

IPRO 355

Enhanced Vision System for Construction Safety

Final Report
12/07/08

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1. Abstract

The goal of our team is to save lives by helping to prevent accidents which occur due to the damage of underground utilities by construction equipment. We seek to do this by introducing the Enhanced Vision System, or EVS. The goal for this semester is to design and build a system for displaying the location of buried utilities to the operators of construction vehicles. This includes producing a proof-of-concept prototype as well as designing the final product that we would later produce. As this project is not merely an IPRO, but also an EnPRO, we are also considering how to turn this idea into a successful business venture. To this end, we will be performing research and creating a business plan.

2. Background

1. We currently do not have a sponsor or customer. We have used industry contacts with Walsh construction to obtain interviews. We have contacted Trimble Worldwide, Inc., a construction electronics manufacturer. Trimble has a line of products called the GeoX family of products, which are hand-held computers with built-in GPS. We have obtained the software development kit from Trimble in order to write our own application for their GeoX hand-held devices. Our goal is to form a relationship with Trimble and obtain a GeoX device for testing and development.
2. Construction accidents are serious matters which must be addressed: 5,000 construction work-site deaths occur annually in the United States, causing annual losses of \$250 million in damages, payments to the injured/bereaved, and lost productivity. We have examined studies of the causes of these accidents and found that a significant number of accidents (around 40-60%) that occurred due to a worker striking a buried underground utility could have been prevented through some sort of advanced way of displaying the locations of the utilities to the worker.
3. Current methods of indicating the location of buried utilities include sprayed paint and flags, which can be washed away or picked up and moved. Currently, little to no technology is being used to replace these methods, which may be due to patent concerns or technological limitations. We have identified a few patents which do address the problem in question, but they companies which hold them seem to not have any market penetration.
4. This is the third semester that this IPRO is running, but the IPRO has only been studying the current problem since last semester. In the previous semester, we defined the problem and performed primary research to identify the scope of the problem. We also obtained materials for making a prototype and began work on the prototype itself. Additionally, we performed some market research and created a business model and plan. As the third semester comes to an end, we have redefined our direction to be that of a software application solution to the problem, versus the hardware software platform that we were initially trying to develop. The major focus of this semester is to lay the ground work and set the next semester up to proceed with software coding and application development.
5. Our most serious ethical concern was IP rights versus public good. We discovered a patent which might have impeded our freedom to operate. If this was the case, the public would be unable to benefit from the technology, as the company which owns the patent did not seem to be actively using it. At the same time, we would be unable to serve the public, as we must respect the IP rights of others. We performed due diligence by researching the matter thoroughly, and in the end discovered that we were not infringing on the other patent, allowing us to make our product and improve safety for the public's benefit.

3. Objectives

- Technology Team
- Define and refine product scope
 - Develop relationship with Trimble
 - Obtain the necessary tools to start developing an application for a Trimble device
 - Identify the features that we want to include in our prototype program
- Preparing semester transition and team turnover
 - Determine the possible programming languages and skills needed to complete our application
 - Selecting academic areas to focus on recruiting people with qualified skills
 - Defining a new product and team direction description for use in advertising the EnPRO for registration purposes
- Pinpointing variables
 - Formalizing a contact list of personnel resources and relationships
 - Obtaining sample data of utility / site information from a live construction site
 - Obtaining the materials and programs needed to hit the ground running next semester
- Business Team
- Features, Benefits, Advantage, and Cost matrix (FBAC matrix)
 - Identify the features that our product will have
 - Enumerate what benefits those features will provide to our customers
 - Determine what advantage, if any, each feature has over the competition or currently used technology
 - List any added costs of having each feature
- Industry analysis
 - Determine our competitors (our research indicates that the companies we identified last semester are not our competition)
 - Determine our suppliers, working in conjunction with the tech team
 - Identify potential distributors
 - Perform Porter's 5 forces analysis
 - Perform SWOT analysis on ourselves as well as our competition
- Business
 - Review our business model
 - Refine our pricing strategy
 - Run financial projections
 - Identify potential risks
 - Revise business plan
 - Consider patent issues

