

IPRO 341: New Product Evaluation and Improvement

Sponsor: Versatility Tool Works and Manufacturing



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Abstract

IPRO 341 is a continuing IPRO, sponsored by Versatility Tool Works, which was created to solve issues in the design of one of their products, a heavy duty tool cabinet. This IPRO looks to find solve issues with the cabinet (which was redesigned after the previous IPRO), and to look forward in order to revolutionize tool cabinets.

Background

The sponsor of IPRO 341 is Versatility Tool Works (VTW). VTW specializes in producing precision tooling and sheet metal components. The company was established in 1972 as a tool and die operation and has since expanded to have one of the most diverse product lines in the industry. The company has recently begun manufacturing storage cabinets for custom tooling.

Last semester the IPRO team analyzed the tool storage cabinet designed by VTW and developed ways in which to improve the performance. Their findings included using stiffeners, Accuride slides, and shot-peened slides. In addition to the cabinet quality improvements, the spring 2009 IPRO 341 team conducted a market research survey to identify the customer's view of the product. The response rate was low, as expected from online surveys, but the results were encouraging. A summery of the results from last

semester can be found in the appendix. Due to the favorable performance of last semester's team, the sponsor has decided to continue sponsorship into the summer semester.

Although this is a continuing IPRO, the objectives set by the sponsor are distinct and not a continuation of last semester's. The sponsor set two objectives. The first objective is the testing of new tool cabinet that Versatility Tool Works has designed. The second objective is to design a new and innovative tool storage cabinet.

Objectives

The sponsor at the onset of the semester determined the goals of the team. The sponsor's objectives were the testing of its new cabinet and the design of a new and innovative cabinet. To address the overall broad objectives of the sponsor, the team broke down the tasks into more manageable subtasks.

