From Project Planning to National Champion - BUV Design, Build and Win

Abstract

The process in which senior Mechanical Engineering Technology students at Miami University planned, designed, built, tested and ultimately won a national design competition for a Basic Utility Vehicle (BUV) is described. Included in this process are a Project Management Course (ENT 316) and two Senior Design capstone courses (ENT 497 and ENT 498). This is a detailed description of the courses, skills, planning, analysis, feedback and assessment.

Introduction

Miami University offers Associate and Bachelor Degree Programs in Applied Science with concentrations in Engineering Technology on both of its regional campuses in Hamilton and Middletown, Ohio. In 2002 a new BS Degree in Applied Science with a concentration in Mechanical Engineering Technology was first offered. This program contains new courses including: Project Management, Mechanical Vibration and Finite Element Analysis along with other traditional Mechanical Engineering courses. Miami University also requires a group of courses (called the Miami Plan) designed to produce a well rounded graduate. The Miami Plan includes courses in English composition, fine arts, humanities, social science, cultures, natural science, and mathematics. Miami students who won the national BUV competition were from the second graduating class from the new BS Mechanical program.

The process followed by this team of three Mechanical Engineering Technology students is the culmination and integration of their Engineering Technology and Miami Plan education into a project management and a senior design sequence which ultimately resulted in the design and construction of a transportation vehicle. This vehicle, called a Basic Utility Vehicle (BUV), was designed and constructed to meet the performance specifications of the Institute of Affordable Transportation (IAT), www.drivebuv.org , a nonprofit organization based in Indianapolis, IN. The BUV is a safe, simple, low cost, low maintenance, easy to manufacture form of transportation for peoples of third world countries. In order to design a vehicle of this complexity the students must research, design, build and test numerous components and sub-assemblies based on their designs. A wide variety of engineering disciplines are employed in this process including conceptualization, research, design, detailing, parts procurement, manufacturing, machining, assembly, troubleshooting, mechanical controls, electrical controls validation, and documentation.

The concept of the BUV was developed by Will Austin, founder of the IAT. The IAT mission statement is "*To improve lives in developing countries by facilitating the spread of simple vehicles that can be assembled almost anywhere, by almost anyone*". The IAT organizes a yearly competition for teams from colleges and universities through out the United States and Canada to evaluate their designs using a number of performance challenges. The organization also requires that vehicle speed be kept to a minimum and that the design be oriented toward women of developing countries. The premise is that if the maximum speed is low, men will not have interest in the vehicle. Cost is another criterion; if the vehicle is too expensive people in developing countries will not be able to purchase or build the vehicle. The design and performance specifications are broad enough to give students significant freedom and creativity.

On April 30, 2005, the competition was held in Indianapolis and all engineering universities were invited to participate. Participants in the 2005 competition included: Purdue University – Indianapolis (IUPUI), University of Dayton, University of Cincinnati, Tri-State University, Sinclair Community College, Marquette University, Northern Illinois University, Milwaukee School of Engineering, University of Missouri, John Brown University, and Alfred State (SUNY). The Miami team finished first overall in this competition as well as first in several events.

The following sections include detailed descriptions and synergies of the three Engineering Technology courses involved in this process and their influence in the planning, design and construction process. Also included are details of the design, analysis, testing and validation.

Project Management (ENT 316)

This course covers background, techniques and case studies in project management. The students develop a fundamental understanding of the concepts for defining, organizing and managing both small and large projects. This course is somewhat unique since in Engineering Technology, project managers are managers as well as extremely active members of the team. The development and nurturing of discussion and organizational skills, cause and effect evaluation techniques, conflict resolution processes, cost analysis models and presentation skills are learned skills. The students, upon completion of this course, are able to (1) define what projects are and how they are used in the industrial and manufacturing world, (2) demonstrate the tools and technology requirements for project management, (3) demonstrate the team concept for project operation and management, and (4) demonstrate the process of finding and critically evaluating information in project management. The textbook used for this course is Project Management: A Managerial Approach 5th Edition by Jack R. Meredith and Samuel J. Mantel Jr. John Wiley & Sons Inc. ISBN 0-471-07323-7. A significant number of supplemental readings and Harvard Business Case (HBS) studies are also used. These cases allow students to evaluate, analyze and role play in order to develop skills as a project manager and team member. A number of suggested cases are listed in Appendix I.

The BUV project began with a detailed discussion among three students, Jim Bachmann, Vince Breidenbach, Sean Reed and myself. The initial exercise was to define the project and its requirements using processes developed in the ENT 316. This involved two primary steps. First they attended the BUV competition in April of 2004 to determine the basic requirements for the design and the nature of the competition. Written and photographic notes were made concerning the itinerary of the competition events. Competition vehicles were also studied and evaluated based on design and performance. The specifications for the 2005 competition were obtained from the Institute of Affordable Transportation and are shown in Appendix II.

