Project reflection:

There were copious aspects of the project that played key roles for the visibility and stability designs throughout the year. These included research, creating product specifications, design concept generation and selection, external feedback, STEM applications, and prototyping/testing.

Defining the problem:

The research began when the team had to determine how much of a hazard forklifts presented in an industrial environment. The research was needed in order to show qualitative and quantitative data to the panel that to prove that this industrial vehicle did present a safety hazard. It was found that forty two percent of forklift accidents are induced by tip-overs, twenty five percent come from people being crushed between the vehicle and a surface, eleven percent of accidents derive from people being crushed between two vehicles and ten percent of forklift accidents come from people being struck or run over by a forklift ("Forklift Safety Training." Accident Statistics. Web. 01 June 2012. <**http://forklift-safety-training.blogspot.com/2006/05/accident-statistics.html** (http://forklift-safety-training.blogspot.com/2006/05/accident-statistics.html) >). All of these statistics, which were also presented in Element A, show that all of the forklift accidents are related to instability and lack of visibility.

Reflection:

From this information as well as other statistics and cases presented in Element A: Presentation and justification of the problem the team presented its problem statement "forklifts have proven to be a significant source of accidents in warehouse working environments due to a combination of factors including lack of visibility and tip-overs." Information to back up the team's claim was necessary not only to get approved on this project but it also showed the team what aspects to focus on when the project began. The research of cases and statistics assisted the team in narrowing down the scenarios in which the team would chose to work on. This was very important because due to the time constraint and lack of extensive knowledge of forklifts the designs created were not going to be able to cover all possible scenarios that could potentially occur. The cases and statistics were essential for the stability design specially since there are three main types of tip-overs: longitudinal, lateral, and the tip-overs that occur while traveling on ramps. From the research and statistics found the stability design was simplified by focusing only on lateral tip-overs that were induced by excessive turning, speeding, and/or overload. Therefore the research behind the problem statement was not only a tool to prove that the problem statement was valid but it was also a great tool to use and refine the possible scenarios.

General forklift research:

At first the team did not realize the amount of research that was involved with this project. This aspect has been necessary from the very beginning down to the last weeks. Initially the team needed to become familiar with forklifts as it was something none of the members dealt with on the daily basis. The classes of forklifts, styles, and their common uses were researched. Things such as the difference in the tires from a class III to a class V forklift was researched. The team spent the first four weeks of the project not only brainstorming possible solutions for the problem statement but also learning more about forklifts, how they worked, how they were used, and why they were used. Etc. The team also spent some of this time researching and becoming aware of OSHA and ANSI regulations to make sure that the designs followed the rules that govern and regulate safety on industrial settings.

Reflection:

Progress could have not been made without learning more about forklifts, although the time spent researching did take a lot time it was a key, and almost mandatory, aspect of this project due to the nature of the problem statement. In order to make safe stability and visibility solutions the team needed to be knowledgeable on the workings of forklifts and the regulations pertaining to them. This general research was also a great aid in developing product specifications. It seems natural to start working on a design right after brainstorming but teams should not be afraid of doing "general research," one of the most important things is to know what it is the team is working on.

Technical research:

The technical research involved trying to find schematics, manuals, forklift product specifications, dimensions and diagrams. This information became very useful when the design dimensions were determined; the information gathered was also used for product specifications such as specification nine "the solution will not increase the width of the forklift under normal operating conditions."

Reflection:

Finding and accessing technical documents proved to be one of the most difficult tasks for the team in this project. After the stability design was changed from a moving counterweight to a device that activates upon turn technical information regarding the VSM, the forklift's main computer, and the ECU, the Engine Control Unit, as well as many other components of the forklift were needed. This information was not available from Toyota Material Handling (Toyota Material Handling, U.S.A., Inc. 1 Park Plaza, Suite 1000 Irvine, CA 92614) since it could create a liability issue. This greatly limited the possibility of directly interfacing with the main computer of the forklift which would have simplified the design and made it more desirable to a "potential buyer." Yet the team worked with the materials that were available either via the internet or through the technical department of forklift dealerships such as Thompson and Johnson (Thompson & Johnson Equipment Co., Inc.63A Railroad Avenue Albany, NY 12205). Although these limitations may not have allowed to design the most desirable prototype it did teach the team about working with the resources available and still being able to create a design that met the product specifications.

Creating Product specifications:

The product specifications were the guidelines by which the team brainstormed and designed both the stability and visibility solutions. In order to come up with thorough specifications the team decided it was best to brainstorm the main things that the design needed to accomplish and branch out into more specific parts from there. These main aspects were safety, forklift class, the type of environment the forklift was surrounded by, industry regulations, and the goal the design was supposed to accomplish. From these main ideas the team branched out into more specific product specs. We knew the importance of the specs and that was why the first ten specifications were created within the first six weeks of the project. Many of the specifications were based on the research that the team found. For example specifications three, "the technology necessary to implement all aspects of the solution does exist," and four, "the solution will adhere to both OSHA and ANSI forklift regulations," both required research in order to determine what regulations OSHA and ANSI had placed on forklifts. Although the majority of the specifications were created at the beginning of the project more specifications were added during the design process. This held true even days before the team's midterm presentation when one of the members,*[redacted student name]*, came to the realization that a temperature specification had been overlooked before. He became aware of this as he was creating a decision matrix for the visibility solution, the swinging periscope. From this, specifications 16.1, "the solution can withstand temperatures as high as 134°F," and 16.2 "the solution can withstand temperatures as low as -22°F," were added to the list of product specifications.