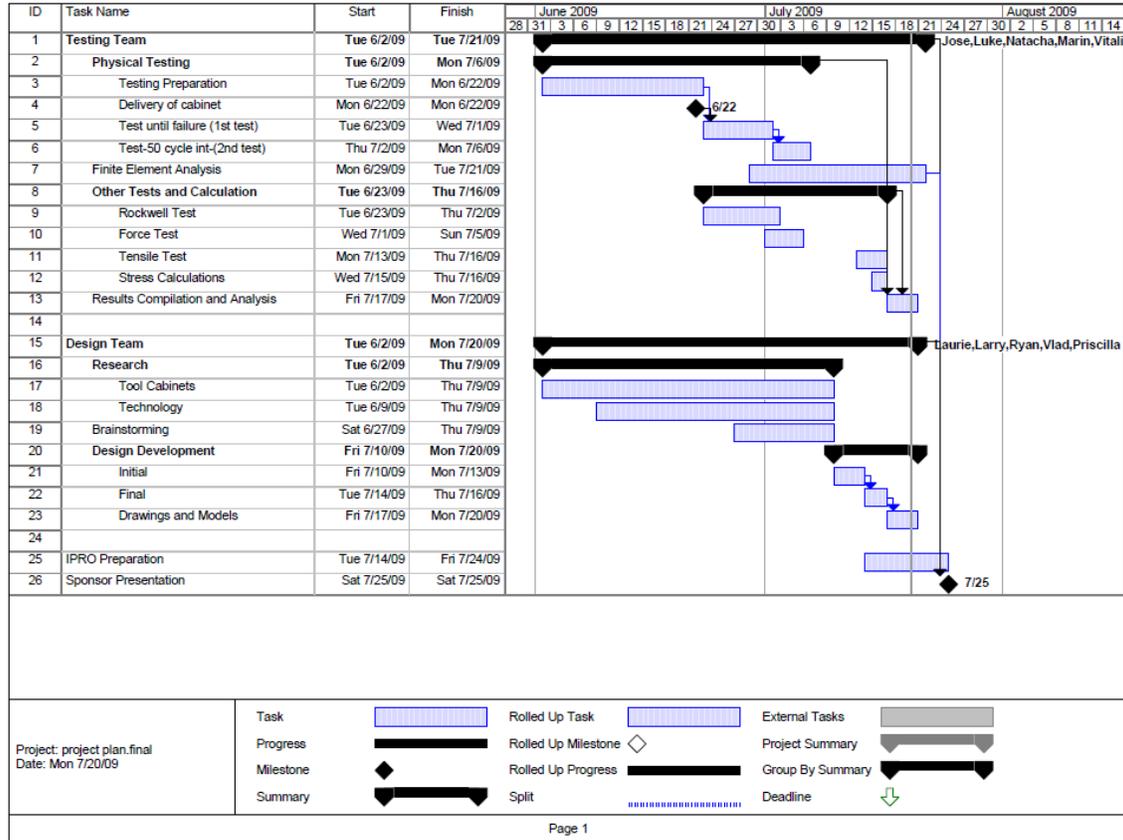
Testing of new cabinet

- Simulation Test
 - Simulated use of cabinet
- Other Tests
 - Rockwell Test
 - Force Test
 - Tensile Test
 - Stress Calculations
- Finite Element Analysis
 - Validate results and recommendations

New Product Development

- Brainstorming
 - Individual and Group
- Research
 - Tool cabinets
 - Technology that can be incorporated
 - Feasibility of brainstormed ideas
- Initial development of designs
 - Determine feasibility
 - Expert opinions
- Final development of designs
 - Benefits
 - Drawings and Models

Methodology



The Gantt chart above shows what tasks the team performed and when. The original project plan that was developed was broad and versatile.

The testing team suffered a late start due to a late delivery of the cabinet to be tested. Additionally, the cabinet failed after 421 cycles on the first test and 250 cycles on the second test. Although recommendations were made to improve the cabinet, the sponsor was unable to construct new parts to be tested due to production scheduling. As a result, the plan changed and the information gathered went into a computer simulation to determine if the validity of the recommendations.

The design team followed a plan similar to the Gantt chart. However, at the beginning of the semester it was unknown how much time would be needed for research, brainstorming, and design development. However, given the predetermined deadline of June 24, the work performed in the last three weeks was focused on the ideas researched and brainstormed up to that point.

As a result, the specifics of the methodology used to generate the results changed with the project. Additionally, the original marketing objective was dropped due to a lack of available working hours to fully accomplish such a big task without sacrificing the results of the other objectives.

Team Structure and Assignments

The team was split up into two teams, the testing team and the design team. For most of the semester the two teams worked independently to accomplish the relative goals, however it was not a strict division so opinions were shared between the two teams. Additionally, toward the end of the semester, the testing team was able to provide valuable insight for the designs developed by the design team.

One change made to the team structure was due to the dissolution of the marketing team. This action also dissolved double roles, which mostly occurred on the design team, and allowed for more focus on the testing and design aspects of the project.

Testing Team

Marin Assaliyski, *Aerospace & Mechanical Engineering*

- Assembles and performed testing on initial cabinet design.
- Analyzed results and looked into alternative building materials.
- Performed finite element analysis and static loading analysis to determine weak points
- Implemented a new design by rearranging several pieces and welding them
- Made a new design which alters the geometry of the guides and thereby their stiffness.

Vitali Basiourski, *Mechanical Engineering*

- Brainstormed and researched innovative tool cabinets: different kinds of circular and angled drawers
- Trouble shot the motor and system VTW provided and tested drawer
- Investigated different programs to use for FEA
- Brainstormed ways to improve current drawers and
- Participated in group brainstorming to improve on current ideas such as circular toolbox design

Luke Grabowski, *Mechanical Engineering*

- Performed testing of newly designed cabinet for VTW
- Examined and investigated with the testing team the graphs showing deformation along the guide.
- Performed an FEA analysis on rack slide to study further the stresses caused by the 420lb load
- Applied new method to make drawer assembly more rigid

Jose Guerrero, *Aerospace & Mechanical Engineering*

- Conducted a variety of tests such as physical tests, force test, hardness test, and tension test and took measurements
- Stress calculations for deformed beam
- Performed finite element analysis

