: Harddrive	DP2.1.1: CD/DVD	DP2.1.2: Software	DP2.2: Cell phone signal	DP3: Mobile platform	DP3.1: lock	DP3.2: "Briefcase"	DP3.3: "Briefcase"	DP4: Unit Housing	DP4.1: Unit skeleton	DP4.1.1: Inner padding	DP4.1.2: Casing	DP4.1.2.1: Insulation/ cooling system	DP4.1.2.2: Casing material	DP4.1.3: Stabalizers	DP4.2: Gas power
FR0: Provide mobile surveillance	X																				
FR1: Capture video surveillance of client's property		X			O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O
FR1.1: View property			X	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O
FR1.2: Transmit images			O	X	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O
FR2: Retrieve video via human interface		O	O	O	X					O	O	O	O	O	O	O	O	O	O	O	O
FR2.1: Store data		O	O	O		X			O	O	O	O	O	O	O	O	O	O	O	O	O
FR2.1.1: Access data		O	O	O			X	O	O	O	O	O	O	O	O	O	O	O	O	O	O
FR2.1.2: Writing data		O	O	O			O	X	O	O	O	O	O	O	O	O	O	O	O	O	O
FR2.2: Transmit data		O	O	O		O	O	O	X	O	O	O	O	O	O	O	O	O	O	O	O
FR3: Move surveillance unit		O	O	O	O	O	O	O	O	X				O	O	O	O	O	O	O	O
FR3.1: Prevent theft		O	O	O	O	O	O	O	O		X	O	O	O	O	O	O	O	O	O	O
FR3.2: Assemble unit on site		O	O	O	O	O	O	O	O		O	X	O	O	O	O	O	O	O	O	O
FR3.3: Disassemble unit on site		O	O	O	O	O	O	O	O		O	O	X	O	O	O	O	O	O	O	O
FR4: Operate in remote environment		O	O	O	O	O	O	O	O	O	O	O	O	X							
FR4.1: Protect unit (in environment)		O	O	O	O	O	O	O	O	O	O	O	O		X						O
FR4.1.1: Protect Camera		O	O	O	O	O	O	O	O	O	O	O	O			X	O	O	O	O	O
FR4.1.2: Protect Harddrive		O	O	O	O	O	O	O	O	O	O	O	O			O	X			O	O
FR4.1.2.1: Protect from temperature		O	O	O	O	O	O	O	O	O	O	O	O			O		X	O	O	O
FR4.1.2.2: Protect from environments		O	O	O	O	O	O	O	O	O	O	O	O			O		O	X	O	O
FR4.1.3: Maintain structural integrity		O	X	O	O	O	O	O	O	O	O	O	O			O	O	O	O	X	O
FR4.2: Power unit		O	O	O	O	O	O	O	O	O	O	O	O		O	O	O	O	O	O	X

