# Implementation of a Sustainable Project Management Methodology for Cal Poly SAE Baja

A Senior Project submitted

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by

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# ABSTRACT


Implementation of a Sustainable Project Management Methodology for SAE Baja

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A lack of project organization manifested through unclear team goals, rush deliveries of materials, lost tools and materials, half days of effort due to improper planning, wasted design time, missed submission dates, lack of clear job positions at competition, and low competition scores. A process was created to properly manage the team and it was implemented through the use of various templates, examples, and calculation programs. Each deliverable received feedback from this project's stakeholders and changes were reflected in the final process. The results were as follows:

**Table 1: Summary of Results**

| | |
|---|---|
| Implement a sustainable project management methodology | Each step of the process tested on 2012-2013 Cal Poly SAE Baja team |
| Complete Milestones on or before their due dates | On time:<br>• Competition Registration<br>• Cost Report<br>• Design Report (On Schedule)<br>• Go/No Go date 2 weeks early |
| Reduce current year's waste by 50% over last year | • No rushed shipments<br>• No half days<br>• Cost report decreased from $16,500 to $15,000 |
| Create the opportunity to increase current year's points by at least 25% over last year's overall point score | • Competition Score Estimation: 800 points<br>• Previous year's score: 517.15<br>• 54.7% increase |

# ACKNOWLEDGMENTS

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# I. Introduction

## Background

The Society of Automotive Engineers (SAE) is a global body of scientists, engineers, and practitioners that advances self-propelled vehicle and system knowledge in a neutral forum for the benefit of society (About SAE Baja, 2012). Every year SAE hosts international university competitions to provide students with the opportunity to not only design, build, test, promote, and race a vehicle within the limits of the rules, but also to generate financial support for their project and manage their educational priorities (About SAE Baja, 2012).

Baja SAE consists of three regional competitions that simulate real-world engineering design projects and their related challenges. Engineering students are tasked to design and build an off-road vehicle that will survive the severe punishment of rough terrain and sometimes even water (About SAE Baja, 2012).

The competition consists of three days. The first day is a static day and is when technical inspection, the sales presentation, and design presentation take place. The design presentation is judged on serviceability, manufacturability, ergonomics, and innovation. The second day consists of four dynamic events: maneuverability, rock crawl, acceleration, and hill climb. The final day is a four hour wheel-to-wheel race.

## Problem

In the previous five years of competition monitored, it was noticed that a lack of project organization manifested in a multitude of ways. Problems experienced included:

- Unclear team goals
- Rush deliveries of materials

- Lost tools and materials
- Half days of effort due to improper planning
- Wasted design time
- Missed submission dates
- Lack of clear job positions at competition
- Low competition scores

Listed below is an estimate of the lost time and money which could have been avoided as well as the costs the team may incur by funding this project. It was decided that in the event that this project avoided one rush shipment, the project would pay for itself.

**Table 2: 2011 Loss estimates**

| Incident Description | Incident Frequency | Incident Impact | Total |
|---|---|---|---|
| Half Days | 12 | 3 hours | 36 hours |
| Rush Shipments | 1 | $142.87 | $142.87 |

**Table 3: Estimated Project cost**

| Supply | Quantity | Cost + (8.75% Tax) | Item Total |
|---|---|---|---|
| Folders (12 Pack) | 1 | $5.43 | $5.43 |
| Template Disks | 6 | $10.86 | $65.16 |
| Printing Supplies | N/A | Subsidized | $0 |
| | | **Total** | $70.59 |

## Purpose

The purpose of this senior project is to prepare Cal Poly SAE Baja for competition in an organized, efficient, and cost effective manner. The team and car are to be competition ready by the dates required by the competition and the Cal Poly SAE constitution.

**Objectives**

- Implement a sustainable project management methodology
- Complete Milestones on or before their due dates
    - Team registered no later than December 17th, 2012
    - Cost Report submitted by March 1st, 2013
    - Car running by March 3rd, 2013
    - Design Report submitted by April 8th, 2013
    - Team Competition Assignments drafted before April 16th, 2013
    - Cal Poly Baja car competition ready no later than May 2nd, 2013
- Reduce current year's waste by 50% over last year
- Create the opportunity to increase current year's points by at least 25% over last year's overall point score

**Scope**

It will be the responsibility of this project to generate and implement all methodologies through the use of its deliverables; however it is up to the SAE Baja team to use these deliverables throughout the 2012-2013 competition season and monitor the progress of the team. The only exception will be the Schedule of Activities and Resources. The current team lead, team manager, and sub-system leads will be working on the Schedule of Activities and Resources jointly with this project's manager to ensure its accuracy so that it can be used as an example for following years. Once a detailed schedule is made and agreed upon, it will be the job of the current team lead and manager to alter the schedule as they are faced with obstacles and monitor their progress.

Scope must also be limited to the project management process. Formalizing that process may require the integration on the basic steps of the mechanical design process. However, the specific methods of mechanical design will be up to the team to learn and implement within the structure provided by this report.

Certain management processes overviewed, particularly in the control phase, may require more resources than this project has available. Those processes will be mentioned for the use of the team if they wish to implement them in the future, but will not be implemented by this project. Due to the variability in testing, the testing process will be left up to the discretion of the team and sub-system leads.

**Deliverables**

It was asked by the current team lead that this project design a management process as well as create a schedule which can be used as an example of level of detail required for future years. The team lead also asked for an outline of a typical design review for Baja's annual preliminary and critical design reviews. It was asked by the technical advisor to create a method by which the benefit and resource usage of a new sub-system design can be quantified. In addition, all requirements for the senior project class must be met. Expected deliverables include:

- Project management process outline
    - Necessary process documentation
- Preliminary Design Review
- Critical Design Review
- Benefit and Resource Quantification
- Detailed schedule

**Solution Approach**

The process implemented will first be researched and alternative approaches to solve the observed problems will be considered. Documentation of the research performed will be located in the Literature Review section of this report. A process corresponding with the current timeline of the team will be created and documented using various templates, examples, and calculation based programming. Deliverables will be considered living documents and given to the stakeholders for use and improvements will be made based on their feedback. Finalized deliverables will be created based on the feedback, as well as a management process outlining the template's use, will be given to the current team lead for use in next year's competition season. Furthermore, the mechanical design process will be integrated to ensure that team and sub-system goals are met by the designs. All sub-assemblies will be considered as projects as well as the Baja car and team as a whole.

As such, the templates will be designed so that students are capable of correctly utilizing them the first time. Furthermore, a process outline will be provided to suggest a timeline for each part of the process. Thus, the process should be streamlined yearly for both the team lead and system leads. Since the sustainability of this project is of high importance and its application is to a team which is constantly changing to meet demands by the school and competition, continuous improvement will be built into the system. The students will be allowed input at the end of each season to suggest improvements upon the current management system.

## II. Literature Review

### Background

The first phase of the SAE Baja project is the design stage (About SAE Baja 2012), however it is important to note that SAE Baja is a Mechanical Engineering Competition. At the start of this project, the Mechanical Design Process was not a consideration until it was asked by the current SAE Baja team lead to develop template slides to aid the mechanical engineering students in a series of two design presentations followed by a design judging at the annual competition.

The literature review will contain information on current Project Management and Mechanical Design Processes. The goals of this review are to find and merge similarities in the processes, integrate dissimilarities, and tailor these processes for the use of Cal Poly SAE Baja.

## Overview

Methodologies included in this report are: Design→Build→Test (About Baja SAE, 2012), the Mechanical Design Process (Budynas, Nisbett, Shigley, 2011), and Conception→Selection→Planning→Evaluation and Termination (Meredith and Mantel,1989). It is also necessary to find ways to formalize the management process in a manner which is sustainable and specifically tailored to the needs of the SAE Baja team at Cal Poly.

The team volunteers its time for the sole purpose of learning automotive design and manufacturing principles. In addition to the time requirements of SAE Baja, each member is also enrolled in a full load of classes every quarter. As such, their time is very limited. Therefore, it was necessary to research ways to implement the project management process in a time efficient manner.

## Conception and Selection

The mechanical design process consists of: Identification of Need, Problem Definition, Synthesis, Analysis and Optimization, Evaluation, and Presentation (Budynas et al, 2011). The Identification of Need and Problem Definition steps coincide with the project management process of conception and selection.

The identification of need suggests that there is a customer in mind that has a need which must be fulfilled by the project. Therefore, the purpose of the project is to meet the need of the customer. It is important for the project manager to clearly understand the problem that the customer is facing and create goals and/or objectives to meet them (Meredith and Mantel, 1989).

To minimize the risk that the project gets off-track or falls short of meeting commitments to the customer, objectives and/or goals are formed (Meredith and Mantel, 1989). Goals are also sometimes known as objectives, but it is important to note that objectives are sometimes specific, quantified targets that represent steps toward accomplishing the goals (Worth, 2009).

The Identification of Need, Problem Statement, and Goal Creation steps were developed during the definition phase, but the Synthesis, Analysis/Optimization, Evaluation, and Presentation steps had yet to be accounted for. These steps will be included in the management process and will become part of the planning stage, even though it is not a typical management process. It is outside of the scope of this project to review literature for the Analysis/Optimization, Evaluation, and Presentation steps of the Mechanical design process. Since these steps allow the students to plan the work, it is suggested that these steps take place during the planning phase.

The ME approach to the design process adds complexity to the management process, but it still does not account for many steps in the definition phase that will aid in a successful project. This is because the design process doesn't include many aspects of the Project Proposal. The project proposal states client requirements (Summers, 2005). Clients are sometimes known as the stakeholders. The stakeholders are anyone who has a vested interest in the project (Lewis, 1991). The Proposal needs to state the stakeholders in order to meet their requirements. The project proposal also includes the statement of work. The statement of work includes the goals, project constraints, such as budget and schedule, and success metrics (Summers, 2005). Finally, the specifics of what is to be given to the customer at the end of the project need to be defined (deliverables) and the scope of the project developed for each sub-system (Summers, 2005). The purpose of scoping is to create a process through which clarity, agreement, and commitment are obtained (Briner et al, 1996). The scoping process will help the key players in the organization think about what the implications of the project might be and how it may affect the project definition (Briner et al, 1996).

**Systems Engineering**

The methodology which seems to fit all of the above steps is the systems engineering process. Specifically, the systems engineering "Vee" model encompasses all three processes. Requirements are the necessary attributes defined for a system before and during design. The customer's need is the ultimate system requirement from which all other requirements flow (Grady, 1993). Requirements are the formal means of communicating needs and ideas between people. (Bahill, 1997). Both the preliminary and detailed design match with the current mechanical engineering process. Little is said about the development stage in Bahill's paper, but if the development phase is treated like the control stage for project management and the build stage outlined by SAE, then it fits well that the next step is testing. Finally, the car is operated during competition. For SAE Baja, there is a feedback loop after the operation/maintenance phase to the requirements phase the next year. The car and team's performance are reviewed during in informal audit called the debrief meeting and the review information is used to create projects for the next season.

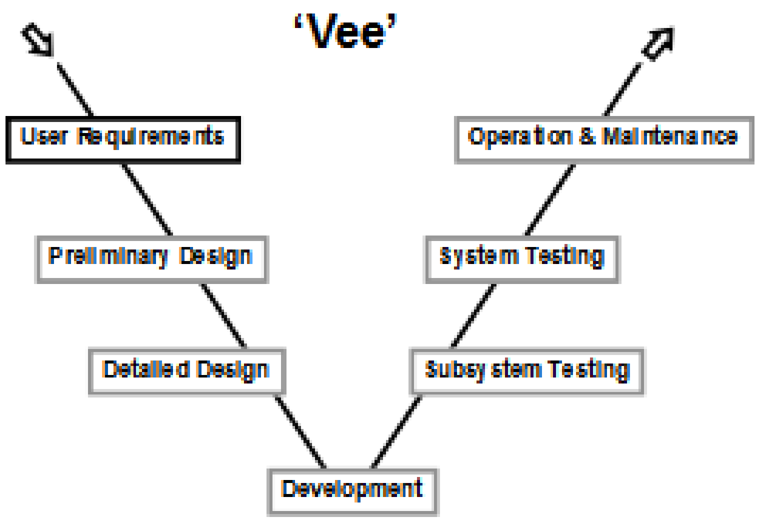


Figure 1: Systems Engineering ‘Vee’ Model

### Innovation

Not only is innovation an important part of the conception/selection process, but it is also one of the design judging criteria. Therefore, an innovation process should be considered, annually, by the team. The innovation process is as follows:

1. Discovering Opportunities: Identify the target customers, Identify the problem that the target customers face, and discover signals that the customers are dissatisfied with the current state of things.
2. Blueprinting the Idea: Use multiple sources of inspiration to develop an idea (look at current similar designs), determine where your idea can be “good enough”, and develop a comprehensive blueprint for your idea.
3. Assess and Test Idea: Assess the potential of your idea, Identify the biggest assumptions behind realizing that potential, design experiments to address the validity of those assumptions, and draw conclusions from those experiments.

4. Move Forward: Manage resources to maximize progress and delegate tasks.

(Anthony, 2012)

The Cal Poly SAE Baja team should identify its target market and assess any needs that the market may have. At least one need should be chosen and the problem solved by a small team created by the SAE Baja Team Lead. Since this need will be innovative, the team should follow the steps outlined above, but also follow the project management process outlined in this report.

**Planning**

Once the project definition has been completed, the planning stage allows the team to plan the work that takes place during the Build stage. Since the Build stage is a series of manufacturing processes, it must be preceded by the planning stage. The planning stage consists of creating a work breakdown structure (WBS), scheduling, resource considerations, a team control system, and risk analysis (Lewis, 1991).

Typically, the planning stage starts with a work breakdown structure (WBS). The WBS breaks the work down into smaller increments or tasks, each of which can be estimated with relatively good accuracy in terms of time and budget (Lewis, 1991). The WBS simplifies the work, but it does not create a sequence of the activities (Lewis, 1991). There are multiple methods of sequencing the activities. A simple bar chart can be constructed, but it is impossible to see the interrelationships between the various tasks (Lewis, 1991). Henry Gantt developed a system of using a bar chart to schedule and report progress using a bar chart, which were subsequently called “Gantt Charts” (Lewis, 1991).

Of the literature reviewed, two major processes were considered to create a Gantt Chart, the Performance Evaluation Review Technique (PERT) and the Critical Path Method (CPM). The

PERT makes use of probabilistic methods from statistics (Lewis, 1991). The PERT method may be difficult for younger Baja members who haven't taken statistics, so it was decided that the CPM should be used. Both PERT and CPM offer a way of finding the longest path through a project. This path is called the Critical Path. However, the critical path method, when originally constructed, has idealized project flows, doesn't directly acknowledge resource constraints, and operates in a static environment where no new projects are introduced over time (Sriram and Eastman, 1994). All of these claims are true if the networks are written by hand. With the aid of modern software such as Microsoft Project, project durations are easily altered with changing flow and the network is automatically updated (Biafore, 2007). Projects and their activities can be added after the project has initially been scheduled. Also, resources can be entered, given numerical limits, and automatically leveled within available slack or by delaying the project finish date (Biafore, 2007). For these reasons, as well as the simplicity of the CPM, it will be implemented with the use of a Gantt Chart by this project during the planning phase.

While the project is in the build stage, multiple activities may take place at once. A shortcoming of the scheduling procedures covered is that they do not address the issues of resource utilization and availability (Meredith and Mantel, 1989). If these activities require the same resources and are located on the critical path, the overall project duration may be increased. A Project Manager must consider the trade-offs of resource allocation such as performance, time, and cost by comparing allocation alternatives on a cost per time basis (Meredith and Mantel, 1989).

Once designs are completed, their risks can be analyzed during the planning stage to discover whether the risks are at an acceptable level to move to the execution stage. Risk assessments vary widely from one application to the next, but the major assessment activities are: Understand the Risk, Identify the Source of Risk, Consequence Assessment, Likelihood Assessment, Risk Characterization, Communicate Uncertainty, and Documentation of the Process (Yoe, 2012). It is also important to decide upon contingency plans and what the contingency trigger will be.

**Execution**

The execution stage has many names. For Project Managers, it is the Process Control stage. It is also known as the Build stage and/or Work stage by SAE Baja. Since there are so many ways that a Project Manager can implement process control during the execution stage, it will be broken into several categories: Team Culture, Leadership, Control Process, Quality, and Inventory Control.

**Team Culture**

The proper attitude is what makes a successful project. A winning attitude is necessary to form a winning habit. Unfortunately, contrary to many claims, winning pays (Golembiewski, 2008). It brings positive publicity to the University and the potential for new resources (Golembiewski, 2008). However, winning a competition is not everything. One must keep the perspective that the point of SAE Baja is to enhance the students' education (Golembiewski, 2008). In order to win, the student engineer must consider the trade-offs that will earn the greatest amount of points in competition. However, learning must be considered a priority as well. It is outside of the scope of this project to ensure the progress of the students' learning, but simply by following the process, all students should learn something about the project management process.

**Leadership**

Based on the review of available literature, the following section gives suggestions that the team should follow for the SAE Baja leadership roles.

As a generalization, the team leader creates and communicates their vision to the team, but effective executive leadership theory considers the leader, the leader's behavior, and the situation (Taylor and Rosenbach, 1989). As such, the leader should be able to recognize and articulate the need to significantly alter the direction and operation of the project. This needs to be done in multiple ways such as align the managers to the benefit and application of this new direction (Briner et al, 1996). Resistance situations require considerable thought and subtlety to overcome seemingly natural resistance (Pinto and Trailer, 1999). A good leader can understand long term objectives, fill in short term details, and communicate those visions in ways that are compelling (Taylor and Rosenbach, 1989).

Managers positions are much more action oriented. Their responsibilities fall primarily into three separate areas. They have a responsibility to the parent organization, the project, and the members of the team (Meredith and Mantel, 1989). They must keep senior management fully informed, reduce the likelihood of risks, and make sure that the project is preserved in spite of the conflicting demands made by the stakeholders (Meredith and Mantel, 1989).

Historically, the leadership roles have not been specifically defined. It is the goal of this project not only to provide recommendations to leadership roles, but also to keep in mind that the roles are kept dynamic to adapt to new leaders' availabilities and strengths. The suggestions from the review of literature and from the IME Project Management course will be given to the SAE Baja Team and should be read at the start and finish of every competition season. During the Closeout Phase, the audit should review how well the Team Lead and manager followed these roles and make specific suggestions for the next season's Team Lead and Team Manager.

**Control Process**

It is the job of the Project Manager as well as the Sub-System Leads to monitor the plan and take corrective action if the project falls behind schedule or goes over budget. Earned value analysis (EVA) is a method of quantifying the project's process at any given time (Cullen 2012). The formulas are simple and can easily be implemented by SAE Baja and can be automatically generated by regularly updating Microsoft Project (Biafore, 2007). A detailed schedule will need to be kept in order to track the planned value of the project. Expenses need to be logged to determine the actual cost of the project as it progresses. Once a status update with the Earned Value (EV) is reported, the Schedule Variance (SV) and Cost Variance (CV) can be calculated. The Schedule Variance can be used to monitor the progress of the project and the Cost Variance can be used to track if the project is over or under budget. Finally, each sub-system should be evaluated by using performance indexes for cost and schedule which provide insight to the sub-system's cost and time efficiency, respectively. All of the above values will be calculated for the team by keeping an updated schedule of activities and resources using Microsoft Project.

**Quality**

There are fourteen steps of quality improvement (Crosby, 1984). However, only relevant steps are included in this review. Some steps have been combined to simplify the process. The steps and their application are as follows:

1. Management Commitment: Ensure that management is truly committed.
2. Measurement: The hassle of measurements is not having clear measurements. Quality must be measurable or it is nearly impossible to communicate in definite terms.
3. Cost of Quality: Tradeoffs must be discussed of the Price of Conformance and the Price of Nonconformance
4. Quality Awareness: All students must be aware of what defines quality.

