



Final Report

Illinois Institute of Technology
November 30, 2006

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Sponsor: Warehouse Education and Research Council and
the Kern Family Foundation

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1 Introduction

“How to maximize the profit of a warehouse?”

“What are the actual costs? How are they itemized?”

“Outsourcing - Yes or No?”

In an effort to help companies dealing with such issues the Warehousing Education and Research Council (WERC) has come up with a plan to develop a web-based tool. The tool will provide assistance to companies seeking to outsource logistics operations in figuring out vital information that will help in the decision-making process.

The IPRO 319 team’s objective for this semester was to create a model of a distribution operation which will aid companies seeking to outsource logistics operations. More specifically, the team’s main objective was to create a web-based application for efficient and cost-effective analysis allowing companies to determine the effectiveness of outsourcing any aspect of a warehouse. This team also established a strong team-working environment based on the knowledge and capabilities of each individual given their different fields of study for the successful completion of the goals presented for the IPRO group, as well as gaining useful experience and knowledge for every member.

During the fall semester, the team has set forth and accomplished the following objectives:

- Analyze logistics processes (Shipping, Manufacturing, Transportation, etc.)
- Define crucial resources used in these processes and structure them
- Research costs associated with logistics processes
- Develop a model that represents these costs associated with logistics processes
- Develop a web-based Logistics Outsourcing Tool

2 Background

Presently warehousing companies are finding it difficult to maximize their profits. One of the ways that is used to maximize profits is determining the outsourcing benefits in operations. Many companies are spending a lot of time and resources to calculate financial figures that help them determine if outsourcing certain logistics of their company can benefit them.

The Warehousing Education and Research Council (WERC) is an association of distribution experts and specialists from bordering professions that come together to share practical knowledge and professional expertise with the aim of improving individual and industry performance. WERC has sponsored the I²PRO 319 team to create a unified source for calculating costs. This source is the Logistics Outsourcing Tool, a web-based application that will simplify the process of calculating warehouse operating costs.

The project required research of logistics processes in a warehouse, resources and costs associated with such processes. An analysis of the research was conducted. After completing the research phase, the team did the following: defined the type of industries that model can be used for; determined mathematical formulas and created the model and the web tool necessary to help with the outsourcing decision-making process; and finally organized the information discovered into a presentation. The practical solution was followed by feedback from WERC representatives who helped us to stay on track and assisted us in making improvements to the development plan.

The budget of I²PRO 319 has been relatively low. During the course of this I²PRO the team used funds only for presentation materials.

The team was unable to find information on any successful or failed models with a similar purpose. Yet we feel very strongly that some private businesses possess functional methods to determine the effectiveness of outsourcing.

3 Purpose

I²PRO 319’s objective this semester was to create a web-based application for efficient and cost-effective analysis of outsourcing aspects of a given warehouse. In the process of researching the problem we have analyzed and focused our attention on the three most important features within a warehouse: Equipment, Labor, and Building.



Figure 1 The three major groups where costs in warehouse are allocated

After the research phase we honed in on the costs and relationships associated with each process in order to create an effective and relevant model. Then we entered the development phase and divided into three sub-teams: a mathematic modeling sub-team, a tool development sub-team, and a marketing sub-team. We also did quality assurance in which nearly the whole team was involved.

Within each phase we had some milestones – both, dates given by the I²PRO Office for the deliverables as well as milestones and deadlines we allocated on our own: preparation of interview-material for meetings with warehouse officials, review-meetings with our sponsor, and agreements between the sub-teams for the delivery of versions or hand-overs.