Second, a project plan was established. This involved the development of a work breakdown schedule, a task list of the necessary steps required for the project and the use of a Gantt chart generated by using Microsoft Project®, which is shown in Appendix III. At this point it became clear that the time and funding necessary were both significant. Once organized and milestones established the process began. A parts list was developed, a preliminary budget was organized and the processes of acquiring the funds and parts were underway. As with any project, the plan is one of the most important aspects. In some cases, planning can take up to 20% of the total time. With this project planning was only about 5%. This is because there were a number of fixed specifications for the project which eliminated several planning steps. For example, the vehicle was required to use a 12’ length x 5.5’ width 2-wheel drive SUV or truck chassis with differential, a 8.5 to 12 hp internal combustion engine, a 900 lb maximum front end weight, tractor braking and a three wheeled vehicle with front steering.

The students organized a five minute presentation about their project and presented it at a semi-annual Miami University School of Engineering and Applied Science Industrial Advisory Council meeting. The purpose of this presentation was two fold. First, it provided an opportunity for the students to organize a proposal for a project. This process involved a guided program of establishing objectives, goals, a project plan, a preliminary budget and a Gantt chart. The template developed for this purpose is shown in Appendix IV.

Secondly, it provided the students a venue to sell their project to a seasoned group of industrial advisors. It also provided a path to request financial support for their project. The presentation was well received and was rewarded with a grant from CH2M Hill Miamisburg, OH, to fund a large portion of the project. This process is very similar to that which occurs every day in the industrial world.

Thus, project management was the initial step in the process. It focused the students on planning, organizing, budgeting, milestone establishment and team work. These skills and techniques were essential and continued throughout the project. The performance against the time and budget were found to be acceptable. The early planning process allowed the project to begin one semester earlier than normal for Miami’s capstone design projects. This process is highly recommended for future planning of curriculum and for others interested in a project such as this. It provides additional synergies and additional time for design, construction and testing of projects. It also allows for additional interaction among students, faculty and mentors.

Senior Design Project (ENT 497)

ENT 497 is normally the planning stage for the Senior Design process. Students are expected to visualize, discuss and look for potential projects. This involves discussion with faculty as well as industrial mentors and outside companies. Students are also encouraged to organize into teams of no more than three members. The semester involves a series of guest lecturers and special presentations on research, design, cost analysis, ethics, patents and several others. By the end of the semester the students are expected to have a completely developed and organized project with a budget, time line and funding. Each project team has a faculty and/or industrial mentor. At the end of the semester each team presents their entire proposal in both Microsoft PowerPoint® and written formats to the Engineering Technology faculty. Their grade for the course is based on their oral and written presentations. This part of the process requires the students to include skills learned in the Miami Plan courses. The inclusion of cultural perspective, writing skills, mathematics skills and many others are what separate Miami graduates from other Engineering Technology graduates.

For the BUV project, the process for ENT 497 was completed very early in the semester. In fact, it was nearly completed by the beginning of the semester. This occurred because of the time constraint discovered during planning discussions in the Project Management course. It was clear that if work did not begin early on this project there would be insufficient time for completion. So for much of the time during the ENT497 semester, students on the BUV project were in the design and constructions stages of the process. This was only possible because they began the process early, organized their thoughts and planned their project well in advance. They were, however, able to make use of the guest lecturers and presentations in order to further refine their design and planning processes. It created a framework for organizing the project and preparing for their final presentation and write-up for the ENT 498 course.

The design of the vehicle was kept simple and included the following sub assemblies: a front end steering assembly, an engine and power train, a driver's compartment, and the cargo bed/ passenger area. Designing various components in a gasoline powered vehicle required knowledge not included the students' portfolio of design knowledge. Thus, to design all of the components required a significant amount of research. This research ranged from major components and assemblies down to research for individual nuts and bolts needed for the assembled BUV. This research included internet searches, catalog and product brochures located at local companies, and hands on visual identification of parts in local stores. Internet searches were used to locate tires, transmissions, torque converters, and chassis bushing. Catalog searches were used for bearings, locknuts, lock washers, and material selection. Visual part identification included coil over shocks, hitch pins, and electrical components.

The conceptualization started with a rolling chassis from 1995 Chevrolet Tracker 4X4, and a myriad of sketches and drawings. The students began with the cargo bed/passenger area, followed by the engine, torque converter, transmission, drive shaft, and roll cage. Design, research, and calculations were performed to determine the torque speed and loads based on a 10 hp Kohler Engine, the rear end gear ratio and tire size. Examples of a few of the design calculations are shown in Figure 1 below:

Torque = Force x Distance
Power (Hp) = Torque x n (rotational speed) / 550

Motor Speed	Motor Torque	Motor HorsePower
n_m	T_m	Hp_m
rpm	lbs ft.	
2000	14.8	6
2200	14.83	6.65
2400	14.86	7.2
2600	14.9	7.7
2800	14.7	8.1
3000	14.55	8.5
3200	14.3	8.9
3400	14.1	9.3
3600	13.85	9.65
3800	13.6	10

