CHANGING LIVES WITH MOBILITY
THE BASIC UTILITY VEHICLE PROJECT

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Abstract *? The Institute for Affordable Transportation (IAT) is a non-profit organization devoted to developing high-quality, low-cost transportation for third-world countries. As part of this humanitarian vision, the IAT enlists educational institutions in the design and development of a class of transportation known as a Basic Utility Vehicle (BUV). Through this partnership, engineering and technology (as well as other academic) schools, departments and students can explore a design project option that possesses significant, far-reaching implications for humanitarian application. An annual competition tests student-designed prototype BUV's. Manufacturing standards derived from best practices help enable efficient production and global integration. With this type of project, students encounter real-world technical and logistical challenges while at the same time gaining exposure to today's global/ethical considerations. This paper introduces the organization that is the genesis of this initiative, gives an overview of BUV student competitions, suggests and highlights service-based student BUV projects and culminates with a call for participation.*

THE INSTITUTE FOR AFFFORDABLE TRANSPORTATION

The Institute for Affordable Transportation (IAT) is a not-for-profit public charity devoted to developing high-quality, low-cost transportation for the *working poor* in Third World countries. The IAT is based in Indianapolis, Indiana and is funded by individuals, foundations, and international corporations.

The IAT's mission is to improve living standards and enable economic growth in the Third World by creating a simple vehicle that can be assembled *almost anywhere*, by *almost anyone*. This form of transportation has come to be known as the Basic Utility Vehicle (BUV). BUVs promote trade and reduce poverty at a grassroots level. Besides rural transportation, BUVs also represent a mobile power source (i.e. powering generators, water pumps, etc) for further development [1].

As a source of inspiration, the IAT engages young engineering and technology talent in service-based projects to design and develop BUV's. The IAT utilizes college students for cost-effective market research and product development via competitions and projects. Teams of engineering students generate prototype BUV designs. BUVs are designed around the specifications in Table I.

TABLE I
BUV DESIGN COMPETITION SPECIFICATIONS

Cost:	<$900 for new design
Payload:	1000 lbs
Speed:	20 mph (governed)
Weight:	500 lbs.
Materials:	Not specified (plastics and composites encouraged)
Maximize:	Number of unassembled kits that fit in 20' ocean container
Minimize:	Total cost of ownership, custom designed parts, part number count
Parts Excluded	Doors, body panels, glass, trim, gauges, hydraulics, radiator, heater

BUVs are best suited for warm climates and non-mountainous areas. Warm areas are chosen because BUVs are open-air vehicles. Flat topography is preferred because the economical engine has limited power. BUVs are designed for low-traffic, rural applications. The BUV's low mass, limited power, and limited maneuverability may hinder driver safety in city areas. Target consumers will be micro-business owners with incomes less than $5000 per year. Most target countries are in Africa, although a few are in South Asia and Latin America.

Prototype designs and market research will be listed at www.drivebuv.org. This Web site will help manufacturers identify markets and develop products based on prior research and experience. The Web site encourages collaboration and technology sharing. Entrepreneurs and manufacturers worldwide can utilize student designs to significantly reduce product development costs.

An annual BUV design competition brings together the ideas of these student teams for a grueling series of tests and obstacle courses. This year's student BUV's will be evaluated by a team of experts from industry and academia on Saturday, May 10, 2003. The entire competition is completed in one day. As in previous years, the IAT will award trophies and corporate prizes (i.e. the top teams received gifts from RCA, and free Indy 500 tickets compliments of Borg Warner and the Indianapolis Motor Speedway [2].

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BUV STUDENT COMPETITIONS

Each year, the Institute for Affordable Transportation gives participating educational institutions the opportunity to go head-to-head with other student design teams.
Prior to the field competition, teams are asked to provide:

- A Working Prototype
- Engineering Report (e-mail & hardcopy)
- CAD Drawings
- Costed BOM with part #, source.
- Financial Analysis (100k units/year)

The inaugural BUV Design Competition was held on May 26, 2001 in Brazil, Indiana. The course was muddy, rugged, overgrown, and impeded - a good simulation for the lack of infrastructure found in rural areas of developing countries. The events of the day included a safety inspection, specification check, endurance test, judges driving circuit, hill climb, acceleration & brake test, trail making event, creek crossing, ditch crossing, and a timed slalom course. The competitive spirit of the collegiate teams during the competition was evident, especially during the creek-crossing event and the timed slalom course. Despite a rigorous series of events, there were no vehicle breakdowns. The winning vehicle entry was designed by Auburn University (Figure 1). The 2001 BUV competition runner-up was designed by Lafayette College (Figure 2).