- 1 Project planning phase**
 Identify Objectives
 Task Division
Create Project Plan 09-22

- 2 Research Phase**
 Library Research
 WERC Research – web
 Interview Industry Workers
Create Midterm Deliverables 10-20

- 3 Division into Sub-teams**
 Mathematical Modeling
 Tool Development
 Marketing
Create Final IPRO Deliverables 11-22

- 4 Presentations**

Figure 2 The milestones for the IPRO 319 team

4 Research Methodology

In task-oriented sequential terms, the team has conducted research using five basic research methodologies:

- quantitative methodologies
- qualitative methodologies
- statistical analysis
- action research
- personal reflection (in empirical and constructive research)

Starting from the first task of understanding the requirements and needs of the sponsors and clients the team used qualitative methods such as interviews and group discussions. We updated and presented our progress while keeping in touch with WERC representatives and implementing their feedback. Rita M. Coleman, Deputy Executive Director and Robert L. Shaunnessey, Executive Director of WERC have visited the team on September 7, 2006 and November 2, 2006.

Additionally, the team's research included a September 22, 2006 visit to a functioning Chicago warehouse owned by the Strive Group, where we applied the following research methods: quantitative method of observation, qualitative method of interviews, personal reflections, and data collection for statistical analysis. The first draft

of important input and output variables for the mathematical model was based on the data from this site visit

The discussions with the invited experts proved to be another invaluable part of our research methodology. The information we got from the warehousing professionals was very significant to the mathematical modeling sub-team. On October 3, 2006 Mark Wozniak from Liquid Packaging, Inc. visited the classroom to answer the team's questions about warehouse operations and financial issues. On October 5, 2006 Bob Horwath from Keystone Aniline came to speak in further detail about the costs important for warehousing businesses. Interviews helped us organize and clarify the list of variables for the model.

No surveys were created or conducted by the team of IPRO 319; yet we were able to get benchmarking information on best-in-class figures out of a *Materials Handling Management* journal survey based on private information. Using this data, the team was able to build our cost comparison/benchmarking model. The team members never stopped supplementary research and looked over a number of journals and related Internet sources (including industry-specific journals like *Warehousing Management*, *The International Journal of Logistics Management*, *IOMA's Report on Managing Logistics*, *Modern Materials Handling*, and others) to gather more information for the tool. The IPRO team also obtained balance sheets of real warehouses and analyzing them allowed us to further develop the list of important variables and relationships between them. All of the research listed above, along with personal experience and reflections helped us build our model for the Logistics Outsourcing Tool.

The tool development team consulted with WERC's technology department about the development environment to be used. The sub-team started development in ASP.NET 2.0. WERC informed us that we should use ASP.NET 1.1 in order for the tool to be compatible with their system. The group accommodated WERC's request and migrated the project to ASP.NET 1.1.

5 Assignments

Our current team organization has not changed since the creation of the project plan and midterm report.

5.1 Designation of Roles

Team Leader: Tito Rodriguez

Assistant Team Leader: Amol Gunale

Minute Taker: Alexandra Romanova-Smith is in charge of recording decisions made during meetings including task assignments or changes under consideration.

Agenda Creator: Tito Rodriguez is responsible for creating an agenda for each team meeting. This provides structure to the meetings and offers a productive environment.

Time Keeper: Alexandra Romanova-Smith will be responsible for making sure meetings go according to agendas.

Weekly Timesheet Collector/Summarizer: Tito Rodriguez is responsible for collecting weekly timesheets from each member of the team and updating everyone with a summary report.

Master Schedule Maker: Tito Rodriguez is responsible for collecting schedules from all the team members and developing a master schedule, which tells the team when members are available and how to contact them.

5.2 Sub-teams: members and responsibilities

During the second half of the semester the team consisted of different sub teams which are related to and interact with each other as shown in the figure.

