BASIC UTILITY VEHICLE

A student competition to design simple vehicles to serve in impoverished areas worldwide

Agricultural Systems Management & Agricultural and Biological Engineering

Technical Advisor: Dr. John Lumkes

ASM 495 coordinator: Dennis Buckmaster

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Jaret Wicker *Joe Leedy* *Ryan Fischer*

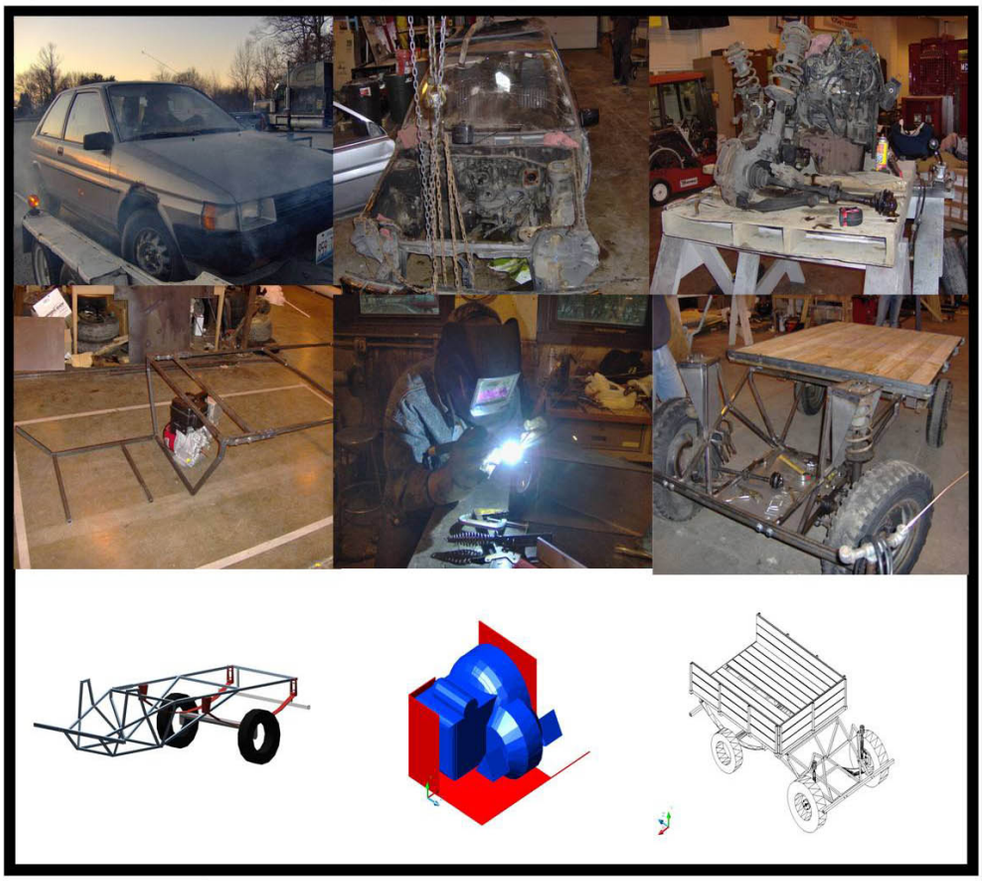
April 19, 2007

Senior Capstone Project

The equipment needed to assemble a BUV is very simple, even small repair shops have many of the tools required. BUV assembly can occur *almost anywhere*, by *almost anyone*

Design Objectives

- **Minimize total lifetime cost of ownership**
- **Utilize off-the-shelf components where possible to minimize part costs**
- **Employ simple, durable, low maintenance design**
- **Utilize as few as two people to assemble vehicle. Utilize Design For Assembly (DFA) methods**
- **Minimize machining, welding, and fixtures for Third World assembly to reduce investment/skill required**
- **Emphasize safety in all aspects of design. Protect driver and passengers from moving parts**
- **Emphasize reliability (repairing the vehicle in the field is very difficult due to remote location & poor infrastructure)**



Other Requirements:

- Power unit must be bolted to the rear unit. All used parts must come from the same vehicle make
- Any parts of the salvaged car may be reused except the engine and unibody
- Provide new frame to locate strut towers, control arms, engine, driver seat, etc...
- Allow for alignment of suspension components

Performance Requirements:

