

Basic Utility Vehicle (BUV) Team

A Baccalaureate thesis submitted to the
Department of Mechanical and Materials Engineering
College of Engineering and Applied Science
University of Cincinnati

in partial fulfillment of the
requirements for the degree of

Bachelor of Science

in Mechanical Engineering Technology

by

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ABSTRACT

Each year UC students take part in building a Basic Utility Vehicle for the annual BUV Competition. In 2013, the Senior Project BUV team proved their innovative and creative skill set by coming in 3rd place. A few of their technical specifications include an angled Iron frame, cargo bed area less than 18ft², and a 2000lb payload at a 20-degree slope. (2) The use of wood and angle Iron helped to reduce the cost and weight of the BUV. (2) They recommend that future groups continue using the frame, chassis, truss design, and angle Iron for future models. (2) Problems they encountered were a broken PVC barrel rotating out of place and front design of the suspension wasn't fit for a 3ft drop. (2) They suggested that future teams secure barrels before working on irrigation system and design the front suspension. (1)

PROBLEM DEFINITION & RESEARCH

PROBLEM STATEMENT

Every year since 2001 the Institute of Affordable Transportation (IAT) has held a Basic Utility Vehicle (BUV) competition. IAT is a non-profit organization located in Indianapolis, IN that is devoted to developing high-quality, low-cost transportation. The BUV should be developed to provide a durable, low cost vehicle that can be built and maintained in a third world country. The vehicle is designed for mobility, to transport people, water, and various other materials. The vehicle should be suitable for farming and operating in areas without roads. The design should be in kit form and should be able to assemble with ease.

We have delegated responsibilities for this project, however, we will be working closely as a team and that includes sharing ideas and supporting roles. I am responsible for the frame and chassis components. We are working closely with Professor David Conrad on every step of this project to ensure that we meet our time and design goals.

Research and Background Information

2012 Purdue BUV Design



Figure 1 - 2012 Purdue BUV (2)

The vehicle above was designed to carry two 55-gallon barrels that are filled by a water pump that is driven by the main drivetrain via belt and feed connection. This system did not support a water pump discharge but instead used gravity to expel water from barrels. The benefit to this system is the low fill time that was achieved using an on board 11hp Honda engine. The drawbacks to this system include a high discharge time and if the belt connection were to snap, the pump would serve no purpose until a replacement belt were found.

2013 University of Cincinnati BUV Design



Figure 2 - 2013 UC BUV (1)

Based on Purdue's BUV the 2013 UC BUV and adding their own modifications, this team placed third overall in the competition. This system uses a gasoline powered water pump connected to three 55-gallon barrels via PVC piping at the top of the barrels. The discharge system included a single PVC piping connected at the bottom of the barrels and utilized gravity to expel water from the barrels.

The benefits of this system include simplicity and ease of use. However, due to the use of a single PVC pipe connection between barrels, the connection was severed while in transit over rough conditions. The connection to the first barrel was still in contact but the other two barrels were unable to filled during the competition, thus resulting in a loss of points.