- Communicated with VTW for delivery of materials

Natacha Tchobanova, *Mechanical Engineering*

- Conducted testing and provided insight into drawer design
- Provided technical skills related to conceptual feasibility for design team

Design Team

Ryan Attard, *Chemical Engineering*

- Looked into ways to incorporate high tech ideas into a low tech product
- Brainstormed possible innovative storage cabinet designs and their pros and cons
- Participated in group brainstorming to improve on current ideas and choose three main ideas to present to the sponsor
- Researched ways to improve a simple design through innovation

Lawrence Dorn, *Architecture*

- Took prior experience in the workplace and applied it to design concepts
- Communicated regularly with Versatility for the Testing and Design teams
- Modeled new design tool cabinets through drawing and physical modeling

Laurie Feldman, *Architecture*

- Did research on tool cabinets currently on the market
- Contributed to design ideas for next generation design
- Participated in group discussions to brainstorm pros and cons of cabinet designs
- Participated in group discussion determining what direction to take the objectives given to us by the sponsor
- Completed CAD drawings of design ideas

Vlad Ruzs, *Business*

- Performed research to understand the market situation that VTW faces
- Researched storage cabinet designs to obtain basic ideas of what is currently the standard in design and performance
- Brainstormed possible innovative storage cabinet designs and their pros and cons
- Researched cabinet designs to determine what, if any, similar designs to our own currently exist
- Participated in group brainstorming to improve on current ideas and choose three main ideas to present to the sponsor

Priscilla Zellarchaffers, *Chemical Engineering*

- Provided insight into conceptual design
- Researched into RFID systems currently in use in tool cabinets
- Found new ways to apply technology to tool cabinets
- Investigated ways to better store oddly shaped tools

Budget

The team did not have any significant costs for this semester. Equipment for testing was provided by the sponsor and other resources used were of no additional cost to the team.

Code of Ethics

Refer to The Seven Layers of Integrity by June Ferrill

Overarching principle:

Our team will test and analyze methods of improving the tool storage cabinet of Versatility Tool Works, research possible new markets for the product and use the data gathered to design a new and innovative tool storage cabinet.

1) Law and Regulations:

Canon: We will comply with all intellectual property and regulatory laws to the best of our abilities.

Pressure: To make a product that does not infringe on other intellectual property.

Risk: Not doing enough research into patents that exist on parts, specifically the slides, used in the product.

Risk: The patent research being performed too narrowly and other seemingly unrelated patents being infringed.

Measure: The research being disregarded because it is unusable and/or unprofitable to the sponsor.

Pressure: To complete the work and provide promising results on time.

Risk: Exposing the project to unnecessary liabilities due to the legal research being insufficient because of time restrictions.

2) Contracts:

Canon: We will abide by all the terms of the contracts and all non-disclosure agreements, implicit or explicit, that apply to our project.

Pressure: To use the information disclosed to the team for personal gain.

Risk: Violating terms of contracts with sponsor which can lead to withdraw of support.

Measure: Sponsor withdrawing its support for the project.

Pressure: Needing assistance from third parties for analysis and research.

Risk: Violating non-disclosure agreements.

Risk: Releasing trade secrets and/or sensitive information to outside parties.

Measure: Sensitive information showing up in competitors' products.

3) Professional Codes:

Canon: We will abide by the industry professional codes as pertaining to safety.

Pressure: Create a new and innovative product that is very cost effective but overlooking a serious design flaw.

Risk: The product not providing any real value in the end.

Risk: Not considering safety issues in lieu of price.

Pressure: Design a high quality product.

Risk: The sponsor will not be able to take advantage of the new design due to its high price.

Measure: The adaptation of the new design by the sponsor.

4) Business and Industry Standards:

Canon: Performing to the highest ethical standards of the tool storage industry and providing the most value to our sponsor.

Pressure: To produce results that will provide value only in the short term.

Risk: A tainted image of the sponsor in the long term.

Risk: A decrease in sales of other products to a customer due to the failure of the tool storage cabinet.

Measure: The discontinued interest of Versatility Tool Works in the project.