5. Corrective Action: What actions are necessary for a nonconformance part?
6. Goal Setting: Set goals to work up to the ultimate zero defects goal.
7. Error-Cause Removal: Ask what problems are being encountered and how these problems can be addressed.
8. Team recognition/Zero Defect Celebration: A huge team milestone
9. Sustainability: Make sure that future teams can recreate quality control processes.

(Crosby, 1984)

Quality is often sacrificed in the name of time efficiency for SAE Baja since there is often less than ten months to design, build, and test a race vehicle in an international competition. Part quality has been a huge debate amongst the team members and a system must be in place to settle disputes. A dispute resolution process will be implemented by this project, but the quality improvement process should be implemented by the team. It is outside of the scope of this project to implement a part quality improvement process; however, quality improvement will be considered annually to improve this management process.

**Inventory Control**

One of the types of waste being reduced by this project is inventory loss. In order for the team to manage their inventory, it must first be classified. One of management's oldest and soundest techniques is the concept of the *vital few and the trivial many* developed by Pareto in the 1530's (Plossl and Welch, 1979). This management system has been adapted in a variety of ways including the ABC system (Plossl and Welch, 1979). The ABC system classifies three groups of inventory and their typical characteristics:

Table 4: ABC Inventory Example (Russell and Taylor, 2009)

| Inventory Class | Importance | % Value By Unit Cost *Demand | % by Inventory Units |
|---|---|---|---|
| A | High | 70-80 | 5-15 |
| B | Medium | 30 | 15 |
| C | Low | 5-10 | 50-60 |

These inventory classes are used to determine the frequency that these inventory units need to be checked for losses, with Class A being the most frequently checked class. Thus, 80% of the dollar loss can be found by closely monitoring 20% of the inventory (Summers, 2005). In the past, important components have been lost due to a lack of accountability. It is highly recommended that the team manager create a small team to classify everything in the Baja cage and create an inventory checklist as well as a frequency to check each inventory class.

**Test/Closeout**

A major vehicle for the evaluation of the project's successes and failures is the project audit (Meredith and Mantel, 1989). The result of an audit is a set of recommendations that might help both ongoing and future projects to:

1. Identify problems earlier
2. Clarify performance, cost, and time relationships
3. Improve project performance
4. Locate opportunity for future technological advances
5. Evaluate the quality of project management
6. Reduce costs
7. Speed the achievement of results
8. Identify mistakes, remedy them, and avoid them in the future

9. Provide information to the client
10. Reconfirm the organization's interest in an commitment to the project

(Meredith and Mantel 1989)

At this stage, testing for SAE Baja is performed to verify their design and manufacturing processes. However, the car is not yet ready for competition. Once testing has been conducted, the car goes back to the design phase for any issues discovered during testing. The final design validation is completed at competition. The competition performance information is used to perform an informal team audit. The audit is then used to create the project's problem statements for the next year's car so that the project process can be repeated. It is recommended that the audit process answer the questions outlined above to aid the next year's team.

## III. Design

### Specifications

During the conception of this project, the current Cal Poly Faculty advisor, this project's advisor, and the current team lead specified that the following qualitative criteria be met by this project's design.

1. Ease of Use: The management process should not add significant time to the current process or daily operations

2. Applicability: Each step of the process must be tailored toward SAE Baja to minimize the learning time yearly

3. Usefulness:  Future teams should see the benefit from the continuous use of this project annually.  Each step should be action-oriented by giving the user something to do, not just to read.

4. Flexibility:  This project's manager added flexibility as qualitative criteria such that each sub-system lead could use this management process for their own sub-system.

**Constraints**

Due to limited budget, the current team lead had asked that the cost of this project not exceed $100.  Furthermore, if any process experimentation needed to be considered or feedback needed, the process timeline must match the team's timeline.  For example, the project definition process created by this project must be completed for testing before the team is ready to define their projects in order for feedback to be given.

**Design Methodology**

Each problem that was observed was considered while conducting the review of literature. Before the theoretical process was introduced, each problem was categorized into larger categories and a tentative countermeasure was suggested.  Below is a summary of the problems and their countermeasures:

- Points and Objectives: A project definition template will create specific, measurable, and attainable goals for the car and each sub-system.  A performance matrix will be used to evaluate these goals based on their relative benefit during each competition event.  By placing focus on designs with the greatest return, there will be a potential for an increase points earned at competition over previous years.

- Waste: A schedule of activities and resources will ensure that all team members have the resources they need for their scheduled tasks. The schedule should decrease waste in the form of half days, rushed shipments. Lost tools will be minimized by the competition assignments. Finally, non-value added design effort should be drastically decreased by constantly considering the team and sub-system goals listed in the definition template.
- Missed Milestones: Sign-out sheets will be created for each member to log their progression. The continual use of Sign-Out Sheets to update the Schedule of Activities and Resources will eliminate missed deadlines as well as most project delays.

**Necessary Process Documentation**

It is important to note that the countermeasures listed above create a new list of deliverables which fit under "necessary process documentation" from the deliverables section in this report. There was also an increase in scope to create testing goals and log sub-system failures during testing. Below is a new, more comprehensive list of the deliverables as well as a description and outline of each.

**Table 5: Comprehensive Deliverables List**

| Deliverable | Purpose | Description |
|---|---|---|
| Project Definition Template | Provides clarity during the design process by identifying:<br>• Problem Statement<br>• Stakeholders<br>• Goals<br>• Success metrics<br>• Scope<br>• Deliverables | Each item includes:<br>• Definition (for beginning members)<br>• Specific examples applying to Baja |

| | | |
|---|---|---|
| Drafted Communication Plan | A roster of all new and continuing Cal Poly SAE Baja continuing members ensures that all members are reachable | This plan includes space for email and telephone as well as space for preferred communication methods for each member. |
| Statement of Authority | Clearly distinguishes the decision making process to avoid breakdowns in chain of command | Signature verifying agreement to this process before the start of the competition year |
| Weighted Project Priority Matrix | • Matrix to distinguish potential relative benefit of each sub-system in relation to another<br>• Allows the team lead to allocate more resources for high priority projects | Each sub-system is weighted based on their potential relative benefit based on criteria decided upon by the team lead. A summation for each system can be generated and each sub-system is ranked by importance. |
| Preliminary Design Review Slides | • Streamlines the mechanical design process and integrate the management process<br>• Presented in a public forum for design feedback | • Project definition template review<br>• Listed design alternatives<br>• Design matrix<br>• Design decision |
| Benefit/ Resource Quantification | • Quantifies benefit and resource of alternative designs or of sub-systems by calculating indices<br>• Used to aid team lead in project cuts or system lead to make design alternative decisions | Indices calculated based on:<br>• Part manufacturing times<br>• Potential benefit -from project priority or design matrix<br>• Skill level required<br>• System or design alternative cost |
| Critical Design Review Slide Template | • Streamlines the mechanical design process and integrates the management process<br>• Presented in a public forum for design feedback | • Brief review of the PDR<br>• Review of how the system and team goals were met<br>• Statement of system parameters<br>• Consideration of sub-system integration<br>• Risk analysis |
| Schedule of Activities and Resources | • Creates a list of daily project tasks<br>• Estimates project duration<br>• Calculates slack and critical path<br>• Levels and assigns resources | • Includes work breakdown structure<br>• Task Predecessors<br>• Task Duration<br>• Task Priority<br>• Resource Input |

| | | |
|---|---|---|
| Microsoft Project Walkthrough | Outlines a step-by-step process to create a usable schedule for SAE Baja | Describes how to:<br>• Set project start date and calendar<br>• Create a work breakdown structure<br>• Estimate task durations<br>• Set task predecessors<br>• Set priorities<br>• Assign and level resources<br>• Monitor schedule using sign-out sheets |
| Sign-Out Sheet/Task Log | • Filled out by each team member after work day<br>• Used by current team manager to update schedule<br>• Used by proceeding year's manager for task duration estimation | Each sheet logs:<br>• Name of worker<br>• Date<br>• Task duration<br>• Percent complete (for schedule updates)<br>• Comments |
| Team Competition Assignments | • Six unique jobs were created so that there was no job confusion during testing or at competition.<br>• A description of the jobs, volunteer sign-ups slots, and lead organizer help was included. | Jobs included:<br>• Drivers<br>• Pit crew<br>• Maintenance<br>• Spotters<br>• Organizers<br>• Lead organizer |
| Testing Goal Sheet/Incident Log | • Creates testing goals for more productive test days<br>• Logs incidents to document the problem and its countermeasure to avoid repeat mistakes | • Test Purpose/Goals<br>• Test Procedure<br>• Test Results<br>• Conclusions/Recommendations<br>• Incident Description<br>• Incident Countermeasure<br>• Future Recommendations |
| Post Season Audit Questionnaire | • Creates a log of the informal audit performed annually by the team called "the debrief meeting"<br>• Increases meeting productivity | • Members fill out a two part questionnaire before the meeting:<br>• Managerial improvement-allows for continuous improvement of the management process<br>• Problems and/or recommendations to future sub-system |
| Management Process Outline | Outlines the overall management process | • Recommends suggested timelines relative to an academic year<br>• Provides an ordered use of the deliverables from this project |

## IV. Methods

The process was put into effect during the 2012-2013 competition season and feedback was collected during the process. Each step was formalized by creating a template, example, or calculation based program such that it could be quickly and easily used by a first year member who was following the process. Each deliverable was treated as a prototype; feedback was recorded and was changed to reflect the feedback in the final process.

Each sub-system lead was asked to fill out the project definition template (Appendix B). The team lead was also asked to fill out a project definition to create vehicle goals, which would become design criteria, and team goals which were used to benefit the team yearly. Success metrics included being on time and on schedule. It was instructed that goals be specific, measurable and attainable. Typical stakeholders included all club members, SAE faculty advisors, and club sponsors. The project definition was included with the statement of authority (Appendix D) and the communications charter (Appendix C) to complete a project proposal for review by the team lead. All sub-systems were considered projects and new design proposals were not guaranteed funding until after the Critical Design Review (CDR).

Sub-system benefit potential was evaluated using the sub-system priority matrix (Appendix E) on a scale of 0→2 where 0 was no potential, 1 was some potential, and 2 was high potential. The team lead was asked to fill out this matrix using initial estimates of design criteria from the vehicle goals on the definition template. Once each sub-system was given a weighted score, it was prioritized so that resources could be delegated during the design phase. The matrix was used again in the same manner after the design phase was completed so that resources could be delegated based on the project priority and manufacturing requirements.

The Preliminary Design Review (PDR) is a review of the current or changing design for each sub-system and is presented to the SAE advisors and the SAE student members. It was asked by the current team lead to create template slides which outlined the material typically in a PDR (Appendix F). During the PDR, the sub-system creates alternatives for each major deliverable. These designs are then weighted in a design matrix so that an alternative decision can be made. It was asked of the sub-system leads to put each major deliverable design decision into one of three categories: fabricate, order, or recycle. Fabricate means that the deliverable must have raw materials ordered so that final parts can be made. An order code means that the final part will be purchased. A recycle code means that the part will be recycled from a previous year's car. Recycling often takes place on high expense items such as air shocks because the team cannot and/or does not need to buy new parts. These design codes are used by the team manager to create the detailed schedule of activities and resources. The PDR slides were created as a template for all members to follow for each major deliverable. A design decision code example was also made with all typical deliverable for each sub-system.

The benefit-resource quantification was, perhaps, the most difficult to implement. It was decided by this project's manager that the quantification serve a dual purpose. The benefit-resource indices could serve as a method of comparing sub-system deliverable alternatives or as a way for the team lead to deny proposals that didn't have enough benefit for the resources required with respect to other sub-systems. There were multiple steps in quantifying benefit and resource usage.

1. All project stakeholders were asked what qualified as a design benefit and how resource is best quantified. The following qualities were decided upon:

- Benefit
    - Performance gains
    - Service time decreases
- Resource
    - Skill level required - lower skill levels result in a lower calculated resource usage
    - Total manufacturing time required
    - Cost

It is important to note that time and cost were purposefully separated due to the fact that all work was done by unpaid volunteers.

2. Skill levels were defined by the same system as the Cal Poly Machine shop: red, yellow, and blue tag. A red tag holder was able to access grinders, sand blasters, cutting equipment, and bending/forming machines. Yellow tag holders had access to manual lathes and mills as well as a welder. However, only students who were deemed good enough to weld by the team lead counted as having the welding skill in the program. Lastly, blue tag holders had access to the CNC machines. The number of skill hours was defined as the total number of hours each student with the particular skill in question had to spend working on the project.

3. The following formulas were developed using these descriptions as a guide:

$$Service\ Index = \left(\frac{Old\ Service\ Time - New\ Service\ Time}{Old\ Service\ Time}\right)$$

$$Performance\ Index = \frac{System\ Weighted\ Score}{Total\ Weighted\ Score}$$

$$Benefit\ Index = Performance\ Index + Service\ Index$$

$$System\ Skill\ Time\ Utilization = \sum (Part\ Times * \%Skill)$$

$$Team\ Skill\ Time\ Available = \left(\frac{Number\ \ of\ People\ With\ Skill}{Total\ People\ on\ Team}\right) * Total\ Team\ Hours$$

$$Time\ Index = \sum \frac{System\ Skill\ Time\ Utilization}{Team\ Skill\ Time\ Available}$$

$$Cost\ Index = \frac{SubSystem\ Budget}{Total\ Team\ Budget}$$

$$Resource\ Index = Time\ Index + Cost\ Index$$

Formula descriptions:

- The Service Index is a percent difference in service time. It is defined as a difference between the time the old sub-system design took to service and the time the new sub-system design will take to service. Only changes were asked to be measured. If certain deliverables remained exactly the same, then service times were not used in the program.
  - Both times were recorded in minutes. Mathematically, a percent difference is unit less.
- A performance index was calculated by using the sub-system priority scores from the project priority matrix and dividing it by the total points possible. Total points possible can be calculated by multiplying all competition component points by the maximum benefit potential.
  - Since the formula divides sub-system points by total points, the result is unit less.
- The benefit index is calculated by adding the percent difference to the performance index.
  - Two unit less indices are used to calculate the benefit index. It is therefore, unit less as well.
- Sub-system skill times were calculated by estimating a manufacturing time for each deliverable, or part, and estimating the percent of that time each skill will need to be utilized for that deliverable. A summation for each deliverable skill time was calculated and was

used as a sub-system skill time. Deliverable manufacturing times were recorded in hours. When multiplied by a percent, the units for sub-system skill times are hours.

- Total team time available for each skill was estimated by multiplying the percent of people with each skill by the total team time, in hours. However, all blue tag holders are able to operate yellow and red tag machines. Yellow tag holders are able to operate red tag machines as well. In order to provide incentive for the sub-system leads, the percent of people with each skill was calculated by dividing the number of team members that could offer the skill by the total number of members on the team.
    - For example, if 50% of the team has a red tag and 50% has a yellow tag. Team red tag time was calculated by multiplying 100% by the total team time available because all members can operate red tag machines and tools. Team yellow tag time was calculated by multiplying 50% by the total team time available because red tag holders cannot operate yellow tag machines and tools. Mathematically, this makes it appear as though there are more red tag hours. This decreases the time index for red tag manufacturing and, thus, provides incentive for sub-system leads to use more red tag manufacturing processes. However, it is important to note that, for this example, when added, red tag hours and yellow tag hours would be 150% of total team hours. It is because of this phenomenon that skill hours cannot be considered a simple percent of total hours and all indices should be used for comparison purposes only.
- A time index was calculated by dividing the sub-system skill hours by the total skill hours. This creates a unit less index.
- A cost index was calculated by dividing the sub-system budget by the total team budget. This creates a unit less index.
- The time and cost index were added to calculate the resource index. All indices are unit less.

4. Once benefit and resource were quantified by these equations, two programs were considered for data entry. A program would need to accept system parameter entry from the user and calculate the indices. Both Microsoft Excel and Matlab were considered for their ease of use and familiarity. Matlab was chosen because the program could prompt the user for necessary information instead of having to search for entry points (as would be necessary in Excel).

5. An algorithm was created in Matlab (Appendix K). The algorithm prompted the user for information which was to be used in the formulas listed above. The algorithm was created in consideration of human error and allowed users to edit mistyped information before moving to the next step. It also summarized their sub-system parameters in a chart for review before displaying their benefit and resource indices.

6. The algorithm was then used to calculate extreme cases for benefit and resource. Each index was recorded and a weight was created by this project's manager to ensure that, even in extreme cases, no single index would exceed a value of one. This was done to avoid the influence of naturally stronger weights of certain index calculations.

7. A slideshow presentation was created to introduce the concept of benefit-resource quantification to the team which included design tips for lowering resource usage and increasing benefit. (Appendix N)

8. A guide was made to teach students how to properly use the program. (Appendix M)

The Critical Design Review (CDR) is presented in a similar fashion as the Preliminary Design Review. However, sub-system designs were to be finalized by this point. Both the management process and mechanical design process were fully integrated into this step, as this was the completion of the planning stage from the management process (Appendix J). A slideshow was created so that the integrated steps would be followed and presented. The steps were as follows:

1. The students were instructed to briefly review the PDR.
2. The synthesis step was presented as sub-system integration. Integration was the means by which the presenting sub-system interacted with other sub-systems.
3. Analysis and optimization was presented by stating all relevant sub-system parameters as well as the methods used to obtain them.
4. An evaluation step described how the new design met all team and sub-system goals from the project definition sheet.
5. The management process was also included by having each sub-system fill out a risk analysis template and presenting a breakdown of their budget.

Once all deliverables had design decisions made, the project manager for this project worked jointly with the team manager, team lead, and sub-system leads to create a work breakdown structure, identify task predecessors, estimate the task durations, and assign resources and priority values for each task. During the build phase, this schedule was to be followed and updated by the sign-out sheets (Appendix P) once weekly by the team manager so that machines could be reserved for use and materials were delivered by their intended use date.

Once the build stage was completed, the car could be tested to validate the success of the design and manufacturing processes. During testing, it was unclear what the purpose of each day was. If there was a purpose, the testing method was unclear. Finally, if there was a system failure, there was no log of the incident or how to avoid it in the future. A testing and incident log was created so that all events of a testing day could be recorded (Appendix Q).

After testing the team would go to competition. One at competition, team members were not sure of the jobs they were to be performing at competition. As such, team members would switch between multiple jobs based on the current needs of the team. During crucial times at competition, team members would have a discussion about who was able to perform the tasks needed, wasting valuable time and creating added stress for the team lead. The team competition assignments were created as a means of preventing idle time as well as to reduce the quantity of lost tools and materials (Appendix R).

Once competition was over, the team lead would hold a post-season "debrief" meeting. Team members would talk about things that they would improve in the following years over the previous year. The team manager typically takes notes about the improvements and some of them would be considered the following year. There was no obvious direction of the meeting and important points would often get missed. A post-season questionnaire was created to audit the team members and increase the efficiency of these meetings (Appendix S). There were two parts to the questionnaire. The first part asked for specific improvements to the SAE officers as well as the team and sub-system leads. This part was meant to be anonymous and it was instructed that comments be limited to a problem statement and a suggested countermeasure. It was important that the team members did not use this as an opportunity to tear down other team members so a note was added to that effect. The second part was used to obtain information for the sub-system so that future sub-system designers could read about suggested improvements in the definition and design process. It was also built into the questionnaire that this management process is considered and recommendations be given to improve the process. This was done so that continuous improvement could be built into the process to maximize sustainability.