2014 University of Cincinnati BUV Design

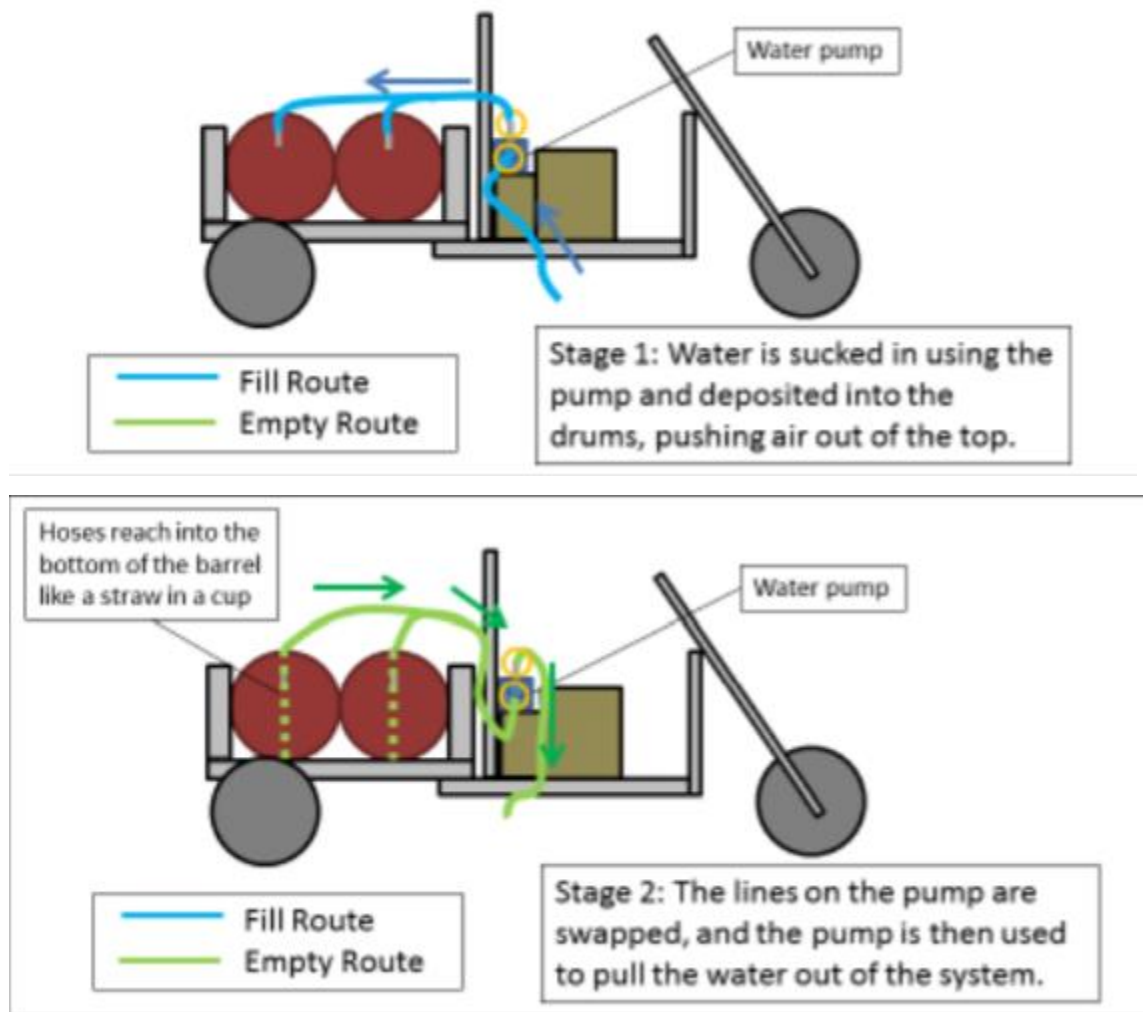


Figure 3 – 2014 UC BUV (1)

The 2014 University of Cincinnati BUV design was similar to that of the 2013 with slight modification to the irrigation system. The same gasoline-powered water pump was used and the fill setup was unchanged. The discharge system was modified so that the pump would extract the water from the barrels via the same pipes. The benefits to this setup include reduced discharge time and minimal material usage.

However, the same flaw as the 2013 team reemerged as the team was unable to fill both barrels due to a severed pipe.

TEAM MEMBER RESPONSIBILITIES

Deamann Strefas
Irrigation System
Bethany Nickson
Chasis
Christopher Steward
Drive Train
Guanchun Ye
Brake System
Dickson Opoku
Front Suspension

Competition Guidelines & Events

The 2017 IAT BUV Competition will be held on Friday & Saturday April 21st and 22nd at 2630 Herold Road in Batavia OH. Teams will be competing to finish a obstacle course where they must transport up to 150 gallons of water. This will be done by pumping pond water into vehicle irrigation system, carrying it for 3 full laps on a 2.2-mile course, and dumping and refilling back at the pond. This cycle will carry on for 7 hours.

See full IAT BUV Specifications in Appendix...

PRODUCT OBJECTIVES

In late April, we will test how well our BUV performs in the 2017 BUV Competition. During the 7-hour contest, the BUVs will run through an obstacle course in off-road conditions transporting water. Throughout our design, we will implement a variety of ways to improve past designs and effectively implement safety, easy maneuverability, comfort, quick and easy maintenance, and reliability.

CUSTOMER PROFILE

The **Team** is focusing on improving items such as:

- Good gas mileage
- Hauling capacity/cargo capacity
- Ability to handle rough terrain
- Ease of maintenance

The BUV should be:

- Affordable – not more than \$6500
- Durable – automotive parts
- Utility – power pump, mill, compressor etc.

CUSTOMER FEATURES

Our main goal of the BUV Team is to develop a durable, low cost vehicle that can be built and maintained in a third world country. We must keep in mind that this vehicle will be used for transporting water and cargo, used in off road conditions, and have at least a 10-year life expectancy. We are developing our BUV to be shipped in the form of a kit and easily maintained over time.

- Durable
- Cost Efficient
- Reliable
- All terrain/weather
- Long Life Expectancy
- Easy to Assemble
- Easy to Maintain
- Good Fuel Economy
- Easy to Operate
- Clear Visibility

PROJECT MANAGEMENT

BUDGET DISTRIBUTION

The bill of materials is listed below. Both pump and barrels were donated keeping costs down to absolute minimum.

Bill of Materials			
Component	Material	Cost (\$)	Total Cost (\$)
<i>Frame & Chassis</i>	Chevrolet S10 Frame	Donated by U-Pull & Pay	\$454.54
	Plywood (1/4 1/2 & 3/4 In.)	\$73.51	
	Bolts and Nuts	\$159.36	
	Angle Iron (3x2x3/8 in & 2x2x3/8 in)	\$221.67	
<i>Suspension</i>	Wheel Hub Slugs M12 x 1.5 x 3 Inch	\$20.45	\$392.82
	Front Wheel Hub and 14 In. Rim	\$123.77	
	Wheel Nuts	\$63.44	
	Flex Joint and Steering Bar	\$49.72	
	Steel Plate and 2x2 inch Angle Iron	\$42.80	
	Special M12 x 1.5 x 110 mm Bolts X4	\$27.64	
	Steering Hub (From David Conrad)	\$65.00	
<i>Brake System</i>	Hydraulic Hose adapter 3/8-24 NPT to 3/4	\$4.47	\$164.40
	Hose Plug 3/4 ID.	\$2.66	
	Hydraulic Joint Plug 3/8-24 Brass	\$12.06	
	Brake Hose Flex 3/8 - 24 Hose X 24 In. X 2	\$24.58	
	Brake Shoes, Brake Cylinders X 2	\$64.68	
	Brake Lines	\$41.42	
	Hydraulic Line Adapter	\$14.53	
<i>Irrigation System</i>	3 Barrels	Provided by UC	\$22.92
	PVC Adapters	\$7.14	
	Bushing	\$4.14	
	PVC Thread	\$11.64	
<i>Drive Train</i>	Engine	Provided by UC	\$314.17
	Transmission	Provided by UC	
	Powershaft	Provided by UC	
	Transaxle	Provided by UC	
	Differential Cover for Chevy S10, DOT 3 Diff	\$60.30	
	Wilwood Master Cylinder X 2	\$105.21	
	Axle Drive Shaft Coupler	\$46.67	
	1 X 1 X 40 In. Angle Iron	\$20.99	
	Drive Train Coupler	\$65.00	
	U-Bolts and Screws	\$10.00	
	Aluminum Sheet Metal	\$6.00	
<i>Other/Miscellaneous</i>	Sand Paper and Disposable Glove	\$14.96	\$206.55
	Hand Drill and Drill Bits	\$79.10	
	Truck Rental	\$20.14	
	Welding Wire 11 Lbs X 2	\$30.35	
	Spray Paint	\$62.00	
	Competition Registration Fee	Donated	
Total BUV Production Cost			\$1,555.40