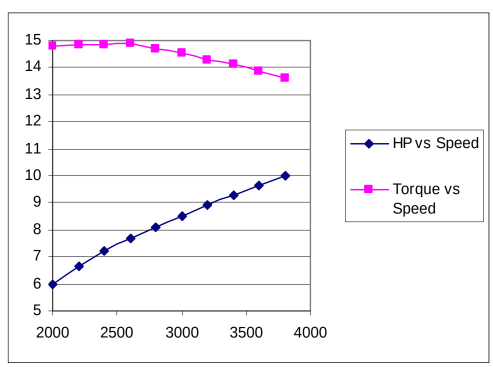


Figure 1 Example design of calculations for torque and speed done in Microsoft Excel®

The front end and steering assembly was based on discovered research from a vehicle designed in the 1970's know as the "Trimuter"[1]. An AutoCAD® drawing of the front end design is shown in Figure 2. Figure 3 is a solid model on the student's BUV design created using Mechanical Desktop® and Solid Works®. Figure 4 is a digital photograph of the actual constructed assembly.

A Bill of Materials for this front end design is shown in Appendix V. The IAT required that the total cost of front end assembly be under $1000. The students' design total was $831.24.

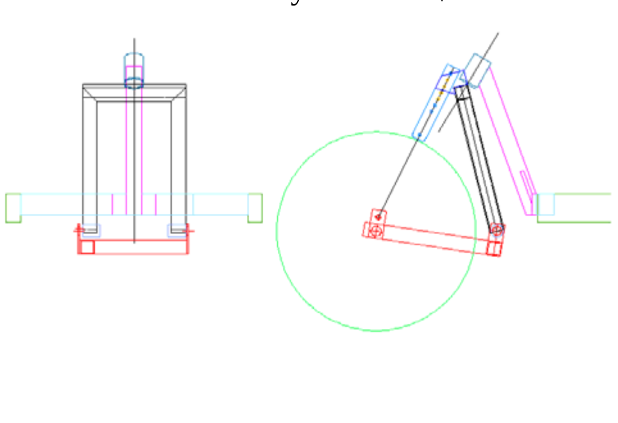


Figure 2   AutoCAD® drawing of the BUV front end assembly based on the Trimuter concept.

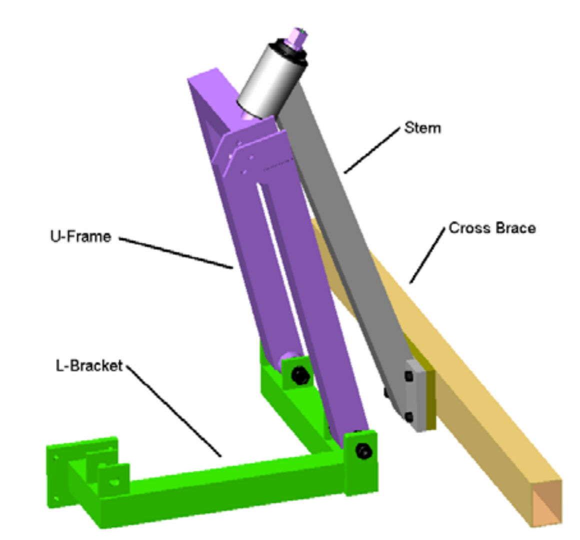


Figure 3 A 3-D Mechanical Desktop® and Solid Works® model of the BUV front end assembly design.

Figure 4   Photo of the constructed front end assembly of the BUV shown during assembly and testing.

Senior Design Project (ENT 498)

ENT 498 is the second semester course for Miami's capstone design course series. Students must complete the design, build and test stages of their projects. They are required to write an extensive report about all aspects of their project, including a reflective essay about their experience. They are also required to present their design and findings to the faculty, industrial partners and academic community at an annual Senior Design forum. This forum includes a table top display and/or model of the project. Their course final grade is based on both the written and oral reports and presentations.

In the BUV project these guideline were followed. During the final stages of the course the students were required to do testing and validation of their vehicle under simulated Institute of Affordable Transportation conditions. During testing, fatigue cracks were observed in the welded corners of the U-member of the front end. The member is shown in Figure 5 below.

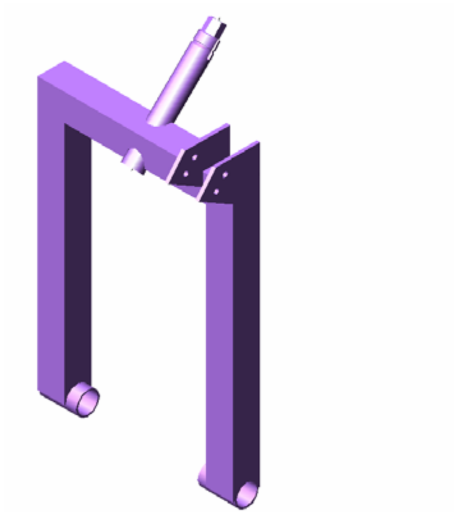


Figure 5 3-D Mechanical Desktop® and Solid Works® model of the front end U-member that exhibited cracking in the welded corners.