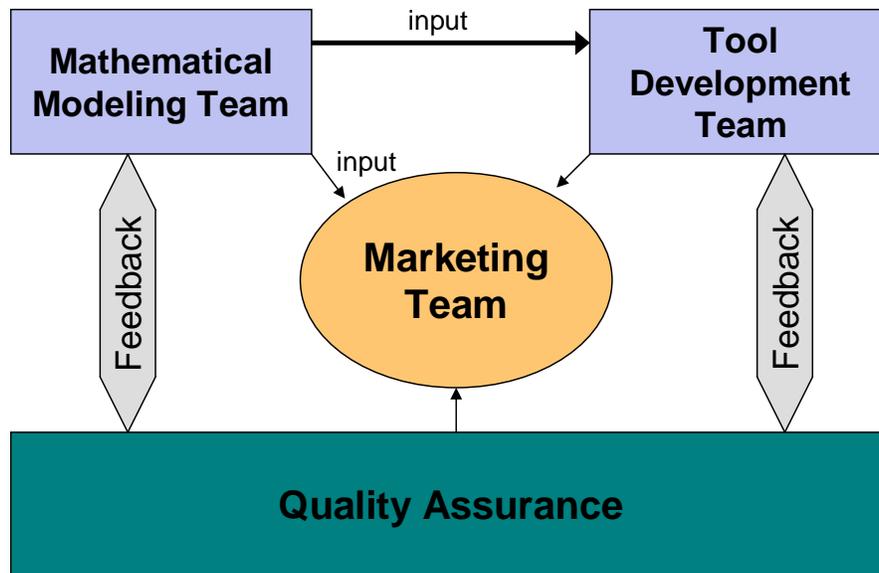


Figure 3 Interaction of the four different teams

Mathematical Modeling Team



The mathematic modeling team developed and built the mathematical model on which the web tool shall be based. To build the model the team used the software MS Excel.

First decisions

At the beginning the whole IPRO-team discussed the variables used as input for the model and the desired output-data. Afterwards this team of four members was responsible for the overall mathematical model. They split up the topics between their members (see below) but worked close together to review the progress constantly.

Development

During the development the mathematical model team worked together with the development team which designed the web tool. However the collaboration between the mathematical modeling team and the tool development team was challenging: according to the project plan the mathematical modeling team must deliver the model as input for the tool development team. Because of a tough time schedule the two teams needed to work simultaneously, and the tool development team couldn't wait for the final model.

Quality Assurance (QA)

It was crucial to ensure that the Logistics Outsourcing Tool works without producing any errors. Therefore we needed quality assurance. The QA for the mathematical model was done by each member of the mathematical modeling team.

Name	Responsibilities
Schwarz, Nickolay (Sub-team leader)	mathematical model: input and output concerning equipment and comparison (part 2) model
Gunale, Amol Venkat	mathematical model: input and output concerning labor cost model, utilities cost model
Rodriguez, Tito	mathematical model: input and output concerning comparison (part 1) and maintenance model
Christopherson, Sean R.	mathematical model: input and output concerning Building cost model, Other costs model

Tool Development Team



The team developed the Logistics Outsourcing Tool based on web technology. It got some input from the mathematical modeling team. But due to the fact that the two teams worked simultaneously on their artifacts until the end of the semester the whole functionality which is included in the mathematical model is not yet implemented in the web tool.

In general there are different tasks which are important for the development of the online tool:

1. media and design of the model to build an usable and appealing graphical user interface (GUI) (front-end development)
2. development of the web tool: logistics tool engine (backend development)

Quality Assurance (QA)

The QA for the web tool was done by HyoungTae and Juhan, two members of the tool development team because this job demanded good knowledge in programming.

Name	Responsibilities
Mehta, Kabir (Sub-team leader)	Logistics Tool Graphic User Interface
Hacker, Maxime	Logistics Tool Engine
Bae, Juhan	Quality Assurance
Cho, HyoungTae	Quality Assurance

Quality Assurance

It was crucial to ensure that the Logistics Outsourcing Tool works without producing any errors; therefore we needed quality assurance.

The QA needed to be done on both developments, the mathematical model done in MS Excel and the web based tool.

- The functionality of the mathematic model is checked by the members of the mathematical modeling team.
- The QA for the web based tool is done by HyoungTae and Juhan, two members of the tool development team.

The task is to make sure that the model works properly, detect every bug and make sure that it will be fixed. This will be done by testing the model with any possible input data, documenting the results (both correct and wrong output) and giving feedback to the other team members.