5) Community

Canon: The team will strive to generate results that will provide value to everyone involved, from the producer to the worker.

Pressure: To design a product that provides benefit only to the producer.

Risk: Product is not thoroughly tested and does not provide the intended value.

Risk: Decreasing productivity of workers due to the design of the product.

Risk: Technology and business fundamentals of the product are not properly researched to provide the most value.

Measure: Failure to successfully market and grow sales of the improved and/or new tool storage cabinet.

6) Personal Relations:

Canon: The team will respect each other's opinions and completed work.

Pressure: To have a team and sub teams with a significant amount of autonomy.

Risk: Sub teams not understanding each other's work.

Risk: Project being delayed due to lengthened discussions and team member conflict.

Pressure: To complete a large, varied amount of work in a short amount of time, such as weekly deliverables

Risk: Team members taking credit for other work.

Risk: Team members not shouldering a similar amount of work.
Measure: Peer review at end of project

7) Moral Values;

Canon: No team member will be required to do anything that violates their own personal, religious, moral, or ethical beliefs.

Pressure: The need to work outside of class.

Risk: Working on days that some consider religious holidays.

Pressure: To complete all assigned work on time.

Risk: Forcing a member to violate personal morals or values to meet deadlines.

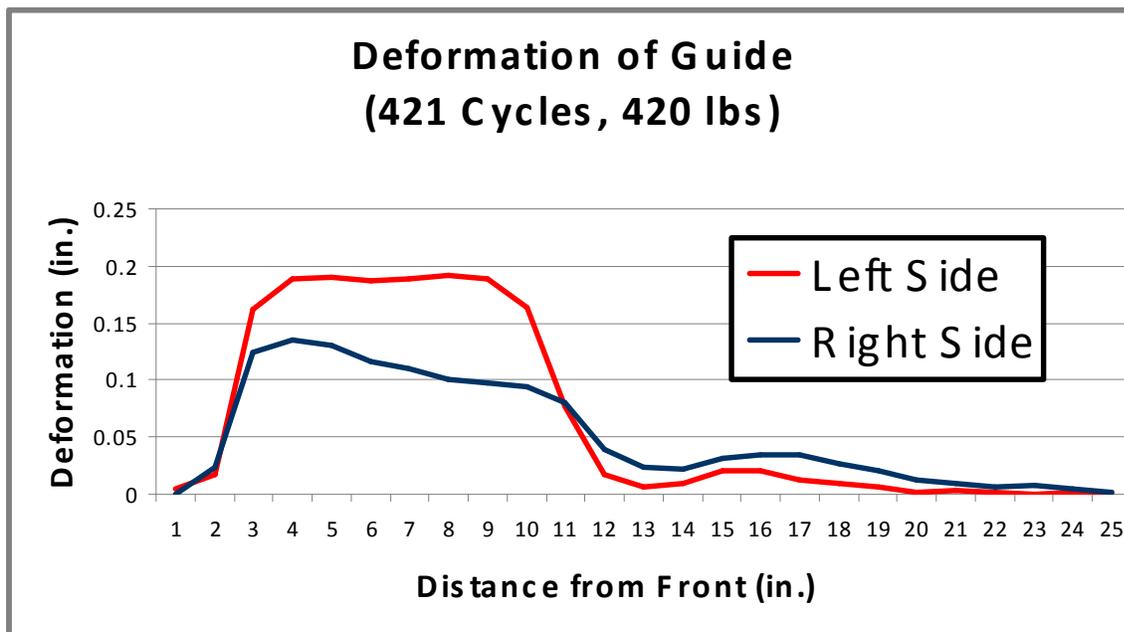
Measure: Member brings up situation to team publicly or privately to the proper hierarchical person, possibly the team leader.

Results

Testing Team

Our testing team performed a variety of testing methods, and they determined that the redesigned drawer failed even more prematurely than the previously tested design, at 421 cycles. However, it was important to note that this cabinet is the first of its kind, and is only a prototype. Tests such as the ones that were performed are important in the design phase in order to improve the design to meet the physical specifications. These results correlate to fifty work days being the lifetime of a drawer at 80% capacity(420 pounds).