The students were instructed to do additional analysis of the components to determine the cause for the cracking. The component was analyzed using ANSYS® Finite Element Software. The results showed high stress in the right angle corners of the member. The weld was not modeled in this process so the high stress is a condition based only on geometry. The fact that the corner was welded magnified the problem. Gussets were added in order to eliminate the cracking problem. The part was reanalyzed and the results showed that the corner still contained high stress but the level was significantly reduced. The vehicle was modified and retested. No cracking was observed. It is recognized that the modified design is not optimum and that a redesign of the member would be necessary for a production vehicle. There was not sufficient time in the schedule to accomplish this design change prior to the competition. It was concluded that for the competition the design was acceptable with noted changes needed for future designs. The design, construction and testing phases were complete. Figure 6 below is a plot of static nodal stress from the FEA analysis showing the high stress condition on the inside corner of the U-member.

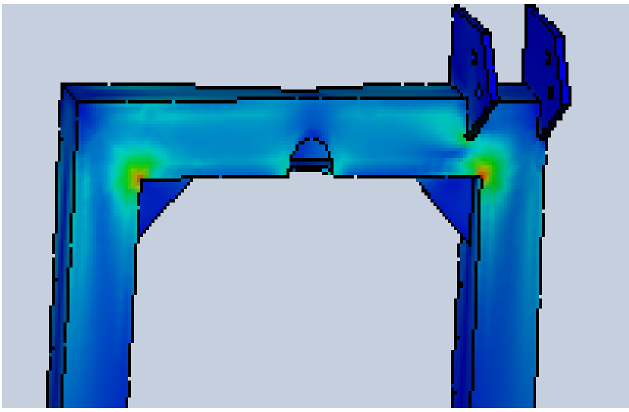


Figure 6 ANSYS® FEA of the welded corners showing the location of the high stress areas (orange). New gussets are shown in this drawing.

Senior Design Presentation day was April 28, 2005. The BUV senior design team's documents and presentations were both excellent. They were judged by a group of outside faculty and industry professionals in twelve different areas which included objective, quality of analysis, literature research, progression of the project, group synthesis and future work. The ratings for the BUV design team was a 3.79 out a possible 4.0. Their table top display was well received and rides in the vehicle were given to faculty, staff and guests.

IAT Competition

One last test remained for this team. On Friday, April 29, 2005, they loaded the BUV and headed for Indianapolis, IN, for the Institute of Affordable Transportation. Inspection and check-in were held on Friday afternoon. A vehicle design compliance inspection was done using the form shown in Appendix VI. The vehicle was in compliance in all categories.

On Saturday, April 30, 2005, the all day competition was held. The competition included the following tasks:

- Endurance test (30 minutes)
- Acceleration test (timed)
- Agility test (timed)
- Mud Pit crossing
- Hill climb
- Obstacle course
- Static pull
- Swamp crossing
- Oral presentation

A total of thirteen universities competed and the Miami BUV team placed first overall with a total score of 80.96. The next closest competitor was IUPUI with a total score of 77.82. The vehicle and team were the class of the field in both performance and looks. Figure 7 below shows the finished vehicle in competition. Figure 8 is a picture of the design team back on the Miami Campus.

Figure 7 Competition photo of the mud pit crossing in Indianapolis, IN

Figure 8 Winning Team photo on the Miami Campus

Summary and Conclusions

In summary this project was the ultimate from many points of view. It not only required the students to think and design in critical engineering terms, but also required that they find funding, build their design, manage a budget, and finally compete against other designers. I cannot think of a more meaningful and real world experience for graduating Engineering Technology students. I would suggest that other Engineering and Engineering Technology programs strongly consider a model such as the one described in providing a similar experience for their students. I also praise Will Austin, Director of the Institute of Affordable

Transportation, for creating such a wonderful event for the students. It will continue to grow and provide new design challenges in the future.

Acknowledgements

The author would like to sincerely thank the three Senior Design Students (now practicing engineers) Jim Bachmann (Force Control), Vince Breidenbach (P&G) and Sean Reed (Enerfab) for their more than 3000 hours of dedicated work focused in design, fabrication, evaluation, analysis, proof testing and presentation for this project. They possessed the perfect combination of skills necessary to complete a project of this magnitude. Jim was strong in design and detailing, while Sean had a wide variety of tools and had used them in the past on vehicle repair. Vince and Jim had external access to machine shops and/or machinists; while Sean had welding skills which helped during the manufacturing process. The group had all the tools required to complete the project from beginning to end. Many of the drawings, photos, calculations and analyses included in this paper are excerpts form their final project report and presentation. Jim, Vince and Sean stand ready to help and advise future students who chose to follow the path they have provided.

The author would also like to thank the other contributors to this project which include Kohler Engines, CH2M Hill, Miami University, Miami Faculty, especially Professors Vipul Ranatunga and Ron Earley and Miami staff, especially Don Becker and Frank Tonner.