Name	Responsibilities
Schwarz, Nickolay	QA for mathematical model
Gunale, Amol Venkat	QA for mathematical model
Rodriguez, Tito	QA for mathematical model
Christopherson, Sean R.	QA for mathematical model
Bae, Juhan	QA for web-based tool
Cho, HyoungTae	QA for web-based tool

Marketing Team



The marketing team is mainly responsible for all marketing material used throughout the project and at IPRO day, and at organizing the presentations for interview-guests, a review-presentation for our sponsor and the IPRO day. It will also be involved in the design of the graphical user interface for the Logistics Outsourcing Tool and will create the verbal sections for the model. Furthermore a logo has been designed, and buttons were designed.

All the other teams will report to the marketing team with their results as inputs for presentations and papers.

Name	Responsibilities
Romanova Smith, Alexandra (Sub-team leader)	Minutes, Presentations, Design and text for web tool, Abstract, Logo creation, Buttons displaying the logo
Hammer, Kerstin	Presentations, Design and text for web tool, Abstract, Poster, Logo creation

6 Obstacles

After an analysis of IPRO 319's objectives the student team has concluded that certain problems may arise before completion is possible. The more significant problem that we faced is the difficulty of completing the task by the end of the semester. The creation and presentation of a flexible mathematical model which can be applied to a real-world situation was a great milestone in itself. As a team we utilized all technologies that could assist us in the completion of the project and reaching our objectives as accurately and efficiently as possible. The technologies used include: web applications and databases; Microsoft programs (MS Project, Excel, Word, and Power Point); programming languages (C#, .NET, Java); and Adobe products (Illustrator, Photoshop, and Acrobat) for presentation deliverables.

The team encountered another obstacle during the project planning phase, although the problem became more apparent in the second half of the semester. The project was chronological in nature and it was not easy to run different tasks concurrently. In the first half of the semester the team worked in its entirety to create the project plan and conduct the necessary research. After completing research and creating midterm deliverables the team split into sub-teams, each with a specific task. Since modeling was dependent on research and development was dependent on the model, it was challenging for the sub-teams to work in parallel. To overcome this barrier, we created a version system. After the first version of the model was complete, the development team began to work on it. In the mean time, the modeling group started to add features. The addition of these features eventually evolved to the version two of the mathematical model, however the development team could not begin to work on version two until the modeling team finalized it. Since tool development proved to require more time to finish, this strategy worked well. The modeling group managed to complete three versions of the product while the development team finished creating version one.

Further analysis of the problem at hand revealed that security issues must be taken into account. Information privacy is an important issue for potential clients and the team protected the clients' data. After brainstorming, interviews with industry professionals, and structured group discussions the team has concluded that most security protection issues involved with the Logistics Outsourcing Tool will be provided by WERC. There are security resources already implemented on the WERC's website. The tool itself does not store the clients' information to any database. When output information is saved as an XML file, it is streamed directly to the client's machine.

Another obstacle was more technical. The tool is a tutorial that creates a consistent look and feel for the users. On almost all of the input pages the user is asked to type the number of costs they would like to enter. Subsequently, the tool generates the user-specified number of rows. Each of these rows contains information that is relevant to the current stage of the tutorial. The development team worked for weeks to get this functionality to operate. The development environment is ASP.NET with C# code-behind. This is a stateless environment, meaning that each time a button is clicked or a

page is posted, a page goes through a lifecycle. There are many steps to the lifecycle, but let us be concise by mentioning only the relevant ones. A page starts in the Page_OnInit method. This method creates the controls that are to be dynamically placed on the page in html format. After the Page_OnInit method, the page loads data into the newly created controls (via LoadPostBack method). Imagine that the number 5 a control “myTextbox” before a button “myButton” was clicked. During the Page_OnInit the 5 does not exist in “myTextbox”, however after the method LoadPostBack is called, the 5 is in “myTextbox”. It is more common to use the method Page_Load (called after LoadPostBack) than to use Page_OnInit. If the dynamic textboxes are created in Page_Load - or in any method that comes after LoadPostBack - there will be no reference to the textboxes and therefore no data in them. To keep with the current structure of the tool, all dynamic controls must be created in Page_OnInit.

