Financial Reporting at the MIT Formula SAE Team: A Case Study

by

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Submitted to the Department of Mechanical Engineering in Partial Fulfillment of the Requirements for the Degree of

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ABSTRACT

A case study was performed on the financial reporting at the MIT Formula SAE team. For each section of the car it was necessary to provide three main financial documents: Bill of Materials, Process Descriptions, and Fasteners. Additionally, the team had to adhere to specific guidelines for preparing these documents and for compiling them all together to create the team's cost report.

The purpose of the case study was threefold. First, it was intended to improve upon the quality and score of the cost report from previous years. Second, it was intended to alleviate some of the pressure from the team managers by not having to worry about preparing the cost report themselves. Finally, the case study was intended to help facilitate the preparation of the cost report in future years, so it does not have to be overshadowed by the completion of the vehicle. Therefore, the trend of increasing performance of the cost report can be maintained.

In the end, the study proved to increase the team's cost report score, allowed the team managers to focus more on the production of the vehicle, and yielded templates and instructions, as well as a standard, for preparing future cost reports.

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INTRODUCTION

Each year the MIT Formula SAE (Society of Automotive Engineers) team conceives, designs, fabricates, and competes with a small formula-style racing car. Colleges and universities from all over the world participate in Formula SAE, and the year culminates in May when each team takes its finished vehicle to Detroit, MI in order to put its vehicle to the test via various scoring events (see Table 1).

Static Events	**Points**
Presentation	75
Engineering Design	150
Cost Analysis	100
Dynamic Events	**Points**
Acceleration	75
Skid-Pad	50
Autocross	150
Fuel Economy	50
Endurance	350
Total Points	**1,000**

Table 1: Breakdown of the scoring events (reproduced from 2005 Formula SAE Rules).

The case study performed focused on the cost analysis event, which is worth 10% of the team's score. The cost analysis event is broken down even further (see Table 2). Of the 100 points allocated to the cost analysis, the cost report is responsible for 30 of these points. Upon first glance, one might think 30 points is not very important in a competition with a 1000 point maximum. But in a competition with 120+ participants, having those 30 points can prove to be the difference in finishing 7 or 8 spots higher than if the team did not have them.

The MIT Formula SAE team is young; it was created only a few years ago. While many institutions have a deep Formula SAE program already established, MIT is still building and

$\frac{30 \times (25{,}000 - Pyour)}{25{,}000 - Pmin}$	30 Points	Lowest cost – each of the participating schools will be ranked by total adjusted retail cost from the BOM and given 0-30 points based on the formula on the left. Pyour is the adjusted cost of your car (with penalties), and Pmin is the adjusted cost of the lowest cost car. If Pyour is greater than $25,000 US, the car will be disqualified from the Cost Event.
	30 Points	The Cost Report – written, professional presentation of cost data – The report score will be given based on the quality of the cost report, its accuracy and thoroughness. The range for the report score is 0 – 30 points.
	20 Points	Event Day/Visual Inspection – The cars will be reviewed for part content and manufacturing feasibility. 0 – 20 points.
	20 Points	Event Day/Manufacturing Processes – The teams must be prepared to discuss in detail the manufacturing processes for 2 items chosen at random form the list in Section 4.3.5. 0 – 10 points per item.
Total	100 Points	

Table 2: Breakdown of the Cost Analysis event (reproduced from 2005 Formula SAE Rules).

structuring its team. These other institutions are essentially on "cruise control." Each year they utilize their past designs and make any necessary improvements to increase their current year performance. This allows them to build their car quickly and test it thoroughly before competition. Because MIT's team is young, still learning, and still working out the kinks, completing the car on time each year has proved to be very challenging. If there is no car, there is no MIT team at competition, period. Therefore, it has been the practice of the team managers to put the cost report on the back burner until the last minute, so they can concentrate all their efforts on completing the vehicle. This practice of completing the cost report at the last minute has resulted in incomplete and unprofessional cost reports. Although they finished the car in time for competition, they lost out on much of the cost report score, which could have been vital in the end in improving the team's final score.

Therefore, it was the purpose of this case study to improve the quality of the cost report, allow

team managers to focus on the construction of the vehicle, and lay groundwork to facilitate future preparations of the cost report in order to continually improve its thoroughness and professionalism.