Finally, an outline of the overall process will be created with similar information as this section. It has an 11 step process to manage the team throughout the competition season and provides typical completion times for each step. This process will be located in a binder which houses a new team lead flash drive as well as all necessary process documentation. The management process outline paper will outline the final design with all suggested changes implemented (Appendix A).

## V. Results and Discussion

Once an initial process had been created, the following feedback was given during the testing process:

**Table 6: Deliverable Feedback**

| Deliverable | Feedback | Implemented Change |
|---|---|---|
| Project Definition Template | • Space for date<br>• Define statement of work<br>• Include SAE rules and Cal Poly charter<br>• Allow for more space for goals<br>• Define stakeholders<br>• Too much detail on goal specificity example<br>• Success Metrics= Measurements | • Space for date added<br>• Statement of work defined and applied to Baja<br>• A URL was provided for the SAE rules and it was instructed that the rules and charter must be followed<br>• Added space for goals<br>• Stakeholders defined and examples given<br>• Goal specificity example made more simple<br>• Metrics explained as measurements |
| Drafted Communication Plan | No specific feedback | |
| Statement of Authority | No specific feedback | |
| Weighted Project Priority Matrix | • Change design criteria to competition components to shift thought process and increase competition points<br>• More resolution on the potential scale | • Design criteria was changed to competition components with their score as the weight<br>• A potential scale of 0-5 was used for added flexibility |
| Preliminary Design Review Slides | • No specific feedback given | |

| | | |
|---|---|---|
| Benefit/ Resource Quantification | • Decrease technicality of slideshow presentation<br>• Change input order so % Weld time wasn't confused with % Yellow tag time<br>• A list of things should be printed at program start that the user needs to input<br>• Explain service times to be considered<br>• Part name entry for review<br>• Infinite loop issue<br>• Part review table out of alignment | • The slideshow was introduced as "Best Bang for the Buck". Examples were given of high/ low benefit and resource as well as a theoretical graph for how the indices will be used<br>• Input reordered<br>• Instructions added to beginning of program<br>• Service times explanation added to instructions<br>• The program took input for part names that were displayed when part information was reviewed<br>• Program simplified, infinite loop fixed<br>• Table review changed to list review<br>• "How to Use Benefit and Resource Program" walkthrough was created |
| Critical Design Review Slide Template | • Add a budget considerations slide | • A budget slide was added. It was asked that the sub-system lead consider major deliverables as well as fluids, hardware, etc. |
| Schedule of Activities and Resources | • Create a Microsoft Project Walkthrough paper to teach new managers how to use program<br>• Add task priority | • Paper created<br>• Priorities added |
| Microsoft Project Walkthrough | No feedback given | |
| Sign-Out Sheet/ Task Log | • Ask for set-up time<br>• Ask for tools used<br>• Add description and examples of the types of comments needed for each task<br>• Faster information entry | • Set-up time ranges included in check box for fast entry<br>• Typical tools used included in check box for fast entry<br>• Descriptions and examples added |
| Team Competition Assignments | • Add strapping down the driver to Pit Crew job description | • Job description modified |

| | | |
|---|---|---|
| Testing Goal Sheet/Incident Log | • Add descriptions for each section and how they pertain to Baja | • Descriptions added |
| Post Season Audit Questionnaire | • Ask about the most important thing the team member learned from this year's competition<br>• Ask about specific changes for next year's designs | • Questions added |
| Management Process Outline | • Add Table of Contents<br>• Ease folder navigation | • Table of Contents added<br>• Tabs added for each process document |

The 2012-2013 competition season was the first to test this management process. The competition will not occur until after the completion of this project so specific competition results could not be acquired such as competition organization and point scores. However, a competition score estimation that was made by the current team lead states an expected point score of 800 points. This is a 54.7% increase from the previous year's score of 517.15. In addition to a potential increase in score, the team had a running car that met the Go/No Go criteria two full weeks before the scheduled date. It was also reported that the team was registered for competition on time, there had be no rushed shipments, the cost report was submitted on time, and the design report was underway to be finished and submitted on time. Cost report was down from a vehicle total of $16,500 to $15,000.

Since missed submission dates and low competition scores were problems which this project set to solve, these results were expected. This process design encompasses all major process steps and adds steps where necessary; however there is still significant bias in the mechanical design process. Specific ways to reduce bias will be discussed further in the recommendations section of this report. This project cost significantly less than the maximum $100 limit set by the current team lead at a final cost of $87.05. This was 87% of the budget set by the team lead, but 23% over the original budget estimation.

## VI. Conclusions and Recommendations

Poor project organization manifested through unclear team goals, rush deliveries of materials, lost tools and materials, half days of effort, wasted design time, missed submission dates, and a lack of clear job positions at competition. Ultimately, wasted effort, wasted funds, and low competition score resulted from this lack of organization. A process was created to properly manage the team and it was implemented through the use of various templates, examples, and the Benefit and Resource Quantification. Each deliverable received feedback from this project's stakeholders and changes were reflected in the final process.

The most important result from this project is that the Cal Poly SAE Baja team saw a benefit from a more organized project management process. A follow-up project should be scheduled such that the project finish date is after the competition season so that more specific results can be reviewed and feedback on the overall process is given to adjust the final process.

At the conclusion of this project, many recommendations should be considered by future team leads for implementation:

1. The team should consider a method of quantifying the benefit of a sub-system which does not include the bias of the team lead such as in the Project Priority Matrix. A lap performance simulator, competition points estimator, or similar tool would allow for a less biased quantification of design value with less dependence on the team lead's judgment.
2. A new Microsoft Project walkthrough should be created every year which a new version comes out.
3. A minimum of one project which follows the innovation process outlined in the Literature Review section should be considered yearly.

4. An inventory control system such as the one in Literature Review section should be created.
5. A part quality control method such as the one in Literature Review section should be created.
6. Should the team find that the budget section in the critical design review and detailed schedule of activities and resources are not adequate, a bill of materials and ordering schedule should be created.
7. The team lead and team manager follow the roles discussed in the Literature Review section.

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## Appendix A. Start Here: Management Process Outline

Before the competition season begins, read all post season debrief questionnaires from the previous season. Consider the innovation process in the Literature Review section of the "Sustainable Project Management Process for Cal Poly SAE Baja" senior project written by Theo Graziadei. Please fill out all templates on NEW printouts. DO NOT write on the templates printed in this folder, they are for reference purposes only. Quotes refer to files on the team lead flash drive under "Project Management Process". The team lead flash drive should be tethered to the front flap of this binder.

**Project Proposal** - First two weeks of fall quarter

1. "Project Definition" Template:
    - Fill out a project definition template for overall team goals
    - Have each sub-system lead fill out a project definition template. If you are a sub-system lead, then you must fill another one out for your sub-system as well.
    - Make sure that all components are included in the deliverables section. (i.e. it must be defined who will produce a rotor carrier - brakes or drivetrain). **Don't let major deliverables go through design unaccounted for.**
2. "Communications Charter": After a few weeks, you should know who will be staying with Baja.
    - Read the instructions during a team meeting and pass out the roster for everyone to fill out.
    - Update the Google Group and email the final copy to everyone on the team.
3. "Statement of Authority" (Conflict Resolution):

- Print as many copies as there are members on the communication plan
- Read the instructions during a team meeting and have each member sign a sheet
- Collect the sheets and store for review in the event of future disputes

4. "Sub-System Priority Matrix" Template:
    - Read the instructions and follow
        - Use the "Project Definition" sheet for each sub-system

**Plan and Design** - Complete by the end of fall quarter.

- Have your team manager order a new engine, if necessary.
- Apply for a Polaris sponsorship. You do not need an order list to apply for a sponsorship
    - http://www.polarissuppliers.com/sae_team/Polaris_SAE_Sponsorship.htm
- Have your team manager register for the competition.

5. "Preliminary Design Review (PDR) Template Slides" - Present before week 4 of Fall quarter
    - Have each sub-system lead follow the slides during the design process
    - Optional: View process for using benefit/resource quantification algorithm for deliverable alternatives
6. Detailed Schedule of Activities and Resources - Follow "Microsoft Project Walkthrough"
    - Ask each team lead to use the design decisions from the PDR to create a deliverables sheet with action codes. Use the "Deliverable Design Decisions 2012" as a guide
    - Look at the "2012 Baja Schedule" to view an example of the detail necessary for a schedule (using Microsoft Project on campus).
    - Have your team manager begin making a schedule (see "Microsoft Project Walkthrough")

- Work with your team manager to enter priorities for each task. Consider the Go/No Go date.

7. "Critical Design Review (CDR) Template Slides" – Present before week 10 of Fall quarter
   - Review and present the Benefit/ Resource Index slides at a team or sub-system meeting
   - Have each sub-system lead follow the CDR slides during the design process-send out CDR slides and "Risk Analysis" template to each sub-system lead.
   - Re-evaluate each sub-system's priority based on their final estimates of the goals from their "Project Definition" template. Use the "Sub-System Priority Matrix".
   - Have each sub-system lead evaluate their project using the "br_index" program
     - Read "How to Use the Benefit and Resource Program"
   - In the event of limited budget, cut new sub-system designs that have lower benefits and/or higher resource utilizations than other sub-systems

- If there will be any frame building over Winter Break, order frame material after CDR.
- BEGIN WORKING ON DESIGN AND COST REPORT ASAP!!! YOU WILL REGRET IT IF YOU PUT IT OFF!!! HAVE THE SUB-SYSTEM LEADS HELP!!!

**Build** – Should be completed AT LEAST one month before the Baja car leaves for competition. Check Go/ No Go date with SAE officers.

8. Have each team member fill out the "Sign-Out Sheet(s)" every day after work
   - Have your team manager update the schedule weekly using the "Sign-Out Sheet(s)"

- Use the updated schedule to make sure that each sub-system is on schedule for manufacturing, ordering, and assembling. Use this information during each weekly team meeting.

**<u>Test and Closeout</u>** – After Go/ No Go date

- Have your team manager begin looking for hotels for competition travel.

9. "Test Preparation and Incident Log" – Complete before testing
    - Before each drive/ testing day, have a sub-system lead fill out the test preparation sheet
    - Print and bring the test preparation sheet to each drive/ testing day
    - In the event of a sub-system failure, log the results using the incident log. Take pictures.
    - A number of the incident logs should be printed and filled out during competition in the event of an incident
10. "Team Assignments at Competition" – Before leaving for competition
    - Print the "Team Assignments at Competition" and read each job description out loud at a team meeting.
    - Ask for volunteers for each position.  Make sure each position is accounted for.
    - E-mail the completed form so each member has a description of their roles at competition.
    - Run through the entire SAE rule book and make sure that the car passes all rules.

- Print and bring each sub-system’s “Risk Analysis” template from the CDR.
- Print and bring each sub-system’s “Project Definition” template. These templates will be used when filling out the “Post Season Debrief Questions”.
- Print and bring all necessary car documentation (bolt equivalencies, frame material receipts, etc.)
- Make sure the manager has secured hotel rooms.

11. “Post Season Debrief Questions” – Night after competition (endurance race)
    - Before the debrief meeting, have each member fill out the post season debrief questions
    - The first part of the questions are meant to be anonymous
    - The second part of the questions are to be used for improvements by future sub-system designers
    - Review the questionnaire during the meeting
    - Allow team members to keep their questionnaire until after the meeting to make any edits during the meeting

## Appendix B. Step 1: Project Definitions

School Year:

Sub-System Name:

Project Classification (circle one): Compliance/ Emergency (must be done to meet rules)

Strategic (meant to meet team goals)

Stakeholders: List any *person(s)* who will influence project in any way. (ex: Baja team, Baja team lead, SAE advisors, SAE officers, sponsors, etc.)

Purpose: Gap between where you are and where you want to be. This gap must be confronted with obstacles that make closing the gap difficult. Purpose should answer why are we doing this project? (Typically a negative statement)

Statement of Work: Contract between you and SAE Baja. Once the statement of work is formally agreed upon, it becomes the requirements that your sub-system must meet.

**Rules:**

All projects must meet or exceed the current year's rules as stated by SAE Baja international. http://students.sae.org/competitions/bajasae/rules/

All Projects must adhere to the Cal Poly SAE constitution.

(list more here)

**Goals:** Should be based on the purpose statement. Be specific (ex: "serviceability" should be written as "increase serviceability of brake assembly and drivetrain"). Make sure the goals are measurable (ex: service time should be decreased by 10%). Don't set unrealistic goals. Don't set goals that aren't challenging, either. Include all team goals (ex: if the team goals are to reduce weight by 30 lbs, include how many of those pounds your system will lose)

**Constraints:** Time (Estimate Min/Max duration of Project)

Budget (Estimate Max Budget of Project)

(add more here)

**Success Metrics:** How do you measure success of the project? Included are common metrics for every project. Success metrics must be measurable/ quantifiable.

On Time
On Budget
High Quality
No damage (to people socially or physically)

(add more here)

Scope: Puts clear boundaries on project while taking into account the stakeholder's expectations. Describes major activities and defines project's place in relationship to other projects. Should answer what this project will and will *not* do.

Deliverables: What major components are the project supposed to produce? (ex: suspension must deliver A-arms, air shocks, uprights, etc.)

## Appendix C. Step 2: Communications Charter

Instructions:

All members should be contacted first using their preferred primary contact method. This method will be determined by the member as the best way to contact them. If the primary method of contact is deemed ineffective, a team member withholds the right to use any other method of contact, however the current team lead is solely responsible for changing the primary contact method.

For multiple phone numbers and email addresses, please write the one that you are most likely to see the soonest. Please select *one* primary communication method. (I.e. If you are less likely to read an email or answer a phone call than respond to a text, check the text box.) Only check one box. The direct email option is to receive an email directly from the recipient, whereas the group email option will come from the recipient through calpolybaja@googlegroups.com and all members will be able to view the message. Please choose the option which you are most likely to see the soonest.

Note: The primary method will only be for contacting you on specific issues regarding you. All general announcements will still be done over the Google Group.

By putting your information into the communications charter, you agree to the communications charter.

| Name | Email Address | Direct | Group | Phone Number | Text | Call |
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## Appendix D. Step 3: Statement of Authority

(Dispute Resolution and Chain of Command)

All undisputed decisions will be decided upon by the current team lead, ___________. In the team lead's absence and interruption of the communication charter, all decisions are to be made by the acting team manager, ___________. Decisions in dispute will be voted upon and chosen based upon a majority vote by the team. Only returning second year members and members with multiple years on the team will get a vote. In the event that a dispute arises which requires a vote, all voting members must be given at least three hours' notice to cast their vote, either in writing or verbally. These members should be contacted as stated in the communications charter. All members are allowed to state an argument relevant to the decision in dispute, but only multiple-year members may propose a vote. All members who may have important information regarding the decision must be sought out to state their argument. All disputed decisions which do not adhere to these guidelines will be null and void.

I have read and agree to the above dispute resolution statement.

______________________________________

Print Name

_____________________________________________________

Sign Name Date

## Appendix E. Step 4: Sub-System Priority Matrix

**<u>Read Instructions Carefully Before Evaluating Matrix</u>**

**Instructions:**

1. **Project Definition**: Consider all non-compliance/emergency sub-systems. A safety sub-system is a compliance sub-system because it must be done. It should be your first priority and does not need to be evaluated in this matrix. Base the potential benefit upon goals from "Project Definition" template.
   - » *<u>Goals must be specific, measurable, and attainable</u>*
2. **Evaluate Potential**: Evaluate the potential benefit that the sub-system being considered will have, relative to the other sub-systems, in aiding the competition component being considered (see the proceeding matrix)
   - » Values assigned are an arbitrary scale of 0-5, where a value of zero means zero potential and a value of five mean high potential
3. **Record:** Multiply Potential Score by Competition Component Weight and record under weighted score
4. **Total:** Add up and record the Total Weighted Score for each sub-system.
5. **Prioritize:** Evaluate the Priority of the project based on its total weighted score. (1-7)
6. **Assign:** Assign more people to sub-systems with a higher priority, greater design difficulty, and/or greater manufacturing complexity

**Notes:**

- o Extra spaces may be included or required based on the number of sub-systems and competition components considered.
- o It is possible to have sub-systems of equal priority.
- o Projects that will benefit design report/presentation, cost, or other non-dynamic components of competition should be considered

| | | | Frame | Suspension | Drive Train | Brakes | Steering | Panels |
|---|---|---|---|---|---|---|---|---|
| **Competition Component** | **Weight** | **Subsystem Benefit Potential** | Weighted Score | Weighted Score | Weighted Score | Weighted Score | Weighted Score | Weighted Score |
| Endurance | (400pts) | No→Hi Potential (0-5) | | | | | | |
| Design Report | (150pts) | No→Hi Potential (0-5) | | | | | | |
| Cost | (100pts) | No→Hi Potential (0-5) | | | | | | |
| Maneuverability | (75pts) | No→Hi Potential (0-5) | | | | | | |
| Acceleration | (75pts) | No→Hi Potential (0-5) | | | | | | |
| Hill Climb | (75pts) | No→Hi Potential (0-5) | | | | | | |
| Acceleration | (75pts) | No→Hi Potential (0-5) | | | | | | |
| Rock Crawl | (75pts) | No→Hi Potential (0-5) | | | | | | |
| Sales Presentation | (75pts) | No→Hi Potential (0-5) | | | | | | |
| Design Presentation | (50pts) | No→Hi Potential (0-5) | | | | | | |
| Total Weighted Score | | | | | | | | |
| Priority | | | | | | | | |

## Appendix F. Step 5: PDR Template Slides Outline

- Write your sub-system name, and the names of the members here.