Finally, our team has recognized barriers and obstacles in terms with teamwork and ethics. As described in the project plan, every team member works on the development of the model. It has been difficult for us to get each person’s opinion and draw a conclusion smoothly. The problem was exacerbated by the fact that we have a very diverse group with only two native English speakers. We might have needed to communicate slower, even in circumstances when a decision is made quickly. Working together as a team, respecting the opinions of others and understanding one another, we have learned when we need to speak out and when we need to listen to others. In addition, Professor Shields has encouraged us to work on becoming better team members over the course of the semester, rather than trying only to reach good IPRO results. The team considered how work could be assigned individually and how important communication between sub-teams is. The team addressed problems by using one in-class meeting per week for discussion about accomplishments and task assignments.

7 Results

7.1 The mathematic model

Based on the results of our research phase we made a list of parameters that would be included in our model. For example, costs such as equipment cost, labor cost, facility building cost, electricity cost, administrative cost, taxes, and insurance cost. The model also includes parameters such as total square feet area and usable square feet area, actual number of pallets stored and the capacity of warehouse to store the pallets. One of the most important metrics in warehouses is the number of pallets stored per square feet. Then our results varied upon different version of the model we used.

At the beginning (model 1.0) we calculated only types of costs and their total (building, equipment, labor and others). Afterwards we started to improve our model and entered efficiency calculations. So our second model already included more detailed results such as productive hour's calculations for equipment and labor, overtime paid hour's calculation and others (please refer to Figure 4 below to analyze our outputs that are results of the model). Finally in our last model modification we added statistical and comparison benchmarking model with current market values of certain input variables and output variables (refer to Figure 4).