METHODS

The first step in taking on such a project was to learn the rules and guidelines within the Formula SAE realm. The national SAE organization released a booklet of rules that each team had to adhere to in order to qualify its vehicle to compete. The booklet was entitled 2005 Formula SAE Rules (Rules). This was the booklet used for the 2004-2005 academic year. Figure 1 portrays Section 4.3.4.1 of the Rules, the general requirements of the cost report. These requirements basically state that the cost report be an accurate representation of the cost it took for the

4.3.4.1 General Requirements
The Cost Report must:

(A) Reflect the actual, one-off, prototype vehicle brought to the event in terms of specification.

(B) List and cost every part on the prototype vehicle. This includes any data acquisition systems and radios if they are fitted on the vehicle at any time during the competition. The only exceptions are that, per Section 4.3.7 of the Rules, any finish and on-board fire suppression systems do not need to be included in the cost.

(C) Be based on the estimated costs of materials, fabrication, and assembly of the car. The costs shall be calculated as defined in Section 4.3.6 of these rules.

(D) Be based on the actual manufacturing technique used on the prototype, e.g. cast parts on the prototype should be costed as cast, and fabricated parts as fabricated, etc.

The reported cost of the prototype vehicle will exclude R&D, tooling (e.g. jigs, moulds, patterns, and dies), capital expenditures (e.g. plant, machinery, and tools). The prototype vehicle's calculated cost should not exceed $25,000. If the cost exceeds this outer boundary, it will be disqualified from the Cost Event and receive zero points for the event.

Figure 1: Section 4.3.4.1 of the Rules (reproduced from 2005 Formula SAE Rules).

team to bring the prototype vehicle to its current state at competition, less the exceptions of parts listed in the Rules. This required each team member to keep track of his own components, knowing exactly how much it cost him to fabricate them.

In order to facilitate the judging of a team's cost report, SAE set an accounting standard for each team to follow. This standard consisted of three main documents: Bill of Materials (BOM), Process Descriptions, and Fasteners. A BOM was provided for each of the 8 commodity sections of the vehicle: Brake System, Engine & Drivetrain, Frame & Body, Instruments & Wiring, Miscellaneous, Fit & Finish, Steering System, Suspension & Shocks, and Wheels & Tires. Within the BOM, the cost of each component within that commodity was reported. A component was labeled as either purchased or manufactured on site. Furthermore, manufactured on site meant that the component was either entirely fabricated on site or was purchased and altered on site. Each component that was deemed manufactured on site had to be represented in the Process Descriptions. Here the material and process labor utilized to manufacture the component were recorded. Additionally, fasteners were considered separate when being accounted for because they were reported on the Fasteners document. The Fasteners total was then in turn reported on the BOM. Finally, all labor used to assemble the components into the commodity and/or onto the vehicle was reported on the respective BOM. Each and every commodity section contained these three fundamental financial documents, outlining the cost of producing the commodity. Figure 2 illustrates this process visually via a flowchart. Naturally, the chart was extrapolated to include all 8 commodities and all the components in each commodity. Although simplistic, it conveys the basic process utilized when accounting for costs.