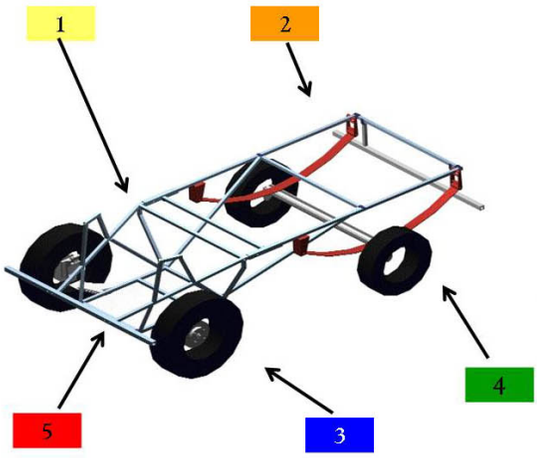
- Capable of climbing 20% slope with a 1100 lb load
- Power an automotive alternator (when needed) as an auxiliary power unit (and 12V DC outlets)

What are the most common BUV applications?

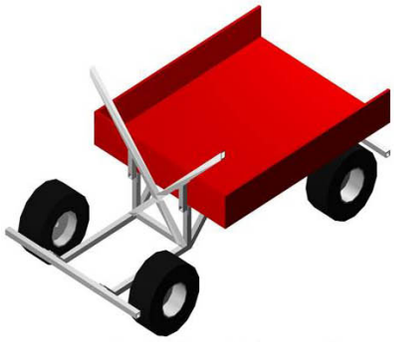
- medical vehicle
- farm vehicle carrying farm inputs / outputs
- material carrier at construction projects.
- water distribution (drip irrigation) or water purification
- school bus for children

Design Information

Frame Construction



1. **Front Frame**: Constructed from 1-inch steel tube, the front can be disconnected from the rear frame for shipping in the bed
2. **Back Frame**: Made of 1-inch steel tube, the rear frame supports the bed. Leaf springs and the front springs from the donor vehicle are used to support the 1,100lbs regulated
3. **Drive Wheels**: mounted on the front, these aggressive and durable wheels will pull the BUV through any terrain encountered
4. **Rear Wheels**: Maximizing the use of the donor car, we used the rear axle and wheels for the rear end assembly.
5. **Bumper**: Constructed of 1.5-inch tube, the bumper bolts to mounts on the front frame so that it may be removed if damaged and for shipping purposes



Original Design

Power Transfer

Continuously Variable Transmission (CVT)

Type: Symmetrical
Recommended Horsepower
Min: 8 Max: 18
Drive Belt: 7/8" Top Width
Drive Clutch Engagement Range:
Min: 1600RPM Max: 3100RPM
Speed Reduction Ratios:
High: 1:1 Low: 2.43:1

Transmission Ratios
1st: 11:1
2nd: 6:1
3rd: 3.8:1
4th: 2.8:1

Drive Sprocket: 16 tooth
Driven Sprocket: 48 tooth
Reduction: 3:1

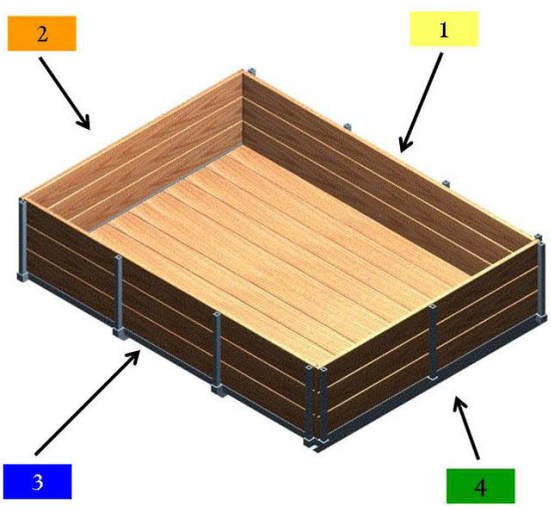
Engine

10hp Briggs Intek I/C 10 amp alternator
Overhead Valve Design
Cast Iron Cylinder Sleeve
Mounting: Horizontal
Electric Start: Recoil & Electric
Fuel Tank: 1 gallon
Shaft Size: 1"x3-21/32"
Height: 16.3"
Depth (Less Shaft): 12.2"
Width: 16.5"

Updated design with dumping mechanism and tailgate hinged at top or bottom

Bed Construction

1. **Bed Floor & Sidewalls**: Made from deck boards, the wood is lightweight and easily replaceable as compared to other materials
2. **Tailgate:** The tailgate is hinged at the top and bottom. Un-pinning the top allows the tailgate to swing down like a conventional pick-up truck tailgate. Un-pinning the bottom will allow the tailgate to swing out like a dump-truck tailgate to allow spreading of rock, mulch or other loose materials
3. **Bed Frame:** Constructed from 1-inch steel tube and 1.5-inch angle iron, the vertical posts will un-pin from the bottom frame to allow the wooden sides to be removed for repair or hauling large items
4. **Bed Dump:** Capable of dumping, the bed is hinged in the rear with a locking mechanism in the front