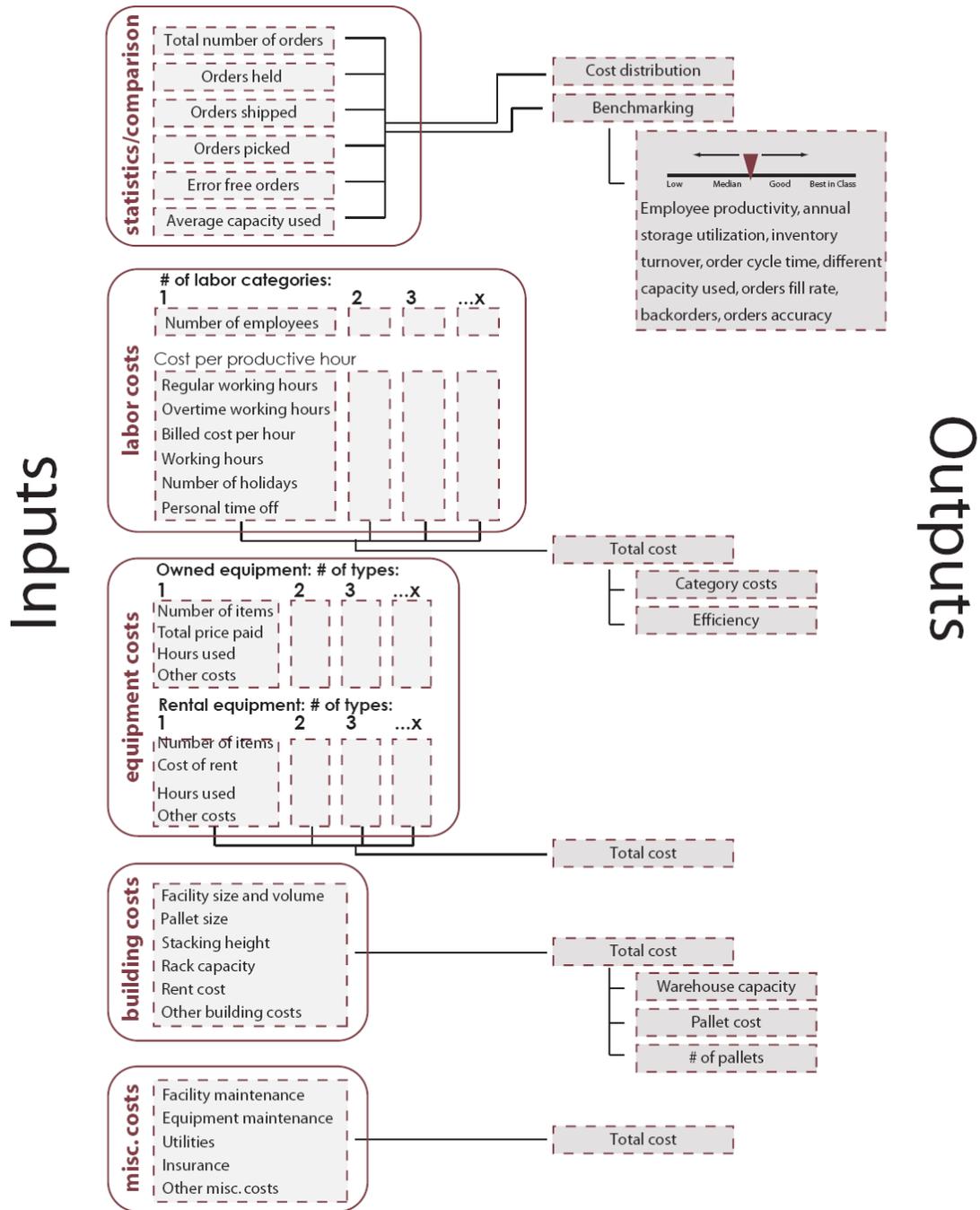


Figure 4 The input and output variables of the Logistics Outsourcing Tool

7.2 The web application

The first version of the tool is complete. It is a six-step tutorial that asks users to break down their warehouse costs. The user is walked through building costs, labor costs, equipment costs, maintenance costs and miscellaneous costs. The results are shown on the last screen with an option to save their data in XML format, in case they wish to return at a later time. Each category is shown on the results page as a numerical value and a percentage of the total costs.

Each of the six parts is a data structure and each is contained within a wrapper object called “Container”. The user-end web application is driven by “Container”. It holds the user’s data and performs necessary calculations. Please refer to Figure 5 below.