Purpose/Problem Statement

- State the purpose and or problem of your sub-system as from your project definition sheet
    - i.e. The Problem is that the radio box is not water proof
    - The Purpose of my Project is to design a waterproof box

Goals

- Restate your goals on your Project Definition sheet
    - Goals must be specific, measurable, and attainable
    - Your goals may become your functional criteria (see design matrix slide)
- i.e.
    - Weight: <1 pound w/o radio and wires.
    - Completely waterproof to incident water (not at depth)
    - Cost: <$10

Deliverables

- Restate the major deliverables from your project definition sheet
- Deliverables should include all components on in your system
    - i.e.
        - one box fitted to radio
        - One reseal able cap
        - One Frame mount

Design Alternatives

- State all design alternatives considered to fulfill your functional criteria
    - i.e. Box Materials
        - Poly Carbonate
        - 1018 Steel
        - 6061 Aluminum
    - Water Proofing
        - groove and gasket
        - Threaded cap
        - glue

DESIGN/DECISION MATRIX

- You must include a weighted design/decision matrix to choose between the design alternatives
    - List alternatives
    - Include Functional criteria
        - Can be based off of goals: i.e. weight and effectiveness
    - Include Functional criteria weights
    - Evaluate alternatives based on criteria and fill in your matrix
- If you do not know how to create a decision matrix, ask your current team lead
- You may need more than one decision matrix for more than one deliverable

Design Choice

- Based on the decision matrix, choose the design alternative with the highest weighted score
    - You may also use the benefit and resource program to analyze the alternatives further
        - Ask your team lead for details

## Appendix G. Step 6: 2012 Baja Schedule

| Task Name | Duration | Start | Finish | Predecessors | Resource Names | Priority |
|---|---|---|---|---|---|---|
| **Baja** | **201.88 days?** | **Tue 9/18/12** | **Sat 5/11/13** | | | **500** |
| **Design** | **59.5 days** | **Tue 9/18/12** | **Thu 12/6/12** | | | **500** |
| **Frame** | **17.85 days** | **Tue 9/18/12** | **Thu 10/11/12** | | | **500** |
| Project Definition | 2.55 days | Tue 9/18/12 | Thu 9/20/12 | | | 500 |
| Project Alternatives | 2.55 days | Thu 9/20/12 | Sat 9/22/12 | 12 | | 500 |
| Alternative Decision | 2.55 days | Sat 9/22/12 | Thu 9/27/12 | 13 | | 500 |
| PDR Slides | 2.55 days | Thu 9/27/12 | Sat 9/29/12 | 14 | | 500 |
| Project Details/ Final Design | 2.55 days | Sat 9/29/12 | Thu 10/4/12 | 15 | | 500 |
| Risk Analysis | 2.55 days | Thu 10/4/12 | Sat 10/6/12 | 16 | | 500 |
| CDR Slides | 2.55 days | Sat 10/6/12 | Thu 10/11/12 | 17 | | 500 |
| **Suspension** | **17.85 days** | **Thu 9/20/12** | **Sat 10/13/12** | | | **500** |
| Project Definition | 2.55 days | Thu 9/20/12 | Sat 9/22/12 | | | 500 |
| Project Alternatives | 2.55 days | Tue 9/25/12 | Thu 9/27/12 | 4 | | 500 |
| Alternative Decision | 2.55 days | Thu 9/27/12 | Sat 9/29/12 | 5 | | 500 |
| PDR Slides | 2.55 days | Sat 9/29/12 | Thu 10/4/12 | 6 | | 500 |
| Project Details/ Final Design | 2.55 days | Thu 10/4/12 | Sat 10/6/12 | 7 | | 500 |
| Risk Analysis | 2.55 days | Sat 10/6/12 | Thu 10/11/12 | 8 | | 500 |
| CDR Slides | 2.55 days | Thu 10/11/12 | Sat 10/13/12 | 9 | | 500 |
| **Brakes** | **59.5 days** | **Tue 9/18/12** | **Thu 12/6/12** | | | **500** |

| | | | | | | |
|---|---|---|---|---|---|---|
| Project Definition | 8.5 days | Tue 9/18/12 | Thu 9/27/12 | | | 500 |
| Project Alternatives | 8.5 days | Thu 9/27/12 | Tue 10/9/12 | 20 | | 500 |
| Alternative Decision | 8.5 days | Tue 10/9/12 | Sat 10/20/12 | 21 | | 500 |
| PDR Slides | 8.5 days | Sat 10/20/12 | Thu 11/1/12 | 22 | | 500 |
| Project Details/ Final Design | 8.5 days | Thu 11/1/12 | Tue 11/13/12 | 23 | | 500 |
| Risk Analysis | 8.5 days | Tue 11/13/12 | Sat 11/24/12 | 24 | | 500 |
| CDR Slides | 8.5 days | Sat 11/24/12 | Thu 12/6/12 | 25 | | 500 |
| **Drivetrain** | **59.5 days** | **Tue 9/18/12** | **Thu 12/6/12** | | | **500** |
| Project Definition | 8.5 days | Tue 9/18/12 | Thu 9/27/12 | | | 500 |
| Project Alternatives | 8.5 days | Thu 9/27/12 | Tue 10/9/12 | 28 | | 500 |
| Alternative Decision | 8.5 days | Tue 10/9/12 | Sat 10/20/12 | 29 | | 500 |
| PDR Slides | 8.5 days | Sat 10/20/12 | Thu 11/1/12 | 30 | | 500 |
| Project Details/ Final Design | 8.5 days | Thu 11/1/12 | Tue 11/13/12 | 31 | | 500 |
| Risk Analysis | 8.5 days | Tue 11/13/12 | Sat 11/24/12 | 32 | | 500 |
| CDR Slides | 8.5 days | Sat 11/24/12 | Thu 12/6/12 | 33 | | 500 |
| **Steering** | **59.5 days** | **Tue 9/18/12** | **Thu 12/6/12** | | | **500** |
| Project Definition | 8.5 days | Tue 9/18/12 | Thu 9/27/12 | | | 500 |
| Project Alternatives | 8.5 days | Thu 9/27/12 | Tue 10/9/12 | 36 | | 500 |
| Alternative Decision | 8.5 days | Tue 10/9/12 | Sat 10/20/12 | 37 | | 500 |
| PDR Slides | 8.5 days | Sat 10/20/12 | Thu 11/1/12 | 38 | | 500 |
| Project Details/ Final Design | 8.5 days | Thu 11/1/12 | Tue 11/13/12 | 39 | | 500 |
| Risk Analysis | 8.5 days | Tue | Sat | 40 | | 500 |

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|---|---|---|---|---|---|---|
| | | 11/13/12 | 11/24/12 | | | |
| CDR Slides | 8.5 days | Sat 11/24/12 | Thu 12/6/12 | 41 | | 500 |
| **Safety** | **59.5 days** | **Tue 9/18/12** | **Thu 12/6/12** | | | **500** |
| Project Definition | 8.5 days | Tue 9/18/12 | Thu 9/27/12 | | | 500 |
| Project Alternatives | 8.5 days | Thu 9/27/12 | Tue 10/9/12 | 44 | | 500 |
| Alternative Decision | 8.5 days | Tue 10/9/12 | Sat 10/20/12 | 45 | | 500 |
| PDR Slides | 8.5 days | Sat 10/20/12 | Thu 11/1/12 | 46 | | 500 |
| Project Details/ Final Design | 8.5 days | Thu 11/1/12 | Tue 11/13/12 | 47 | | 500 |
| Risk Analysis | 8.5 days | Tue 11/13/12 | Sat 11/24/12 | 48 | | 500 |
| CDR Slides | 8.5 days | Sat 11/24/12 | Thu 12/6/12 | 49 | | 500 |
| **Panels** | **59.5 days** | **Tue 9/18/12** | **Thu 12/6/12** | | | **500** |
| Project Definition | 8.5 days | Tue 9/18/12 | Thu 9/27/12 | | | 500 |
| Project Alternatives | 8.5 days | Thu 9/27/12 | Tue 10/9/12 | 52 | | 500 |
| Alternative Decision | 8.5 days | Tue 10/9/12 | Sat 10/20/12 | 53 | | 500 |
| PDR Slides | 8.5 days | Sat 10/20/12 | Thu 11/1/12 | 54 | | 500 |
| Project Details/ Final Design | 8.5 days | Thu 11/1/12 | Tue 11/13/12 | 55 | | 500 |
| Risk Analysis | 8.5 days | Tue 11/13/12 | Sat 11/24/12 | 56 | | 500 |
| CDR Slides | 8.5 days | Sat 11/24/12 | Thu 12/6/12 | 57 | | 500 |
| **Manufacturing** | **199.88 days?** | **Tue 9/18/12** | **Thu 5/9/13** | | | **500** |
| **Frame** | **56.65 days** | **Thu 10/11/12** | **Tue 12/18/12** | **11** | | **500** |
| Firewall Tubes-DONE | 2 days | Thu 10/11/12 | Sat 10/13/12 | | | 500 |
| Rear Floor Tubes-DONE | 0.5 days | Sat 10/13/12 | Sat 10/13/12 | 106 | | 500 |

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|---|---|---|---|---|---|---|
| Rear Triangulation Tubes-DONE | 0.5 days | Sat 10/13/12 | Sat 10/13/12 | 106 | | 500 |
| Fore-Aft Bracing Tubes-DONE | 0.5 days | Sat 10/13/12 | Tue 10/16/12 | 113 | | 500 |
| Gearbox Tubes-DONE | 0.5 days | Sat 10/13/12 | Tue 10/16/12 | 112,113 | | 500 |
| Engine Tubes-DONE | 0.5 days | Sat 10/13/12 | Tue 10/16/12 | 112 | | 500 |
| Rear Suspension/Bumper Tubes-DONE | 0.5 days | Tue 10/16/12 | Tue 10/16/12 | 115 | | 500 |
| Frontal Floor Tubes-DONE | 0.5 days | Mon 12/10/12 | Mon 12/10/12 | 63,106 | | 500 |
| Steering Mount Tubes | 0.5 days | Mon 12/10/12 | Mon 12/10/12 | 107 | | 500 |
| Seat Mount Tube-DONE | 0.5 days | Mon 12/10/12 | Mon 12/10/12 | 107 | | 500 |
| Anti-Submarine Tube | 0.5 days | Mon 12/10/12 | Mon 12/10/12 | 120 | | 500 |
| Nose Section Tubes-DONE | 1.5 days | Mon 12/10/12 | Tue 12/11/12 | 107 | | 500 |
| Pedal Mount Tube | 0.5 days | Tue 12/11/12 | Tue 12/11/12 | 108 | | 500 |
| Front Suspension Tubes-DONE | 1.5 days | Tue 12/11/12 | Wed 12/12/12 | 108 | | 500 |
| Front Down Tubes-DONE | 2 days | Wed 12/12/12 | Thu 12/13/12 | 109 | | 500 |
| Side Impact Tubes-DONE | 0.5 days | Thu 12/13/12 | Thu 12/13/12 | 110 | | 500 |
| Suspension Tabs | 7 days | Fri 12/14/12 | Tue 12/18/12 | 111,116 | | 500 |
| **Administrative** | **145.25 days?** | **Tue 9/18/12** | **Fri 3/1/13** | | | **500** |
| Order Bolts drilledheadbolts.com | 1 day? | Tue 9/18/12 | Tue 9/18/12 | | Delivery Services | 500 |
| Order Brake Fittings and Line | 2 days | Tue 9/18/12 | Wed 9/19/12 | | Delivery Services | 500 |
| Order Bulk Aluminum speedymetals.com | 7 days | Tue 9/18/12 | Tue 9/25/12 | | Delivery Services | 500 |
| Order Bearings, Rod Ends, Snap Rings | 7 days | Tue 9/18/12 | Tue 9/25/12 | | Delivery Services | 500 |
| Get Polaris Sponsorship | 30 days | Tue 9/18/12 | Mon 10/22/12 | | Delivery Services | 500 |
| Order Polaris Parts | 30 days | Tue | Mon | 68 | Delivery | 500 |

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|---|---|---|---|---|---|---|
| | | 10/23/12 | 11/26/12 | | Services | |
| Order Frame Material | 7 days | Sat 12/1/12 | Sat 12/8/12 | 11 | Delivery Services | 500 |
| Competition Registration | 1 day | Mon 12/17/12 | Mon 12/17/12 | | Eric Hamilton | 500 |
| Order System Material Onlinemetals.com | 14 days | Thu 12/20/12 | Fri 1/4/13 | | Delivery Services | 500 |
| Order Engine | 102 days | Tue 9/18/12 | Mon 1/14/13 | | Delivery Services | 500 |
| Cost Report | 14 days | Tue 2/12/13 | Fri 3/1/13 | | | 500 |
| **Steering** | **86.75 days** | **Fri 12/7/12** | **Sun 3/3/13** | **42** | | **500** |
| O) Steering Column-DONE | 7 days | Fri 12/7/12 | Fri 12/14/12 | | Delivery Services | 500 |
| Lower Trunion Block-DONE | 2 days | Fri 1/4/13 | Sat 1/5/13 | 64 | Mill,Ryan Slein | 500 |
| Upper Trunion Blocks-DONE | 1.5 days | Fri 1/4/13 | Sun 1/6/13 | 64 | Mill,Ryan Slein | 500 |
| Clean Rack and Pinion | 0.5 days | Sat 2/2/13 | Sat 2/2/13 | | Random Noob | 900 |
| **Steering Links** | **35.38 days** | **Fri 1/4/13** | **Sat 2/16/13** | | | **500** |
| Cut Steering Links-DONE | 0.25 days | Fri 1/4/13 | Fri 1/4/13 | 64 | Horizontal Bandsaw,Random Noob | 500 |
| Face and Chamfer Ends of Steering Links | 0.25 days | Fri 1/4/13 | Fri 1/4/13 | 174 | Lathe,Random Noob | 500 |
| Drill Holes - Steering Links | 0.5 days | Sat 1/5/13 | Sat 1/5/13 | 176 | Lathe,Random Noob | 500 |
| Tap Holes - Steering Links | 0.25 days | Sat 1/5/13 | Sat 1/5/13 | 177 | Lathe,Random Noob | 500 |
| Mill Steering Link Flats | 0.5 days | Sun 1/6/13 | Sun 1/6/13 | 178 | Mill,Random Noob | 500 |
| Assemble Rod Ends | 0.5 days | Sat 2/16/13 | Sat 2/16/13 | | Random Noob | 500 |
| Steering Stops | 0.5 days | Sun 3/3/13 | Sun 3/3/13 | | Horizontal Bandsaw,Random Noob | 950 |
| **Suspension** | **139.82 days** | **Sat 10/13/12** | **Thu 3/21/13** | **10** | | **500** |
| **Front Arms** | **113.33 days** | **Sat 10/13/12** | **Thu 2/14/13** | | | **500** |

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|---|---|---|---|---|---|---|
| **Rear Links** | **4.85 days** | **Fri 1/4/13** | **Mon 1/7/13** | | | **500** |
| Cut Rear Links-DONE | 0.4 days | Fri 1/4/13 | Fri 1/4/13 | 64 | Horizontal Bandsaw,Random Noob | 500 |
| Face and Chamfer Ends of Rear Links-DONE | 0.4 days | Fri 1/4/13 | Sat 1/5/13 | 99 | Lathe,Random Noob | 500 |
| Drill Holes into Rear Links-DONE | 0.4 days | Sat 1/5/13 | Sat 1/5/13 | 101 | Lathe,Random Noob | 500 |
| Tap Rear Link Holes-DONE | 0.4 days | Sat 1/5/13 | Sat 1/5/13 | 102 | Lathe,Random Noob | 500 |
| Assemble Rod Ends | 0.4 days | Sat 1/5/13 | Sat 1/5/13 | 103,66 | Random Noob | 500 |
| Mill Flats - Rear Links-DONE | 3.25 days | Sat 1/5/13 | Mon 1/7/13 | 103 | Mill,Random Noob | 500 |
| **Lower A Arms** | **91.8 days** | **Sat 10/13/12** | **Thu 1/17/13** | | | **500** |
| Bearing Holder-DONE | 7 days | Sat 10/13/12 | Mon 10/22/12 | | Delivery Services | 500 |
| Cut Lower A Arm Tubes-DONE | 0.5 days | Fri 1/4/13 | Fri 1/4/13 | 64 | Horizontal Bandsaw,Random Noob | 500 |
| Slit Lower A Arm Tubes-DONE | 1 day | Sat 1/5/13 | Sat 1/5/13 | 79 | Vertical Bandsaw,Random Noob | 500 |
| Oil Filled Bronze Bearings | 2 days | Fri 1/4/13 | Sat 1/5/13 | 64 | Lathe,Random Noob | 500 |
| Bushing Holders-DONE | 2.38 days | Fri 1/4/13 | Sun 1/6/13 | 64 | Lathe,Random Noob | 500 |
| Notch Lower A Arm Tubes-DONE | 3 days | Sat 1/5/13 | Mon 1/7/13 | 79 | Grinder,Kyle VanAllen | 500 |
| Bearing Holder Duckfoot-DONE | 3.38 days | Fri 1/4/13 | Mon 1/7/13 | 64 | Vertical Bandsaw,Kyle VanAllen,Drill Press,Grinder | 500 |
| Weld Lower A Arm Assembly | 0.1 days | Mon 1/7/13 | Mon 1/7/13 | 79,80,81,82,84,85 | Tig Welder,Scott Frey | 500 |
| Heat Treat Lower A Arm | 1 day | Mon 1/7/13 | Thu 1/10/13 | 86 | Furnace,Kyle VanAllen | 500 |
| Assemble Rod Ends and | 1 day | Sat | Thu | 87,66 | Kyle | 500 |

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|---|---|---|---|---|---|---|
| Spherical Bearings | | 1/12/13 | 1/17/13 | | VanAllen | |
| **Upper A Arms** | **113.33 days** | **Sat 10/13/12** | **Thu 2/14/13** | | | **500** |
| Bearing Holder-DONE | 7 days | Sat 10/13/12 | Mon 10/22/12 | | Delivery Services | 500 |
| Cut Upper A Arm Tubes-DONE | 0.5 days | Fri 1/4/13 | Fri 1/4/13 | 64 | Horizontal Bandsaw,Random Noob | 500 |
| Crush Upper A Arm Tubes-DONE | 0.1 days | Sat 1/5/13 | Sat 1/5/13 | 90 | Kyle VanAllen | 500 |
| Upper A Arm Threaded Inserts-DONE | 1.5 days | Fri 1/4/13 | Sat 1/5/13 | 64 | Lathe,Random Noob | 500 |
| Notch Upper A Arm Tubes-DONE | 1.5 days | Sat 1/5/13 | Sun 1/6/13 | 91 | Grinder,Kyle VanAllen | 500 |
| Weld Upper A Arm Assembly | 1 day | Sun 1/6/13 | Thu 1/10/13 | 94,93,92 | Tig Welder,Kyle VanAllen | 500 |
| Heat Treat Upper A Arm | 1 day | Sat 2/2/13 | Sat 2/2/13 | | Furnace,Kyle VanAllen | 500 |
| Assemble Rod Ends and Spherical Bearings | 1 day | Thu 2/14/13 | Thu 2/14/13 | 96,66 | Kyle VanAllen | 500 |
| **Rear Uprights** | **25.38 days** | **Sat 2/16/13** | **Thu 3/21/13** | | | **500** |
| Machine Part | 10 days | Sat 2/16/13 | Sat 3/16/13 | | Kyle VanAllen | 500 |
| Drill Bolt Holes | 1.63 days | Sat 3/16/13 | Thu 3/21/13 | 74 | Mill,Kyle VanAllen | 500 |
| Insert Bearing | 0.5 days | Thu 3/21/13 | Thu 3/21/13 | 74 | Kyle VanAllen | 500 |
| **Drivetrain** | **102.75 days?** | **Thu 12/6/12** | **Sat 3/23/13** | **34** | | **500** |
| Engine Crush Cans | 1.38 days | Thu 12/6/12 | Sat 12/8/12 | 65 | Mill,Matt Myers | 500 |
| (Un)Bolt Wheels | 0.1 days | Mon 12/10/12 | Mon 12/10/12 | | Random Noob | 500 |
| **Gearbox Tube Inserts** | **43.6 days** | **Thu 12/6/12** | **Sun 1/6/13** | | | **500** |
| Drill Holes In Gearbox Tube | 2 days | Thu 12/6/12 | Mon 12/10/12 | 115 | Hand Drill,Matt Myers | 500 |
| Weld Gearbox Tube Inserts | 0.5 days | Mon 12/10/12 | Mon 12/10/12 | 243 | Scott Frey | 500 |
| Machine Gearbox Tube Inserts-DONE | 1.5 days | Fri 1/4/13 | Sun 1/6/13 | 64 | Lathe,Nick Bonafede | 500 |