The failing was in the guide, which was not stiff enough, and caused a deformation on both sides of the cabinet, shown in the graph below. The deformation shown caused the drawer to open unevenly and caused a great deal of friction. Along with the slide bending, the bearings also dug into the slides, which created an even greater friction forces.



After the initial test to test the longevity of the cabinet, a number of other tests were performed, and some vital flaws in the design were found. The two main tests were hardness and strain tests: the most important result was the difference in hardness of the bearings compared to the guide, where the bearings were a factor of seven times harder.

Following the hardness test we performed analytical tests on the drawers, including a 2D-Finite Element Analysis in order to further refine the design by finding the weakest points in the design. They used the data used from the strain tests in the Finite Element Analysis, which showed the stresses. This showed that the bearing forced the maximum yield upon the guides.

Design Team

The design team began the semester by researching existing product and technologies in the market. The research was very broad. It included general cabinets, alternative cabinet designs, possible technologies to incorporate, etc. The design team deliberated and brainstormed the new or more detailed research every week to generate a variety of ideas to consider presenting to the sponsor. The highlights of this part of the project includes circular designs based on the lazy-Suzan cabinet, diagonal drawers for easy access to tools, RFID technology to determine contents without opening drawers, a combination cabinet, and a job site center.

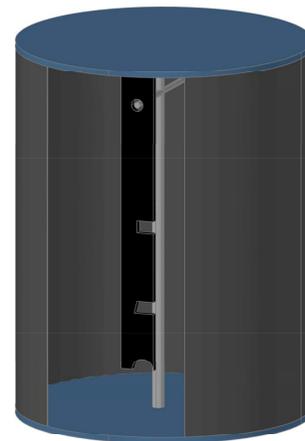


Lazy-Suzan cabinet style

The lazy-Suzan design generated many different ideas. However, the team did see much benefit to a simple rotary cabinet (like the one shown on the right) and sought ways of taking advantage of the circular design. The team developed two circular designs, but in the end, only one was chosen to be incorporated into the combo cabinet.

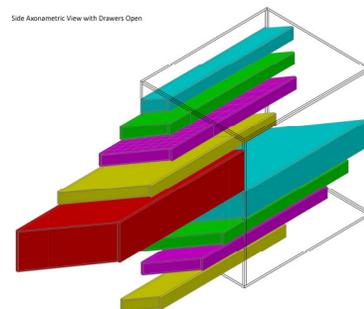
Circular cabinet for long narrow tools

The design that was discarded was a circular cabinet for storing long narrow tools. Since these tools do not always make the best use of space in a rectangular cabinet, hung upright might prove a more innovative model. Although the team did develop the idea further as a circular cabinet, it was incorporated into the combo cabinet by designing a space in the cabinet where long narrow tools can be placed upright.



Diagonal drawers

Another idea that the team considered was designing a cabinet with diagonal drawers for easy access to tools. The idea was that tilting the drawer 45% would let



workers locate and grab tools much easier than a flat drawer. A few designs were created such as a side opening cabinet with diagonally installed drawers. Although the team thought the idea was good, the technical aspects of constructing such a cabinet for industrial use made this cabinet fall off the final list.

RFID Technology

To answer the question of knowing what is inside a drawer without opening it, the team researched the application of radio frequency identification (RFID) to cabinets. Besides this useful feature, RFID has a few other benefits. The second benefit is the ability to control access to drawers much like an RFID enabled ID card can open a door. Also, RFID can be used to keep track which tool was taken out of the cabinet for accountability purposes. The third benefit is providing insight into how tools are used which can help with process/product redesign as well as managerial accounting. The fourth benefit is that RFID can increase usability on drawers by eliminating the extra wear caused by opening the wrong drawer. Lastly, RFID can be incorporated into many different drawer designs such as the Combo Cabinet and Job Site Center.

However, there are some drawbacks to using RFID, the major one being cost effectiveness. Initial diagnosis yielded a variety of price ranges based on quality. Thus, due to the large quantity of metal of the cabinet it is unclear how much effective equipment would cost. Finally, as with most new ideas, there is a concern about getting the customer to see the benefit of the technology.