4. Methodology

Color code: Entire Team Technology Team Business Team

Timeframe:	Deliverables/Plans
09/15 – 09/19	<ul style="list-style-type: none"> Interviews (Sam, Melissa, David, Kevin, Jeff, Mike, Chuck) Project plan (Jeff)
09/22 – 09/26	<ul style="list-style-type: none"> Input data source finalization (Kevin, Chuck) Begin software and programming (Jeff, Chuck) Integration of data inputs (Jeff, Chuck) Review of site operator interview. (Sam, Melissa, David) Begin Market research and competitive analysis, and product feasibility analysis. (Leo,Sara)
09/29 -10/03	<ul style="list-style-type: none"> Finalize our Midterm Plan (Tech Team) Semi-final list of final product hardware options (Mike) Enclosure details discussion (Kevin, Mike w/Tech Team) Start first draft of business plan (Business Team) <ul style="list-style-type: none"> Interview Results Market analysis (Leo, Sara) Value Proposition (Tom, Melissa) Business Model (Leo,Sara) Updated FBAC. (Sam, David)
10/06 – 10/10	<ul style="list-style-type: none"> Overlay of subterranean utilities onto 2D overview map (Jeff, Chuck) Enclosure details and specs final draft (Kevin, Mike) Obtain money needed for enclosure materials (Jeff) Final product hardware decision (Mike w/Tech Team) Budget for hard materials needed to build final product (Mike) Complete the first draft of the business plan. Competitive analysis (Leo, Sara, Tom) SWOT Analysis (Leo, Sara, Tom) Porters Five Forces (Leo, Sara, Tom) Mid-term review week
10/13 – 10/17	<ul style="list-style-type: none"> Enclosure materials acquisition (Kevin, Mike) Final product mock-up discussion (Mike, Kevin w/Tech Team) Business Model review and start 2nd draft
10/20 – 10/24	<ul style="list-style-type: none"> Enclosure fabrication (Kevin, Mike) Mock-up final specifications / design (Mike, Kevin) Obtain money needed for mock-up materials (Jeff) Suppliers, factory or aftermarket installation. (David, Sam, Melissa) Preliminary financials. (Sara, Leo) Work out financial scenarios and at the same time start risk analysis. (Sam, Tom, Leo, Sara) Work on Exhibit poster and brochure

10/27 – 10/31	<ul style="list-style-type: none"> • Mock-up materials acquisition (Kevin, Mike) • Review 1st draft of financials and start 2nd draft. • Incorporate risk analysis to match business model(s) and financial scenarios. (Business team) • Exhibit poster and brochure due
11/03 – 11/07	<ul style="list-style-type: none"> • Mock-up fabrication (Kevin, Mike) • Refine business plan. <ul style="list-style-type: none"> • Final FBAC. (Sam, Tom) • Updated competitive analysis. (Sara, Leo, Tom) • Updated comprehensive business model. (Sara, Leo)
11/10 – 11/14	<ul style="list-style-type: none"> • Programming and software for prototype finalized (Jeff, Chuck) • Final prototype testing (Jeff, Chuck) • Updated financial analysis. • Updated risk analysis.
11/17 – 11/21	<ul style="list-style-type: none"> • Discussion of IPRO Day presentation material / capabilities (Tech Team) • Discussion of abstract / brochure details (Tech Team) • Photos taken to be used for abstract / brochure; poster • Incorporate financial analysis into business plan. • Legal liability issues review (David, Sam, Melissa)
11/24 – 11/28	<ul style="list-style-type: none"> • IPRO Day Presentation Details Final (Tech Team) • Abstract / brochure details finalized and submitted (Jeff) • IPRO Poster for project details finalized and submitted (Jeff) • Patents and Intellectual property review (Leo, Tom, Sara)
12/01 – 12/05	<ul style="list-style-type: none"> • Submit final Market analysis, business model, business plan, and financial analysis for upload on IPRO day (12/3) • Burn Final report on CD due on 12/4 (Sam)

5. Team Structure and Assignments

Team Members:

- David Connelly
 - Position: Business Team Leader
 - Year: 4th
 - Finance/Construction Management
- Jeff Mizek
 - Position: Tech team, Team Leader
 - Year: 3rd
 - Major: Electrical Engineering
 - Concentration: Systems and Control
- Chuck Sticha
 - Position: Tech Team Leader
 - Year: 4th
 - Major: Information Technology and Management
 - Concentration: Network Security; Systems Administration
- Sara Sustersic
 - Position: Business team
 - Year: 4th
 - Major: Business Administration
 - Concentration: Finance, Marketing
- Leo Bassett
 - Position: Business team
 - Year: 4th
 - Major: Business Administration
 - Concentration: Finance
- Tom Montgomery
 - Position: Business team
 - Year: 5th
 - Major: Architecture
 - Concentration: N/A
- Melissa Lee
 - Position: Business Team, IPRO day coordinator
 - Year: 4th
 - Major: Biochemistry
 - Concentration: N/A
- Kok Ann Gan
 - Position: Business Team
 - Year: 4th
 - Major: Biology
 - Concentration: N/A
- Kevin O'Leary
 - Position: Tech Team
 - Year: 5th
 - Major: Business Applied Science
 - Concentration: Construction Management
- Michael Beemsterboer
 - Position: Tech Team
 - Year: 4th
 - Major: Architecture
 - Concentration: N/A

Team Member Skills:

- David Connelly
 - Primary Skills
 - Real life experience in the Construction Industry and heavy equipment operation
 - Business Plan writing, budgeting, construction methods and procedures.
 - Contacts in construction industry.