Table 1 – Budget

SCHEDULE

Task	Project Date	Actual Date
Design Agreement	10/5/2016	10/5/2016
Separation of Duties	11/9/2016	11/9/2016
Bill of Materials (BOM)	11/18/2016	12/18/2016
Design Phase	12/14/2016 – 2/12/2017	12/14/2016 – 2/24/2017
Oral Presentation	2/13/2017	2/13/2017
Design Modification	2/13/2017 - 2/20/2017	2/13/2017 - 2/27/2017
Fabrication	2/13/2017 – 3/20/2017	2/27/2017 - 4/3/2017
Testing	3/13/2017 – 3/27/2017	4/3/2017 - 4/20/2017
Modifications	3/27/2017 – 4/3/2017	4/4/2017 - 4/20/2017
Final Testing	4/1/2017 - 4/6/2017	4/21/2017
Tech. Expo	4/7/2017	4/6/2017
Final Presentation	4/14/2017	4/14/2017
BUV Competition	4/22/2017	4/22/2017

Table 2 – Schedule**Design**

Two methods were considered when designing the irrigation system: a gasoline powered water pump or an electrical water pump powered by a power take-off connection.

Design Alternatives

1. Gasoline powered water pump

Water pump systems for homes/RVs utilize a gasoline powered water pump in which the pump is driven by an engine that is integrated into the design of the pump. This set up is ideal due the minimum connections and low costs. These setups usually have a kill switch and other features such as chokes and throttles.



Figure 4 - Pacific Hydrostar 1" Clear Water Pump (7)

2. Electric powered water pump

Water pumps driven by electric power require a more complex setup. For this design, an alternator would be needed to keep the battery charged and a power inverter would also be needed for power connection.



Figure 5 - Wayne 12V 1" Transfer Pump (5)

Design Selection

To keep costs at a minimum the gasoline powered water pump was chosen despite point deduction for the competition. The pump selected is the Pacific Hydrostar 1" Clear Water Pump. This pump was obtained by donation from the 2014 BUV team.

Design Concept

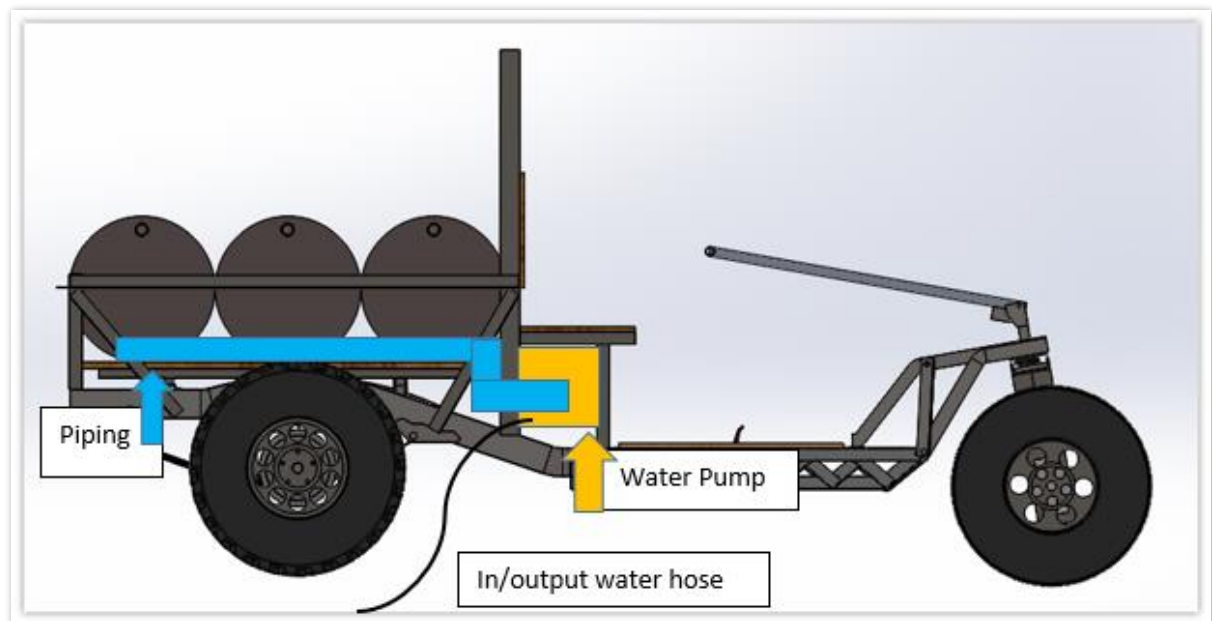


Figure 6 – Design Concept

Based on 2014 design results, I wanted to secure the water pump out of sight which is why placement under the seat was ideal. The idea of a single pipe connecting all three barrels to the water pump would keep material cost to a minimum and would simplify the overall design. Previous years had trouble keeping the connection between each barrel in contact so the foundation of this design revolves around the idea of a quick-disconnect system between the barrels and the pipe. By disconnecting the pipe from the barrels and securing to the frame, this would eliminate any potential damage or breakage to the pipe.