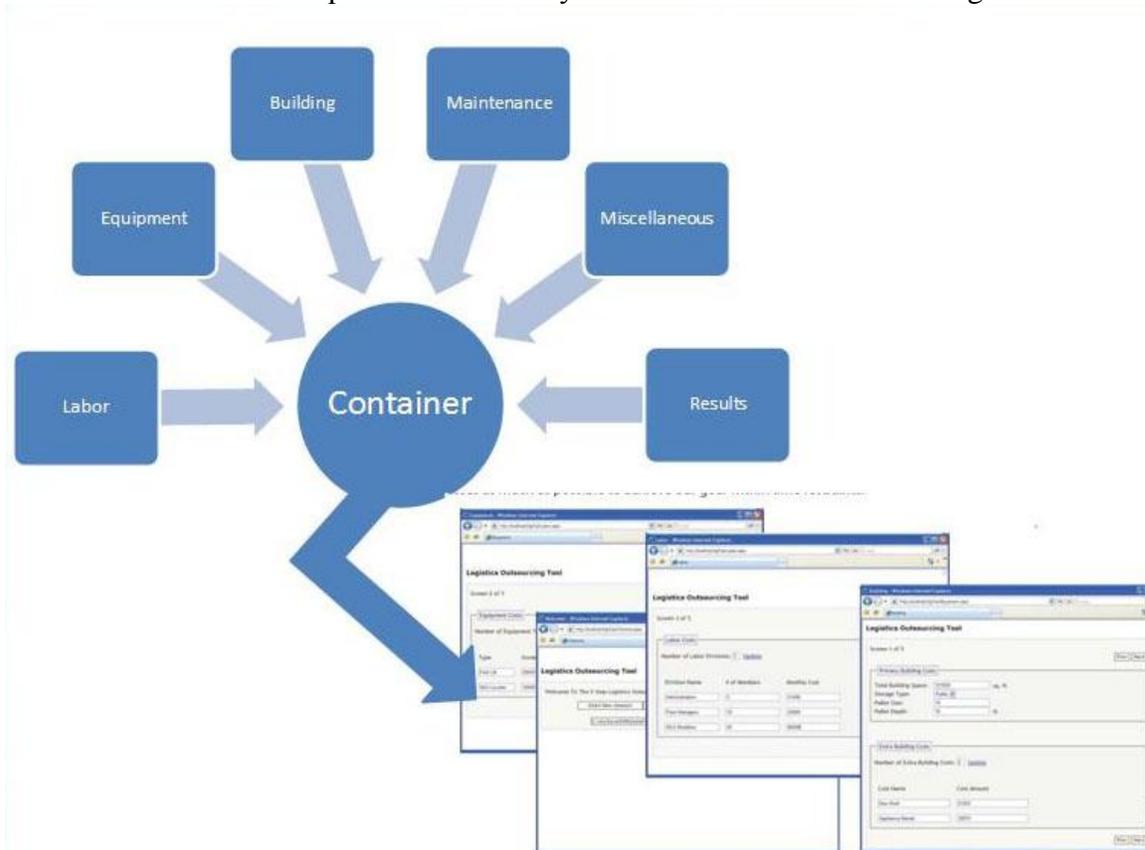


Figure 5 Structure of the web tool

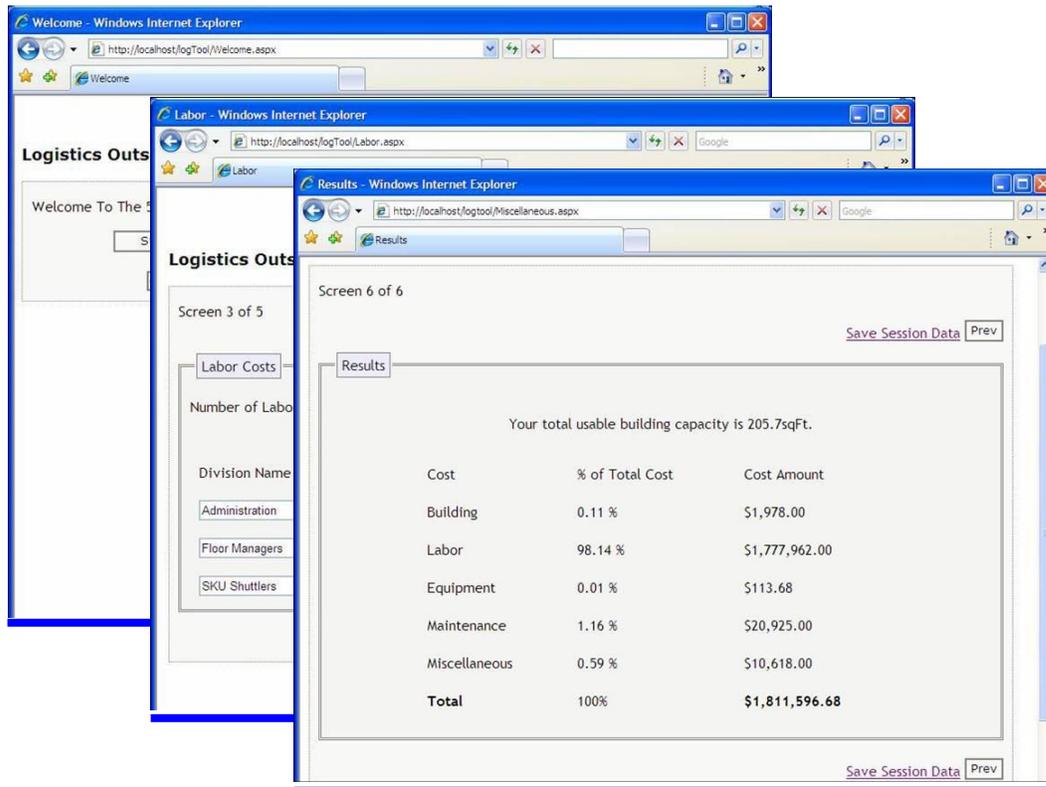


Figure 6 Screenshots from the Logistics Outsourcing Tool

7.3 Overall results

The whole IPRO team got to know a lot about the warehouse operations during the semester. Warehouses and logistics companies play a huge role in everyone's lives as they are constantly involved in movement of essential things that people need on a daily basis. We learned about various costs associated with the warehouse operations. We had the opportunity to closely witness warehouse operations during our visit to a warehouse.