FIGURE 1
2001 BUV COMPETITION WINNER – AUBURN UNIVERSITY

The Auburn vehicle was compact, nimble, and powerful. The team had the manpower to divide the vehicle into three sections and try various designs. Their vehicle scored high on all of the tests. Unique features included handle bar steering (more leverage), high approach angle/departure angle, and easily removable seats. The turning radius, acceleration, and top speed were noticeably higher than the other vehicles. The weakness of the design was the weight, high center of gravity and limited cargo area.

FIGURE 2
2001 BUV COMPETITION RUNNER-UP – LAFAYETTE COLLEGE

The Lafayette vehicle had a long wheelbase and offered a comfortable ride. The Lafayette students made significant progress toward simplifying assembly issues and minimizing the packaging space of the large vehicle. The entire Lafayette team of 7 students could ride on the vehicle. The Lafayette vehicle was hindered by its weight, cost, and speed.

Both vehicles utilized swing arm suspension in the rear, ATV style tires, a 10 hp engine, a torque converter and a chain driven solid rear axle. Auburn utilized box tubing and Lafayette utilized round tubing with quick assembly fittings. Both vehicles displayed good ground clearance except for the final sprockets, which were vulnerable to road obstacles.

Continuing Learning Opportunities

Judges for the competition were chosen for their particular expertise in the fields related to the BUV initiative. Dr. Kim of John Brown University studies the transfer of appropriate technology to developing countries. Dr. Zhang, an engine expert, and Dr. Flemming, a structural expert, represented mechanical engineers from industry. The leading producer of torque converters, Hoffco-Comet Industries, sent design engineer Bob Warmeir to judge the BUV powertrains.

During lunch, guest speaker Chris Hart gave an overview of rural transportation in developing countries. Using several examples from his work in Zambia, Africa, he highlighted the unique requirements for Basic Utility Vehicles.

The First Annual BUV Design Competition was a definite success. The students, judges, volunteers and fans enjoyed the day and the rain ceased after the first event. The six vehicles on display instilled an appreciation for the uniqueness and usefulness of BUVs.

The Second Annual BUV competition was held on May 18, 2002 in Zionsville, IN. A design evolution was evident in the 2002 entries with a new IAT specification to "Maximize cargo area and unhindered space above cargo platform to facilitate loading & unloading cargo".

Once again, several days of rainfall prior to the event made for perfect conditions to test the meddle of the BUV prototype designs. A warm welcome from driving legend Derek Daly ushered in the opening ceremonies as he challenged the crowd to follow dreams that help us learn, grow and serve others.

The competitive events of the day began with a safety inspection and a specification check. Afterwards each vehicle and driver faced a myriad of obstacle courses which involved an Endurance and Bump Test, Judges Driving Circuit, Acceleration / Deceleration test, Hill Climb, Ditch Crossing and the Water Crossing. These courses were once again carefully configured to represent the poor road conditions common throughout the developing world.

The 2002 BUV judging panel included Leon West from the University of Arkansas (Structural Design), Matthew Green from the University of Texas (Appropriate Technology), Ken Kalies from Hoffco-Comet (Powertrain), Jerry Hornback from Arvin-Meritor (Assembly / Cost), Scott Young from Rolls-Royce Turbines (Packaging), Dr. Kenton Fleming (Design / CAD), Dr. Zhang from SPECAR (Components / Quality) and Dan Kettles from Delphi Automotive Systems (Serviceability).

The winning entry for the 2002 BUV design competition was the Purdue School of Engineering and Technology at Indiana University Purdue University Indianapolis (Figure 3). The runner-up vehicle was designed by Rose Hulman (Figure 4).