Appendix E: Concept C Design Matrix

	DP0: Surveillance Unit	DP1: Cameras	DP1.1: Strobing camera	DP1.2: interface to harddrive	DP2: Data	DP2.1: Harddrive	DP2.1.1: Projector	DP2.1.2: Software	DP2.2: Human	DP3: Mobile platform	DP3.1: lock	DP3.2: RC Cars	DP3.3: RC Cars	DP4: Unit Housing	DP4.1: Unit skeleton	DP4.1.1: Inner padding	DP4.1.2: Casing	DP4.1.2.1: Insulation/ cooling system	DP4.1.2.2: Casing material	DP4.1.3: Stabalizers	DP4.2: Turbine
FR0: Provide mobile surveillance	X																				
FR1: Capture video surveillance of client's property		X			O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O
FR1.1: View property			X	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O
FR1.2: Transmit images			O	X	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O
FR2: Retrieve video via human interface		O	O	O	X					O	O	O	O	O	O	O	O	O	O	O	O
FR2.1: Store data		O	O	O		X			O	O	O	O	O	O	O	O	O	O	O	O	O
FR2.1.1: Access data		O	O	O			X	O	O	O	O	O	O	O	O	O	O	O	O	O	O
FR2.1.2: Writing data		O	O	O			O	X	O	O	O	O	O	O	O	O	O	O	O	O	O
FR2.2: Transmit data		O	O	O		O	O	O	X	O	O	O	O	O	O	O	O	O	O	O	O
FR3: Move surveillance unit		O	O	O	O	O	O	O	O	X				O	O	O	O	O	O	O	O
FR3.1: Prevent theft		O	O	O	O	O	O	O	O		X	O	O	O	O	O	O	O	O	O	O
FR3.2: Assemble unit on site		O	O	O	O	O	O	O	O		O	X	O	O	O	O	O	O	O	O	O
FR3.3: Disassemble unit on site		O	O	O	O	O	O	O	O		O	O	X	O	O	O	O	O	O	O	O
FR4: Operate in remote environment		O	O	O	O	O	O	O	O	O	O	O	O	X							
FR4.1: Protect unit (in environment)		O	O	O	O	O	O	O	O	O	O	O	O		X						O
FR4.1.1: Protect Camera		O	O	O	O	O	O	O	O	O	O	O	O			X	O	O	O	O	O
FR4.1.2: Protect Harddrive		O	O	O	O	O	O	O	O	O	O	O	O			O	X			O	O
FR4.1.2.1: Protect from temperature		O	O	O	O	O	O	O	O	O	O	O	O			O		X	O	O	O
FR4.1.2.2: Protect from environments		O	O	O	O	O	O	O	O	O	O	O	O			O		O	X	O	O
FR4.1.3: Maintain structural integrity		O	O	O	O	O	O	O	O	O	O	O	O			O	O	O	O	X	O
FR4.2: Power unit		O	O	O	O	O	O	O	O	O	O	O	O		O	O	O	O	O	O	X

Appendix F: Final Design Matrix

	DP0: Surveillance Unit	DP1: Cameras	DP1.1: 4 cameras with IR	DP1.2: Interface to data	DP1.2.1: Axis 4 port video server with 4 inputs	DP1.2.2: Cabling	DP2: Data	DP2.1: Computer with USB Port	DP2.1.1: USB Port	DP2.1.2: Monitor	DP2.2: WI-FI	DP2.2.1: D-Link 3G Mobile Router	DP2.2.2: Mobile Broadband Card	DP3: Unit Housing	DP3.1: Trailer	DP3.2: Trailer	DP3.2.1: Lock	DP3.2.2: Stabalizers	DP3.3: Camera Holder	DP3.3.1: Pole	DP3.3.2: Pole Crank	DP3.3.3: Pole Support	DP4: Unit Housing	DP4.1: Equipment Storage Casing	DP4.2: Housing Ventilation System	DP4.3: Solar panels with battery	DP4.3.1: Prostar 15M with Meter Controller	DP4.3.2: Morningstar Suresine Inverter	DP4.3.3: Solar Panel
FR0: Provide mobile surveillance	X																												
FR1: Capture video surveillance of client's property		X					O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O
FR1.1: View property			X	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O
FR1.2: Transmit images			O	X			O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O
FR1.2.1: Transmit video			O		X	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O
FR1.2.2: Connects cameras to server			O		O	X	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O
FR2: Retrieve video via human interface		O	O	O	O	O	X							O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O
FR2.1: Store data		O	O	O	O	O		X			O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O
FR2.1.1: Access data		O	O	O	O	O			X	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O
FR2.1.2: Viewing data		O	O	O	O	O			O	X	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O
FR2.2: Transmit data		O	O	O	O	O		O	O	O	X			O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O
FR2.2.1: Routes video data		O	O	O	O	O		O	O	O		X	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O
FR2.2.2: Enables viewing of data		O	O	O	O	O		O	O	O		O	X	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O
FR3: Move surveillance unit		O	O	O	O	O	O	O	O	O	O	O	O	X									O	O	O	O	O	O	O
FR3.1: Assemble unit on site		O	O	O	O	O	O	O	O	O	O	O	O		X	O	O	O	O	O	O	O	O	O	O	O	O	O	O
FR3.2: Disassemble unit on site		O	O	O	O	O	O	O	O	O	O	O	O		O	X			O	O	O	O	O	O	O	O	O	O	O
FR3.2.1: Maintain structural security		O	O	O	O	O	O	O	O	O	O	O	O		O		X	O	O	O	O	O	O	O	O	O	O	O	O
FR3.2.2: Maintain structural integrity		O	O	O	O	O	O	O	O	O	O	O	O		O		O	X	O	X	O	O	O	O	O	O	O	O	O
FR3.3: Contains video device		O	O	O	O	O	O	O	O	O	O	O	O		O	O	O	O	X				O	O	O	O	O	O	O
FR3.3.1: Elevates camera		O	O	O	O	O	O	O	O	O	O	O	O		O	O	O	O		X	O	O	O	O	O	O	O	O	O
FR3.3.2: Lifts camera		O	O	O	O	O	O	O	O	O	O	O	O		O	O	O	O		O	X	O	O	O	O	O	O	O	O
FR3.3.3: Contians camera		O	O	O	O	O	O	O	O	O	O	O	O		O	O	O	O		O	O	X	O	O	O	O	O	O	O
FR4: Operate in remote environment		O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	X						
FR4.1: Protect unit (in environment)		O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O		X	O	O	O	O	O
FR4.2: Protect from temperature		O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O		O	X	O	O	O	O
FR4.3: Power unit		O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O		O	O	X			
FR4.3.1: Convert power to useable form		O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O		O	O		X	O	O
FR4.3.2: Converts power to useable form		O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O		O	O		O	X	O
FR4.3.3: Collect sunlight		O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O		O	O		O	O	X

