The Basic Utility Vehicle (BUV) – A Humanitarian Capstone Project

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Abstract
Engineering and technology schools, departments and students are encouraged to explore a capstone design project option that possesses significant, far-reaching implications for international humanitarian application. An Indianapolis, Indiana-based non-profit organization called the "Institute of Affordable Transportation (IAT)" engages young engineering and technology talent through service-based capstone projects to design and develop a class of transportation known as a Basic Utility Vehicle (BUV). 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.* To propagate this initiative, the IAT hosts an annual collegiate BUV competition that tests student-designed prototype BUV's. Ultimately, the student efforts from these competitions will help provide mobility, freedom and economic hope to people in rural areas of developing countries. This paper introduces the organization that is the genesis of this initiative, gives an overview of the first two IAT collegiate competitions (including examples of student-designed and other vehicles), reflects on the academic benefits to participating students and faculty and culminates with an invitation to academic institutions to become involved in this life-changing initiative.

The Institute for Affordable Transportation (IAT)
The IAT's main initiatives include researching the need and feasibility of BUVs, administering collegiate competitions, and promoting the need for the vehicle to all stakeholders. As BUV designs finalize, the IAT will ensure that the end consumer is served by assisting stakeholders with logistics, customs, financing and taxes.

IAT's strategy utilizes college students for cost-effective market research and product development via competitions and projects. BUVs are designed around these 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.

The transportation infrastructure in rural areas of developing countries is generally geared toward the formal work sector, and specifically men. Ironically, women carry the majority of the transport burden within the family. Women are responsible for getting the families' water, fuel, food, and transporting the children and elderly to schools and clinics. Frequently, transport services are not available, unaffordable or scheduled inappropriately for women. Consequently, women's productivity and capacity to meet their families' needs are diminished. Just as the automobile enabled men and eventually women in developed countries, BUVs can enable women in rural areas of developing countries. The possibilities are endless and their common denominator is freedom…freedom to commute to education or a better job, freedom to get medical attention, freedom to buy from the best market, freedom to visit relatives, freedom to expand a business, freedom to help the community or friends. Unlike a motorcycle, a BUV provides a woman the option of taking her children with her.

IAT seeks funding from individuals, foundations, corporations, and governments. Targeted corporate sponsors include manufacturers of golf carts, snowmobiles, specialty vehicles, automotive parts, small engines, motorcycles, go-karts, ATVs, and cars. Support is also sought from professional societies.

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.[1]

Annual BUV Design Competitions

The First Annual BUV Design Competition was held on May 26, 2001 in Brazil Indiana. The course was muddy, rugged, overgrown, and impeded. This was a good simulation for the lack of infrastructure found in rural areas of developing countries. Despite a rigorous series of events, there were no vehicle breakdowns.

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 the timed slalom course. Each event had a purpose. For example, the Trail Making Event was to see if brush and weeds get tangled in the machinery. Students from first place Auburn University and runner-up Lafayette College were awarded free tickets to the Indianapolis 500 Race on the following day (compliments of Borg Warner Automotive).

Figure 1 – 2001 BUV Competition Winner Auburn University

The Auburn vehicle (Fig. 1) 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 weaknesses of the design were the high weight, high center of gravity and the limited cargo area.

Figure 2 – 2001 BUV Competition Runner-up Lafayette College

The Lafayette vehicle (Fig. 2) 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.

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".

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 carefully configured to represent the poor road conditions common throughout the developing world.

Figure 3 – 2002 BUV Competition Winner Indiana University Purdue University Indianapolis

The BUV built by IUPUI (Fig. 3) 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 (Fig. 4) 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.

The 2002 BUV competition also included entries from the private sector. The inclusion of private-entry vehicles in the competition proved to be an incredible asset to students who attended the event. An exchange of ideas, methods and applications between the participating students and private designers (many with 3rd world field experience) was extremely benificial.

Figure 5 – 2002 BUV Competition Private Entry "Zambia"

The "Zambia" BUV (Fig. 5) 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.

Figure 6 – 2002 BUV Competition Private Entry "El Burro"

Also presented was "El Burro" (Fig. 6), a special version of BUV. The front wheel and handle bar assembly, which can be completely detached from the rest of the vehicle, contains both the engine and drive train and can be re-attached to different body extensions or used separately as a generator.

The date for the third annual BUV competition is May 10, 2003. You are cordially invited to the 2003 BUV Design Competition. This annual event harnesses the creative energy of college students from across the nation in an effort to develop a simple, low-cost utility vehicle that can benefit low-income people in rural areas of developing countries. Student teams have designed

and built these vehicles over the past year and will compete in a series of tests and evaluations to determine the best design.[2]

IUPUI Student Design Project

Faculty of the Department of Mechanical Engineering Technology, Purdue School of Engineering and Technology at IUPUI are very impressed by the goals of the Institute of Affordable Transportation. The faculty determined that one method of establishing involvement in the IAT effort was to participate in the Basic Utility Vehicle (BUV) engineering design competition.

Student pursuing their bachelors degree in Mechanical Engineering Technology 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. In January 2001, faculty coordinating the MET senior design project announced the option of designing a BUV and participating in the IAT Design Competition. Four senior Mechanical Engineering Technology agreed to undertake the project.

The senior design team first laid 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 2002 B.U.V. Collegiate Design Competition on 18, May 2002.

The design of the BUV working prototype incorporated various "off-the-shelf" technologies. The frame was fabricated by welding 1 inch x 2 inch A513 steel tubing. The roll cage was fabricated as a separate unit by welding using 1 inch x 1 inch A513 steel tubing. The BUV incorporated existing technology by incorporating the rear axle, rear suspension, front suspension and torque converter of a commercially available golf cart. The golf-cart wheels and tires were replaced by units used for off-road applications such as ATV's. The steering mechanism is a combination of a custom design chain and shaft design that incorporated some parts from the golf cart. The IUPUI vehicle received first place in the 2002 IAT Design Competition.

Faculty Perspective

This project was 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 – 15 weeks total.

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.

The faculty of the Department of Mechanical Engineering Technology intends to continue to encourage students to participate in the Institute of Affordable Transportation activities and design competitions and will support their students' endeavors.[3]

As with most service-based projects, a sense of ownership and pride in workmanship are instilled in student design team members. Students encounter real-world technical and logistical challenges while at the same time gaining exposure to today's global/ethical considerations.

In closing, the author wishes to extend an invitation to other educational institutions by including a letter from the Director of the IAT.

Letter to Senior Design / Capstone Professors
In developing countries, many micro-businesses cannot grow because they cannot afford the trucks that enable growth. Help us reinvent the "motor vehicle" by endorsing the Basic Utility Vehicle (BUV) Design Competition. The student teams will ultimately help manufacturers serve the underprivileged market. Engineering students nationwide will design and build prototypes that will be judged by professors and industry executives in May.
Basic Utility Vehicles (BUVs) are rugged, simple vehicles that can carry 1000-pounds of cargo. Using primarily off-the-shelf parts, the unassembled BUV skid pack will cost about $900 before duties and freight. They are designed for warm climates, slow speeds (under 20 mph), and rural, unpaved roads. BUVs provide mobility, freedom, and economic hope to people in rural areas of developing countries.
What are the benefits to your engineering college?
Support a good cause and humanitarian project.
Challenge students with exciting "real-world" problems and learning experiences.
Generate goodwill and publicity (the competition is a publicity magnet.
Kohler Engines and Briggs & Stratton have provided IAT with engines for participating schools with advising professors. Please send IAT your team's contact information in order to get a free engine.

Kind Regards,

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