Author Biographical Sketch

Gary Drigel is an Assistant Professor in the Engineering Technology Department at Miami University (Ohio). He received his Bachelor of Science Degree (1973) and Masters Degree (1980) in Metallurgical Engineering from the University of Cincinnati. He has also completed all his course work and part of his thesis work for a Ph.D. in Materials Engineering at UC. Gary is a Registered Professional Engineer in the State of Ohio. He has 30+ years of engineering and research experience gained at Armco Research and Technology in Middletown, Ohio and has been a professor at Miami University for 5 years. He can be reached at drigelgs@muohio.edu, Miami University, 4200 East University Blvd., Middletown, OH 45042.

References

[1] D. Acheson, V. Yasinskiy, A Collaborative International Humanitarian Project in Engineering Education, Proceedings: The 6th International Conference on Engineering Design and Automation, 2002

[2] Harvard Business School, Soldiers Field, Boston, Massachusetts 02163, http://www.hbsp.harvard.edu

[3] "Build UrbaSport-A Car for All Reasons", Mechanix Illustrated, Feb 1980

[4] Robert Q. Riley, "Transportation Challenges of the 21st Century", Museum of Modern Art, New York, NY, September 7, 1999

[5] Robert Q. Riley, "Transportation 2000: Options for a New Millennium", Northwest Alternative Fuels and Transportation Conference, Portland, Oregon, April 20, 2000

[6] Angelo, T.A. and Cross, K.P..; *Classroom Assessment Techniques* 2nd edition; Jossey-Bass: San Francisco, CA; 1993

Other Reference Materials

Kohler Engines	http://www.kohlerengines.com/onlinecatalog/productdetail.jsp?engnID=1360
Firestone	http://www.firestoneag.com/databook/productlist.asp?ref=75
Whittet-Higgins	http://www.whittet-higgins.com/part.php?series_id=40
Timken	http://www.timken.com/products/bearings/products/TaperedRollerBearings
Hoffco-Comet	http://www.hoffcocomet.com/comet/index.asp
Federal-Mogul	http://www.federal-mogul.com/
Browning	http://www.emerson-ept.com/
McMaster-Carr	http://www.mcmaster.com/
IAT	http://www.drivebuv.org/
Dodge	http://www.dodge-pt.com/
Engineering Tool	http://www.engineeringtoolbox.com/
Climax Metal	http://www.climaxmetal.com/
Mules of America	http://www.mechanicalmulesofamerica.com/
Efunda	http://www.efunda.com/
Triodyne INC.	http://www.triodyne.com/SAFETY~1/SB_V11N4.PDF
RQ riley	http://www.rqriley.com/tm.html
Jim Cushman	http://www.hobbytech.com/comet.htm

Contributors

Hamilton Caster	http://www.hamiltoncaster.com/
Tresters Used Auto Parts	
Firestone	http://www.firestoneag.com/databook/productlist.asp?ref=75
Kohler	http://www.kohlerengines.com/onlinecatalog/productdetail.jsp?engnID=1360
Force Control	http://www.forcecontrol.com/
P&G	http://www.pg.com/main.jhtml
Miami U. Middletown	http://ent.ham.muohio.edU/
Miami U. Hamilton	http://ent.ham.muohio.edU/

Appendices

Appendix I

Harvard Business (HBS) and other case studies list

"The Case of the Machinist's Mutiny", W. Bruce Chew, Harvard Business Review Case 90602
"Geartrain international: Medina, Ohio", Jack R Meredith, Prentice Hall
"Oilwell Cable Company", Jack R Meredith, Prentice Hall
"The Bowing 767: From concept to Production (A) and (B)", Harvard Business School Case 9-688-040 and 9-688-041
"Columbia's Final Mission", Harvard Business School Case 9-305-032
"Transformation at Ford". Harvard Business School Case 9-390-083
"Final Voyage of the Challenger" Harvard Business School Case 9-671-037
"GM Powertrain", Harvard Business School Case 9-698-008
"Adam Aircraft", Harvard Business School Case BAD010
"Xerox and Fuji Xerox", Harvard Business School Case 9-391-156
"Toyota Motor Manufacturing, U.S.A., Inc.", Harvard Business School Case 9-693-019
"Goodyear: The Aquatred Launch", Harvard Business School Case 9-500-039
"Competitive Information Policy at Pratt & Whitney", Harvard Business School Case 9-394-154
"Turner Construction Company: Project Management Control Systems", Harvard Business School Case 9-190-128
"Johnson controls, Automotive Systems Group: Georgetown, Kentucky Plant", Harvard Business School Case 9-693-086