Appendix G: Final Design Drawings

Figure 3. Final Internal Storage Design

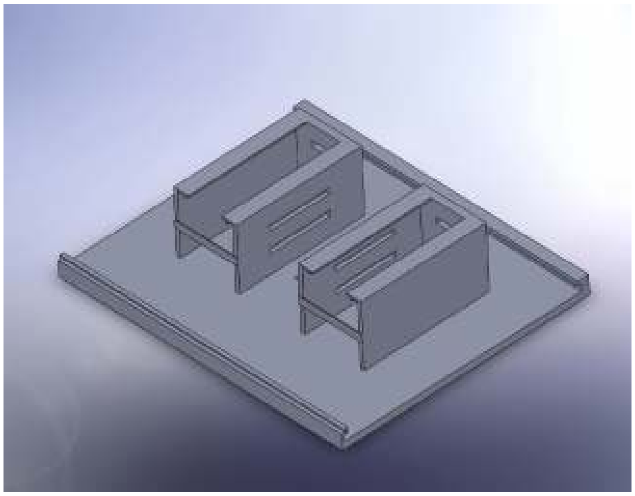
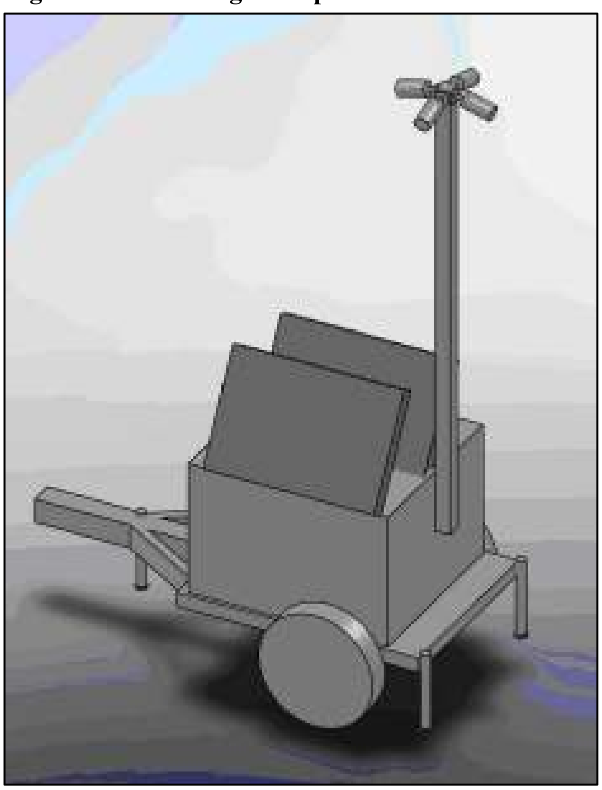