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|---|---|---|---|---|---|---|
| Shifter Linkage | 2.75 days | Sat 2/2/13 | Thu 2/7/13 | | Plasma Cutter,Drill Press,Tig Welder,Matt Myers,Scott Frey | 990 |
| **Gas Tank Tabs** | **3.95 days?** | **Sat 2/2/13** | **Thu 2/7/13** | | | **500** |
| Gas Tank Tabs | 0 days? | Sat 2/2/13 | Sat 2/2/13 | | | 500 |
| Cut Gas Tank Tabs | 0.3 days | Sat 2/2/13 | Sat 2/2/13 | 64 | Cutoff Wheel,Random Noob | 500 |
| Drill Hole - Gas Tank Tabs | 0.3 days | Sat 2/2/13 | Sat 2/2/13 | 236 | Drill Press,Random Noob | 500 |
| Weld Gas Tank Tabs | 0.6 days | Tue 2/5/13 | Thu 2/7/13 | 237 | Tig Welder,Scott Frey | 500 |
| O) Throttle Cable | 7 days | Sat 2/2/13 | Sat 2/9/13 | | Delivery Services | 995 |
| **Throttle Cable Guide Dowels** | **2.03 days** | **Sat 2/9/13** | **Tue 2/12/13** | | | **500** |
| Machine Throttle Cable Guide Dowels | 0.63 days | Sat 2/9/13 | Sat 2/9/13 | | Lathe,Matt Myers | 995 |
| Weld Throttle Cable Guide Dowels | 0.75 days | Sat 2/9/13 | Tue 2/12/13 | 247 | Tig Welder,Scott Frey | 995 |
| Drip Pan | 1 day | Sat 2/9/13 | Sat 2/16/13 | | Random Noob | 950 |
| Front Hubs | 0.2 days | Sat 2/16/13 | Sat 2/16/13 | | Random Noob | 970 |
| **Engine** | **25.48 days** | **Mon 1/14/13** | **Sat 2/16/13** | | | **500** |
| Order Engine | 0 days | Mon 1/14/13 | Mon 1/14/13 | 62 | Matt Myers,Nick Bonafede | 500 |
| Test Engine | 0.5 days | Sat 2/16/13 | Sat 2/16/13 | | Matt Myers,Nick Bonafede | 980 |
| Mount Engine | 0.1 days | Sat 2/16/13 | Sat 2/16/13 | 214 | Random Noob | 985 |
| (Un)Bolt CVT | 0.2 days | Sat 2/16/13 | Tue 2/19/13 | 215 | | 500 |

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|---|---|---|---|---|---|---|
| Replace Oil and Seals in Gearbox | 0.4 days | Tue 2/19/13 | Thu 2/21/13 | 216 | Matt Myers,Nick Bonafede | 990 |
| Rear Hubs | 0 days | Sat 2/23/13 | Sat 2/23/13 | | Lathe | 970 |
| Splash Guards | 1 day | Sat 2/16/13 | Sat 2/23/13 | | Random Noob | 950 |
| Shifter | 1.63 days | Sat 2/9/13 | Sat 2/23/13 | | Lathe,Nick Bonafede | 990 |
| **Half Shafts** | **7.23 days?** | **Sun 3/3/13** | **Tue 3/12/13** | | | **500** |
| Half Shafts | 0 days? | Sun 3/3/13 | Sun 3/3/13 | | | 500 |
| Cut Half Shafts to Length | 0.1 days | Sun 3/3/13 | Sun 3/3/13 | 64 | Horizontal Bandsaw,Nick Bonafede | 950 |
| Cut Splines into Half Shafts | 3 days | Sun 3/3/13 | Sat 3/9/13 | 225 | Mill,Nick Bonafede | 950 |
| Heat Treat Half Shafts | 0.98 days | Sat 3/9/13 | Tue 3/12/13 | 226 | Furnace,Nick Bonafede | 950 |
| **CV Joints** | **18.68 days** | **Thu 2/21/13** | **Sat 3/16/13** | **217** | | **500** |
| O) Boot Clamps | 0.25 days | Thu 2/21/13 | Thu 2/21/13 | | Delivery Services | 500 |
| Clean Out Grease | 0.25 days | Sat 2/23/13 | Sat 2/23/13 | | Random Noob | 950 |
| Repack Grease | 0.25 days | Sat 2/23/13 | Sat 2/23/13 | 219 | Random Noob | 950 |
| Mount to Half Shafts | 0.25 days | Sat 3/16/13 | Sat 3/16/13 | 220,223 | Random Noob | 950 |
| O) Tires | 14 days | Mon 3/4/13 | Tue 3/19/13 | | Delivery Services | 500 |
| Mount Tires | 1.75 days | Tue 3/19/13 | Sat 3/23/13 | 231 | Matt Myers,Nick Bonafede | 500 |
| **Safety** | **118.25 days?** | **Thu 12/6/12** | **Tue 4/9/13** | **50** | | **500** |
| O) Nomex Shirts | 3 days | Fri 12/7/12 | Mon 12/10/12 | | Delivery Services | 900 |
| **Seat Tube Threaded Inserts** | **4 days** | **Thu 12/6/12** | **Tue 12/11/12** | | | **500** |
| Fabricate Seat Tube Inserts-DONE | 2.13 days | Thu 12/6/12 | Mon 12/10/12 | | Lathe,Random Noob | 500 |

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|---|---|---|---|---|---|---|
| Drill Holes In Seat Tube-DONE | 0.5 days | Mon 12/10/12 | Mon 12/10/12 | 120 | Hand Drill,Ryan Slein | 500 |
| Weld Seat Tube Inserts-DONE | 0.5 days | Tue 12/11/12 | Tue 12/11/12 | 184,185 | Scott Frey,Tig Welder | 500 |
| O) Fire Extinguisher | 5 days | Fri 12/7/12 | Wed 12/12/12 | | Delivery Services | 980 |
| Fire Extinguisher Mount | 0.5 days | Wed 12/12/12 | Wed 12/12/12 | 106,192 | Drill Press,Random Noob | 750 |
| Fabricate Siren Mount | 0.5 days | Fri 1/4/13 | Sat 1/5/13 | 64 | Cutoff Wheel,Sheet Metal Shear,Random Noob | 970 |
| Mount Backup Siren | 0.1 days | Sat 1/5/13 | Sat 1/5/13 | 205 | Random Noob | 800 |
| Seat | 0.1 days | Sat 2/9/13 | Sat 2/9/13 | 183 | Random Noob | 500 |
| Fabricate Brake/Backup Light Mount | 0.5 days | Sat 2/9/13 | Sat 2/9/13 | 64 | Sheet Metal Shear,Cutoff Wheel,Random Noob | 900 |
| Mount Brake Light | 0.1 days | Sat 2/9/13 | Sat 2/9/13 | 199 | Random Noob | 800 |
| Mount Backup Light | 0.1 days | Sat 2/9/13 | Sat 2/9/13 | 199 | Random Noob | 800 |
| **Seat Belt Tabs** | **32.63 days** | **Fri 1/4/13** | **Thu 2/14/13** | | | **500** |
| Cut Seat Belt Tabs | 0.6 days | Fri 1/4/13 | Sat 1/5/13 | 64 | Plasma Cutter,Random Noob | 500 |
| Drill Hole - Seat Belt Tabs | 0.3 days | Sat 1/5/13 | Sat 1/5/13 | 189 | Drill Press,Random Noob | 500 |
| Weld Seat Belt Tabs | 0.6 days | Sat 2/9/13 | Thu 2/14/13 | 190 | Tig Welder,Scott Frey | 500 |
| **Transponder Tab(s)** | **3.48 days** | **Sat 2/9/13** | **Thu 2/14/13** | | | **500** |
| Cut Transponder Tab(s) | 0.3 days | Sat 2/9/13 | Sat 2/9/13 | 64 | Plasma Cutter,Rand | 600 |

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|---|---|---|---|---|---|---|
| | | | | | om Noob | |
| Drill Hole - Transponder Tab(s) | 0.3 days | Sat 2/9/13 | Sat 2/9/13 | 208 | Drill Press,Random Noob | 600 |
| Weld Transponder Tab(s) | 0.6 days | Sat 2/9/13 | Thu 2/14/13 | 209 | Tig Welder,Scott Frey | 600 |
| Brake Light Wiring | 1 day | Tue 2/12/13 | Thu 2/14/13 | 198 | Ryan Slein | 800 |
| O) Seat Belt | 5 days | Sat 2/9/13 | Thu 2/14/13 | | Delivery Services | 950 |
| Verify Helmets | 0.1 days | Sat 2/16/13 | Sat 2/16/13 | | Random Noob | 850 |
| Verify Radios | 1 day | Sat 2/9/13 | Sat 2/16/13 | | Random Noob | 800 |
| Radio Box Mount | 1 day | Sat 2/9/13 | Sat 2/16/13 | | Drill Press,Cutoff Wheel,Random Noob | 750 |
| Mount Transponder | 0.1 days | Sat 2/16/13 | Sat 2/16/13 | 207 | Random Noob | 600 |
| Backup Light Wiring | 1 day | Tue 2/12/13 | Sat 2/16/13 | 202 | Ryan Slein | 800 |
| Radio Box | 3 days | Sat 2/9/13 | Fri 3/1/13 | | Random Noob | 800 |
| Safety | 0 days? | Tue 4/9/13 | Tue 4/9/13 | | | 500 |
| **Panels** | **88.45 days?** | **Sat 1/5/13** | **Thu 4/25/13** | **58** | | **500** |
| Throttle Plate Cover | 0.5 days | Sat 2/16/13 | Sat 2/16/13 | | Cutoff Wheel,Random Noob | 400 |
| **False Floor** | **11.03 days** | **Sat 2/2/13** | **Sat 2/16/13** | | | **500** |
| Cut False Floor | 1.13 days | Sat 2/2/13 | Sat 2/9/13 | | Sheet Metal Shear,Random Noob | 900 |
| Bend False Floor | 1.78 days | Sat 2/9/13 | Sat 2/16/13 | 283 | Sheet Metal Brake,Random Noob | 900 |
| **Firewall** | **15.63 days** | **Sat 2/2/13** | **Sat 2/23/13** | | | **500** |
| Firewall Template | 1 day | Sat 2/2/13 | Sat 2/9/13 | | Random Noob | 500 |

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|---|---|---|---|---|---|---|
| Cut Firewall | 1 day | Sat 2/16/13 | Sat 2/23/13 | 253,64 | Random Noob | 900 |
| **Skid Plates** | **22 days** | **Sat 2/9/13** | **Sat 3/9/13** | | | **500** |
| Nose Plate | 10.88 days | Sat 2/9/13 | Sat 2/23/13 | | Composite Room[50%] ,Ryan Slein | 990 |
| **Belly Pan** | **22 days** | **Sat 2/9/13** | **Sat 3/9/13** | | | **500** |
| Belly Pan Template | 0.5 days | Sat 2/9/13 | Sat 2/9/13 | | Ryan Slein | 950 |
| Layup Belly Pan | 2.63 days | Sat 2/9/13 | Sat 2/16/13 | 276 | Composite Room[50%] ,Ryan Slein | 990 |
| **Belly Pan Tabs** | **5.63 days** | **Sun 3/3/13** | **Sat 3/9/13** | | | **500** |
| Cut Belly Pan | 0.6 days | Sun 3/3/13 | Tue 3/5/13 | | Plasma Cutter,Random Noob | 800 |
| Drill Holes - Belly Pan | 0.5 days | Tue 3/5/13 | Sat 3/9/13 | 279 | Drill Press,Random Noob | 800 |
| Weld Belly Pan | 0.3 days | Sat 3/9/13 | Sat 3/9/13 | 280 | Tig Welder,Scott Frey | 800 |
| **CVT Cover** | **6 days** | **Tue 3/5/13** | **Tue 3/12/13** | | | **500** |
| Cut CVT Cover Mold | 2 days | Tue 3/5/13 | Sat 3/9/13 | | Ryan Slein | 700 |
| Layup CVT Cover | 1 day | Sat 3/9/13 | Tue 3/12/13 | 286 | Composite Room[50%] ,Ryan Slein | 700 |
| **Body Panels** | **12.25 days** | **Sun 3/3/13** | **Tue 3/19/13** | | | **500** |
| **Body Panel Tabs** | **1.15 days** | **Sun 3/3/13** | **Tue 3/5/13** | | | **500** |
| Cut Body Panel Tabs | 0.3 days | Sun 3/3/13 | Sun 3/3/13 | 64 | Plasma Cutter,Random Noob | 600 |
| Drill Hole - Body Panel Tabs | 0.3 days | Sun 3/3/13 | Sun 3/3/13 | 259 | Drill Press,Random Noob | 600 |
| Weld Body Panel Tabs | 0.33 days | Sun 3/3/13 | Tue 3/5/13 | 260 | Tig Welder,Scott Frey | 600 |

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|---|---|---|---|---|---|---|
| Body Panel Templates | 1 day | Sun 3/3/13 | Tue 3/5/13 | | Ryan Slein | 700 |
| Layup Body Panels | 3.5 days | Tue 3/12/13 | Tue 3/19/13 | 256 | Composite Room,Ryan Slein | 700 |
| **Number Panels** | **61.28 days?** | **Sat 1/5/13** | **Sat 3/23/13** | | | **500** |
| Number Standoffs | 0.1 days | Sun 3/3/13 | Sun 3/3/13 | | Random Noob | 300 |
| **Number Panel Tabs** | **48.78 days?** | **Sat 1/5/13** | **Thu 3/7/13** | | | **500** |
| Cut Number Panel Tabs | 0.3 days | Sat 1/5/13 | Sat 1/5/13 | 64 | Plasma Cutter,Random Noob | 500 |
| Drill Hole - Number Panel Tabs | 0.3 days | Sat 1/5/13 | Sat 1/5/13 | 268 | Drill Press,Random Noob | 500 |
| Weld Number Panel Tabs | 0.3 days | Sat 1/5/13 | Sat 1/5/13 | 269 | Tig Welder,Scott Frey | 500 |
| Number Panel Tabs | 0 days? | Sun 3/3/13 | Sun 3/3/13 | | | 500 |
| Number Panel Tabs | 0 days? | Thu 3/7/13 | Thu 3/7/13 | | | 500 |
| Number Panel Templates | 1 day | Sun 3/3/13 | Sat 3/9/13 | | Random Noob | 500 |
| Numbers | 1.13 days | Sun 3/3/13 | Sat 3/9/13 | | Scroll Saw,Random Noob | 500 |
| Layup Number Panels | 3.25 days | Sat 3/9/13 | Sat 3/23/13 | 263 | Composite Room[50%],Random Noob | 500 |
| **Nose Cover** | **88.15 days?** | **Sat 1/5/13** | **Thu 4/25/13** | | | **500** |
| **Nose Cover Tabs** | **0.9 days** | **Sat 1/5/13** | **Sat 1/5/13** | | | **500** |
| Cut Nose Cover Tabs | 0.3 days | Sat 1/5/13 | Sat 1/5/13 | 64 | Plasma Cutter,Random Noob | 500 |
| Drill Hole - Nose Cover Tabs | 0.3 days | Sat 1/5/13 | Sat 1/5/13 | 295 | Drill Press,Random Noob | 500 |
| Weld Nose Cover Tabs | 0.3 days | Sat 1/5/13 | Sat 1/5/13 | 296 | Tig | 500 |

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|---|---|---|---|---|---|---|
| | | | | | Welder,Scott Frey | |
| Nose Cover | 0 days? | Sun 3/3/13 | Sun 3/3/13 | | | 500 |
| Nose Cover Template | 0.1 days | Sun 3/3/13 | Sun 3/3/13 | | Random Noob | 500 |
| Layup Nose Cover | 3.23 days | Sun 3/3/13 | Sat 3/16/13 | 292 | Composite Room[25%],Random Noob | 500 |
| Nose Cover | 0 days? | Thu 4/25/13 | Thu 4/25/13 | | | 500 |
| **Brakes** | **140.38 days?** | **Thu 12/6/12** | **Thu 5/9/13** | **26** | | **500** |
| **Front** | **75.88 days** | **Thu 12/6/12** | **Sat 2/16/13** | | | **500** |
| O) Front Hubs | 0 days | Thu 12/6/12 | Thu 12/6/12 | 69 | Delivery Services | 500 |
| O) Front Calipers | 0 days | Thu 12/6/12 | Thu 12/6/12 | 69 | Delivery Services | 500 |
| O) Front Master Cylinder | 0 days | Thu 12/6/12 | Thu 12/6/12 | 69 | Delivery Services | 500 |
| O) Pressure Switches | 0 days | Thu 12/6/12 | Thu 12/6/12 | 69 | Delivery Services | 500 |
| O)Front Rotors | 0 days | Thu 12/6/12 | Thu 12/6/12 | 69 | Delivery Services | 500 |
| Front Caliper Mount | 6 days | Fri 1/4/13 | Sat 2/2/13 | 64 | Mill,Ryan Flatland | 500 |
| **Pedals** | **35.38 days** | **Fri 1/4/13** | **Sat 2/16/13** | | | **500** |
| **Fabricate Pedal Box** | **1 day** | **Fri 1/4/13** | **Sat 1/5/13** | | | **500** |
| Cut Pedal Box Tubes | 0.5 days | Fri 1/4/13 | Fri 1/4/13 | 64 | Horizontal Bandsaw,Random Noob | 500 |
| Weld Pedal Box | 0.5 days | Sat 1/5/13 | Sat 1/5/13 | 133 | Tig Welder,Scott Frey | 500 |
| **Fabricate Brake Pedal** | **35.38 days** | **Fri 1/4/13** | **Sat 2/16/13** | | | **500** |
| Cut Brake Pedal Sheet | 0.5 days | Fri 1/4/13 | Thu 1/17/13 | 64 | Horizontal Bandsaw,Ryan Flatland | 500 |
| Bend Brake Pedal | 0.25 days | Thu | Thu | 136 | Ryan | 500 |

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|---|---|---|---|---|---|---|
| Sheet | | 2/14/13 | 2/14/13 | | Flatland | |
| Drill Brake Pedal Sheet | 0.5 days | Thu 2/14/13 | Sat 2/16/13 | 137 | Mill,Ryan Flatland | 500 |
| Weld Brake Pedal Sheet | 0.25 days | Sat 2/16/13 | Sat 2/16/13 | 138 | Tig Welder,Scott Frey | 500 |
| **Fabricate Gas Pedal** | **32.58 days** | **Sun 1/6/13** | **Sat 2/16/13** | | | **500** |
| Cut Gas Pedal Sheet | 0.5 days | Sun 1/6/13 | Sat 2/9/13 | 64 | Plasma Cutter,Ryan Flatland | 500 |
| Bend Gas Pedal Sheet | 0.25 days | Thu 2/14/13 | Thu 2/14/13 | 141 | Ryan Flatland | 500 |
| Drill Gas Pedal Sheet | 0.5 days | Thu 2/14/13 | Sat 2/16/13 | 142 | Mill,Ryan Flatland | 500 |
| Weld Gas Pedal Sheet | 0.25 days | Sat 2/16/13 | Sat 2/16/13 | 143 | Tig Welder,Scott Frey | 500 |
| **Rear** | **76.55 days** | **Thu 12/6/12** | **Tue 2/19/13** | | | **500** |
| O) Rear Rotor(s) | 0 days | Thu 12/6/12 | Thu 12/6/12 | 69 | Ryan Flatland | 500 |
| O) Rear Caliper | 0 days | Thu 12/6/12 | Thu 12/6/12 | 69 | Ryan Flatland | 500 |
| (Un)Bolt Rear Master Cylinder | 0.1 days | Sat 1/5/13 | Sat 1/5/13 | 132 | Random Noob | 500 |
| Rear Rotor Carrier | 4 days | Thu 12/6/12 | Thu 1/17/13 | 65 | Lathe,Ryan Flatland | 500 |
| Recycle Bias Bar | 0.1 days | Sat 2/16/13 | Sat 2/16/13 | 146,135,140 | Random Noob | 500 |
| **Rear Caliper Mount** | **36.05 days** | **Fri 1/4/13** | **Tue 2/19/13** | | | **500** |
| Cut Rear Caliper Mount Sheet Steel | 0.5 days | Sun 1/6/13 | Sat 2/9/13 | 64 | Plasma Cutter,Ryan Flatland | 500 |
| Weld Rear Caliper Mount Sheet steel | 0.38 days | Sat 2/9/13 | Tue 2/12/13 | 152 | Tig Welder,Scott Frey | 950 |
| **Inserts** | **33.48 days** | **Fri 1/4/13** | **Thu 2/14/13** | | | **500** |
| Machine Rear Caliper Inserts | 2 days | Fri 1/4/13 | Sat 1/19/13 | 64 | Lathe,Ryan Flatland | 500 |
| Drill Rear Caliper Insert Holes | 1 day | Tue 1/22/13 | Thu 2/14/13 | 158 | Hand Drill,Ryan | 500 |