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Basic Utility Vehicle: Brandt Erwin (ABE), Ryan Fischer (ASM), Brian Oum (ASM), Joe Leedy (ASM), Joshua Stoelting (ASM), Ryan Zook (ASM)
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Tailgate with hinge on top

Tailgate with bottom hinged

Specifications

Cost:	<$1000 for materials (unassembled)
Payload:	1100 lbs (including driver)
Max Dimensions:	10 ft length, 62" width
Cargo Bed Length:	6'6" minimum
Ground Clearance:	> 8"
Engine:	8.5 hp - 12 hp air cooled, internal combustion engine
Driveline:	Two wheel drive, Front Wheel Drive
Angle of Approach/Departure:	> 45 degrees approach, > 35 degrees departure
Driver Seat Height:	Sitting surface of driver seat < 36" from ground
Tires:	Aggressive Tires or Tire Chains
Safety Equipment:	Driver seat belt, parking brake, bumper, horn, brake light, front lights, rear lights, kill switch, eight light reflectors (2 per side), tie-downs, or boat cleats (for securing cargo), "anti-roll" protection (roll-bar stops vehicle rotation at ¼ roll), Provide generous safety shielding to protect driver and cargo from moving parts

BILL OF MATERIALS

	MSRP	Location	Our Cost	Location	Half Price
Donor Car					
1988 Toyota Tercel 4-Cylinder 4-Speed Manual	$350.00	James Sturgeon	$350.00	James Sturgeon	$175.00
1988 Toyota Tercel Service Manual	$17.99	Autozone	$17.99	AutoZone	$9.00
Donor Car Total	$367.99		$367.99		$184.00
Front Frame					
Tube					
25' - 1" x 1" x 1/8" Carbon Steel Square Tube	$33.75	Purdue Central Machine	$33.75	Purdue Central Machine	$16.88
6' - 1-1/2" x 1-1/2" x 3/16" Carbon Steel Square Tube	$9.96	Purdue Central Machine	$9.96	Purdue Central Machine	$4.98
Steel					
5 sq ft - 10-Gauge Carbon Steel For 2 Strut Mount Buckets	$20.00	Kelly Construction Group	$20.00	Kelly Construction Group	$10.00
8 sq ft - 10-Gauge Carbon Steel For Skid Plate	$32.00	Kelly Construction Group	$32.00	Kelly Construction Group	$16.00
1/4 sq ft - 10-Gauge Carbon Steel For Control Arm Mounts	$1.00	Kelly Construction Group	$1.00	Kelly Construction Group	$0.50
Fasteners					
20 - 1/2" x 3" Grade 5 Bolts	$18.80	Fastenal	Donated	Fastenal	$9.40
30 - 1/4" x 1" Stainless Steel Grade 5 Pan Head Machine Screws	$7.50	Fastenal	Donated	Fastenal	$3.75
20 - 1/2" Nylock Nuts	$23.20	Fastenal	Donated	Fastenal	$11.60
Front Frame Total	$146.21		$96.71		$73.11
Front Suspension					
Control Arms					
Lower Control Arms From Toyota Tercel	$0.00	Donor Car	$0.00	Donor Car	$0.00
Strut Tower					
Strut Assembly From Toyota Tercel	$0.00	Donor Car	$0.00	Donor Car	$0.00
Springs					
Rear Coil Springs From Polaris Ranger	$88.18	Don Wood Polaris	Donated	Purdue Quarter Scale	$44.09
Wheels					
14" x 5-1/2" Steel Wheels From Ford Ranger	$162.00	Car Parts Wholesale	Donated	Purdue University ABE	$81.00
Tires					
2 - Firestone Titan 7-14R1	$190.96	Esserman Tire Service	Donated	Purdue University ABE	$95.48
Fasteners					
2 - 1/2" x 3" Grade 5 Bolts	$1.88	Fastenal	Donated	Fastenal	$0.94
4 - 1/2" x 2" Grade 5 Bolts	$2.60	Fastenal	Donated	Fastenal	$1.30
6 - 1/2" Nylock Nuts	$6.96	Fastenal	Donated	Fastenal	$3.48
Front Suspension Total	$452.58		$0.00		$226.29
Rear Frame					
Tube					
32' - 1" x 1" x 1/8" Carbon Steel Square Tube	$43.20	Purdue Central Machine	$43.20	Purdue Central Machine	$21.60
8' - 1-1/2" x 1-1/2" x 3/16" Carbon Steel Square Tube	$13.28	Purdue Central Machine	$13.28	Purdue Central Machine	$6.64
1' - 5" x 1/8" Carbon Steel Round Tube	$2.00	Purdue Central Machine	Donated	Purdue University ABE	$1.00
Steel					
2 sq ft - 10-Gauge Carbon Steel For 2 Coil Spring Mounts	$8.00	Kelly Construction Group	$8.00	Kelly Construction Group	$4.00
1-1/2 sq ft - 10-Gauge Carbon Steel For Leaf Spring Mounts	$6.00	Kelly Construction Group	$6.00	Kelly Construction Group	$3.00
Rear Frame Total	$72.48		$70.48		$36.24
Rear Suspension					
Axle					
Rear Axle From Toyota Tercel	$0.00	Donor Car	$0.00	Donor Car	$0.00
Tube					
2' - 2" x 2" x 3/16" Carbon Steel Tubing	$4.00	Purdue Central Machine	Donated	Purdue University ABE	$2.00
Steel					
1/2 sq ft - 3/8" Carbon Steel Plate For Leaf Spring Mounts	$5.00	Purdue Central Machine	Donated	Purdue University ABE	$2.50
Leaf spring					
Leaf Springs From Previous BUV From Ford Ranger	$0.00	Previous BUV	Donated	Purdue University ABE	$0.00
Springs					
Coil Springs From Toyota Tercel For Rear Helper Springs	$0.00	Donor Car	$0.00	Donor Car	$0.00
Wheels					
2 - 15" x 6" 4-Lug Steel Wheels From Grain Auger	$70.00	Iliana Truck Parts	Donated	Gum Farms	$35.00
Tires					
2 - 30" x 7" Implement Tires From Grain Auger	$60.00	Iliana Truck Parts	Donated	Gum Farms	$30.00
Fasteners					
4 - 2-1/2" x 6" x 1/2" Square U-bolts	$23.98	AutoZone	$23.98	AutoZone	$11.99
4 - 1/2" x 4" Grade 5 Bolts	$4.72	Fastenal	Donated	Fastenal	$2.36
12 - 1/2" Nylock Nuts	$13.92	Fastenal	Donated	Fastenal	$6.96
Rear Suspension Total	$181.62		$23.98		$90.81
Seat					
Seat					
Front Seat From 1988 Toyota Tercel	$0.00	Donor Car	$0.00	Donor Car	$0.00
Seat Total	$0.00		$0.00		$0.00