Figure 4. Final Design in Operation Mode



Appendix H: FMEA

Component	Function	Failure Mode	Consequence	Cause	Mitigation
Camera	Watch property	Does not watch property	Area is not monitored	Lens damage	Replace camera
Video Server	Transmit video	Corrupts video Fails to transmit	No video is recorded	No power Loose connections	Restore power Replace wiring
Camera Cabling	Connects cameras to server	Incorrect transfer of data	Video doesn't reach server	Wiring damage	Replace cables
Trailer	Provide mobility	Can't move unit	Unit loses mobility	Flat tires Hitch breaks Axle breakage	Replace broken units
	Houses hardware	Hardware exposed	Component damage	Housing collapse Environment damage	Fix/replace housing
	Supports camera pole	Camera unsupported	Camera falls off	Mounting breaks	Replace pole support
	Provides access to hardware	Hardware inaccessible	Reduced accessability	Panel gets stuck Panels don't open	Remove and replace broken panels
	Prevents unauthorized access	Anyone can access unit	Unit damage Data loss Component theft	Damage Improper handling	Replace panel locks Ensure panels are closed
Ventilation system	Cools hardware	Components overheated	Parts sustain damage	Blocked vents	Cleaning
	Eliminates foreign particles	FOD exposure	Parts sustain damage	Ventatilation system fails to work properly	Replace fans in ventilation system
Pole	Elevates cameras	Pole doesn't raise	Unit can't properly watch property	Mechanical failure	Fix/replace pole
	Stabilizes components	Doesn't stabilize components	Cameras unable to take video	Mechanical failure	Fix/replace pole supports
Batteries	Powers unit	No supplied power	Unit doesn't function Component failure	Overheat Improper charging Limited lifespan	Ventilation Controlled recharge Replace before expiration
	Stores power	No power held	Unit doesn't function	Limited lifespan Improper charging	Controlled recharge Replace before expiration
Solar Panels	Collects sunlight	Stops collecting sunlight	Unit can't charge batteries	Cracks/damage Improper placement Environment	Replace solar panels
Solar controller	Converts power to usable form	Can't convert sunlight into usable energy	Unit can't charge batteries	Controller malfunction Bad connections	Replace solar controller
Mobile Router	Provide network access	Wireless access stops working	Unable to access unit remotely	Malfunction Power issues	Replace unit Debug problem
Internal data storage	Stores video	Video is lost or unreadable	There is no video recording	Data corruption Component	Replace unit Debug problem
USB/CD drive	Allows extraction of video	Video is unaccessable	No later access	Corrupt data Malfunctioning drive	Replacement parts

Appendix I: BOM

Level	Component	Quantity	Model	Price Per
0	**Surveillance Unit**			
1	Camera			
2	Multiple Cameras			
3	75' varifocal camera /w IR	1	CFC6049IR	$200
3	30' camera w/IR	1	CFC6038IR	$110
3	60' camera w/IR	1	CFC6039IR	$140
2	Interface to Data			
3	Axis 4 port video server w/4 inputs	1	241QA	$1,000
3	Cabling	AR	TBD	TBD
1	Data			
2	DVR* (Optional)	1	TBD	<$1,500
2	WI-FI			
3	D-Link 3G Mobile Router	1	DIR-450/451	$200
3	Mobile Broadband Card*	1	KX582	$250
1	Unit Housing			
2	Trailer			
3	Harbor Freight Trailer	1	2575-5VGA	$280
3	Lock*	1	CAID Made	TBD
3	Stabilizers*	2	CAID Made	TBD
3	Motion/ Vibration Alarm w/ GPS	1	CS-2205	$300
2	Equipment Storage Casing*	1	CAID Made	TBD
2	Power System			
3	Prostar 15M w/ Meter Controller	1	PS-15M	$145
3	Morningstar Suresine Inverter	1	SI-300-115B	$263
3	Solar Panel	2	GEPVP-100	$1,000
3	Batteries	4	8G27	$165
2	Camera Holder			
3	Pole*	1	CAID Made	TBD
3	Pole Crank*	1	CAID Made	TBD
3	Pole Support*	1	CAID Made	TBD

Appendix J: Budget

Table 5. Budget Overview

Category	Total Amount	Sponsor Funded	U of A Allocation
Camera	$1,800	$1,000	$800
Housing	$1,853	$1,153	$700
Data	$1,950	$1,950	$0
Total	**$5,603**	**$4,103**	**$1,500**

Appendix K: Prototype Pictures