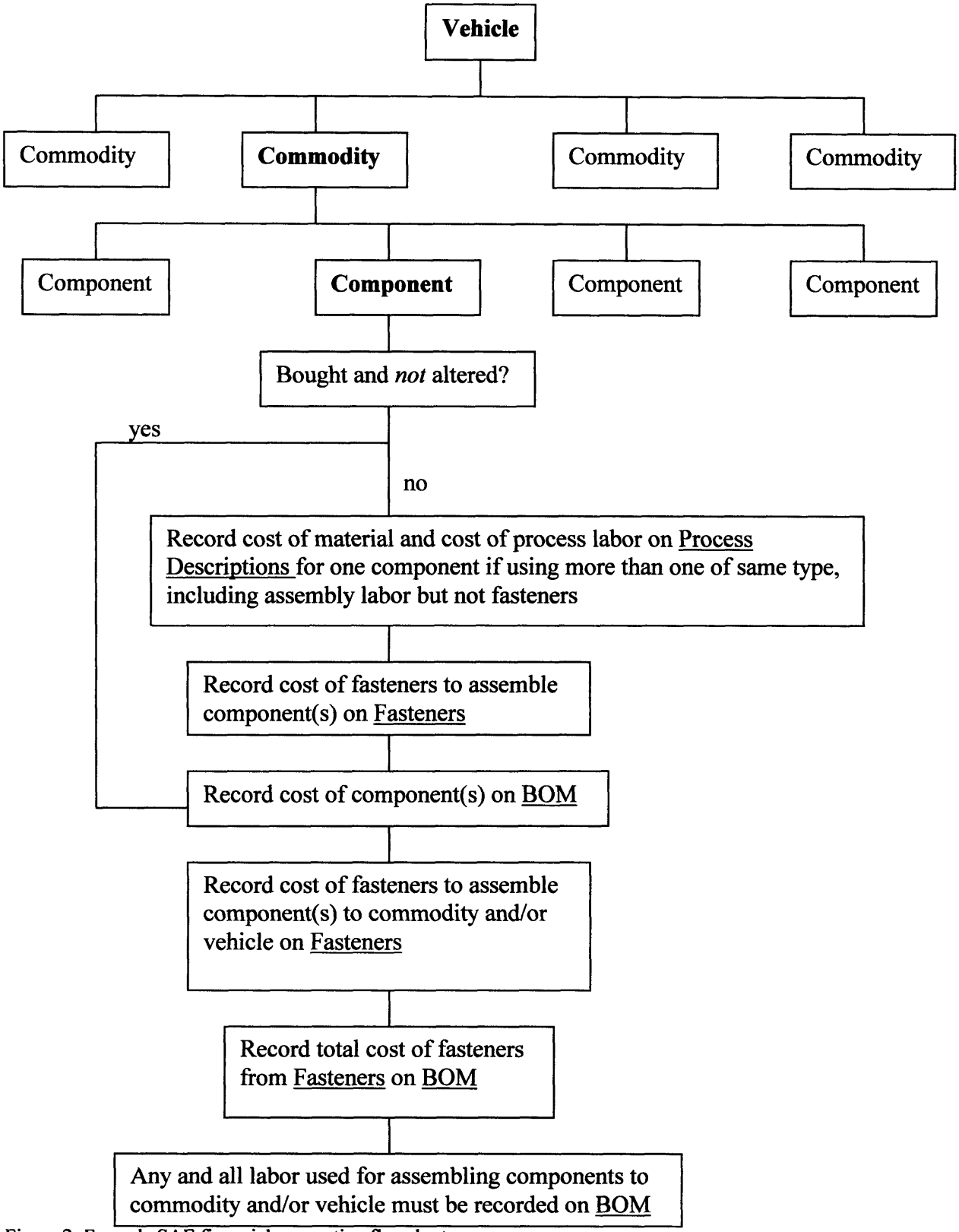

Figure 2: Formula SAE financial accounting flowchart.

In order to set a standard for every team's costing, SAE provided a series of costing tables for commonly used materials and processes. Table 3 illustrates an example of such a costing table.

Mild steel, e.g. 1010, 1025	$0.30/pound
Aluminum	$0.75/pound
Labor (all activity)	$35.00/hour
Tube bends	$0.75/bend

Table 3: Example of Costing Tables from the Rules (reproduced from 2005 Formula SAE Rules).

Therefore, no matter how much a team actually paid for their aluminum, they had to report it at $0.75/pound. This kind of standard prevented a team from decreasing their costs through discounts they may have received. These costing tables were applied in the Processes Descriptions document, where a manufactured component's cost of material and process labor were outlined.

An example utilizing the above SAE procedures follows. The 2005 MIT Formula SAE team manufactured a Floor Pan for the Frame & Body commodity section. Because it was manufactured, it had to be represented in the Process Descriptions document first with its cost of material and cost of process labor. The team used 7 lbs. of aluminum for material. The Rules cost aluminum at $0.75 per pound for a total of $5.25. With this aluminum, they performed various operations in order to construct the Floor Pan. They made 4 cuts, de-burred for 6 minutes, made 4 bends to form its shape, drilled 23 holes, and assembled it for 30 minutes. The Rules cost the above operations thusly: $0.20/cut, $35.00/hour of labor, $0.05/bend, and $0.35/hole. Applying the cost per unit to each operation and adding in the material yielded a cost of $35.30 for the Floor Pan. Table 4 portrays this information as it appeared in the team's cost report. There were a few details not discussed so far, i.e. the entries for "Sub." and "Manning." "Sub." was simply the subcomponent or material within a given component. Each