Fabrication

Fabrication and assembly of the irrigation system was conducted at OCEAS, Victory Parkway North Lab building.

Fabrication was cut to a minimum thanks to the simplicity of the overall design. Setting up the barrel once the truck bed was fabricated was the easy part. To secure the barrels in place, ratchet straps were used and anchored to the bed of the truck. These straps are design for heavy loads of up to 900 lbs and each barrel had two straps securing them down.

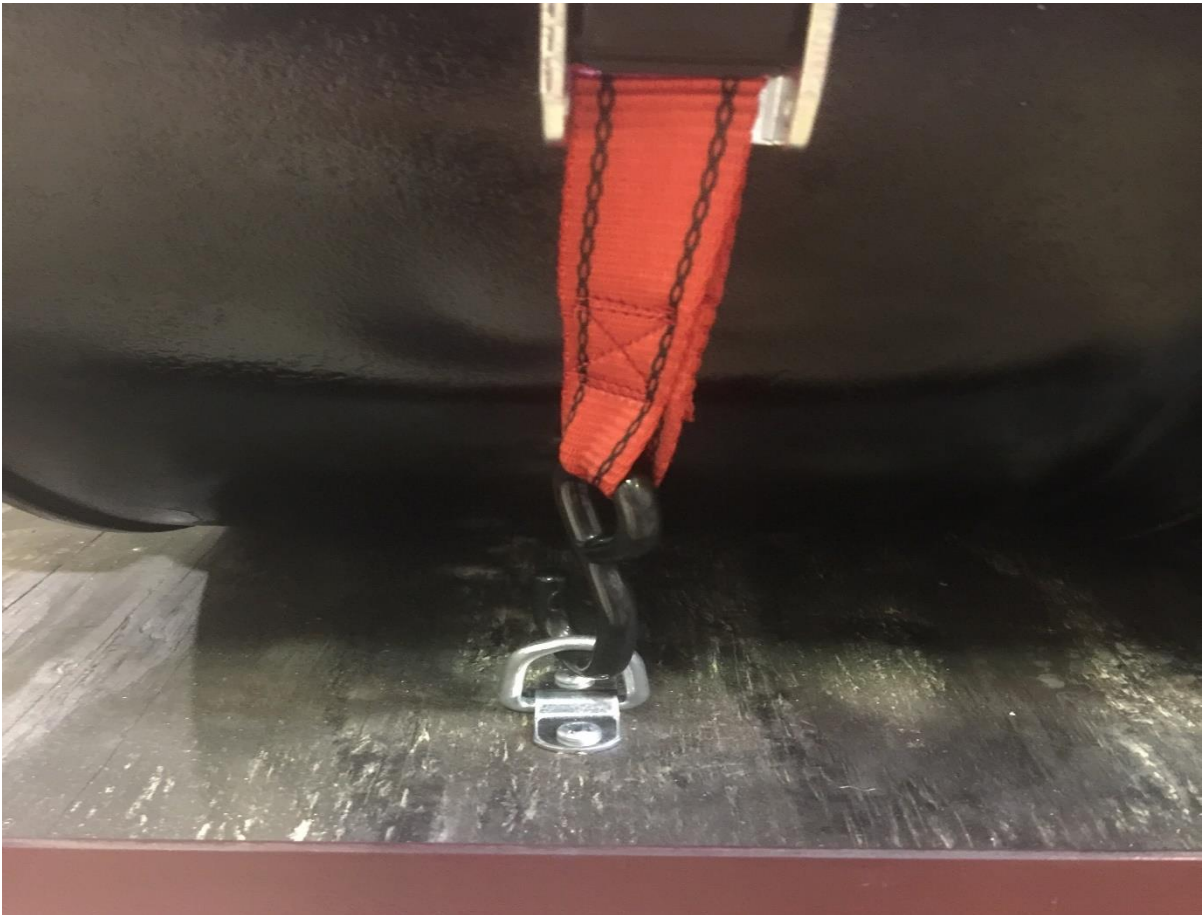


Figure 7 - Anchor Set-up

Once the barrels were in place and secured, accurate measurements for the input connections could be made. After the measurements were taken, bracketing placement could be made which consists of two points where the pipe would be hung from.



Figure 8 - Measuring for Brackets

The water pump was then mounted under the seat and lines were added and connected. Four bolts were used to secure the water pump down.



Figure 9 - Water Pump Mounting

A small cut-out was needed on the side where the input connection to the water pump was located.



Figure 10 - Input Connection Cut-Out

The final setup is pictured below. Velcro was used instead of bracketing. A single bolt secured each strap and the Velcro was weatherproof to handle all outdoor conditions.



Figure 11 - Final Setup



Figure 12 - Side-view Final Setup

Testing

Testing was completed at Victory Parkway North Lab Building using the oversized sinks located inside. The sink was filled and then used to fill the barrels and then put back into the sink.