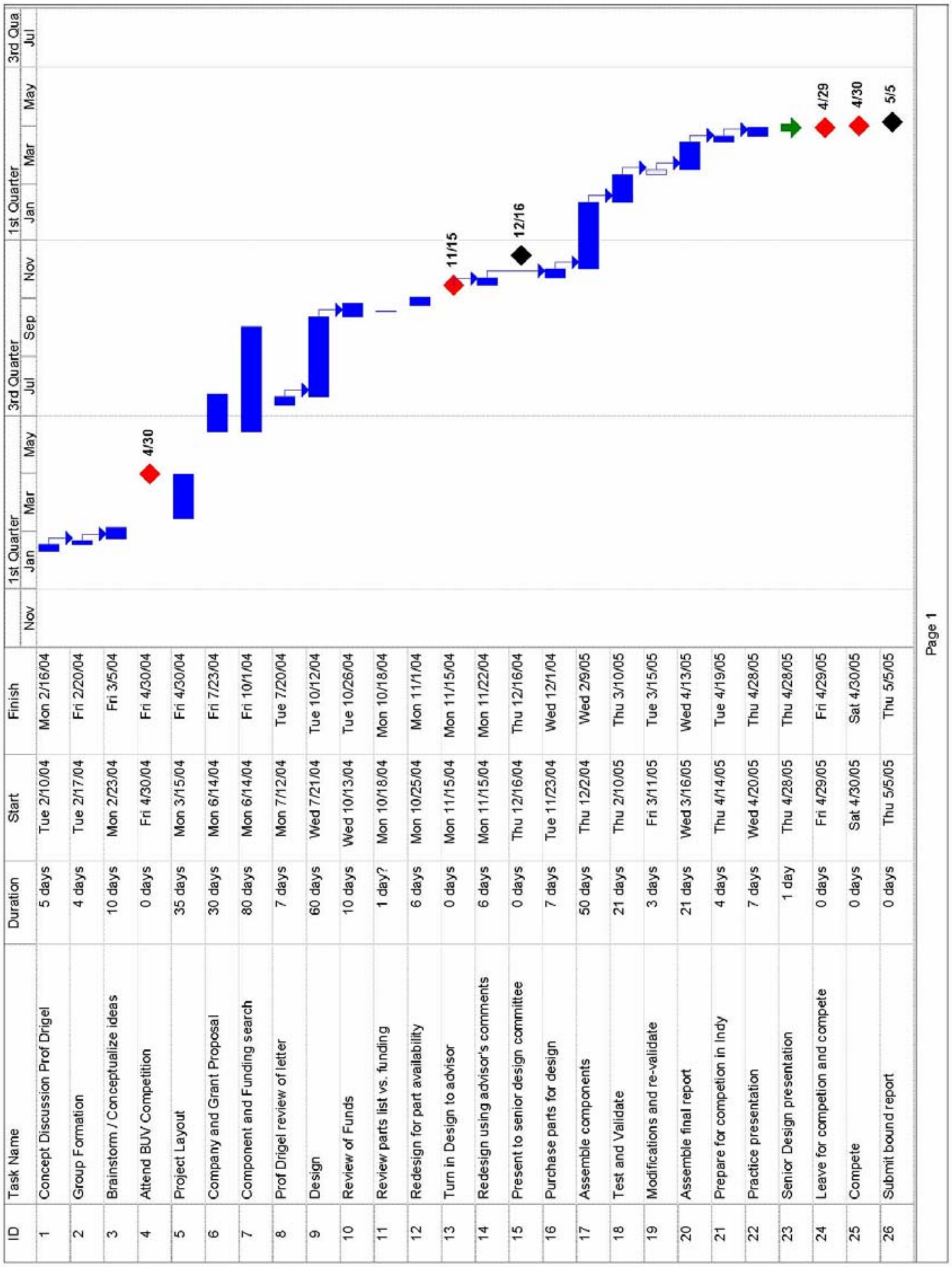
Appendix II

BUV Design Competition Requirements

Cost (as a kit):	$900 for front end unit (pre-welded) Does not include final assembly, freight, duties.
Payload:	550 kg or 1210 lbs (including driver)
Turning Diameter:	< 5 m or 16.5 feet
Top Speed:	32 km/h or 20 mph on grass (governed)
Mass / Weight:	< 135 kg or 297 lbs (for front-end assembly)
Brakes:	Tractor braking (right/left or both) utilizing existing truck brakes
Cargo Bed	Use existing pick-up bed, or utilize a stake bed (i.e. stake pockets and wood)
Engine	8.5 -12 hp internal combustion engine
Transmission:	Type not specified, but reverse required (reverse may be human-powered if the driver can activate it from the drivers seat area.)
Materials:	UV resistant, corrosion resistant
Ground Clearance	> 10.5" except at differential, leaf springs, or lower shock mounts
Packaging (full unit)	All parts of front unit must fit inside or beneath a regular length pick-up rear-end on a shipping skid. Fully assembled unit must be less than 11 ft long
Packaging (front unit)	Minimize crate-size required for shipping the front kit alone (welding complete)
Assembly Time	< 6 man-hours to assemble front kit (pre-welded, pre-painted parts) & connect to rear unit. Time does not include cargo bed.
Safety Equipment:	Driver seat belt, parking brake, bumper, horn, kill switch, rescue hooks (fore/aft), on-board fire extinguisher passenger handles/ropes (for securing cargo also), **"**anti-roll" protection (shoulder height roll-bar helps stop vehicle rotation at ¼ roll and shields driver from cargo space), 1 headlight, 2 tail-lights, 2 brake lights, two light reflectors per side
Front Suspension	Suspension type not specified. Teams may use a **salvage motorcycle front steering unit on their prototype.** This would **substitute** for using a new, heavy duty, Chinese front unit at $175 OEM cost which includes forks/suspension, wheel, tire, headlight, thumb throttle, and handbrake. Teams may use other suspensions (i.e. rubber torsion) as well.