Floor Pan

Material

Sub.	Qty.	Description	Volume	Weight	$/Unit	Cost
A	1	Aluminum	72.50	7.00	$ 0.75	$ 5.25
					Subtotal	$ 5.25

Process Labor

Sub.	Qty.	Amount	Description	Manning	Unit	$/Unit	Cost
A	1	4.00	Cut to Shape	1	cut	$ 0.20	$ 0.80
A	1	0.10	De-burr	1	hour	$ 35.00	$ 3.50
A	1	4.00	Form Shape	1	bend	$ 0.05	$ 0.20
A	1	23.00	Drill Holes for Installation	1	hole	$ 0.35	$ 8.05
A	1	0.50	Assembly	1	hour	$ 35.00	$ 17.50
						Subtotal	$ 30.05
						Total	$ 35.30

Table 4: Example of a process description entry (reproduced from MIT FSAE 2005 Cost Report).

material used was labeled alphabetically beginning with A. Then in the "Process Labor" section, the particular material being operated on was matched up under "Sub." with its corresponding letter. In the example above, only one material was used; therefore, all the operations were performed on "Sub. A." Additionally, "Manning" was another multiplier in determining the cost of an operation. In the above example, only one person performed all the operations; therefore, the entry was always "1." This was the case most of the time. But it could have been the case where it required 2 people to assemble the Floor Pan in the same amount of time. In this scenario, "Manning" would have been "2" and the cost of "Assembly" would have doubled to $35.00 from the additional labor, increasing the total cost of the Floor Pan to $52.80.

Following the flowchart introduced earlier, the cost of $35.30 for the Floor Pan was then recorded on the BOM. This entry is displayed in Table 5. The column "We Paid" is omitted because of space constraint but was not utilized in the actual cost report because the Floor Pan was a manufactured component. The "We Paid" column was used for components that were

Component	P/M	Description /Part #	Qty	Retail Cost	Unit	Supplier /Tel#	Total Retail Cost	Ref. Process	Ref. Receipt	Requires Written Mfg. Process
Floor Pan	M	Custom	1	$35.30	Each	MIT	$35.30			Yes

Table 5: Example of a BOM entry (reproduced from MIT FSAE 2005 Cost Report).

purchased at discount and had a higher retail cost. In this case, the associated part # was listed under "Description/Part #" and "P" was listed under "P/M", signifying that it was purchased. "Ref. Process" directed the judges to which page that that particular component's process description could be found.

Finally, any fasteners used to assemble the Floor Pan or to assemble it to the vehicle was reported on the Fasteners document. In this case, none were used. But if they were, a simple entry of quantity, description of fasteners, purpose of fasteners, unit cost, and total cost was used. As mentioned before, the total of the Fasteners document was then reported on the BOM.

In addition to the 3 financial accounting documents, receipts and other backup material such as photos, prints, or part drawings were required in each commodity section. The receipts were used to prove the price of costly items. Items such as raw material or fasteners did not require receipts. The line item "Ref. Receipt" on the BOM was used to direct the judges to which page(s) the receipt(s) for that particular component could be found. The other backup material was simply used to show the judges another perspective of a component; part drawings were the most utilized on the MIT team.

After learning the rules and guidelines within the Formula SAE realm, a method had to be devised in order to compile the cost report. The individuals who knew the inner makings of the vehicle the best were those who were actually building the car. The team was organized

into a team manager, project engineers who were responsible for one or more of the 8 commodity sections, and engineers who were responsible for several components within a commodity section. After learning the organization structure of the team, it was possible to connect with appropriate people for what was needed.

First, templates of the Process Description document (Appendix A) and Fasteners document (Appendix B) were created. The template for the Process Description document contained instructions on how to fill it out. These instructions were to make the process more clear than how it was described in the Rules. Filling out the Process Description documents was the most critical part of compiling the cost report because these documents provided the backbone to the personal design and fabrication of the vehicle. The templates were distributed to all the engineers and project engineers. They then filled them out for their respective components and returned them. A thorough review of their entries was performed, and it was found that a few individuals, especially new members, were still unsure about how to fill them out correctly. Meetings were set up with each of these individuals in order to verbally talk out each component and make the correct entries. After doing so, they learned how to correctly fill out the documents.