Pacific Hydrostar: Fill and Empty Times	
Time to Fill	Time to Empty
5:38	4:17

Table 3 – Fill/Empty Times

Time to fill was expected to be higher due to the presence of air in lines and needed to be filled prior to turning the pump on.

Conclusion/Recommendation

The IAT BUV Competition was held on Saturday, April 22nd. Our team was unable to complete one lap of the competition due to front suspension failure. As a result, the irrigation system was unable to be put into act out in the field. Had the front suspension not failed during the first lap, our BUV would have had to make two complete laps before we could fill on the third lap.

My recommendations for the next BUV senior design team are as follows. First, if full points are of concern then do go forward with the electric pump set up. The design is more complex but once the math is figured out it could prove to be more beneficial. This is because gasoline is used to fill both the water pump and the BUV itself and the electrical pump would eliminate that need. Second, by continuing to use the quick disconnect and the fill/empty method of using the same line despite not being put to the test during the competition it was still positively received by all judges.

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APPENDIX A – COMPETITION SPECIFICATIONS

BUV FARM TANKER & TRANSPORTER 2017 Design Specifications:

- Engine Use up to 11 horsepower unmodified engine. An auxiliary fuel tank may be added.
- Exhaust Stock muffler, which may be relocated, with additional heat shields as needed.
- Gauges An engine temperature indicator located in view of the driver.
- Fuel Retail pump fuel and oil with provisions to prevent spilling fuel on a hot engine.
- Transmission It is builder's choice, to meet event conditions, but should have reverse** and should have at least two forward speeds** not counting any variable drive features.
- Power Takeoff The ability to power auxiliary equipment** at approximately 1000 rpm. A V-belt drive is anticipated for auxiliary equipment.
- Electrical A 12 volt 35 amp or larger automotive alternator and an automotive battery are required**.
- Cargo Bed The bed must hold two, but may hold three 55 gallon standard steel drums. The drums must be located on their sides with the small hole at the top. The drums must be located as low as possible in the bed. The drums must not be stacked in any manner. The front of the cargo bed must have a 16 inch minimum high bulkhead between the driver and the cargo. The other sides of the bed must be a minimum of 8 inches high. Drums should be easily removable for cargo**.
- Roll Bar A minimum height of 36 inches above the surface the driver is seated upon. The roll bar must be completely padded above the seat height. It must have a cross member that covers the ends of the vertical structures, and adequate bracing to prevent the vehicle from rolling over.
- Driver Safety A helmet is required for each person aboard the vehicle. Seat belts are at the option of the team and the team advisor.
- Safety Items To participate in the event, you must have the following safety items:
1. An engine shutoff device marked with a nine-inch red streamer located within reach of the driver.
 2. A *dead man* throttle with the spring located directly on the engine throttle linkage and not on the throttle control devices of vehicle.
 3. Guarding from all moving parts and Padding of all sharp or dangerous areas.
 4. Automotive horn, a fire extinguisher, and a high visibility safety flag above the vehicle.
- Brake System A redundant brake system** that will prevent total brake failure if a brake line is severed anywhere on the vehicle. The brakes must be located at the wheels and not on the drive-line. A front wheel brake is not required on three wheeled vehicles. The parking brake is not considered the redundancy that is required. Hydraulic drives may use reverse for brakes.
- Parking Brake A parking brake capable of overcoming the engine power. It may be on the drive-line.

- Tires Agricultural tread, or aggressive tire chains are required. Chains must be carried by the vehicle if removed from the tires.
- Towing Each vehicle must have a 20 foot looped-end tow strap. There must be an attachment point at the front of the vehicle for towing. The trailer ball will be the rear attachment point for towing.
- Trailer Hitch A 1-7/8 inch trailer ball must be mounted 15 inches above the ground when the vehicle is unloaded.
- Weatherproof The vehicle should have protection from the weather elements to provide better reliability and greater durability.
- Speed Maximum of 20 MPH.
- Load Maximum of 165 gallons of water, weighting roughly 1376 pounds.
- Water Pump Ability to fill 55-gallon drums from within 15 feet of a pond. All pumping equipment and hoses must be carried on the vehicle during the event. Pump driven form PTO device only.
- Name Plate The school name and team number displayed in 4-inch font on all sides of the vehicle.

APPENDIX B – COMPETITION GUIDELINES

Features

- Affordable – 20% of the cost of a small truck
- Flexible – easy to modify cargo area
- Comfortable – automotive suspension
- Durable – automotive parts

Performance

- 20 mph
- 1200 lb payload (and low ground pressure)
- 50+ mpg diesel
- power other devices (water pump, mill, etc.)

Specifications

- 10 hp engine (diesel or gas)
- 1000 lb vehicle weight (low ground pressure)
- 12' L x 5' W; cargo bed 6.5' L

Service / Maintenance

- common "off-the-shelf" parts
- easy access to engine and drivetrain
- 95% less parts than a typical car

Packaging & Shipping

- 8 assembled units per ocean container
- crate size 2'H x 2'H x 4'L for power kit
- farm classification (lower duty rates)

Automotive Grade Components

- suspension / axle / rear frame
- brakes / tires / wheels / hubs
- expected life: 20+ years for auto parts

Safety

- high driver visibility
- speed limited to 20 mph
- low center of gravity

Cultural Factors

- middle steering, gender friendly
- car-like operation; no shifting, no clutch
- easy to rescue
- customize as necessary (canopy, lights, etc.)