Combo Cabinet

The team developed two final cabinet designs. The first design is the Combo Cabinet, which is a mix of different storage styles to answer the need to store different types of tools. In this design, the team incorporated a circular design with a rectangular design to increase the efficiency of the space used. As can be see in the drawings below, the cabinet is designed to me modular and versatile; thus, it can be added onto existing cabinets, used in a continuous arrangement, or as an end piece. Another added benefit is the space gained by using quarter circle drawers. As the figures below show, when opened, two to three drawers can be accessed at the same time instead of just one. The third benefit is the use of the space created by the circular design (i.e. the rest of the square or rectangle that houses the quarter circle drawers when closed) for storing long narrow tools.

Obviously there is no perfect design so there are some drawbacks to this cabinet. One drawback is the cost effectiveness of creating such a system. To be able to sell the cabinet, the cost has to be within the range of what rectangular cabinets cost. Unfortunately, the idea is not radical so the cabinet cannot be priced at a high premium.

Figure 1: Single Rotary Configuration

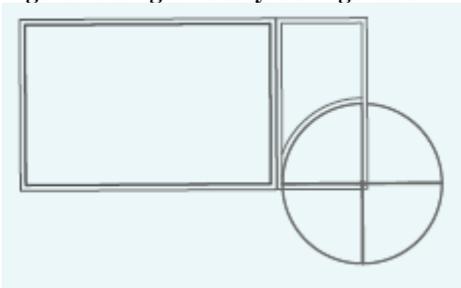


Figure 2: Continuous Configuration

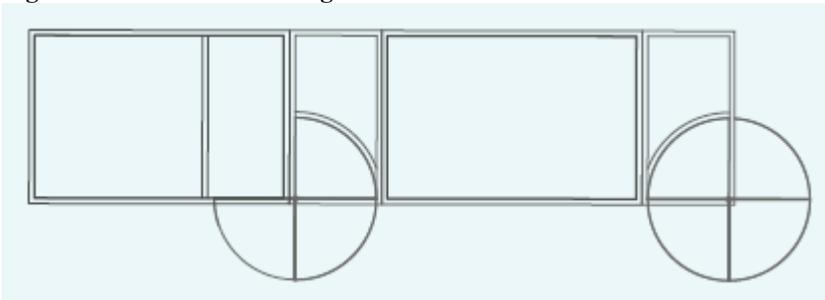
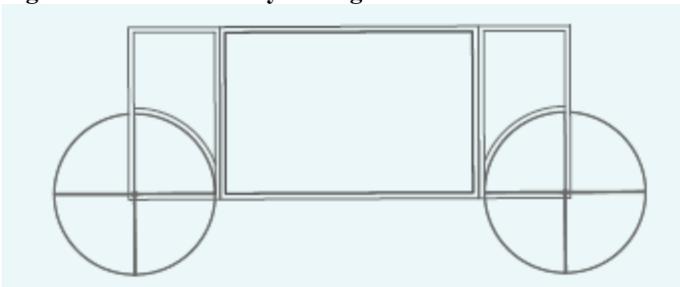


Figure 3: Double Rotary Configuration



Job Site Center

The second design the team focused on is the Job Site Center. This design is based on the idea of creating storage for bigger tools that are used on a job site such as a power generator and air compressor as well as hard to store tools such as power cords. The benefits of this design is decreasing theft by locking shared movable tools to the box, the versatility of storing many different tools and tools normally not found in a jobsite box, commonly used tools are stored in separate compartments for easy access, and the no drawer tool box is easy to design and build. In addition, the Job Site Center, and the Combo Cabinet, can be incorporated with RFID for added benefits.

One drawback of this design is unwanted vibrations caused by the generator and air compressor inside the unit. There are a few ways to resolve this issue but more research is needed. Another drawback is the lack of apparent novelty of the product. This, as with the Combo Cabinet, limits the premium price that can be charged for the product.