We as a team have learned a lot about the importance of teamwork. We need to respect the opinions of other teammates and should contribute as much as we can towards achieving the objective of the project. We should not impose our opinions or ideas onto others. Without every member's contributions this project would not have been possible to do within the time constraints.

8 Recommendations

Next semester, it would be best to focus the attention on further developing the web tool. Hold off on mathematical model creation. The current Excel model is complex and it will likely take development half of a semester to catch up. A development lifecycle system might help break the teams down into efficient sub-teams. The source code for the web tool contains the information necessary to understand its structure as we have written it.

The team has developed the first version of the tool but there is much more to add. The mathematical modeling team has developed a comprehensive logistics tool. It is more advanced than the ASP.NET version.

It is easy to add a new page to the web tool when needed. The web.config file includes an application setting key for each of the pages. To add a new page, a key can be simply added for it as long as the “LastPage” key is equal to the page with the highest numerical value. The code was created with the version system and continuous further development in mind.

To successfully work on this product, it is important to learn ASP.NET since the WERC website operates on it. There are books and online tutorials that help tremendously. Knowing ASP.NET and C# is the key to making further progress on this project. If you get stuck, the best place to look for answers is on Google Groups, ASP.NET forums, and TheCodeProject.com examples.

Finally, it may be helpful to find other tools like the Logistics Outsourcing Tool. If they do not exist, gather industry information for the costs our model supports. Useful resources are listed in the References section of this report.

9 References

9.1 Online resources

Warehouse Education and Research Council, www.werc.org
Logistics Management Journal, www.logisticsmgmt.com
Material Handling Management Journal, www.MHMonline.com

9.2 Journal Articles

“*Cheap Tricks*”, Logistics Management, June 2006
“*How to Hold the Line on Labor Costs*”, Logistics Management, August 2006
“*Surviving – Getting By – Thriving*”, Material Handling Management, January 2006
WERC Sheet newsletter, July-August 2006
WERC Watch newsletter, Fall 2005

9.3 Interviews

September 7, 2006
Rita M. Coleman, WERC, Dep. Exec. Director
Robert L Shaunnessey, WERC, Exec. Director

September 22, 2006
Visit to Strive Group, Inc.
Doug – chief operating officer
Tom Duskas -- facility manager
Maria -- assembly line manager
Jose -- quality assurance manager
Lionel -- Shipping/receiving manager
Scott Welden -- finance controller

October 3, 2006
Mark Wozniak, Liquid Packaging Inc.

October 5, 2006
Bob Horwath, Keystone Aniline Corporation

November 2, 2006
Robert L Shaunnessey, WERC, Exec. Director

9.4 IPRO-specific sources

“Tips for Seamless Team Presentations – A Baker’s Dozen”, Judith Filek, Face-to-Face Communications Skills Newsletter, September 2006
Communication, Ethics, Project Management, and Teamwork IPRO Office Learning Objectives, <http://igroups.iit.edu/>

10 Acknowledgements

The cooperation and information supplied by our interviewees were very valuable to the project’s progress. Bob Horwath and Mark Wozniak shared their expertise regarding warehouse operations and financials of warehousing.

Our sponsor, the Warehouse Education and Research Council (WERC) gave us access to members-only research reports available from www.werc.org. Rita M. Coleman and Robert L. Shaunnessey from WERC answered our questions thoroughly and gave us initial direction for the project. Mike Moss was our contact for questions relating to software development and the WERC website.

The team thanks the entire staff of the Strive Group who allowed us to visit their warehouse and shared sample financial reports with us. We are indebted to them for their cooperation and enthusiasm. All students in our team benefited from their engagement in the IPRO.

We would also like to thank our faculty advisor, Herb Shields, for providing us with great advice and the contacts for interviews. His encouragement and strong interest in the project helped to make this IPRO successful.