	MSRP	Location	Our Cost	Location	Half Price
Bed					
Angle Iron					
50' - 1-1/2" x 1-1/2" x 1/8" Carbon Steel Angle Iron	$58.00	Purdue Central Machine	$58.00	Purdue Central Machine	$29.00
Lumber					
21 - 5/4" x 6 x 12' Pressure Treated Deck Boards	$251.37	Lowes	Donated	Von Tobel Lumber	$125.69
Tubing					
16' - 1" x 1" x 1/8" Carbon Steel Tubing	$21.60	Purdue Central Machine	$21.60	Purdue Central Machine	$10.80
Fasteners					
180 - 1/4" x 2" Grade 5 Carriage Bolts	$18.20	Fastenal	Donated	Fastenal	$9.10
180 - 1/4" Nuts	$7.20	Fastenal	Donated	Fastenal	$3.60
Hinge					
48" x 2" x 0.120" Surface Mount Piano Hinge with 3/8" Rod	$23.75	McMaster-Carr	$23.75	McMaster-Carr	$11.88
Pins					
12 - 1/4" PTO Locking Pins	$11.94	Rural King	$11.94	Rural King	$5.97
Bed Total	$388.06		$113.29		$194.03
Drivetrain					
Transaxle					
Toyota C-140 4-Speed Manual Transaxle	$0.00	Donor Car	$0.00	Donor Car	$0.00
Engine					
1 - Briggs & Stratton InTek I/C 205 cc Electric Start and 10 Amp Alternator	$495.00	Small Engine Warehouse	$275.00	Small Engine Warehouse	$247.50
Common Shaft					
1' - 3/4" Stainless Steel Solid Rod	$12.00	Purdue Central Machine	Donated	Purdue University ABE	$6.00
Sprockets					
1 - 48-tooth 1/2 Pitch Sprocket	$13.99	Rural King	$13.99	Rural King	$7.00
1 - 16-tooth 1/2 Pitch Sprocket	$4.49	Rural King	$4.49	Rural King	$2.25
1 - 3/4" Hub for 16-tooth Sprocket	$4.99	Rural King	$4.99	Rural King	$2.50
1- 1-1/4" Hub for 48-tooth Sprocket	$6.49	Rural King	$6.49	Rural King	$3.25
1 - 1/2" Pitch No. 40 Idler Sprocket	$13.49	Rural King	$13.49	Rural King	$6.75
Chain					
10' - 1/2" Pitch No. 40 Roller Chain	$9.99	Rural King	$9.99	Rural King	$5.00
CVT					
Comet Model 40 Series Torque Converter	$210.00	Comet Industries	$210.00	Comet Industries	$105.00
Belt					
10-1/4" CVT Drive Belt	$30.00	Comet Industries	$30.00	Comet Industries	$15.00
Bearings					
2 - 3/4" Self-aligning b earing	$17.98	Rural King	$17.98	Rural King	$9.99
2 - 3-hole Flange Kits for 3/4" b earings	$4.98	Rural King	$4.98	Rural King	$2.49
Drivetrain Total	$823.40		$591.40		$411.70
Electrical					
Lights					
6 - Headlights	$66.00	NAPA	Donated	NAPA	$33.00
2 - Brake/Turn Signal Lights	$20.00	NAPA	Donated	NAPA	$10.00
4- Parking Lights	$18.00	NAPA	Donated	NAPA	$9.00
4- Reflectors	$8.00	NAPA	Donated	NAPA	$4.00
Terminals					
1- Box	$9.00	NAPA	Donated	NAPA	$4.50
Fuse Box					
1- Fuse Box	$10.00	NAPA	Donated	NAPA	$5.00
Fuses					
5- 20 amp.	$10.00	NAPA	Donated	NAPA	$5.00
Wire					
2- 100' rolls 14 ga.	$20.00	NAPA	Donated	NAPA	$10.00
Electrical Total	$161.00		$0.00		$80.50
Steering					
Steering Column					
	$0.00	Donor Car	$0.00	Donor Car	$0.00
90 * gear box					
	$10.00	McMaster-Carr	Donated	Purdue Quarter Scale	$5.00
Rack & Pinion					
	$0.00	Donor Car	$0.00	Donor Car	$0.00
Steering Total	$10.00		$0.00		$5.00
Brakes					
Rotors					
Front Rotor Pair For 1988 Toyota Tercel	$0.00	Donor Car	$0.00	Donor Car	$0.00
Calipers & Pads					
Remanufactured Loaded Front Caliper Pair For 1988 Toyota Tercel	$74.99	AutoZone	$74.99	AutoZone	$32.50
Core Charge For Old Calipers For 1988 Toyota Tercel	($93.00)	AutoZone	($93.00)		($93.00)
Master Cylinders					
Master Cylinder For Toyota Tercel	$0.00	Donor Car	$0.00	Donor Car	$0.00
Master Cylinder For Toyota Tercel	$62.99	AutoZone	$62.99	Autozone	$31.50
Brake Lines					
Front Brake Lines For 1988 Toyota Tercel	$0.00	Donor Car	$0.00	Donor Car	$0.00
Brakes Total	$44.98		$44.98		($29.00)