APPENDIX C – HOUSE OF QUALITY

		Engineering Requirements (Units)														Customer Satisfaction Rating (0.00 - 1.00)						
		Importance wt.	Payload Force (lbs)	Material Selection (CrashNo)	Spinning Time (Sec/min)	Hydraulic Brake (CrashNo)	Ground Clearance (Inch)	Guarding (YearNo)	Paint & Lubricants (YearNo)	Sweating Radius (ft)	Metric Fasteners (YearNo)	# of Steps to Assemble (ft)	Weight (lbs)					CP	A	B	C	
Customer Requirements			1	2	3	4	5	6	7	8	9	10	11	12	13	14						
1	Durable	0.10	0	0		1	1	3	3													
2	Cost effective/expensive	0.15		0					1	1		3	3									
3	Reliable	0.15	3	3		3	1	1			1											
4	All terrain/all weather	0.15	3	0			0	0	3				3									
5	Long life expectancy	0.05	3	3		3	1	1	0			3										
6	Easy to assemble	0.10		3								0	3									
7	Maintainability	0.10		3				3	0			3										
8	Fuel economy	0.05	0	1																		
9	Easy to operate	0.10	3		0	3	1	1		0	1	3										
10	Clear visibility	0.05					3	3														
Total Importance		1.00	2.7	4.0	0.0	1	1.0	2.6	2.3	0.0	0.3	1.8	2									
Engineering requirement importance																						
Performance																						
	Current Product																					
	competitor A																					
	competitor B																					
	competitor C																					
	New Product Targets																					

APPENDIX D – QFD

Interaction Matrix														
Engineering Requirements	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Engineering Requirements	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Payload Force (lbs)	1	3		1		3			1					
Material Selection (Yes/No)	2					3					9			
Start/Run Time(Seconds)	3													
Hydraulic Brake(Yes/No)	4							1						
Ground Clearance (inches)	5													
Guarding (Yes/No)	6								9	3				
Paint & Lubricants (Yes/No)	7									3				
Steering Radius(ft)	8									3	3			
Metric Fasteners(Yes/No)	9									1				
# of Steps to Assemble (#)	10													
Weight(lbs)	11													
0	12													
0	13													
0	14													

Basic Utility Vehicle

Advisor: Prof. Moise Cummings

Deamann Strefas, Dickson Opoku, Christopher Steward, Bethany Nickson, & Guanchun Ye

Objectives

- Problem Statement
- Background & State-of-the-Art
- Competition Guidelines
- QFD & House of Quality
- Bethany – Chassis & Frame
- Dickson – Suspension
- Guan – Brake System
- Deamann – Irrigation System
- Christopher – Drive Train
- Proof of Design
- Up-to-Date Schedule
- Up-to-Date Budget
- Current Build
- Recommendations
- Overview
- Questions

Problem Statement

IAT is a non-profit organization located in Indianapolis, IN that is devoted to developing high-quality, low-cost transportation to provide mobility, freedom and economic hope to people in rural areas of developing countries. The vehicle is designed to transport people, water, and various other materials. To develop a durable, low cost vehicle that can be built and maintained in a third world country. The vehicle should be suitable for farming and operating in areas without roads. The design should be in kit form and should be able to assemble with ease. Regulations for competition are given on the spec sheet provided by the Institute of Affordable Transportation. The vehicle is to be ready for competition on April 22nd 2018.

Background & State-of-the-Art

IAT has held this competition every year since 2001
More recent submissions has shown the best results

Purdue, 1st Place Winners (2012)

- Wood & Angle Iron Material
- Decrease overall Weight, increase speed

UC, 3rd Place Winners (2013)

- Recommend using angle iron and plywood for material; using truss design for chassis
- Weighted pressure was on the intermediate shaft which causes Drive train to have error

Current BU V in Production (2016)

- Cost about \$5000 to produce



Competition Guidelines

Features

- Affordable – 20% of the cost of a small truck
- Flexible – easy to modify cargo area
- Comfortable – automotive suspension
- Durable – automotive parts

Performance

- 20 mph
- 1200 lb payload (and low ground pressure)
- 50+ mpg diesel
- power other devices (water pump, mill, etc.)

Specifications

- 10 hp engine (diesel or gas)
- 1000 lb vehicle weight (low ground pressure)
- 12' L x 5' W; cargo bed 6.5' L

Service / Maintenance

- common "off-the-shelf" parts
- easy access to engine and drivetrain
- 95% less parts than a typical car

Packaging & Shipping

- 8 assembled units per ocean container
- crate size 2'H x 2'H x 4'L for power kit
- farm classification (lower duty rates)

Automotive Grade Components

- suspension / axle / rear frame
- brakes / tires / wheels / hubs
- expected life: 20+ years for auto parts

Safety

- high driver visibility
- speed limited to 20 mph
- low center of gravity

Cultural Factors

- middle steering, gender friendly
- car-like operation; no shifting, no clutch
- easy to rescue
- customize as necessary (canopy, lights, etc.)