Appendix III

Gantt chart for BUV project created in Microsoft Project®



ID	Task Name	Duration	Start	Finish
1	Concept Discussion Prof Drigel	5 days	Tue 2/10/04	Mon 2/16/04
2	Group Formation	4 days	Tue 2/17/04	Fri 2/20/04
3	Brainstorm / Conceptualize ideas	10 days	Mon 2/23/04	Fri 3/5/04
4	Attend BUV Competition	0 days	Fri 4/30/04	Fri 4/30/04
5	Project Layout	35 days	Mon 3/15/04	Fri 4/30/04
6	Company and Grant Proposal	30 days	Mon 6/14/04	Fri 7/23/04
7	Component and Funding search	80 days	Mon 6/14/04	Fri 10/1/04
8	Prof Drigel review of letter	7 days	Mon 7/12/04	Tue 7/20/04
9	Design	60 days	Wed 7/21/04	Tue 10/12/04
10	Review of Funds	10 days	Wed 10/13/04	Tue 10/26/04
11	Review parts list vs. funding	1 day?	Mon 10/18/04	Mon 10/18/04
12	Redesign for part availability	6 days	Mon 10/25/04	Mon 11/1/04
13	Turn in Design to advisor	0 days	Mon 11/15/04	Mon 11/15/04
14	Redesign using advisor's comments	6 days	Mon 11/15/04	Mon 11/22/04
15	Present to senior design committee	0 days	Thu 12/16/04	Thu 12/16/04
16	Purchase parts for design	7 days	Tue 11/23/04	Wed 12/1/04
17	Assemble components	50 days	Thu 12/2/04	Wed 2/9/05
18	Test and Validate	21 days	Thu 2/10/05	Thu 3/10/05
19	Modifications and re-validate	3 days	Fri 3/11/05	Tue 3/15/05
20	Assemble final report	21 days	Wed 3/16/05	Wed 4/13/05
21	Prepare for competion in Indy	4 days	Thu 4/14/05	Tue 4/19/05
22	Practice presentation	7 days	Wed 4/20/05	Thu 4/28/05
23	Senior Design presentation	1 day	Thu 4/28/05	Thu 4/28/05
24	Leave for competion and compete	0 days	Fri 4/29/05	Fri 4/29/05
25	Compete	0 days	Sat 4/30/05	Sat 4/30/05
26	Submit bound report	0 days	Thu 5/5/05	Thu 5/5/05

Appendix IV

Miami University
School of Engineering & Applied Science
Department of Engineering Technology

ENT 497/498
Senior Project

Objective:

This document is intended as a guide in preparing a proposal for your senior thesis. Your proposal shall contain each of the items outlined in the attached document. The document shall be prepared by your project team and submitted for approval by your advisor. The completed document will serve as a contract between your group and your advisor that must be completed in order to receive a grade for your project and the course (ENT497 / 498). Should a change in any phase of your project or plan be required, you must submit an amended plan for consideration and approval by your advisor and/or the faculty.

Primary Sections of the Proposal:

1. ***Title***
2. ***Team Members***
3. ***Advisors' Names***
4. ***Supporting Company:*** *This can be an outside company, person or university*
5. ***Objective:*** *What do you intend to do?*
6. ***Applicability or Justification:*** *The reason you selected this project and why you feel it is important.*
7. ***Step-by-Step Plan:*** *A step-by-step list of tasks to be done to complete your project (be specific). Each step shall be numbered.*
8. ***Time line or Gantt Chart:*** *This will be associated with the step-by-step plan above and should include each task, time to complete, target dates, and parties responsible.*
9. ***Cost:*** *You shall look at each step and determine what, if any, financial cost is needed and how this will be financed.*
10. ***Summary and final comments:*** *This a catch-all area for anything not covered in the previous sections*

Miami University
School of Engineering & Applied Science
Department of Engineering Technology

ENT 497/498
Senior Project

Title:

Team Members:

Advisors' Names:

Supporting Company:

Objective:

Justification or Applicability:

Step-by-Step Plan:

Time Line:

Cost:

Final Comments:

Appendix V

Bill of Materials and Cost for Front End Assembly

Sub Assembly - Front End					
REF#	**Part#**	**Description**	**QTY.**	**Remarks**	**Price**
1	101	Mast Post	1	DWG. REQ'D	$57.50
2	102	HHCS 3/8-16 x1	4		
3	103	L-Washer 3/8	4		
4	104	Cross Brace	1	DWG. REQ'D	$23.49
5	105	Bearing Cup	2	Timken LM48548	$15.00
6	106	Bearing Cone	2	Timken LM48510	$7.00
7	107	Cover, Bearing Cavity	2	DWG. REQ'D	$2.35
8	108	L-Nut N-065	1		$7.50
9	109	L-Washer N-065	1		$2.25
10	110	U-Frame	1	DWG. REQ'D	$180.00
11	111	Bushings MOOG	4	K-6063	$65.98
12	112	Shoulder Bolt 5/8-13	1/2/1900		$9.00
13	113	Nyloc Nut 1/2-13	2		
14	114	Flat Washer 1/2	2		
15	115	L-Bracket	1	DWG. REQ'D	$165.00
16	116	Spindle	1	1995 Chevy Tracker	
17	117	HHCS 3/8-16 x1	4		
18	118	L-Washer 3/8	4		
19	119	Lug Nuts	5		$5.20
20	120	Coil Over	1		$57.68
21	121	Shoulder Bolt 3/8 x 2 1/2	3		$7.11
22	122	Shoulder Bolt 3/8 x 2	1		$2.17
23	123	Flat Washer 5/16	4		
24	124	Nyloc 5/16-18	4		
25	125	Shock Post	1	DWG. REQ'D	$72.30
26	126	Tire			$26.50
27	127	Rim			$26.67
28	128	Handle Bar	1		$9.98
29	129	Post	1		$88.57
30	130	HHCS 3/8-16 x 1 1/4	1		
31	131	LockWasher 3/8			
				Total	$831.24

Appendix VI

BUV DESIGN SPECIFICATION – Statement of Compliance '05

Students to fill-in

Institute for Affordable Transportation

Volume = 1200/ yr

Your Vehicle: **Specifications**

Use non-metric

$	Cost (as a kit):	<$900 This cost does not include final assembly, freight, duties.
Lbs	Payload:	550 kg or 1210 lbs (including driver)
Ft^2	Cargo Deck Space	18 square feet or more
	Passenger Mode	Seating for at least 5 people (including driver)
mph	Top Speed:	32 km/h or 20 mph on grass (governed)
lbs	Mass / Weight:	< 135 kg or 297 lbs for front end assembly.
in.	Ground Clearance:	> 10.5" (except for differential, leaf springs, or shock mounts)
ft	Turning Diameter:	< 5 m or 16.5 feet
Y / N	Tractor Braking	Tractor Braking (right/left or both) utilizing existing truck brakes
ft	Overall Length:	< 11 ft
hp	Engine horsepower	8.5 hp - 12 hp Internal combustion engine
	Reverse Type	Reverse required (what type is it…hand crank, hybrid, manual lever, other etc)
mi	Range:	Not Specified. Calculate using fuel tank that came with engine. (paved road)
	Angle of Departure:	Not specified
in	Center of Gravity	Not specified. Measure from ground in inches
	Ramp Break-over Angle	Not specified
in	Seat Height	Not Specified. Measure driver-seat (surface of seat) to ground (with driver seated)
	Front Frame Mat'l:	Not Specified. Steel type, box tube or round tube, wall thickness for main rails.
	Max Gear Reduction	Not specified. What is you maximum overall gear reduction?
$	Cost (front frame ready for install)	Cost of front frame complete (i.e. ready to attach to rear unit). Includes only structural parts). Does not include paint, controls, seat, or powertrain. Use $2/hr for labor/burden.
Circle items to the right that are on your BUV	Safety Equipment: Is driver protected from moving parts?	Driver seat belt, parking brake, bumper, horn, kill switch, rescue hooks (fore/aft), on-board fire extinguisher passenger handles/ropes (for securing cargo also), **"**anti-roll" protection (shoulder height roll-bar helps stop vehicle rotation at ¼ roll and shields driver from cargo space), headlight, 2 tail-lights, 2 brake lights, two light reflectors/side, *Team# & college name on each side of BUV*
__________ __inches	Front Suspension	List the type of suspension. Wheel travel in inches.

Data related to the performance, objectives, and provisions sections of the Design Spec.

		Number of "off-the-shelf" parts
		Number of fabricated or custom parts
		Total Number of Parts
%		% of fabricated parts to Total Number of Parts
		Count of unique Part #s (i.e. 4 screws of the same type count as 1 part number),
in.		Inches of weld on prototype
in.		Distance from ground to bottom of engine (inches)
m-h		Assembly time for front kit in man-hours (assume all welding and painting is complete)
m-h		Time to attach and integrate front unit (already assembled) to rear unit (man-hours)
ft^3		Cubic Feet of Packaging Crate required **per front kit** (must be rectangular box) w/**no** parts pre-welded)
ft^3		Cubic Feet of Packaging Required **per front kit** (must be rectangular box) with all parts pre-welded)
lbs		Weight of cargo bed
lbs		Weight of entire vehicle
Y / N		Ability to power an auxiliary unit (i.e. generator, water pump, etc via a belt drive or other)
Y / N		5 minute conversion (or less) from cargo mode to passenger mode for 6 passengers.
Circle to the right		Does the vehicle make provision for a canopy? Can it readily accommodate one?

General Info: Describe the following

Brake & Parking Brake Activation____

Transmission Parts:____

Steering Mechanism____