Please note that all specifications are located in Element C: Presentation and justification of solution design requirements.

Reflection:

Creating product specifications only matters as long as the team abides to them. This was at times very difficult to accomplish such as with specification six, "The solution will function, when correctly implemented, on the Toyota 8 Series Model 8FGCU20, a counterbalance forklift truck and will have the potential to be easily and quickly implemented on different forklift models as well," and specification thirteen, "each solution will not weigh more than 700 pounds." One of the reasons the stability idea was changed was due to specification thirteen. The "centripetal force and gravitational force moments: determining the mass of the moving counterweight" calculations in Element E showed that the counterweight needed weighted more than seven hundred pounds. As a result the team returned to brainstorming and came up with the motor system that pushed the accelerator pedal upward. Specification six often led to changes in the design in order to make it more adjustable because, even though the team used the 8FGCU20 for dimensions and testing, variations in other similar forklifts had to be kept in mind. Working with the product specs brought the team one of the most fundamental learning experiences, never before did members have to create something based on a set of criteria that had to be kept in mind throughout the entire year. Something that was learned from this experience was to create the product specifications early on in order to make progress with the design, but also to be aware of circumstances that give rise to more specifications because not all can be brainstormed at once; it is an ongoing process.

Design concept generation and selection:

Copious design decisions were made throughout the project, from choosing a forklift to deciding what material was best to make the swinging periscope. Decision matrices were used to come about these decisions with minimal room for "attachment" to a certain idea. These matrices were time consuming since more often than not research was needed to back up the criteria. Although these matrices took anywhere from two days to three weeks to make the time was well spent since the team could be confident that the decision made based on the matrix was as technical as it could be to the best of the members' ability. The matrices ranged from material decisions, to system analysis, such as the "Sensing System Analysis" located in Element D.

Reflection:

The decision matrices helped maintain the decisions that were made technical. When creating decision matrices the product specifications must be kept in mind at all times. Brainstorming the criteria of a matrix with the specs in mind tie the choice made to the product specifications that needed to be met. This also simplifies the making of a matrix.

External Feedback:

Working and learning with experts from the industry made the learning experience from this project very unique. From the very beginning to the end the team maintained contact with forklift companies for forklifts, materials, guidance and feedback. The team worked with companies such as Lifttech Equipment Companies. Inc (2820 Curry Road Schenectady contact: 518-356-5932),the Toyota Material and Handling Headquarters (Toyota Material Handling, U.S.A., Inc. 1 Park Plaza, Suite 1000Irvine, CA 92614)and Thompson and JohnsonEquipment Co.(63A Railroad Avenue Albany, NY 12205). The Albany branch of Thompson and Johnson was the main source of guidance, assistance and feedback throughout the entire project. The team visited the warehouse at least once a month to receive feedback from the Branch Manager, Mr. Ascoli, and the Service Manager, Mr. Molano.When the stability idea was changed *[redacted student name]*and *[redacted student name]* visited Mr. Molano to learn more about the VSM, the forklifts main computer and also to ask what his thoughts were on the new design (see Element J: Documentation of external evaluation for Mr. Molano's comments on the design). *[redacted student name]* and *[redacted student name]*also visited Mr. Molano to receive feedback from him as well as from other company technicians.

Reflection:

When working with forklifts, or any other type of industrial equipment, the chances of the team members to possess in-depth knowledge on the subject are slim. It is essential to maintain contact with a professional that knows about this type of equipment. The guidance and feedback is crucial to developing a product that, from an expert's point of view, is usable and practical in the field.

STEM applications:

Due to the nature of the project there were substantial amounts of math and physics involved. The visibility team used reflection principles learned in physics as well as stopping distance calculations. Certain physics laws such as Newton's First Law were applied on failure analyses. Calculations and physics principles regarding the combined center of gravity of the forklift, centripetal forces, moments, and RPM conversions were used. Please note that all of these calculations are located in Element C: Applications of STEM principles and practices.

Reflection:

The calculations performed were carefully executed. Although the team had some confidence in the calculated results, it would have been ideal if all of the calculations had been reviewed and approved by more than one professional in the field. This would have only added confidence in the answers obtained. Given the possibility we would have performed the calculations that were not reviewed sooner in order for someone to take a look at them and provide feedback.

Prototyping/Testing:

The team made sketches in engineering notebooks with dimensions; most of these sketches were produced in CAD to visualize what the device would look like and to determine whether the dimensions used were valid. An initial prototype of the visibility design was made and has been tested on various aspects. A mock up of the stability design was made at first and now the initial prototype is now almost complete. Due to the change in designs half-way through the year the team has not been able to do testing on the stability design as of now.

Reflection:

The devices were both created by following the design drawings that were made prior to the building. The visibility design was tested and the results were analyzed. The stability design is almost complete and tests will be performed to test its functionality. Something that could have been done differently was to test some of the stability design components individually before testing the overall functionality of the design. This way there would have been some data available to analyze. But overall both devices were successfully designed and prototyped to meet the product specifications.