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|---|---|---|---|---|---|---|
| | | | | | Flatland | |
| Weld Rear Caliper Inserts | 0.25 days | Thu 2/14/13 | Thu 2/14/13 | 159 | Tig Welder,Scott Frey | 900 |
| Cut Rear Caliper Mount Tubes | 0.2 days | Tue 2/12/13 | Sat 2/16/13 | 153 | Horizontal Bandsaw,Random Noob | 500 |
| Notch Rear Caliper Mount Tubes | 0.63 days | Sat 2/16/13 | Sat 2/16/13 | 154 | Grinder,Ryan Flatland | 500 |
| Weld Rear Caliper Mount Tubes | 0.25 days | Sat 2/16/13 | Tue 2/19/13 | 155 | Scott Frey,Tig Welder | 500 |
| **Brake Lines** | **70.13 days?** | **Sat 2/9/13** | **Thu 5/9/13** | | | **500** |
| Brake Lines | 0 days? | Sat 2/9/13 | Sat 2/9/13 | | | 500 |
| O) Front Soft Brake Line | 0 days | Sat 2/9/13 | Sat 2/9/13 | 70 | Ryan Flatland | 500 |
| Front Split Line | 1 day | Sat 2/9/13 | Thu 2/21/13 | 70,146 | Flaring Tool,Ryan Flatland | 500 |
| Run Rear Line | 0.75 days | Sat 2/9/13 | Thu 2/21/13 | 70,146 | Flaring Tool,Ryan Flatland | 500 |
| Brake Lines | 0 days? | Thu 5/9/13 | Thu 5/9/13 | | | 500 |
| Assemble | 2 days | Thu 5/9/13 | Sat 5/11/13 | 72,105,123,167,180,211,251,97,100,117,149,147,165,170,204,232,257 | | 500 |

# Appendix H. Step 6.1: Deliverable Design Decisions 2012

| **Frame** | **Action Codes** | **Duration** |
|---|---|---|
| Firewall Tubes | **O** | 2 weeks |
| Front Floor Tubes | **F** | 4 hours |
| Nose Section Tubes | **F** | 12 hours |
| Front Suspension Tubes | **F** | 12 hours |
| Front Down Tubes | **F** | 2 days |
| Side Impact Tubes | **F** | 4 hours |
| Rear Floor Tubes | **F** | 3 hours |
| Rear Triangulation Tubes | **F** | 5 hours |
| Fore-Aft Bracing Tubes | **F** | 6 hours |
| Gearbox Tubes | **F** | 3 hours |
| Rear Suspension/Bumper Tubes | **F** | 6 hours |
| Suspension Tabs | **F** | 7 days |
| Steering Mount Tubes | **F** | 2 hours |
| Pedal Mount Tube | **F** | 2 hours |
| Seat Mount Tube | **F** | 1 hour |
| Engine Tubes | **F** | 2 hours |
| Anti-Submarine Tube | **F** | 1 hour |
| Paint Chassis | **F** | 1 day |
| **Suspension** | **Action Codes** | |
| Weld Upper A-Arms | **F** | .5 hours |
| Notch Tubes | **F** | 1.5 days |
| Upper Bearing Holder | **O** | 7 days |
| Upper Threaded Inserts | **F** | 1 day |
| Weld Lower A-Arms | **F** | .5 hours |
| Lower Bearing Holder | **O** | 7 days |
| Shock Mount Tab | **F** | 2 days |
| Lower A-Arm Bushing Inserts | **F** | 2 days |
| Lower A-Arm Bushings | **F** | 1 days |
| Rear Control Links | **F** | 4 days |
| Front Shocks | **R** | .5 hour |
| Rear Shocks | **R** | .5 hour |
| Front Uprights | **R** | 2 hours |
| Rear Uprights | **F** | 1 month |
| **Brakes** | **Action** | |

**Legend**

| **Action** | **Action Code** |
|---|---|
| Order | O |
| Fabricate | F |
| Reuse | R |

| | **Codes** | |
|---|---|---|
| Gas Pedal | **F** | 8 hours |
| Brake Pedal | **F** | 8 hours |
| Front Master Cylinder | **O** | 1 month |
| Rear Master Cylinder | **R** | .5 hours |
| Bias Bar | **R** | .5 hours |
| Front Calipers | **O** | 1 month |
| Front Caliper Mount | **F** | 3 days |
| Rear Caliper(s) | **O** | 1 week |
| Front Soft Brake Lines | **O** | 1 week |
| Front Split Line | **F** | 3 hours |
| Rear Run Line | **F** | 3 hours |
| Front Rotors | **O** | 1 month |
| Rear Rotor(s) | **O** | 1 month |
| Rear Rotor Mount | **F** | 10 hours |
| Rear Caliper Mount | **F** | 5 hours |
| Pedal Box | **F** | 6 hours |
| Front Caliper Line Tabs | **F** | 1 hour |
| Pressure Switches | **O** | 2 days |
| Brake Bleeding | **F** | 3 hours |
| **Drivetrain** | **Action Codes** | **Duration (days)** |
| Engine | **O** | Jan-13 |
| CVT | **R** | 0.2 |
| Gearbox | **R** | 0.2 |
| CV Joints | **R** | 0.5 |
| Half Shafts | **F** | 1 |
| Front Hubs | **R** | 0.2 |
| Rear Hubs | **O** | 14 |
| Wheels | **R** | 0.1 |
| Tires | **O** | 14 |
| Engine Crush Cans | **F** | 1 |
| Gearbox Tube Threaded Inserts | **F** | 1 |
| Throttle Cable | **O** | 7 |
| Throttle Cable Guide Dowels | **F** | 0.5 |
| Shifter | **F** | 1 |
| Shifter Linkage | **F** | 1 |
| Gas Tank Tabs | **F** | 0.5 |
| Splash Guards | **F** | |
| Drip Pan | **F** | |
| Gas Tank | **O** | 14 |

| **<u>Steering</u>** | **Action Codes** | |
|---|---|---|
| Rack and Pinion | **R** | 4 hours |
| Upper Trunion Blocks | **F** | 1 day |
| Lower Trunion Blocks | **F** | 2 days |
| Steering Stops | **F** | 2 hours |
| Tie Rods | **F** | 3 hours |
| Steering Wheel | **O** | 3 days |
| Steering Shaft | **O** | 3 days |
| Bearing Holder | **O** | 1 day |
| Bearing | **O** | 3 days |
| U Joint | **O** | 3 days |
| Quick Release | **O** | 3 days |
| **<u>Safety</u>** | **Action Codes** | |
| Seat | **R** | 1 day |
| Seat Tube Threaded Inserts | **F** | 4 hours |
| Seat Belt | **O** | 5 days |
| Seat Belt Tabs | **F** | 1 day |
| Fire Extinguisher | **O** | 5 days |
| Fire Extinguisher Mount | **F** | 4 hours |
| Helmets | **R** | 0 |
| Radios | **R** | 0 |
| Radio Box | **F** | 3 days |
| Radio Box Mount | **F** | 4 hours |
| Brake Light | **R** | .5 hour |
| Brake/Backup Light Mount | **F** | 4 hours |
| Brake Light Wiring | **F** | 1 day |
| Nomex Shirts | **O** | 3 days |
| Backup Light | **R** | .5 hours |
| Backup Light Wiring | **F** | 1 day |
| Backup Siren | **R** | .5 hour |
| Siren Mount | **F** | 4 hours |
| Transponder | **R** | .5 hours |
| Transponder Tab(s) | **F** | 2 hours |
| **<u>Panels</u>** | **Action Codes** | |
| Nose Skid Plate | **F** | 5 days |
| Belly Pan Skid Plate | **F** | 5 days |
| Skid Plate Tabs | **F** | 1 day |
| Body Panels | **F** | 6 days |

| | | |
|---|---|---|
| Firewall | **F** | 2 days |
| Body Panel Tabs | **F** | 2 days |
| CVT Cover | **F** | 4 days |
| False Floor | **F** | 2 days |
| Throttle plate cover | **F** | 1 day |
| Nose Cover | **F** | 2 days |
| Nose Cover Tabs | **F** | 2 hours |
| Number Display Panel(s) | **F** | 2 days |
| Numbers | **F** | 1 day |
| Number Standoffs | **R** | 1 hour |

# Appendix I. Step 6.2: Microsoft Project 2010 Walkthrough

***I highly suggest watching the "Learn Microsoft Project In 16 minutes Flat" video posted on YouTube or another similar video. It will explain the basics as they are described here with a video to follow. If you need relevant examples, read the rest of this walkthrough and/ or the "2012 Baja Schedule".***

http://www.youtube.com/watch?v=sPwURRG9_Gs

**Step 1:** Set baseline calendars

Go to the Project tab and click the "Project Information" button. Set the project start date to the first day of Fall quarter. Next, edit the project calendar. Click the "Change Working Time" button. It is easiest if you set all days as work days. Look up major academic holidays (Winter Break, Spring Break, etc.) and enter them as exceptions. Set a new schedule for each major holiday. Use the resource calendars to adjust availabilities of individuals (see Enter Resources section).

**Step 2:** The Work Breakdown Structure (WBS)-Finish before PDR

A work breakdown structure is breakdown of the Baja Project. For example, Baja consists of six basic sub-systems: Frame, suspension, drivetrain, brakes, panels, and safety equipment. Let's use suspension as an example. Suspension can be broken down into front and rear and again by upper and lower. Then, each component can be broken down into parts. For example, the front upper A-Arm consists of two arms, a bearing holder, and two threaded inserts.

The arms, bearing holder, and threaded inserts are considered low level tasks. Low level tasks are tasks that have been broken down enough that time and cost estimations can be ACCURATELY created.

Tasks that have sub-tasks are called summary tasks (look at the model for clarification). Each breakdown is represented by a new line and an indentation.

Have each sub-system lead fill out a "Deliverable Design Decision" sheet by following the "Deliverable Design Decisions 2012" example. Use your knowledge of the car's manufacturing and the deliverable design decisions from each sub-system lead to create a WBS for the entire Baja Project. Look at the 2012 Baja Schedule for an idea of how detailed to make the list. Here is how the work breakdown structure would look for this example:

**Model:**

- Baja Project
  - Suspension
    - Front
      - Lower
      - Upper
        - Manufacture Arms……………….… (summary task)
          - Cut arms to length…… (low –level task)
          - Notch arms
        - Cut Bearing Holder
        - Cut Threaded Inserts
        - Weld Upper A-Arm assembly
    - Rear
  - Drivetrain

Make sure to include ordering parts, the cost report, and the design report as tasks. Under the Task tab, next to the font choice, you will see green arrows. These arrows adjust the breakdown level by moving the indent.

**Step 3:** Estimate task durations – Finish after PDR

This step is fairly straightforward. The first thing to do is highlight all tasks, right click and click automatically schedule tasks. This makes sure that all summary tasks are automatically calculated. Meet with each sub-system lead to estimate durations for each low level task. Durations can be based on past experience, but it is preferred if the previous year's sign out sheet is used to estimate the duration of similar tasks. Enter the durations for each low level task. You can also use the task start and finish date to automatically calculate the task durations. Summary tasks are automatically calculated by adding up the low-level tasks. As such, since Baja Project is the main summary task, its total duration and finish date will be automatically calculated.

**Step 4:** Enter predecessors – Finish before CDR

Each task has a corresponding number to the left of it in the margin. If one task must be completed before another task, the task number must be entered in the predecessors' column. For example, the A-arm can't be welded until all components are complete. If ordering welding rod has a task number of 1, manufacturing arms has a task number of 3, cut bearing holder has a task number of 4, and cut threaded inserts has a task number of 6, then welding the A-arm assembly has predecessors 1, 3, 4, and 6.

**Step 5:** Enter task priorities – Finish before CDR

Meet with the team lead to consider each task's priority. Higher priorities are assigned to tasks that are more important than others. Consider assigning a higher priority to tasks that need to be completed before the Go/No Go date. Make sure that you are in the Gantt Chart view. Find an empty column, click the arrow to view the dropdown menu, scroll down, and click Priority. Assign numerical values for the priority of each task.

**Step 6:** Enter resources – Finish before CDR

All tasks require resources. Resources are defined as anything that will be needed to complete the task. Part manufacturing for Baja requires a tool/ machine, a person, and material for each task. First you must go to the Task tab and click the button that says "Gantt Chart". You will notice a drop down menu appears where you can click Resource Sheet.

Enter the sub-system leads, team lead, team manager, and all basic machines and tools as resources. Look at the "2012 Baja Schedule" to see how it should look. Then enter the number of each resource that you have. 100% means that you have one resource. For example, three lathes would be entered as 300%. You can double click people as well as machines and edit their schedule to match their availabilities. Do this by going to "Change Working Time", click the "Work Weeks" tab, and filling in typical work weeks for the individual.

Finally, go back to the Gantt-chart view and type in the amount of each resource needed to complete the task under the Resource Names column.

You may notice little red stick figures to the left of the task. This means that one resource is over-allocated. For example, there may only be one Joe Blo on your team, but Microsoft Project will schedule Joe Blo as if he can do everything at once. Even though the number of Joe Blo's has been set, Microsoft Project won't take into account the number of Joe Blo's until you level resources. Go to the Resource tab and click Level All. You may consider clicking leveling options and looking over the settings. It is recommended that you allow task splitting since most tasks can be stopped and continued on another day.

**Step 7:** Monitor the schedule – Finish before CDR

Print a report of each person's tasks to be completed on their due dates. Go to the "Project" tab, click the "Reports" button, click the "Custom" button, scroll to the bottom of the pop-up list, click "Who Does What When", and click "Print". Tape this list in the hangar so that all team members can see it.

Make sure that every team member fills out a sign-out sheet after each work day. Record the percent complete of each task by double clicking the task and entering the information under percent complete.

After you entered all of the preceding information, a critical path was automatically created. The critical path is a list of tasks which, if delayed, will delay the project completion date. This path is highlighted in red in the Network Diagram view. This view is located under the task tab and can be found by clicking the drop down menu under Gantt chart. Make sure that no task on the critical path is delayed, especially if your project completion date is close to your Go/No Go date.

# Appendix J. Step 7: CDR Template Slides Outline

- Put your name and sub-system name on this slide

Relevant 3d views

- Don't keep your audience in suspense
- Include all relevant shots of the 3D model and any changes that were necessary
    - Your system MUST have a Solidworks part file of every major deliverable in the car assembly

Brief PDR Review

- Briefly describe purpose, goals, and major deliverables of the sub-system
- Briefly describe all design alternatives considered for each major deliverable
- Briefly ID the alternative decision and WHY it was chosen
    - Include design Criteria given by the team lead
    - Include relevant PDR backup slides in case you are asked to elaborate

Team Goals

- Specifically address how your system met team goals set by team Lead
    - I.e. Weight, cost, serviceability, and design for manufacturability and assembly.
    - Include all formulas, theories, and/or methods used to achieve these results
    - System Goals
- Specifically address how your system meets all of the sub-system goals set by sub-system lead
    - I.e. Stiffness, Deflection, and Efficiency
    - Consider designed modes of failure (ask team lead)
        - Ex: tie rods fail first in steering because they are cheap and easy to replace
    - Include all formulas, theories, and/or methods used to achieve these results

Parameters and Dimensions

- Describe all relevant parameters and/or dimensions for your system
    - Tables and part drawings may be useful in this case
    - Describe how you chose these dimensions and parameters

Packaging and Integration

- Show how your system interacts with other systems
    - Make sure that your system fits with surrounding systems on the car (packaging)
    - Make sure that your system functions well with all connected systems (integration)

Risk Analysis

- Fill out the Risk Analysis Template (from team lead)
- Include a description of all relevant risks to your system
- On this slideshow, identify the risk events and their responses
    - Ignoring an unlikely risk is NOT an option
- Identify the contingencies in place if the risks occur

Budget

- Include a budget for all fabricated or ordered deliverables
    - Include all hardware (nuts, bolts, washers, studs, etc), fluids, etc.
    - This will become your order form and bill of materials