- Secondary Skills
 - Excel applications
 - Object Oriented Programming
 - Written and communication (presentation) skills
- Jeff Mizek
 - Primary skills
 - Electronics, microcontrollers, robotics, RF
 - C, Java, assembly programming
 - CAD experience
 - Secondary skills
 - Photoshop
- Chuck Sticha:
 - Primary skills
 - Networking, Wireless (802.11x), Bluetooth (802.15), and network administration
 - Hardware knowledge; A+, Network+, and Security+ trained
 - Many years in retail / customer service management and planning
 - Secondary skills
 - Java, PHP, Perl, HTML, XHTML, CSS
 - Web application and development
- Sara Sustersic
 - Primary skills
 - Business plan writing and editing
 - Market research
 - Financial modeling and budgets
 - Secondary skills
 - Written and oral communication
 - Sales experience
- Leo Bassett
 - Primary skills
 - Business plan Writing and Editing
 - Financial projections and Project Budgeting
 - Contacts in Steel Industry
 - Secondary skills
 - Sales Experience
 - Presentation Skills
- Tom Montgomery
 - Primary skills
 - Photoshop/Illustrator
 - CAD
 - Secondary skills
 - Web Design
- Melissa Lee
 - Primary Skills
 - Writing, editing, speaking, research
 - Team leading
 - Task management
 - Biological subjects
 - Secondary Skills
 - General communication skills
 - Cold-calling
- Kok Ann Gan
 - Primary Skills
 - Project plan writing
 - Business plan writing
 - Secondary Skills
 - Excel
- Kevin O'Leary
 - Primary skills
 - ESRI / Archview
 - Equipment experience

- Secondary skills
 - Construction
 - Knowledge of industry contacts
- Michael:
 - Primary skills
 - CAD
 - Photoshop
 - Secondary skills
 - 3ds Max

6. Project Budget

- Equipment - \$230
 - This will be used to purchase the parts that will be used to prototype our product. We may need to purchase hardware with which to interface our sensors, a screen to display information to the user, and possibly a camera for obtaining a live-feed.
 - Actually spent: \$0 We did not end up purchasing any equipment, as we refined our product as a software product
- Travel - \$60
 - This money is to pay for transportation to job sites and equipment yards, where the team will interview the people who might install, use, or maintain our product. This must be done in person as much of the explanations involve demonstrating something on the machine itself.
 - Actually spent: ~\$15 Gas to 2 interviews was used to destinations on the south-side of the city.
- Participant Support - \$60
 - These funds are to be used to take contacts who arrange the interviews out to lunch as a thanks for their help. This amount is for two such lunches, which is our predicted number of interviews.
 - Actually spent: \$0 No lunches occurred as planned. Contacts were not entertained by our students for ipro related purposes
- IPRO day - \$100
 - The IPRO day funds will be used in connection with creating the IPRO day presentation and/or exhibit. In the past, such funds have been used to purchase models for demonstrating our concept and batteries to run the microprocessors.
 - Actually spent: ~\$30 We bought AstroTurf and Pipe for display/demo purposes
- Mock-up - \$50
 - These funds will be used for the raw materials that will be used for creating a mock-up of the final product. A facsimile of the product is needed to test for ergonomics, demonstrate ruggedness, and verify dimensions.
 - Actually spent: \$0 As we refined our product as a software product, mock-ups were done using Photoshop or similar software

7. Results

- Our team set up four interviews with experts in all walks of the industry: heavy machinery operator, mechanic, superintendents, and safety personnel
 - We first interviewed a heavy Equipment mechanic from Walsh Construction. They told us it seemed to be a valuable device and gave us ideas on location for mounting, power, connecting to initial equipment.
 - That interview was followed up by a Walsh equipment operator on a job site. He mentioned he would use a device like the one we described, and refined our idea on mounting a device.
 - The Safety Administrator from Local 150 came to a group meeting on campus. His job includes but is not limited to the training of heavy equipment safety in five states. He furthered our understanding of the current problems and mentioned he has never seen, nor heard of anything like EVS, but believes very strongly in our cause and asked us to keep him informed with our groups progress in the future. He also offered their training facilities for beta testing.
 - We also met with our lawyers twice to discuss mutable areas of content from patents to liability of product.
 - Failure of current marking techniques.