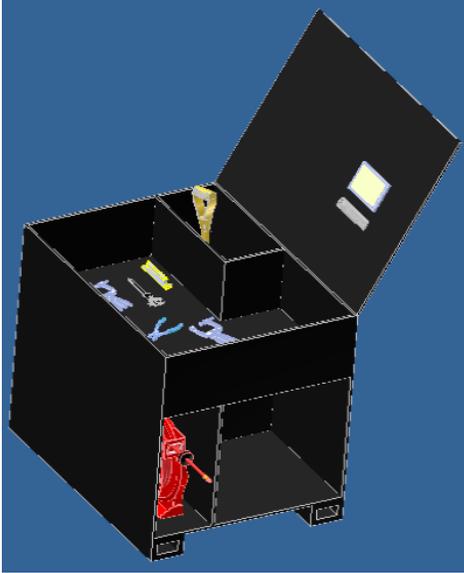


Figure 4: Job Site Center

Obstacles

During the semester, the team faced a variety of obstacles while working toward delivering results to the sponsor.

One obstacle that the team faced was an unanticipated change in the design of the cabinet to be tested. This caused a delay in receiving and starting the testing of the cabinet. To resolve this issue the testing team focused on other objectives. Additionally, to be able to start testing immediately once the cabinet arrived, the testing team prepared all the necessary equipment for testing. To avoid this obstacle in the future, the change in cabinet design should be communicated earlier on. However, during a 16-week semester this would not be such a big problem.

Another obstacle was a time and resource constraint due to a short semester. In order to avoid doing a little work on three objectives, the team chose to focus on the testing and design tasks. This allowed the team to deliver more certain results that could be used on their own instead of delivering broad results that needed to be developed much further before they could be used. There is not much that can be done to address a time obstacle given the fixed resources of the IPRO program over one semester. The best way to address the issue is to pass the work on to subsequent semesters.

A third obstacle faced was designing a patentable product or a product that does not infringe on current patents. This obstacle could not be directly addressed this semester, as we did not have the resources or expertise necessary to perform a patent search. Thus, to diminish the risk, the team focused on designing multiple cabinets. To address this barrier, the sponsor or next semester's IPRO would need to do a patent search on any designs that the sponsor chooses to expand to the next phase.

Recommendations

Testing:

There are a few modifications to the drawer design that could greatly improve the performance overall: thickening the guides, adding a guide channel, and adding a channel to the guide.

Thickening the guide would improve the stiffness, which would decrease the deformation. However, thickening of the guides (by using heavier gauge steel) would require a significant redesign of the carriage, and may be more difficult to bend. This would be the most cost effective way, because harder steels are much more expensive (five times more, or greater).

In addition to thickening the guides, adding more bearings would more evenly distribute the stresses of the drawer along the guide horizontally in order to properly bear the weight. Along with adding more bearings, it would be effective to attach a piece of angle iron to the bottom of the guide.

These redesigns were not completed by the end of the summer term, due to the busyness of Versatility Tool Works, which made the team unable to test any modifications, and in the future it would be possible to test the redesigned cabinet.

Design:

The design team has created a number of innovative designs, each of which could be explored further through engineering analysis and cost analysis, along with market analysis in order to see the desirability of the new product designs.

In particular, in the RFID system, Versatility Tool Works and IPRO 341 would be encouraged to look to companies to contract an inventory management system: the findings from this IPRO have proven that the technology exists and is readily available, however the construction of said system would require extensive technical knowledge which may not be had by IPRO students or current employees of Versatility.