Questions

- Pause for Questions

## Appendix K. Benefit and Resource Quantification Algorithm

```
function br_index

clc;
clear;
close all;

%Predefinition ***Fill These in before running program***
%Enter total number on team, how many people have each type of skill, total
team hours, total team budget, & and all index weights.
%From Team Lead
team_num=17; %***ASK TEAM LEAD***
red_tag=10; %***ASK TEAM LEAD***
yellow_tag=4; %***ASK TEAM LEAD***
blue_tag=2; %***ASK TEAM LEAD***
welders=1; %***ASK TEAM LEAD***
team_budget=10000; %***ASK TEAM LEAD***
total_hrs=2000; %***ASK TEAM LEAD***
service_weight=.017; %***ASK TEAM LEAD***
manufacturing_weight=.058; %***ASK TEAM LEAD***
point_weight=1; %***ASK TEAM LEAD***
cost_weight=1; %***ASK TEAM LEAD***


%Sub-System Benefit: From Project Priority Matrix
total_weighted_score=5000; %***ASK TEAM LEAD***
system_weighted_score=3000; %***ASK TEAM LEAD***

%LEAVE THE REST OF THE CODE ALONE

systime_red=0;
systime_yellow=0;
systime_blue=0;
systime_weld=0;
totalpart_time=0;

tpercent_red = (red_tag + yellow_tag + blue_tag + welders) / team_num;
tpercent_yellow = (yellow_tag + blue_tag) / team_num;
tpercent_blue = blue_tag / team_num;
tpercent_weld = welders / team_num;

ttime_red = tpercent_red * total_hrs;
ttime_yellow = tpercent_yellow * total_hrs;
ttime_blue = tpercent_blue * total_hrs;
ttime_weld = tpercent_weld * total_hrs;

%Before you start...
fprintf('\n***BEFORE YOU START!!!***\n\n');
fprintf('1.) Have your team lead evaluate your sub-system benefit based on
the Project Priority Matrix\n');
fprintf('\n2.) Have your team lead fill in all spaces in the code area that
say "***ASK TEAM LEAD***" in green writing\n');
```

```
fprintf('\n3.) Finish your sub-system budget and add up all deliverable costs
that are due to design changes\n');
fprintf('    Ex: "Our sub-system decided to use a new kind throttle cable"
This is a CHANGING DESIGN\n');
fprintf('    Ex: "Our system decided to use the same rear caliper, but we
cannot reuse the old one.  \n          We need to buy a new one"  This is NOT
A CHANGING DESIGN\n');
fprintf('\n4.) Estimate a decrease or increase in service time due to design
changes.  \n    Have old and new service times ready.\n');
fprintf('    Ex: Account for service times (assembly, adjustment, repair)
that could change as a result of the new designs.\n');
fprintf('        If bolting parts on will take the same time, you do not have
to account for wrench turning time.\n')
fprintf('\n5.) Calculate the number of different parts by using the
deliverables section in your problem\n    definition page and breaking every
component down by the number of parts to be made.\n');
fprintf('    Ex: An A-Arm May have a bearing holder, two tubes, and two
threaded inserts.  There are THREE DIFFERENT PARTS\n')
fprintf('\n6.) Estimate the total time each different part will take to
manufacture in hours\n');
fprintf('\n7.) Add up the total manufacturing time for your system\n');
fprintf('    Total System Hours = SUM(#DifferentParts*#PartsMade)\n');
fprintf('    Ex: Part 1: Time = 2 hours--> 2 parts needed\n');
fprintf('        Part 2: Time = 3 hours--> 3 parts needed\n');
fprintf('       Total System Hours = (2 hours*2 parts) + (3 hours*3 parts)=
13 hours\n');
fprintf('\n8.) Estimate the percent of the total time each different part
will take for each skill (red tag, welder, etc...)\n');
fprintf('    Ex: A part takes 1 hour to weld and 9 hours to mill--The part is
10 percent welder and 90 percent yellow tag\n');
fprintf('\n9.) Write all of the information down and give it to your team
manager for scheduling\n\n');
fprintf('\n***READ THE ABOVE TEXT BEFORE YOU START***\n');


%Enter your system traits
system_cost=input('\nEnter the total CHANGING subsystem budget in USD(This is
Amurrica): $');
while system_cost>team_budget
    fprintf('Your system cost is more than the teams budget!')
    system_cost=input('\nEnter the total CHANGING subsystem budget(This is
Amurrica): $');
end

system_dur=input('\nEnter the total subsystem manufacturing hours(total part
times): ');
old_svctime=input('\nEnter the old service time for your system (min): ');
new_svctime=input('\nEnter the new service time for your system (min): ');
num_parts=input('\nEnter the number of different parts: ');

    %Enter part information-function input start
    while totalpart_time~=system_dur %Prevent part times from not being equal
to total time
        totalpart_time=0;
        for i=1:num_parts
```

```
            ppercent_red=0;
            ppercent_yellow=0;
            ppercent_blue=0;
            ppercent_weld=0;


            fprintf('\nConsider Part %d\n', i);

            %Enter part times and skill percents
            part_name=input('What is the name of this part? ', 's');
            part_time=input('Enter the total time for the part in hours: ');
            num_part=input('Enter the number of this part you will make: ');
            total_percent=100;
            edit=1;
            while total_percent~=100 || edit==1 %Prevent total time percent
from going over 100%
                fprintf('\nRed Tag: Basic grinding, sawing, shearing,
drilling, bending, and media blasting\n');
                ppercent_red=input('Enter the percent of time which requires
a red tag: %');
              if ppercent_red<100
                    fprintf('\nWelder: Estimate the time per part assuming
the welder is already setup\n');
                    ppercent_weld=input('Enter the percent of time which
requires a welder: %');
                  if ppercent_red+ppercent_weld<100
                        fprintf('\nYellow Tag: Estimate the time per part on
Lathes and Mills including setup\n')
                      ppercent_yellow=input('Enter the percent of time which
requires a yellow tag: %');
                     if ppercent_red+ppercent_yellow+ppercent_weld<100
                       fprintf('\nBlue Tag: Estimate the time per part on CNC
Lathes and Mills including coding and setup\n');
                        ppercent_blue=input('Enter the percent of time which
requires a blue tag(CNC): %');
                     end
                 end
              end

              fprintf('\nPlease Review Traits For Part #%d: ', i);
              disp(part_name);
              fprintf('Part Manufacturing Time: %d Hours', part_time);
              fprintf('\nNumber of parts made: %d', num_part);
              fprintf('\nPart Percent Red: %d', ppercent_red);
              fprintf('\nPart Percent Yellow: %d', ppercent_yellow);
              fprintf('\nPart Percent Blue: %d', ppercent_blue);
              fprintf('\nPart Percent Weld: %d', ppercent_weld);

              edit=input('\nWould you like to edit this information?(yes=1 or
no=2) ');

total_percent=ppercent_red+ppercent_yellow+ppercent_blue+ppercent_weld;
                if total_percent~=100 && edit==2
                  fprintf('\nTotal percent not equal to 100\n');
                  ppercent_red=0; %Reset part percents for edit
```

```
                ppercent_yellow=0;
                ppercent_blue=0;
                ppercent_weld=0;
              end
              if edit==1
                ppercent_red=0; %Reset part percents for edit
                ppercent_yellow=0;
                ppercent_blue=0;
                ppercent_weld=0;
                part_time=input('Enter the total time for the part in
hours: ');
                num_part=input('Enter the number of this part you will
make: ');
              end
          end


          %For use in comparing and preventing part times from not being
          %equal to total time
          totalpart_time=totalpart_time+(num_part*part_time);

          %Calculate skill hours for each part
          ptime_red=(ppercent_red/100)*part_time*num_part;
          ptime_yellow=(ppercent_yellow/100)*part_time*num_part;
          ptime_blue=(ppercent_blue/100)*part_time*num_part;
          ptime_weld=(ppercent_weld/100)*part_time*num_part;

          %Calculate hours for each skill
          systime_red=systime_red+ptime_red;
          systime_yellow=systime_yellow+ptime_yellow;
          systime_blue=systime_blue+ptime_blue;
          systime_weld=systime_weld+ptime_weld;

          %Calculate resource load for each skill
          resource_red=systime_red/ttime_red;
          resource_yellow=systime_yellow/ttime_yellow;
          resource_blue=systime_blue/ttime_blue;
          resource_weld=systime_weld/ttime_weld;

          %Create matrix for part information storage and review
          part_descriptions(i,:)=[i part_time num_part ppercent_red
ppercent_yellow ppercent_blue ppercent_weld];
          part_names(i,:)={part_name};

      end
      if totalpart_time~=system_dur %Check for errors between sum of part
times and sum of manufacturing time (should be the same)
          fprintf('\nTotal part times do not equal total system
manufacturing time.\n');
          fprintf('Total Part Times: %d', totalpart_time);
          fprintf('\nTotal System Manufacturing Time: %d\n', system_dur);

      end
  end
```

```
    %Calculate Resource indices
    time_index=(resource_red + resource_yellow + resource_blue +
resource_weld)*manufacturing_weight;
    cost_index=(system_cost/team_budget)*cost_weight;
    resource_index=time_index+cost_index;

    %Calculate Benefit indices
    point_index=(system_weighted_score/total_weighted_score)*point_weight;
    svc_index=((old_svctime-new_svctime)/old_svctime)*service_weight;
    benefit_index=point_index+svc_index;

    %Print Results
    fprintf('\nPlease review your Part Traits\n\n');
    for i=1:num_parts
          fprintf('\nPart Name:');
          disp(part_names(i,1));
          fprintf('Part Time: %d Hours', part_descriptions(i,2));
          fprintf('\nNumber of parts made: %d', part_descriptions(i,3));
          fprintf('\nPart Percent Red: %d', part_descriptions(i,4));
          fprintf('\nPart Percent Yellow: %d', part_descriptions(i,5));
          fprintf('\nPart Percent Blue: %d', part_descriptions(i,6));
          fprintf('\nPart Percent Weld: %d\n', part_descriptions(i,7));
    end

    fprintf('\nThe Benefit Index For Your Subsystem is: %.5f THEOS\n',
benefit_index);
    fprintf('The Resource Index For Your Subsystem is: %.5f THEOS\n',
resource_index);

    fprintf('\nTypical High Benefit: 1.0167\n');
    fprintf('Typical Low Benefit: -1.0028\n');
    fprintf('Typical High Resource: 2.0200\n');
    fprintf('Typical Low Resource: 1.3000e-004\n');
    fprintf('\n***NOTE***\n   THESE ARE TYPICAL RESULTS. YOUR RESULTS MAY
VARY, ESPECIALLY WHEN CHANGING INDEX WEIGHTS\n\n');
end
```

## Appendix L. Benefit and Resource Quantification Algorithm Use Case

***BEFORE YOU START!!!***

1.) Have your team lead evaluate your sub-system benefit based on the Project Priority Matrix

2.) Have your team lead fill in all spaces in the code area that say "***ASK TEAM LEAD***" in green writing

3.) Finish your sub-system budget and add up all deliverable costs that are due to design changes

Ex: "Our sub-system decided to use a new kind throttle cable" This is a CHANGING DESIGN

Ex: "Our system decided to use the same rear caliper, but we cannot reuse the old one.

We need to buy a new one" This is NOT A CHANGING DESIGN

4.) Estimate a decrease or increase in service time due to design changes.

Have old and new service times ready.

Ex: Account for service times (assembly, adjustment, repair) that could change as a result of the new designs.

If bolting parts on will take the same time, you do not have to account for wrench turning time.

5.) Calculate the number of different parts by using the deliverables section in your problem

definition page and breaking every component down by the number of parts to be made.

Ex: An A-Arm May have a bearing holder, two tubes, and two threaded inserts. There are THREE DIFFERENT PARTS

6.) Estimate the total time each different part will take to manufacture in hours

7.) Add up the total manufacturing time for your system

Total System Hours = SUM(#DifferentParts*#PartsMade)

Ex: Part 1: Time = 2 hours--> 2 parts needed

Part 2: Time = 3 hours--> 3 parts needed

Total System Hours = (2 hours*2 parts) + (3 hours*3 parts)= 13 hours

8.) Estimate the percent of the total time each different part will take for each skill (red tag, welder, etc...)

Ex: A part takes 1 hour to weld and 9 hours to mill--The part is 10 percent welder and 90 percent yellow tag

9.) Write all of the information down and give it to your team manager for scheduling

***READ THE ABOVE TEXT BEFORE YOU START***

Enter the total CHANGING subsystem budget in USD(This is Amurrica): $1000

Enter the total subsystem manufacturing hours(total part times): 10

Enter the old service time for your system (min): 60

Enter the new service time for your system (min): 45

Enter the number of different parts: 2

Consider Part 1

What is the name of this part? Bearing Holder

Enter the total time for the part in hours: 2.5

Enter the number of this part you will make: 2

Red Tag: Basic grinding, sawing, shearing, drilling, bending, and media blasting

Enter the percent of time which requires a red tag: %50

Welder: Estimate the time per part assuming the welder is already setup

Enter the percent of time which requires a welder: %60

Please Review Traits For Part #1: Bearing Holder

Part Manufacturing Time: 2.50 Hours

Number of parts made: 2

Part Percent Red: 50

Part Percent Yellow: 0

Part Percent Blue: 0

Part Percent Weld: 60

Would you like to edit this information? (yes=1 or no=2) 2

Total percent not equal to 100

Red Tag: Basic grinding, sawing, shearing, drilling, bending, and media blasting

Enter the percent of time which requires a red tag: %50

Welder: Estimate the time per part assuming the welder is already setup

Enter the percent of time which requires a welder: %20

Yellow Tag: Estimate the time per part on Lathes and Mills including setup

Enter the percent of time which requires a yellow tag: %20

Blue Tag: Estimate the time per part on CNC Lathes and Mills including coding and setup

Enter the percent of time which requires a blue tag (CNC): %10

Please Review Traits For Part #1: Bearing Holder

Part Manufacturing Time: 2.50 Hours

Number of parts made: 2

Part Percent Red: 50

Part Percent Yellow: 20

Part Percent Blue: 10

Part Percent Weld: 20

Would you like to edit this information? (yes=1 or no=2) 2

Consider Part 2

What is the name of this part? Suspension Links

Enter the total time for the part in hours: 5

Enter the number of this part you will make: 2

Red Tag: Basic grinding, sawing, shearing, drilling, bending, and media blasting

Enter the percent of time which requires a red tag: %100

Please Review Traits For Part #2: Suspension Links

Part Manufacturing Time: 5 Hours

Number of parts made: 2

Part Percent Red: 100

Part Percent Yellow: 0

Part Percent Blue: 0

Part Percent Weld: 0

Would you like to edit this information? (yes=1 or no=2) 2

Total part times do not equal total system manufacturing time.

Total Part Times: 15

Total System Manufacturing Time: 10

Consider Part 1

What is the name of this part? Bearing Holder

Enter the total time for the part in hours: 5

Enter the number of this part you will make: 1

Red Tag: Basic grinding, sawing, shearing, drilling, bending, and media blasting

Enter the percent of time which requires a red tag: %100

Please Review Traits For Part #1: Bearing Holder

Part Manufacturing Time: 5 Hours

Number of parts made: 1

Part Percent Red: 100

Part Percent Yellow: 0

Part Percent Blue: 0

Part Percent Weld: 0

Would you like to edit this information? (yes=1 or no=2) 2

Consider Part 2

What is the name of this part? 5

Enter the total time for the part in hours: 1

Enter the number of this part you will make: 5

Red Tag: Basic grinding, sawing, shearing, drilling, bending, and media blasting

Enter the percent of time which requires a red tag: %100

Please Review Traits For Part #2: 5

Part Manufacturing Time: 1 Hours

Number of parts made: 5

Part Percent Red: 100

Part Percent Yellow: 0

Part Percent Blue: 0

Part Percent Weld: 0

Would you like to edit this information? (yes=1 or no=2) 2

Please review your Part Traits

Part Name: 'Bearing Holder'

Part Time: 5 Hours

Number of parts made: 1

Part Percent Red: 100

Part Percent Yellow: 0

Part Percent Blue: 0

Part Percent Weld: 0

Part Name: 'Links'

Part Time: 1 Hours

Number of parts made: 5

Part Percent Red: 100

Part Percent Yellow: 0

Part Percent Blue: 0

Part Percent Weld: 0

The Benefit Index For Your Subsystem is: 0.60425 THEOS

The Resource Index For Your Subsystem is: 0.10135 THEOS

Typical High Benefit: 1.0167

Typical Low Benefit: -1.0028

Typical High Resource: 2.0200

Typical Low Resource: 1.3000e-004

***NOTE***

THESE ARE TYPICAL RESULTS. YOUR RESULTS MAY VARY, ESPECIALLY WHEN CHANGING INDEX WEIGHTS

# Appendix M. Step 7.1: How to Use the Benefit and Resource Program

**IDEA:**

The benefit and resource program is meant as a way to compare design alternatives or sub-systems to each other. Sub-system leads can choose the best design alternative before the PDR by comparing the indexes that this program calculates. The team lead can cut bad sub-system designs by comparing the index for each sub-system.

This program is based on the idea of “best bang for the buck”. Designs that have better performance (best bang) relative to another AND have a lower resource usage (lowest buck) are the better designs. Higher benefit indexes are better. Lower resource indexes are better. See “Benefit and Resource Index slides”.

Below are instructions for the sub-system leads and the team leads. It will tell how to use the program for design alternatives before the PDR or for sub-system cutting before the CDR.

## **INSTRUCTIONS**:

### CDR:TEAM LEAD

1. Add up all of the sub-system manufacturing hours.

2. Add up all of the sub-system budgets

3. Use the CDR information to re-evaluate each sub-system using the sub-system priority matrix

4. Count the total number of people on the team that have a red, yellow, and blue tag as well as the number of welders

5. Open 'br_index' in MATLAB and fill out all numbers next to the notes in green that say "%***ASK TEAM LEAD***" in green writing. Use the numbers you calculated for steps 1-4.

   a. If you feel lucky, play with the index weights

6. Send the program to all of your sub-system leads with all of the new numbers

7. Once the sub-system leads follow the instructions under "CDR: SUB-SYSTEM LEAD", get the indexes from them. Compare the indexes and, if needed, cut bad designs.

### ***Optional: Design Alternatives for PDR
### PDR: SUB-SYSTEM LEAD

1. Open "br_index" program in MATLAB

2. **Team Lead:** Count the total number of people on the team that have a red, yellow, and blue tag as well as the number of welders and enter into program next to the notes in green that say "%***ASK TEAM LEAD***" in green writing

3. Use your weighted design alternative matrix score (from PDR slides) and put in place of “system_weighted_score”.
4. Use an estimate of your sub-system budget and put in place of “team_budget”.
5. Use an estimate of your total sub-system manufacturing time and put in place of “total_hrs”.
6. Press the green arrow (looks like a play button)
7. When prompted for the total number of different parts, enter 1.
8. Use service times, part cost (instead of sub-system cost), manufacturing time, and skill percent (see program prompt) for the deliverable alternative.
9. Record the benefit and resource indexes
10. Repeat for all other alternatives being considered
11. Better alternatives will have a higher benefit and lower resource index. Choose the better alternative to proceed with the critical design review.

**CDR:SUB-SYSTEM LEAD**

1.) Have your team lead evaluate your sub-system benefit based on the Project Priority Matrix

2.) Have your team lead fill in all spaces in the code area that say "***ASK TEAM LEAD***" in green writing

3.) Finish your sub-system budget and add up all deliverable costs that are due to design changes

Ex: "Our sub-system decided to use a new kind throttle cable" This is a CHANGING DESIGN

Ex: "Our system decided to use the same rear caliper, but we cannot reuse the old one. We need to buy a new one" This is NOT A CHANGING DESIGN

4.) Estimate a decrease or increase in service time due to design changes.
    Have old and new service times ready.

Ex: Account for service times (assembly, adjustment, repair) that could change as a result of the new designs.

If bolting parts on will take the same time, you do not have to account for wrench turning time.

5.) Calculate the number of different parts by using the deliverables section in your problem
definition page and breaking every component down by the number of parts to be made.
Ex: An A-Arm May have a bearing holder, two tubes, and two threaded inserts. There are THREE DIFFERENT PARTS

6.) Estimate the total time each different part will take to manufacture in hours

7.) Add up the total manufacturing time for your system
    Total System Hours = SUM(#DifferentParts * #PartsMade)

Ex: Part 1: Time = 2 hours--> 2 parts needed
    Part 2: Time = 3 hours--> 3 parts needed
    Total System Hours = (2 hours*2 parts) + (3 hours*3 parts)= 13 hours

8.) Estimate the percent of the total time each different part will take for each skill (red tag, welder, etc...)

Ex: A part takes 1 hour to weld and 9 hours to mill--The part is 10 percent welder and 90 percent yellow tag

9.) Write all of the information down and give it to your team manager for scheduling

```
You may quit the program at any time by pressing CTRL+C,
HOWEVER ALL YOUR INFORMATION WILL BE LOST
```

## Appendix N. Step 7.2: Benefit-Resource Slides Outline

Bang for the buck
- ✖ There is limited time and budget
- ✖ The team lead needs to know which designs to cut
- ✖ No guarantee that your design will make it on the car

Quantifying bang for the buck
- ✖ A program was made to help the team lead decide which designs to cut, if necessary
- ✖ Designs must provide benefit
- ✖ (serviceability, performance gains, etc.)
- ✖ Designs must not use too many resources
- ✖ (people, skills, money, time, etc.)
- ✖ Bang for the buck is quantified
  - ✖ Bang=Benefit
  - ✖ Buck=Resources

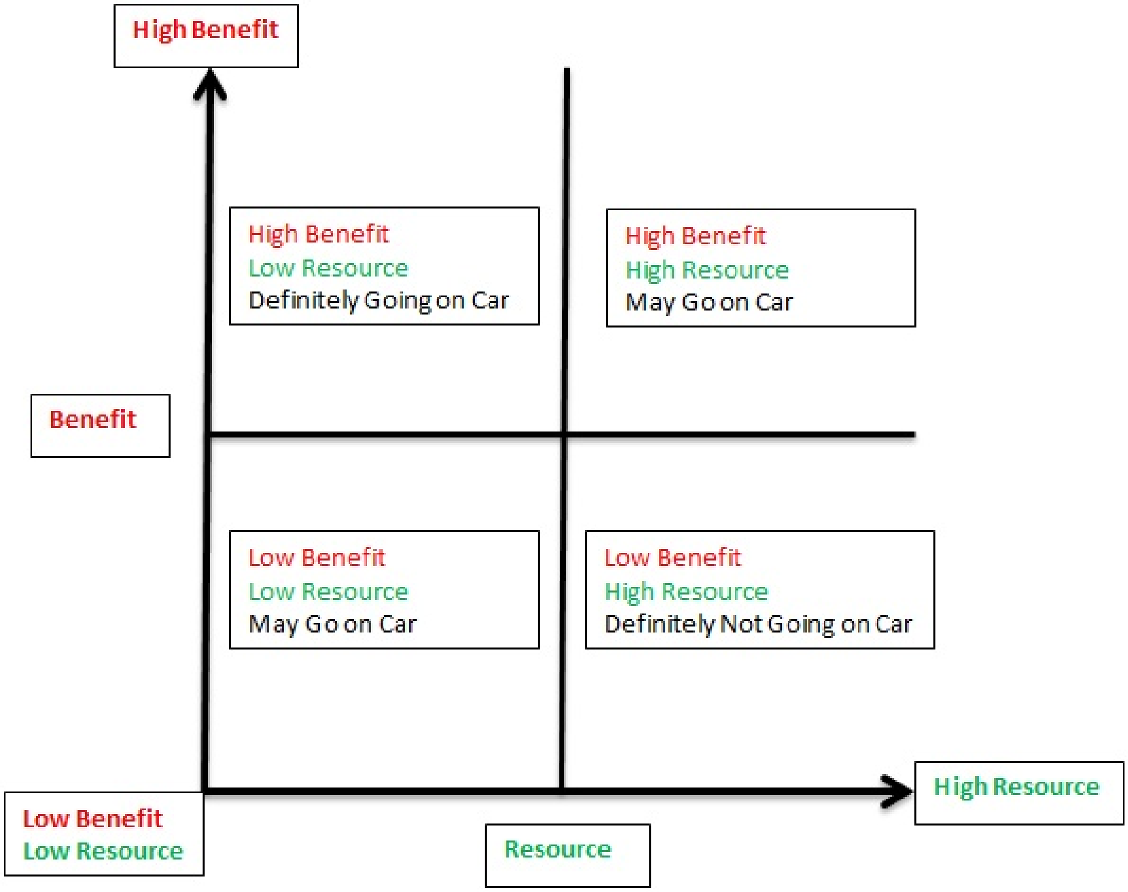
Good example
- ✖ A frame redesign makes the drivetrain easier to service and cuts down the number of tubes
- ✖ This decreases service time and decreases sub-system cost
- ✖ This design change will definitely go on the car

Bad example
- ✖ A new suspension design decided that using carbon fiber would save a half pound
- ✖ Using carbon fiber triples the cost of material and quadruples manufacturing time
- ✖ There is no way that design change will go on the car

The program
- ✖ All sub-system leads must use the program to quantify their design's "bang for the buck"
- ✖ How NOT to beat the program
- ✖ No Lying
- ✖ No Cheating
- ✖ No Stealing
- ✖ No "Cooking the Books"
- ✖ No "Baiting the Hooks"
- ✖ No Likewise Shady Dealings

How to use the program
- ✖ Ask your team lead for the file
- ✖ Open the file in Matlab
- ✖ Locate and click the green arrow to run the program
- ✖ Follow the instructions and prompts

How to beat the program
- ✖ Meet your system goals from your project definition sheet
- ✖ Reduce service times
- ✖ Decrease the part manufacturing times
- ✖ Design parts to use more red and yellow tag skills
- ✖ Decrease the cost of your system
- ✖ Only use this program for deliverables that you are changing
- ✖ Recycled deliverables do not cost anything and will require little resources.