- Unaware of some available products and services.
- Safety the top priority on job sites, thus will investigate any means of improving safety.
- Fiber optics detection equipment unrefined, large market potential.
- Equipment to detect depth would be optimal.
- Obtained sample data from real world project and means of data acquisition for common projects. Discovered common format of data as .dwg file
- Contacted Trimble, a worldwide construction electronics manufacturer.
 - Learned of the GeoX family of hand held computers with built in highly-accurate GPS
 - Established a contact and referred to development contact.
- Determined role of product in the market, and decided to focus on software applications.
 - Acquired the Trimble Software Development Kit (SDK)
 - Develop additional software applications through use of kit.
- Identified potential competitors.
 - Trimble
 - Guardian Prostar
 - Bloodhound
- Created Business Model Projections
 - Target Market
 - Unit Costs
 - Revenue Projections
 - Profitability Projections
 - Stakeholder Assumptions
- Patentability review by intellectual property attorney.
 - Determined that the team's proposed idea does not infringe on any existing patents.
 - Therefore, freedom to operate.
 - However, proposed idea is not able to be patented.

8. Obstacles

- Market research uncovered several products and services similar to the proposed idea objectives.
- Existing patents, as outlined in patentability review.
 - Much time spent researching patents, meaning less time spent on other tasks
- Unable to obtain Trimble hardware or hardware device manufactured by another electronics manufacturer.
 - Must develop software applications using the SDK from Trimble
 - Goal next semester is to obtain a hardware device
- Team members lack technical background, therefore there was a high learning curve
 - Occasionally encountered difficulty when conducting technical research and tasks.
 - Tasks unclearly defined and allocated.
- The team researched existing Patents
 - Any patents found to be similar were recorded, reviewed, and sent to the law student and licensed patent attorney for full review.
- In the initial stages of the semester we were uncertain to the products our competitors may have. The business team began researching construction safety products from other companies to create a understanding of the market. Our hopes were to also modify our product to the wants of the end user.
- We also dealt with the problem of defining our product and all it's amenities. We first began with an idea for a device which displayed a three dimensional view of a construction site and related underground utility markings. That idea was then dropped and instead, a two dimensional view was determined more practical after discussions with actual operator's preference due to depth perception problems associated with 3D, and, what was obtainable during a single semester. This then lead into what our product was/is. We knew what our product's functions should be, but we did not determine whether to sell hardware with software or software to be used with current products. This discussion also brought about questions on maintenance, uploading information, power supplies, updating information, and many others. It was finally decided after discussion and research to sell our product as software for current hardware platforms. The product can be purchased over the Internet and uploaded. Plans and utility information is available through the Civil Engineer of record who located the utilities for Civil drawings.

- We believe that nothing could have been done to avoid these issues which presented questions that needed to be answered in order to move forward into another semester, and to ensure the advancement of our product. The groundwork laid this semester via research and discussion will be of great assistance in the development of a working beta version next semester.
- Next semester's team will need to begin their research where our team ended. They should start with the task of programming software for a product using information obtained from Trimble's website, Auto Cad drawings, and hopefully, a handheld Geo X unit. The business team will have to reestablish relations with Trimble to advance marketing, furthering the integration of our product, and trying to obtain sponsorship. We will also need a firm business model including marketing, finances, and product positioning.

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9. Recommendations:

- Hardware
 - Trimble GeoXT Handheld series as developing platform
 - Simplicity
 - Handheld
 - Windows Mobile
- Application
 - Initially two dimensional
- Acquire sample data to begin testing
 - May test via Walsh, Local 150
- Look at potential software platforms
 - ESRI
 - uaView/uaField
- Find potential companies for business relationships
 - To fill role of sponsor, supplier
- Perform full non-infringement review
- Create a working prototype
- Write a comprehensive Business Plan
- Form an independent company
- Create a software/ hardware package capable of recording lines set down by J.U.L.I.E.
 - Device used for data storage rather than detection
 - Removes need for finding separate data sources
 - Could mitigate some liability

10. Resources and Acknowledgements:

- Seyfarth Shaw LLP
 - Robert Diehl
 - William Fairbanks
 - Brent Clark
 - Mark L.
- Walsh
 - Brian Madding
- Local 150
 - Martin Turek
- Bob Anderson
- Interviewees (names withheld)
 - Mechanic
 - Superintendent
 - Operators