**Challenge**

Develop a 3-wheeled vehicle to be driven by polio survivors, landmine survivors, amputees, and others that no longer have use of their legs. In addition to hand controls and affordability, design emphasis is on the steering, front suspension and a third-wheel drive (front wheel). Design vehicle based on re-using the rear axles and suspension of a small pick-up truck. Design for small scale assembly operations in Africa. Minimize factory investment at a volume of one vehicle per day.

**What is BUV?**

**Mission**

To improve lives in developing countries by facilitating the spread of simple vehicles that can be assembled “almost anywhere, by almost anyone.”

**Vision**

The BUV will go:

...where the streets have no name

...where roads don’t exist

...where people need hope


**Goal**

To jumpstart an industry to bless the working poor

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- Dr. Bernie Engel, Department Head
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- Yanmar
- Mid States Power (Harlan Vanderpool)
- Quality Drive Systems (Roy Navarette)

Others
- ABI Shop: Scott Brand & Gary Williams
- Purdue Quarter Scale Team
- Purdue Central Machine Shop

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**Design Objectives**

- **Cost**
  - Minimize total lifetime cost of ownership
  - Use off the shelf components
  - Also use salvaged or pre-existing components when possible
  - Reduce number of moving parts by avoiding complex gearboxes

- **Performance**
  - Find the right balance between performance and simplicity
  - Design drivetrain system with industrial components that can withstand punishment
  - Allow for easy access of drivetrain components for fine-tuning and maintenance

- **Safety**
  - Protect driver and passengers from all moving parts and sharp edges
  - Coordinate placement of components of drivetrain with weight distribution of vehicle

- **Manufacturing**
  - Group drivetrain components into subassemblies that can easily be bolted onto vehicle
  - Simplify fabrication techniques when possible

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**Basic Utility Vehicle (BUV)**

Craig Blough, Craig Roberts, Eli Jacobson, Matt Londergan

ABE (Machine Systems)

April 23rd, 2009

www.drivebuv.org
Diesel Drivetrain

Design Criteria

- Must use 10hp Yanmar diesel engine
- Make a modular design that can be integrated with the rest of the vehicle
- Provide a high torque at low speeds and provide 20mph top speed
- Design drivetrain capable of towing 1700lbs including a trailer loaded with 500 lbs
- Must be able to disengage driveline to power PTO pulley
- Simplify drivetrain controls (handicapped driver)

Initial Design

Steel Enclosure

- Keeps drivetrain components safe, dry, and secure while being lightweight
- Modular design that bolts straight to front and rear frame modules
- Provides extra structural rigidity for drivetrain components
- Provides storage for tools, spare parts, and other accessories

Main Drive System

- A combination of CVT and chain drive system was chosen over a straight belt drive or Tuff Torq transmission.
- This design choice produced a drivetrain package that is simple, lightweight, high performance, and easy to control and maintain
- Engine positioned low and in center of vehicle to improve weight distribution

Fabrication and Testing

Easy to produce/assemble

- Wire feed and arc welding used to match processes available to theoretical micro-factory
- Used salvaged drivetrain parts from a 1993 S10 to produce custom drivetrain
- Brake and Electrical systems fully integrated into enclosure, allowing for simplified assembly

Optimized weight and performance

- 72T sprocket lightened by 5 lbs through simple machining
- Engine position made adjustable to account for belt wear and wet conditions
- Structural enclosure built with minimum amount of material
- Reinforcements added to increase rigidity after initial testing

Calculations

Max Vehicle Speed

Total Gear Reduction

Engine Speed

Output at High Ratio

Output at Low Ratio

Width

Height

Belt Thickness

PTO Drive System

- A roller chain coupler was chosen to disengage power from driveline and power the PTO pulley
- A variable pitch pulley allows for use of a wide range of belt sizes
- Speed of PTO is adjustable due to CVT
- A friction throttle allows for constant speed while using PTO