After receiving all the process descriptions for manufactured components, the totals were entered into the commodities' BOMs. These BOMs were then given to the project engineers responsible for each commodity, and they entered the remaining purchased components and assembly labor. They also made any necessary additions to the Fasteners documents. Once all the documents

were compiled for each commodity, a meeting was set up with each project engineer in order to review the documents and fix any visible mistakes or miscalculations.

The completion of all 3 documents for all 8 commodity sections marked the completion of the heart and soul of the cost report. The cost of the vehicle was now represented in an organized and professional manner. The only items remaining were adding receipts and other backup material. Here was where the most difficulty occurred. The team did not organize its receipts by component or even commodity. They were organized by who purchased the items. Three members on the team had purchasing rights and each of their receipt folders were overflowing and unorganized. Sifting through all the receipts, searching for relevant purchases, was quite tedious and time-consuming. It was so time-consuming that although the search continued right up until the deadline for the cost report, several receipts went unfound.

Finally, other material such as part drawings and schematics were added to the cost report along with a cover letter and cost summary. It was then formatted and bounded according to the guidelines laid out in the Rules.

RESULTS

The results obtained from this case study were holistically very positive. That is to say, the cost report score improved, the team managers were able to focus more on the production of the vehicle, and there now exists groundwork for facilitative preparations of the cost report.

The 2005 cost report was much more organized, thorough, and professional than the 2004 version. It was for this reason that the increase in the score of the cost analysis event score was believed to be mostly, if not all, due to the improvement in the team's cost report. In fact, it was believed that it helped to overcome a shortcoming in the "lowest cost" sub-event of the cost analysis event. The cost of the 2005 vehicle increased by 21% from $17,268 to $20,814. Assuming that the lowest cost vehicle was the same cost in 2004 and 2005, then MIT's "lowest cost" score certainly decreased from 2004 to 2005. But its overall score in the cost analysis event increased by 12%, suggesting that the cost report made up the difference and then some. (A complete comparison between the 2004 and 2005 scores can be found in Appendix C.)

During the duration of the case study, very minimal interaction with the team managers was required. They were allowed to focus their attention to the vehicle to ensure that it was completed on time. It was hoped that this might continue, more on this issue later.

Lastly, there was substantial groundwork created for future teams to build upon. At last, they have a thorough, organized, professional cost report in which to emulate. Furthermore, the templates created serve as a starting block for which to create the cost report in the first place. Formatting and data entry are very time consuming together, but with formatting now alleviated, all that is needed is the data entry, which is inevitable anyway.

DISCUSSION

Granted, many strides were made throughout this case study in improving the quality, score, and

preparation of the cost report, but a couple issues still linger. These issues were learned while performing the study and were not able to be dealt with at the time. Instead, these issues should be taken into consideration in the future. The issues at hand were bottlenecks, so to speak, in the preparation of the cost report; they took the most time. One of which, as mentioned earlier, was the sever disorganization of the purchase receipts. The other was the timing of the completion of the car.

Organizing the receipts in a manner that is conducive to preparing the cost report is strictly one's preference. But in any event, something should be done. If MIT organizes the receipts by the purchaser, then perhaps further organization within each purchaser's folder can take place. It is the recommendation of this case study that when something is purchased for a particular commodity section, the receipt is organized in the purchaser's folder but also in another sub-folder for that particular commodity. Then when the time comes to prepare the cost report, the managers simply have to look in the purchasers' commodity sub-folders to find the materials used in that commodity.

The other bottleneck pertained to the time that the vehicle was actually completed. This was very, very late. In fact, it was not even completed before the cost report was due. It was very hard to report the cost of components that had not even been manufactured yet. This resulted in lag time, waiting for the engineers to accurately forecast the cost of the unfinished components. Perhaps this issue may never be resolved due to team size and the time commitment of the team members to the team. But nevertheless, it is the recommendation of this case study that the vehicle be designed and built as soon as possible not only to prepare an accurate and thorough

cost report but to also afford more time for testing and improving any unresolved issues on the vehicle itself. This suggestion would not only help to maximize the cost report score but to also help boost the score in *every* other category, which is priceless.