FIGURE 3
2002 BUV COMPETITION WINNER
INDIANA UNIVERSITY PURDUE UNIVERSITY INDIANAPOLIS (IUPUI)

The BUV built by IUPUI performed consistently well on all events and it's intake "snorkel" device allowed the engine to run through substantially high water conditions. The vehicle's robust steering system also sustained the vehicle through the most punishing conditions and as a result IUPUI received first prize in the student competition. However, the IUPUI vehicle was hindered by its low approach angle.

FIGURE 4
2002 BUV COMPETITION RUNNER-UP – ROSE HULMAN

As runner-up, the vehicle built by Rose Hulman performed well on the endurance circuit and demonstrated practical construction measures. By using a Chevette rear axle and drivetrain, they emphasized the potential for recycling first world components in BUV applications. Unfortunately, design weaknesses of the steering linkage system stalled the performance of this entry.

Private Sector Entries

Several innovative non-collegiate entries competed in the 2002 BUV Design Competition. One such entry by designer Chris Hart sported the country name "Zambia", for it's post-competition destination (Figure 5).

FIGURE 5
THE "ZAMBIA" PRIVATE ENTRY BUV

The Zambia BUV performed especially well in the ditch crossing and the linear Acceleration and Deceleration tests. It's rear axle steering also allowed the driver to effectively negotiate the winding trails and paths. The Zambia vehicle was the clear winner in the private sector competition. Currently, 10 units are being produced for field implementation around the world [3].

Another innovative private sector entry was the "Farm Boy" BUV (Figure 6). The Farmboy was rugged, yet agile.

FIGURE 6
THE "FARMBOY" PRIVATE ENTRY BUV

Utilizing a salvaged S-10 pickup rear-end, this vehicle could prove to be a viable solution for transportation needs in neighboring Mexico. Its single front wheel affords a small turning radius and payload capacity is immense**.**

Also presented was "El Burro" (Figure 7), a special version of BUV that resembles a motorcycle.

FIGURE 7
THE "EL BURRO" PRIVATE ENTRY SPECIAL BUV

The front wheel and handle bar assembly of the "El Burro" can be completely detached from the rest of the vehicle. This is an ideal option for transportation situations requiring deep-water river crossings. Both the engine and drive train and can be re-attached to different body extensions or used separately as a generator. The design and use of this special BUV has been implemented in the field in South America for evacuating injured individuals from remote jungle areas. The patient lies on their back with their feet elevated over the rear wheel, thus aiding in combating the condition of shock. Additionally, the driver of the "El Burro" can glance directly down unto the face of the patient while driving to assess their current state. The narrow, flat bottom of the unit allows it to easily "slither" over obstacles such as logs [4].

IUPUI STUDENT DESIGN PROJECTS

Like many other engineering/technolgy institutions, students pursuing their bachelors degree in Mechanical Engineering Technology at IUPUI are required to undertake a senior-level, capstone design project. This one semester course requirement can be undertaken as an individual independent study project, or the requirement can be fulfilled as a significant, team design project. Guidelines for project selection include the requirement to use engineering design skills acquired during the student's undergraduate curriculum. While many senior design projects are "paper-only", the department promotes the physical fabrication of the design whenever possible. Beginning in January 2001, faculty coordinating the MET senior design project announced the option of designing a BUV with the intent to participate in the annual IAT Design Competition. Two student teams from the MET dept. have taken up the challenge thus far. The first winning the 2002 competition and the second confident in their design for the 2003 event.