Totals			
Donor Car	$367.99	$367.99	$184.00
Front Frame	$146.21	$96.71	$73.11
Front Suspension	$452.58	$0.00	$226.29
Rear Frame	$72.48	$70.48	$36.24
Rear Suspension	$181.62	$23.98	$90.81
Bed	$388.06	$113.29	$194.03
Drivetrain	$823.40	$591.40	$411.70
Electrical	$161.00	$0.00	$80.50
Steering	$10.00	$0.00	$5.00
Brakes	$44.98	$44.98	($29.00)
Seat	$0.00	$0.00	$0.00
Total	$2,848.32	$1,309.80	$1,272.67

The Cause

The idea of the *Basic Utility Vehicle (BUV) Power Module* is to incorporate the driver, the powertrain, suspension, and controls (i.e. areas of complexity) in one small space between two drive wheels. The vision is for the power module to be assembled by medium sized businesses in Africa. The rear unit is extremely simple, adaptable, and can easily be fabricated by small businesses throughout Africa. These businesses will provide needed transportation products while providing jobs for families.

Problem Statement: Starting with the front components from a used Toyota Corolla or Toyota Tercel (both high volume global designs) with a manual transmission, design a vehicle to re-use the components to the specifications above. The vehicle is intended to be a cargo carrier for small businesses. Design emphasis is on the power module with regard to cost, ease of assembly, durability, and kit packaging.

We would like the thank our sponsor and donors for their help and support:

Purdue University Agricultural and Biological Engineering Department

Dr. Bernard A. Engel

Kelly Construction Group

Fastenal

Von Tobel Lumber

Purdue Quarter Scale Team

Napa

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