It was due to these bottlenecks that the 2005 cost report was incomplete itself. Although it was a drastic improvement upon the 2004 cost report, it still lacked certain required aspects. For example, receipts and process descriptions were not able to be referenced in the BOMs.

CONCLUSION

At the end of the day, the case study outlined in the previous pages proved to be very beneficial to the 2005 Formula SAE team. It helped to greatly increase the cost report score, to allow the managers to focus more on the construction of the vehicle, and to lay groundwork for future preparations of the cost report. The latter two go hand in hand. That is to say, with groundwork in place, managers would not be required as much time to prepare the cost report. So if they were to spend as much time on it as they did in previous years, then the cost report would greatly improve anyway with the groundwork.

But that is not the end of the story. It is the hope of this study that managers will not succumb to such practices. It is hoped that managers will take the recommendations laid out in this study, namely completing the vehicle earlier, so that more time may be spent on the cost report, as well as other areas. The earlier that something is completed, the more time one has to debug it. This can be said for both the cost report and the vehicle itself.

APPENDIX A

Please fill out the process descriptions of all parts you "purchased and altered"or "manufactured".

Material Section:
"Sub" refers to every different material used for the part. Start with "A" and proceed from there. I set up the "Cost" for each line to multiply "Qty." by "$/Unit". But if your material is costed by weight, you need to adjust the formula to multiply by "Weight" and not "Qty."

Process Labor:
Here reference the material under "Sub." that you are modifying. For example, if you're drilling holes in Material A, then under "Sub." put "A" and fill in the process labor. Do this for every process done to that material. Then go on to "B" and etc.

If you don't know the cost of a material or process, don't worry about it. I'll find it out.

There are tables for 10 parts. Please make more if need be.
PLEASE CONTACT ME WITH ANY QUESTIONS.

Component Name:

Material

Sub.	Qty.	Description	Volume	Weight	$/Unit	Cost
						$0.00
						$0.00
						$0.00
						$0.00
						$0.00
						$0.00
						$0.00
						$0.00
						$0.00
						$0.00
						$0.00
						$0.00
						$0.00
						$0.00
						$0.00
					Subtotal	$0.00

APPENDIX A (cont.)

Process Labor

Sub.	Qty.	Amount	Unit	Manning	Description	$/Unit	Cost
							$0.00
							$0.00
							$0.00
							$0.00
							$0.00
							$0.00
							$0.00
							$0.00
							$0.00
							$0.00
							$0.00
							$0.00
							$0.00
							$0.00
							$0.00
						Subtotal	$0.00
						Total	$0.00

APPENDIX B

Qty.	Description	Purpose	Retail Cost	Unit	Supplier/Tel. #	Total Retail Cost
						$0.00
						$0.00
						$0.00
						$0.00
						$0.00
						$0.00
						$0.00
						$0.00
						$0.00
						$0.00
						$0.00
						$0.00
						$0.00
						$0.00
						$0.00
						$0.00
						$0.00
						$0.00
						$0.00
						$0.00
						$0.00
					Total	**$0.00**

APPENDIX C

Year	Place	Team	Cost Score	Presentation Score	Design Score	Acceleration Score	Skid Pad Score	Autocross Score	Endurance-Economy Score	Total Score
2005	34	MIT	71.6	57.8	60.0	49.0	26.4	17.2	234.0	515.9
2004	41	MIT	63.3	58.4	40.0	48.0	27.4	7.5	168.3	412.9
2005-2004			8.2	-0.6	20.0	1.0	-1.0	9.7	65.7	103.0
% improvement			11.5%	-1.1%	33.3%	2.0%	-3.9%	56.4%	28.1%	20.0%
% contributed to overall improvement			8.0%	-0.6%	19.4%	1.0%	-1.0%	9.4%	63.8%	100.0%
2005 % of total possible points			71.6%	77.1%	40.0%	65.3%	52.7%	11.5%	58.5%	51.6%
2004 % of total possible points			63.3%	77.9%	26.7%	64.0%	54.8%	5.0%	42.1%	41.3%

2004 cost of vehicle	$17,268.00
2005 cost of vehicle	$20,813.88
increase	$3,545.88
% increase	20.53%