QFD & House of Quality

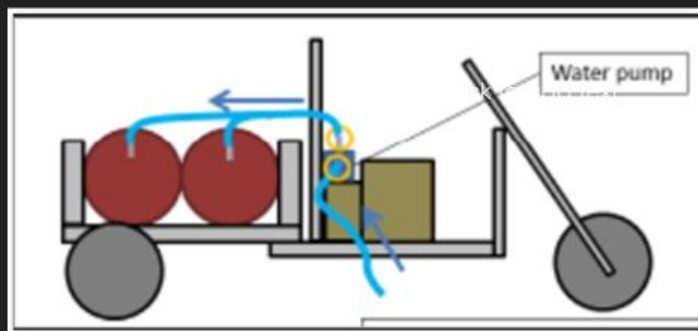
Customer Requirements	Engineering Requirements (units)														Customer Satisfaction Rating (0.00 - 1.00)		
	1. Payload Force (lbs)	2. Material Selection (Yes/No)	3. Start/Run Time (Seconds)	4. Hydraulic Brakes (Yes/No)	5. Ground Clearance (Inches)	6. Guarding (Yes/No)	7. Paint & Lubricants (Yes/No)	8. Steering Radius (ft)	9. Metric Fasteners (Yes/No)	10. # of Steps to Assemble (#)	11. Weight (lbs)	12	13	14			
1. Capacity	1.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2. Cost effectiveness	0.50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3. Reliability	0.50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4. Low maintenance	0.50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5. Low life expenses	0.50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6. Easy to assemble	0.50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7. Durability	0.50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8. Fuel economy	0.50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9. Easy to operate	0.50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10. Clear visibility	0.50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Importance	1.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Engineering requirement importance		0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Performance	Current Product																
	competitor A																
	competitor B																
	competitor C																
	New Product Targets																

Engineering Requirements	Interaction Matrix													
	1. Payload Force (lbs)	2. Material Selection (Yes/No)	3. Start/Run Time (Seconds)	4. Hydraulic Brakes (Yes/No)	5. Ground Clearance (Inches)	6. Guarding (Yes/No)	7. Paint & Lubricants (Yes/No)	8. Steering Radius (ft)	9. Metric Fasteners (Yes/No)	10. # of Steps to Assemble (#)	11. Weight (lbs)	12	13	14
1. Payload Force (lbs)	1	3	1	3	1	3	1	3	1	3	1	3	1	3
2. Material Selection (Yes/No)		2		2		2		2		2		2		2
3. Start/Run Time (Seconds)			3		3		3		3		3		3	
4. Hydraulic Brakes (Yes/No)				4		4		4		4		4		4
5. Ground Clearance (Inches)					5		5		5		5		5	
6. Guarding (Yes/No)						6		6		6		6		6
7. Paint & Lubricants (Yes/No)							7		7		7		7	
8. Steering Radius (ft)								8		8		8		8
9. Metric Fasteners (Yes/No)									9		9		9	
10. # of Steps to Assemble (#)										10		10		10
11. Weight (lbs)											11		11	
12												12		12
13													13	
14														14

Irrigation System

Deamann Strefas

2014 Irrigation Design

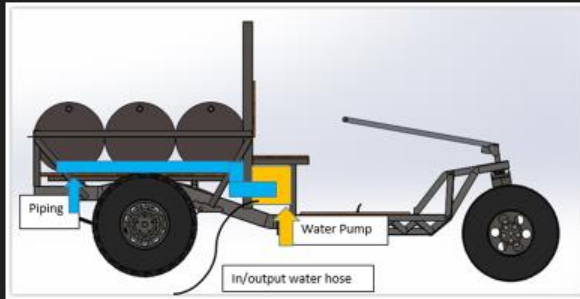


Similar to 2013, water is pumped in through the top of the barrels but is also pumped out through the same holes.

Pros:
Faster than 2013 design
Minimal material use

Cons:
Easily Damaged

Modifications



Relocated water pump under the seat.

Designed quick connect system.

Pros:
Minimal material usage
Eliminates risk of damage during transit

Cons:
To be determined

Modifications



Designed quick connect pumping system.

Easy to use, durable and time efficient.

Eliminates break factor while in transit.

Water Pump Selection

Criteria	Importance Weight %	Pump 1		Pump 2		Pump 3	
		Rating	Weighted Rating	Rating	Weighted Rating	Rating	Weighted Rating
Affordable	25	3	75	2	50	4	100
Easy to Use	15	4	60	2	30	3	45
Reliability	40	3	120	2	80	2	80
Pumping Rate	20	2	40	4	80	1	20
Total	100	N/A	295	N/A	240	N/A	245

Rating	Value
Satisfactory	0
Just Tolerable	1
Adequate	2
Good	3
Very Good	4

Pump one was picked based on the results of the Weighted Rating Method.

This pump is easy to use and affordable.

By choosing this pump, the complexity of the irrigation system is significantly reduced.

Pump Specifications

□ Pacific Hydrostar 1" Clear Water Pump



Horsepower (hp)	1.5
Impeller Material	Aluminum Alloy
Maximum Discharge Flow (gph)	2220
Maximum discharge flow (gpm)	37
Maximum Discharge Pressure (psi)	45.5
Self priming	Yes
Submersible	No

Calculations

Hazen – Williams Equation

$$V = kCR^{0.63}S^{0.54}$$

where:

V is velocity

k is a conversion factor for the unit system ($k = 1.318$ for US customary units, $k = 0.849$ for SI units)

C is a roughness coefficient (150 for PVC and Plastic)

R is the hydraulic radius

S is the slope of the energy line (head loss per length of pipe or h/L)

The Equation must be modified to solve for volumetric flow rate.

Hazen Williams Equation for Flow in Pipe due to Gravity

$$Q = \left(\frac{h_f C^{1.85} d^{4.87}}{10.67 L} \right)^{0.54}$$

$$Q = \left(\frac{2 * 150^{1.85} 1^{4.87}}{10.67 * 20} \right)^{0.54}$$

$$Q = 11.986 \text{ gal/min}$$

$$Q = 719.16 \text{ gal/hour}$$

$$Q \text{ for Pump is } 2220 \text{ gal/hour}$$

Pacific Hydrostar: Empty and Fill Times

Time to Fill	Time to Empty
4:03	2:51

Times based on 2014 BUY Design. New system has not been tested but is anticipated to ADD 20-30 seconds.