Safety

- Aluminum guards used to protect operator and passengers from moving parts and exhaust
- Kill switch lever integrated into operator's station to allow for quick deactivation of engine

BUV Competition Results

- There were issues with the throttle cable, but once fixed, the BUV performed well and obtained 2nd place in the sprint competition
- In the obstacle course, the vehicle did very well until the final obstacle, when the drivetrain fell off of the splined shaft connected to the 72T sprocket

Areas of Improvement

- The driveshaft needs to be lengthened to decrease the yoke angles and subsequent vibrations
- The throttle cable used was too rigid to make extreme bends, a braided cable should be used instead

PTO Drive System

- A friction throttle allows for constant speed while using PTO

Cost

Engine

Cost

Qt

Subtotal

CVT - QDS

Cost

Qt

Subtotal

Chain Drive - Surplus Center

Cost

Qt

Subtotal

Chain Drive - McMaster - Carr

Cost

Qt

Subtotal

CVT

Cost

Qt

Subtotal

TOTAL

1499.19

PURO UNIVERSITY
Electrical Drivetrain

Design Criteria

- To be used in stop and go conditions encountered in trash pickup
- Must be able to propel the vehicle at 1 mph in both forward and reverse
- Design as a modular package that can be easily installed on both past and present BUVs
- Simplify drivetrains controls (handicapped driver)

Requirements at the Wheel

- Sound Requirements at Wheel Hub
- Converted ground speed to rotation at hub
- Sound torque required (from previous vehicle testing)
- Combined rpm and torque to find power required

Sizing the Winch

- Sized with power, torque and speed requirements required at the wheel
- Utilized drum diameter to determine maximum possible sprocket size
- Gear reduction chosen to match requirements at the wheel
- When powering the winch, we utilize a starter battery due to the high current required over a short time

Winch manufacturer specifications

Machining

- 5/16" keyway in axle shaft
- Outer lovejoy bored to 1 ¼", keyed
- Inner lovejoy bored to 1 3/8", welded to small sprocket
- and pressed onto brass bushing
- Sleeve made for axle shaft, drum cut in half, connected to sleeve by shear bolts offset 180˚
- Lock collar machined to ½" to conserve space inside pillow block
- Chain rub block to prevent inner lovejoy from ‘walking out’ and engaging shaft

Areas of Improvement

- The design was very sound, but failed due to an unexpected part failure
  - The Electric FWD successfully powered the axle when jacked up and on pavement,
  - Lovejoy failed on soil with full load
  - Failure along plane of set screw and keyway (180˚ offset)
  - New lovejoy was machined out of stronger steel with the key offset 90˚ from the set screw
  - Redesign would include a more heavy duty lovejoy or a sprocket & chain master link clutching assembly.
  - More difficult engagement, but less likelihood of failure
  - An FEA analysis of the lovejoy would be effective in analyzing the failure mode.

Tests & Competition

- The Electric FWD successfully powered the axle when jacked up
- and on pavement,
- Lovejoy failed on soil with full load
- Failure along plane of set screw and keyway (180˚ offset)
- New lovejoy was machined out of stronger steel with the key offset 90˚ from the set screw
- Second lovejoy failed in competition on soil under full load
  - The design was very sound, but failed due to an unexpected part failure
  - The Electric FWD successfully powered the axle when jacked up and on pavement,
  - Lovejoy failed on soil with full load
  - Failure along plane of set screw and keyway (180˚ offset)
  - New lovejoy was machined out of stronger steel with the key offset 90˚ from the set screw
  - Redesign would include a more heavy duty lovejoy or a sprocket & chain master link clutching assembly.
  - More difficult engagement, but less likelihood of failure
  - An FEA analysis of the lovejoy would be effective in analyzing the failure mode.

Final Cost

- ATV Winch 1 $229.00
- Pillow Block 1 $19.99
- Bearing 1 $11.99
- Lovejoy 2 $12.00
- Sprocket 2 $10.59
- 40 roller chain 1 $3.00
- TOTAL $286.57

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