Senior design teams lay out their project plan as follows:

1. Review specifications supplied by the Institute of Affordable Transportation.
2. Collect data on existing technologies, including golf carts and ATVs.
3. Review materials to be used in building the proposed design.
4. Design vehicle prototype.
5. Perform stress analysis on designed model.
6. Build working prototype of vehicle design.
7. Test working prototype and modify as necessary.
8. Participate in the B.U.V. Collegiate Design Competition

Faculty Perspective

This project is an excellent method of providing a capstone experience for engineering technology students. Several specific benefits of the BUV senior design project have been identified:

- ? Utilization of a team approach and a project scale requiring substantial involvement of all group members.
- ? Short timeline required to complete project.
- ? Presence of a hard deadline for project completion – IAT competition.
- ? Very clear project goal – working prototype.
- ? Very clear design performance specifications – established by IAT.
- ? Practical and humanitarian aspect of project.
- ? Need to apply practical engineering design and analysis tools.
- ? Real-world problem, not contrived classroom problem.
- ? Pride in design, fabrication and competition.[5]

Graphics Support

IUPUI's involvement in the IAT's mission extends beyond the BUV design competition. In 2001, Computer Graphics Technology (CGT) students undertook a project to create a 3D digital database of the privately designed BUV "Zambia" [6].

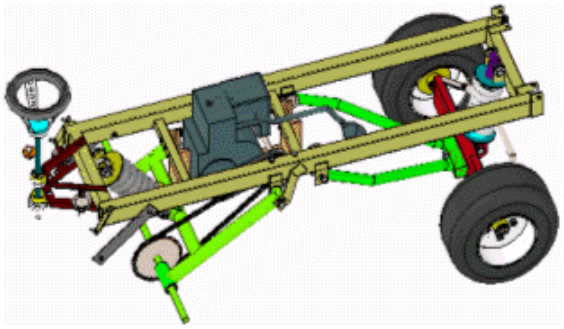

FIGURE 8
3D MODEL CREATED BY COMPUTER GRAPHICS TECHNOLOGY STUDENTS

The IAT anticipates that an "evolution" of best practices will occur in the form of shared three-dimensional CAD files. This collaborative exchange can make the engineering design process thrive while at the same time empowering students with tremendous career skills.

In the fall of 2002 – IUPUI Computer Graphics Technology students once again provided graphical support to the IAT for the "Farmboy" BUV. Teams created 3D geometry of the Farmboy parts, engineering drawings, brochures (Figure 9), option images (Figure 10) and 3D animations of assembly procedures.

FIGURE 9
"FARMBOY" BROCHURE BY COMPUTER GRAPHICS TECHNOLOGY STUDENTS

FIGURE 8
3D OPTION IMAGES BY COMPUTER GRAPHICS TECHNOLOGY STUDENTS

CONCLUSION

The BUV project inspires the hearts and minds of students who are eager to find lasting reward in their academic experiences. A similar project at the University of Texas at Austin gives a student's perspective of service-oriented design courses; "Academic design exercises seemed so irrelevant; what difference did it make if our design report was an order of magnitude off? The [UT Austin] prototyping class changed that" [7].

In closing, the author, his educational affiliate (IUPUI) and the Institute for Affordable Transportation extend a sincere invitation to educational institutions to become involved in this life-changing initiative. Extensive forms, coverage and information including videos are located on the IAT Web page found at http://www.drivebuv.org [8].

REFERENCES

[1] http://www.drivebuv.org/about_iat.htm

[2] http://www.drivebuv.org/academics.htm

[3] http://www.drivebuv.org/postcompetition.htm

[4] Acheson, D, "The Basic Utility Vehicle (BUV) – A Humanitarian Capstone Project", *CD Proceedings: 2003 American Society for Engineering Education Annual Conference and Exposition*

[5] Acheson, D, Austin, W, Rennels, K. "The Basic Utility Vehicle – An International Humanitarian Project", *Proceedings: International Conference on Engineering Technology Research, 2002, pp. 4-8.*

[6] Acheson, D, "Collaborative Graphics for an International Humanitarian Project – The Basic Utility Vehicle (BUV)", *Proceedings: Engineering Design Graphics Division of ASEE 57th Annual Midyear Meeting, 2002, pp. 157 – 161.*

[7] Green, M, Dutson, A, Wood, K, Stone, R, and McAdams, D, "Integrating Service-Oriented Design Projects in the Engineering Curriculum", *CD Proceedings: 2002 American Society for Engineering Education Annual Conference and Exposition*

[8] Acheson, D, Yasinky, V, "A Collaborative International Humanitarian Project in Engineering Education", *CD Proceedings: 6th International Conference on Engineering and Design Automation,2002*