This equations proves that a pump will provide the necessary pumping power needed that gravity cannot provide.

Fabrication

Up Until Now

- x3 – 55gallon barrels from previous senior design BUY team.
- Replaced fittings with new and improved fixtures/adaptors.

In Progress

- Weld pump fixture under seat.
- Install pipes and hanging fixture.
- Install pump.
- Test system.



Proof of Design

- Light Weight angle iron Material
- 10 inch ground clearance
- 2840lbs Payload, w/ 20 degree incline
- Cargo Bed area is approx. 20 ft^2
- Production Cost is relatively low; under \$2000
- 10 hp engine; Product Specification Sheet (Drive train)
- Will have a reverse mode Physical Shift to Reverse: Visual Verification (Drive Train)



Up-to-Date Schedule

Task	Project Date	Actual Date
Design Agreement	10/5/2016	10/5/2016
Separation of Duties	11/9/2016	11/9/2016
Bill of Materials (BOM)	11/18/2016	12/18/2016
Design Phase	12/14/2016 – 2/12/2017	12/14/2016 – 2/24/2017
Oral Presentation	2/13/2017	2/13/2017
Design Modification	2/13/2017 - 2/20/2017	2/13/2017 - 2/27/2017
Fabrication	2/13/2017 – 3/20/2017	2/27/2017 - ongoing
Testing	3/13/2017 – 3/27/2017	4/3/2017 - ongoing
Modifications	3/27/2017 – 4/3/2017	4/4/2017 - ongoing
Final Testing	4/1/2017 - 4/6/2017	N/A
Tech. Expo	4/7/2017	4/6/2017
Final Presentation	4/14/2017	4/14/2017
BUV Competition	4/22/2017	4/22/2017

Up-to-Date Budget

Total Cost of
Production = \$1,555.40



Component	Material	Cost (\$)	Total Cost (\$)
Frame & Chassis	Chevrolet S10 Frame	Donated by U-Pull & Pay	
	Plywood (1/4 1/2 & 3/4 in.)	\$73.51	
	Bolts and Nuts	\$159.36	
	Angle Iron (3x3x3/8 in & 2x2x3/8 in)	\$221.67	\$454.54
	Wheel Hub Slugs M12 x 1.5 x 3 inch	\$20.45	
Suspension	Front Wheel Hub and 14 in. Rim	\$123.77	
	Wheel Nuts	\$63.44	
	Flex Joint and Steering Bar	\$49.72	
	Steel Plate and 2x2 inch Angle Iron	\$42.80	
	Special M12 x 1.5 x 110 mm Bolts X4	\$27.64	
	Steering Hub (From David Conrad)	\$65.00	\$392.82
	Hydraulic Hose adapter 3/8-24 NPT to 3/4	\$4.47	
Brake System	Hose Plug 3/4 ID.	\$2.66	
	Hydraulic joint Plug 3/8-24 Brass	\$12.06	
	Brake hose Flex 3/8 - 24 hose X 24 in. X 2	\$24.58	
	Brake Shoes, Brake Cylinders X 2	\$64.68	
	Brake Lines	\$41.42	
	Hydraulic Line Adapter	\$14.53	\$164.40
Irrigation System	3 Barrels	Provided by UC	
	PVC Adapters	\$7.14	
	Bushing	\$4.14	
	PVC Thread	\$11.64	\$22.92
Drive Train	Transmission	Provided by UC	
	Powershaft	Provided by UC	
	Transaxle	Provided by UC	
	Differential Cover for Chevy S10, DOT 3 Diff	\$40.30	
	Willwood Master Cylinder X 2	\$105.21	
	Axle Drive Shaft Coupler	\$46.67	
	1 x 1 x 40 in Angle Iron	\$30.99	
	Drive Train Coupler	\$65.00	
Other/Miscellaneous	U-Bolts and Screws	\$10.00	
	Aluminum Sheet Metal	\$6.00	\$314.17
	Sand Paper and Disposable Glove	\$14.96	
	Hand Drill and Drill Bits	\$79.10	
	Truck Rental	\$10.14	
	Welding Wire 11 lbs X 2	\$30.35	
Spray Paint	\$62.00	\$206.55	
Competition Registration Fee	Donated		
Total BLV Production Cost			\$1,555.40

Current Build



Current Progress

- Completed Frame & Chassis
- Completed Cargo Bed
- Completed Suspension System
- Completed Brake System
- Partial Irrigation System
- Partial Drive Train

Competition Expectations

- To Complete the 8 hour course
- Problems w/ 10 inch Ground Clearance
- Front Suspension; pivot point
- Initial pump; starter issues

Recommendations

- Design for a better Ground Clearance
- Develop drive train frame while other fabrications are taking place
- Don't wait for chassis to complete to being working drive train
- Better Front Wheel Selection to eliminate pivot point issues
- Instead of current water pump use an electric pump and connect to the battery.

Overview

- Problem Statement
- Background & State-of-the-Art
- Competition Specifications
- QFD & House of Quality
- Bethany – Chassis & Frame
- Dickson – Suspension
- Guan – Brake System
- Deamann – Irrigation System
- Christopher – Drive Train
- Proof of Design
- Up-to-Date Schedule
- Up-to-Date Budget
- Current Build
- Recommendations



Questions