References

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7-Drawer tool cabinet example

<http://www.directindustry.com/prod/winware/automatic-tool-cabinet-29614-231677.html>

Light Duty RFID tool cabinet example

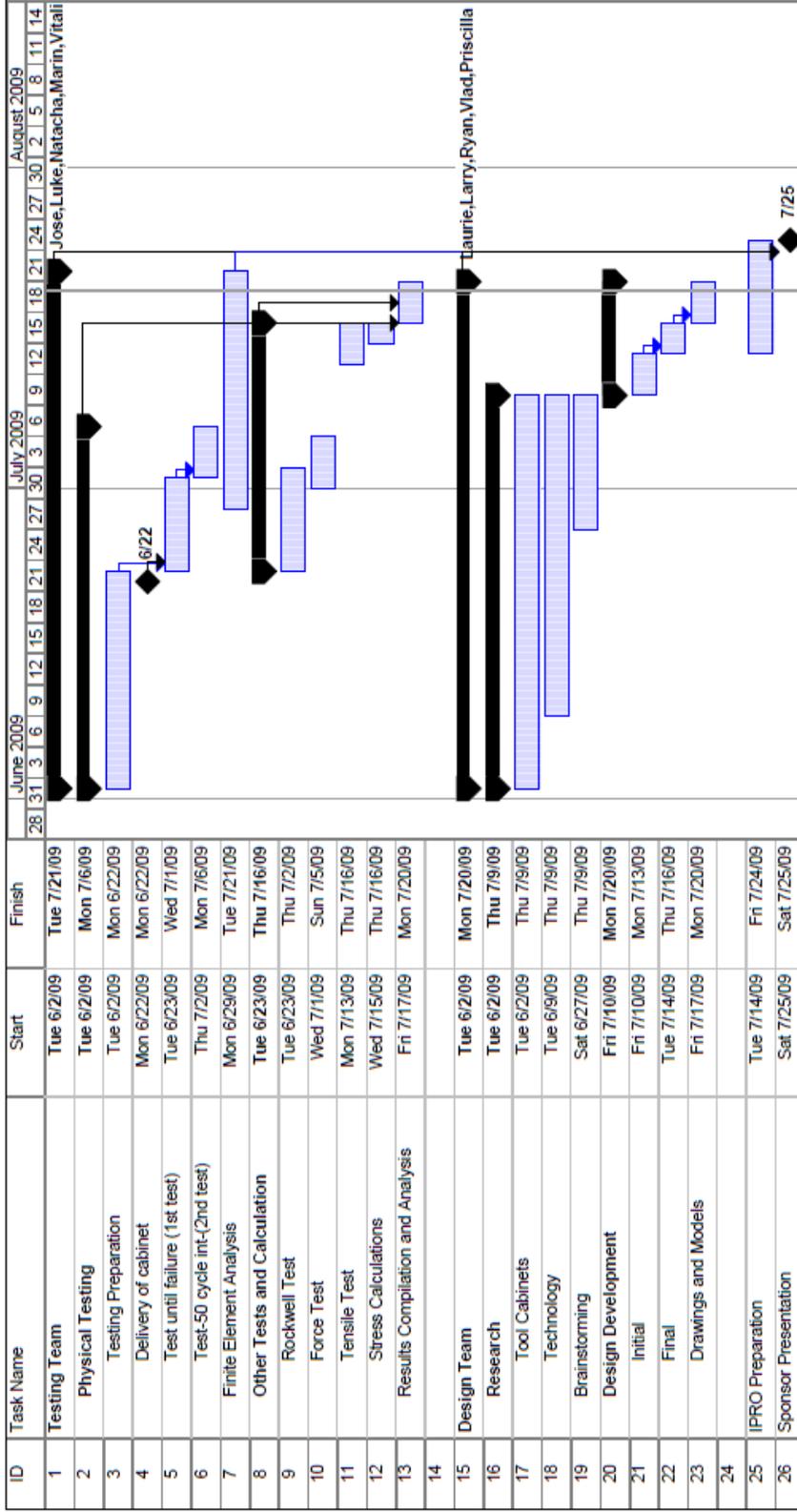
http://www.northerntool.com/webapp/wcs/stores/servlet/product_6970_200358132_200358132

Heavy-duty tool cabinet example

<http://innovationzen.com/blog/2006/08/11/innovation-management-theory-part-3/>

Henderson-Clack model for classifying innovation

Resources



Project: project plan.final
Date: Mon 7/20/09

Task		Rolled Up Task		External Tasks	
Progress		Rolled Up Milestone		Project Summary	
Milestone		Rolled Up Progress		Group By Summary	
Summary		Split		Deadline	

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