High Benefit
High Benefit
Low Resource
Definitely Going on Car
High Benefit
High Resource
May Go on Car
Benefit
Low Benefit
Low Resource
May Go on Car
Low Benefit
High Resource
Definitely Not Going on Car
High Resource
Low Benefit
Low Resource
Resource

## Appendix O. Step 7.3: Risk Analysis Template

**Definitions:**

Risk Event: Brainstorm generalized things that could go wrong with your sub-system.

I.e. May not pass rules, may break, may not have enough time to manufacture

Likelihood: Assign a value (1-5) which describes how likely the risk is to occur

Impact: Assign a value (1-5) which describes the impact of the event

I.e. A system not passing rules may stop the team from competing and would have an impact=5

Detention Difficulty: Ask how difficult it is to stop the risk from ever occurring

I.e. If all you have to do to avoid the system from not passing rules is change one bolt, then the detention difficulty=1

When: When is the risk likely to occur? Consider the phases of the project such as definition, planning, building, and competition

Response: Consider how the risk will be reduced. Typically, a risk can be accepted, avoided, monitored and prepare contingencies, transferred, or mitigate (work hard to reduce the risk). Accepting the risk should be a last resort.

Contingency Plan: If the risk comes to fruition, what is the backup plan?

Trigger: What event will occur that will trigger the contingency plan?

I.e. Once the bolt is inspected, the trigger for the contingency plan should be the judge saying that it will not pass technical inspection.

Who's Responsible: Assign a member of the team to reduce the risk using the Response and enacting the contingency plan. They will be responsible for this risk until the new competition year begins.

**Risk Assessment**

| Risk Event | Likelihood | Impact | Detention Difficulty |
|---|---|---|---|
| | | | |
| | | | |
| | | | |
| | | | |

**Risk Response**

| Risk Event | When | Response | Contingency Plan | Trigger | Who's Responsible |
|---|---|---|---|---|---|
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |

# Appendix P. Step 8: Sign-Out Sheet

**Name:** _______________________________________________ **Date:** ____________________
**Task Description:** Task #1. _________________________________________________________________
(If Necessary) Task #2. _________________________________________________________________
**Tools Used (check all that apply):**
1. ☐Mill ☐Lathe ☐Drill Press ☐Pneumatic Cutoff Wheel ☐Plasma Cutter ☐ Band saw ☐ Welder ☐Other________________
2. ☐Mill ☐Lathe ☐Drill Press ☐Pneumatic Cutoff Wheel ☐Plasma Cutter ☐ Band saw ☐ Welder ☐Other________________
**Estimated Setup Time (minutes):**
1. ☐0-10 ☐10-20 ☐20-30 ☐30-40 ☐40-50 ☐50-60 ☐Other_________________
2. ☐0-10 ☐10-20 ☐20-30 ☐30-40 ☐40-50 ☐50-60 ☐Other_________________
**Total Time Today (hours):**
1. ☐0-1 ☐1-2 ☐2-3 ☐3-4 ☐4-5 ☐5-6 ☐6-7 ☐7-8 ☐8-9 ☐9-10 ☐10-11 ☐11-12 ☐Other________________
2. ☐0-1 ☐1-2 ☐2-3 ☐3-4 ☐4-5 ☐5-6 ☐6-7 ☐7-8 ☐8-9 ☐9-10 ☐10-11 ☐11-12 ☐Other________________
**Estimated Percent Complete:**
1. ☐0-10 ☐10-20 ☐20-30 ☐30-40 ☐40-50 ☐50-60 ☐60-70 ☐70-80 ☐80-90 ☐90-100 ☐Finished
2. ☐0-10 ☐10-20 ☐20-30 ☐30-40 ☐40-50 ☐50-60 ☐60-70 ☐70-80 ☐80-90 ☐90-100 ☐Finished
**Specific Comments:** Please provide comments that may clarify times or help someone doing a similar task in the future. Include any last minute design changes.
Ex: "I had to change the grinding wheel to a cutoff wheel during setup." or "It would be faster if we didn't if there was no pocket in the trunion block" (Use back if necessary)
____________________________________________________________________________________________
____________________________________________________________________________________________
____________________________________________________________________________________________
____________________________________________________________________________________________
___________________________________________________________

--Cut---------------------------------------------------------------------------------------------------------------------------------------------------------------------------

**Sign-Out Sheet**
**Name:** _______________________________________________ **Date:** ____________________
**Task Description:** Task #1. _________________________________________________________________
(If Necessary) Task #2. _________________________________________________________________
**Tools Used (check all that apply):**
1. ☐Mill ☐Lathe ☐Drill Press ☐Pneumatic Cutoff Wheel ☐Plasma Cutter ☐ Band saw ☐ Welder ☐Other________________
2. ☐Mill ☐Lathe ☐Drill Press ☐Pneumatic Cutoff Wheel ☐Plasma Cutter ☐ Band saw ☐ Welder ☐Other________________
**Estimated Setup Time (minutes):**
1. ☐0-10 ☐10-20 ☐20-30 ☐30-40 ☐40-50 ☐50-60 ☐Other_________________
2. ☐0-10 ☐10-20 ☐20-30 ☐30-40 ☐40-50 ☐50-60 ☐Other_________________
**Total Time Today (hours):**
1. ☐0-1 ☐1-2 ☐2-3 ☐3-4 ☐4-5 ☐5-6 ☐6-7 ☐7-8 ☐8-9 ☐9-10 ☐10-11 ☐11-12 ☐Other________________
2. ☐0-1 ☐1-2 ☐2-3 ☐3-4 ☐4-5 ☐5-6 ☐6-7 ☐7-8 ☐8-9 ☐9-10 ☐10-11 ☐11-12 ☐Other________________
**Estimated Percent Complete:**
1. ☐0-10 ☐10-20 ☐20-30 ☐30-40 ☐40-50 ☐50-60 ☐60-70 ☐70-80 ☐80-90 ☐90-100 ☐Finished
2. ☐0-10 ☐10-20 ☐20-30 ☐30-40 ☐40-50 ☐50-60 ☐60-70 ☐70-80 ☐80-90 ☐90-100 ☐Finished

**Specific Comments:** Please provide comments that may clarify times or help someone doing a similar task in the future. Include any last minute design changes.

Ex: "I had to change the grinding wheel to a cutoff wheel during setup." or "It would be faster if there was no pocket in the trunion block" (Use back if necessary)

______________________________________________________________________________________
______________________________________________________________________________________
______________________________________________________________________________________
______________________________________________________________________________________
_______________________________________________________

# Appendix Q. Step 9: Test Preparation and Incident Log

Report Prepared by: Date:

Test Location:

**PRE-TEST PREPARATION**

**Test Purpose and Goals:** What is the purpose of the test? What data do you wish to collect? (ex: The purpose of the test is to verify that the suspension has only 2 degrees of camber change during bump)

**Test Procedure:** (ex: measure the ride height, raise the car off of the ground, cycle the suspension for bump, use angle finder to measure the camber change)

**TEST RESULTS**

**Data:** Log the resulting data.

**Conclusions & Recommendations:** Use the data along with the goals to draw conclusions and provide future recommendations (ex: The camber change was lower in the Optimum-K model. Find the cause. Inconsistency was likely due to manufacturing inaccuracy.)

**INCIDENT LOG**

**Incident Description:** TAKE A PICTURE. Also, describe the incident.

**Countermeasure:** What method was used to fix the problem. (Note: the word countermeasure is used to imply that there may be a better solution in the future. This was done to keep continuous improvement in mind)

**Future Recommendations:** What do you suggest be done in the future (if not the countermeasure) to fix the problem, perhaps on a more permanent basis.

# Appendix R. Step 10: Team Competition Assignments

**Drivers**

Drive during competition between and during dynamic events including brake testing. Drivers must be present the entire time during technical inspection and must be able to perform the vehicle egress as stated by rules. Drivers must also have the most seat time in the vehicle of any team members.

1.
2.

**Pit Crew**

Members of the pit crew must stand in the pit area during the entirety of the Endurance race. One member must refuel the vehicle while the other holds the fire extinguisher and must be able to use it in the event of a fire. The pit crew must also report any damage to the team lead or manager immediately. The pit crew is also responsible for buckling the driver in after refueling and/or in the event of a driver switch.

1.
2.

**Maintenance**

Anyone doing maintenance on the car must have thorough knowledge of the car as well as "on the fly" machining practices. Their job includes but is not limited to: fixing any damage incurred to the vehicle during operation, making sure all fluid levels are checked before each event, and making any alterations to the vehicle in the event of a failed technical inspection.

1.
2.
3.

**Spotters**

During the first dynamic day, one spotter will watch each of the four events: acceleration, maneuverability, rock crawl, and hill climb. If track times are drastically changing with the number of runs, the team lead or manager must be notified immediately. Once the Baja car makes it to the track to which the spotter was designated, that spotter will talk with the driver to ensure that the best routes and maneuvers are taken.

During the second dynamic day, spotters will stand at pre-determined locations along the side of the track and report anything out of the ordinary pertaining to the Baja car to the team leader or team manager immediately.

1. Acceleration:
2. Hill Climb:
3. Rock Crawl:

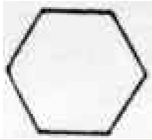
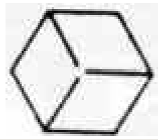
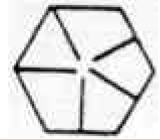
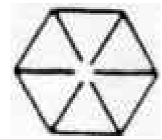
4. Maneuverability:

**Organizers:**

Organizers are responsible for the safety box during the entirety of competition.  They must know where all tools/supplies are located at all times.  Organizers are also responsible to make sure that all items are accounted for after use, especially during and after emergency maintenance.  As such, only organizers can hand out tools.

There will be one lead organizer who is known as the "Tool God".  The Tool God is in charge of tool/supply organization and must make sure that everything that is needed is packed and everything that is packed is repacked at the end of the competition.  Finally, the Tool God is responsible for the torque wrench.  The Tool God must torque every bolt down to the bolt's specification before every dynamic event and any bolts which have been changed during the endurance race.  For the Tool God's convenience, a bolt specification chart has been provided.

1. Tool God:
2.
3.

| U.S. BOLT GRADES | | | |
|---|---|---|---|
|  |  |  |  |
| **SAE 2** | **SAE 5** | **SAE 7** | **SAE 8** |

| | **2** | **5** | **7** | **8** | **SOCKET HEAD CAP SCREW** |
|---|---|---|---|---|---|
| I.D. Marks | No markings | 3 lines | 5 lines | 6 lines | Allen head |
| Material | Low carbon | Medium-carbon, tempered | Medium-carbon, quenched & tempered | Medium-carbon, quenched & tempered | High-carbon, quenched & tempered |
| Tensile strength (Minimum) | 74,000 psi | 120,000 psi | 133,000 psi | 150,000 psi | 160,000 psi |

U.S. BOLT TORQUE SPECIFICATIONS

*Torque in pounds-foot*

| | | **2** | **2** | **5** | **5** | **7** | **7** | **8** | **8** | **Socket head cap screw** | **Socket head cap screw** |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Bolt Dia. | Thread per inch | **Dry** | **Oiled** | **Dry** | **Oiled** | **Dry** | **Oiled** | **Dry** | **Oiled** | **Dry** | **Oiled** |
| 1/4 | 20 | 4 | 3 | 8 | 6 | 10 | 8 | 12 | 9 | 14 | 11 |
| 1/4 | 28 | 6 | 4 | 10 | 7 | 12 | 9 | 14 | 10 | 16 | 13 |
| 5/16 | 18 | 9 | 7 | 17 | 13 | 21 | 16 | 25 | 18 | 29 | 23 |
| 5/16 | 24 | 12 | 9 | 19 | 14 | 24 | 18 | 29 | 20 | 33 | 26 |
| 3/8 | 16 | 16 | 12 | 30 | 23 | 40 | 30 | 45 | 35 | 49 | 39 |
| 3/8 | 24 | 22 | 16 | 35 | 25 | 45 | 35 | 50 | 40 | 54 | 44 |
| 7/16 | 14 | 24 | 17 | 50 | 35 | 60 | 45 | 70 | 55 | 76 | 61 |
| 7/16 | 20 | 34 | 26 | 55 | 40 | 70 | 50 | 80 | 60 | 85 | 68 |
| 1/2 | 13 | 38 | 31 | 75 | 55 | 95 | 70 | 110 | 80 | 113 | 90 |
| 1/2 | 20 | 52 | 42 | 90 | 65 | 100 | 80 | 120 | 90 | 126 | 100 |
| 9/1 | 12 | 52 | 42 | 110 | 80 | 135 | 100 | 150 | 110 | 163 | 130 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 6 | | | | | | | | | | | |
| 9/16 | 18 | 71 | 57 | 120 | 90 | 150 | 110 | 170 | 130 | 181 | 144 |
| 5/8 | 11 | 98 | 78 | 150 | 110 | 190 | 140 | 220 | 170 | 230 | 184 |
| 5/8 | 18 | 115 | 93 | 180 | 130 | 210 | 160 | 240 | 180 | 255 | 204 |
| 3/4 | 10 | 157 | 121 | 260 | 200 | 320 | 240 | 380 | 280 | 400 | 320 |
| 3/4 | 16 | 180 | 133 | 300 | 220 | 360 | 280 | 420 | 320 | 440 | 350 |
| 7/8 | 9 | 210 | 160 | 430 | 320 | 520 | 400 | 600 | 460 | 640 | 510 |
| 7/8 | 14 | 230 | 177 | 470 | 360 | 580 | 440 | 660 | 500 | 700 | 560 |
| 1 | 8 | 320 | 240 | 640 | 480 | 800 | 600 | 900 | 680 | 980 | 780 |
| 1 | 12 | 350 | 265 | 710 | 530 | 860 | 666 | 990 | 740 | 1060 | 845 |

Top

| BOLT TORQUE FACTORS | |
|---|---|
| **LUBRICANT OR PLATING** | **TORQUE CHANGES** |
| Oil | Reduce torque 15% to 25% |
| Dry Film (Teflon or moly based) | Reduce torque 50% |
| Dry Wax (Cetyl alcohol) | Reduce torque 50% |
| Chrome plating | No change |
| Cadmium plating | Reduce torque 25% |
| Zinc plating | Reduce torque 15% |

# Appendix S. Step 11: Post Season Debrief Questions

Please fill out this questionnaire in the spirit of constructive criticism. State the problem in simple terms and suggest solutions. THERE IS NO NEED TO TEAR DOWN A CLUB MEMBER. You may consider specific jobs that were performed that may need improvement or suggest tasks that may have helped the team. Please consider any and all suggestions that may be improved upon in future years. You may write one the back, if needed.

During the current season, review the performance of the team lead, team manager, and SAE officers. This section is to remain anonymous.

1. What specific suggestions would you give to improve the performance of the current team lead?

2. What specific suggestions would you give to improve the performance of the current team manager?

3. What specific suggestions would you give to the SAE officers for next year to improve the club as a whole or the team as a whole?

4. Did you have ample time and resources to complete your project? Do not simply answer yes/no. Also provide feedback for improvement.

5. When faced with a problem, was the team lead, team manager, or system lead always successful in working with you to find a solution? Do not simply answer yes/no. If you have a specific example please explain.

6. Based on this season's performance, who would you suggest for the team lead or team manager's positions and why?

7. Are there any other suggestions to help the team be more successful during next year's competition?

8. Think of any issues that you may have had staying on schedule. What specific improvements would you make to the schedule?

9. Think of any issues that you may have had using the management templates. What specific improvements would you make to the templates (including this one)?

10. Think of any issues that you may have had with the management process. What specific improvements would you make to the process?

Sub-system: ______________________________
Sub-System Lead: ______________________________
Sub-System Team: ______________________________
______________________________

_____________________
________

Please review the definitions sheet for your subsystem from the beginning of the season.

1. Were the system problems from last year solved with your new design? ☐Yes (skip 1a) ☐No
    a. If no, what suggestions do you have to solve the problems from last season?

2. What problems did you face during testing or competition that needs to be fixed by next year's design?

3. Were your system's goals specific, measurable, and attainable? ☐Yes (skip 4b) ☐No (skip 4a)
    a. Did you meet those goals? ☐Yes ☐No
        i. If no, how would you suggest that next year's design team meet those goals?
    b. How would you suggest that those goals are changed so that next year's design team can measure and attain them?

4. Were your system's success metrics specific, measurable, and attainable? ☐Yes (skip 5b) ☐No (skip 5a)
    a. Was your sub-system team successful? ☐Yes ☐No
        i. If no, how would you suggest that next year's design team meet those goals?

b. How would you suggest that those metrics are changed so that next year's design team can measure and attain them?

5. Identify any stakeholders that were missed.

6. Identify any deliverables that were missed.

7. Look at your risk analysis. Were there any risks that were not assessed that should have been? i.e. Something unforeseen went wrong with your system (during manufacturing, testing, or competition) and was not on your risk analysis. List those events here.

8. Were any of the risks listed on your risk analysis realized (did any of them happen)? If so, did the person responsible follow the contingency described on your risk analysis?

9. What are the most important things you learned this year?