CAPSTONE/SENIOR DESIGN EXPERIENCE 2017

MiniPUP II Utility Vehicle

Agricultural & Biological ENGINEERING

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Problem Statement and Background

- PUP (Purdue Utility Project) develops sustainable transportation and utility for developing countries
- These vehicles are capable of running attachments such as maize grinders or water pumps
- PUP vehicles typically cost between $1500-$2000 USD, higher than most smallholder farmers can afford
- The MiniPUP I has been prototyped to have a lower cost and comparable capabilities to the full-size PUP counterparts
- A next generation MiniPUP will be produced to address design weaknesses with the MiniPUP I

Project Goals

1. Allow for the sourcing of vehicle parts from local vendors in developing countries
2. Lower the cost and weight of the vehicle in comparison to the MiniPUP I platform
3. Resolve safety concerns with MiniPUP I, with an emphasis on vehicle center of gravity and weight distribution
4. Improve manufacturability of vehicle with emphasis on larger scale production
5. Reduce number of drivetrain wear components and possible points of failure for improved drivetrain durability and longevity

Design Specifications:

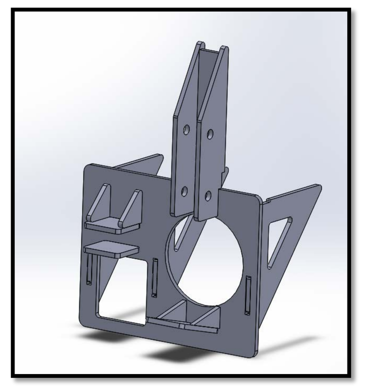
- 6.5 hp engine (4.5hp – 8hp optional)
- 5 speed transmission with reverse
- ≈ 740 lb. empty weight
- 30mm x 30mm x 3mm angle iron frame
- 1000 lb. payload capacity
- ≈ 20 mph top speed
- 70/30, rear/front weight distribution
- Automotive front strut suspension

Impact on Society and Sustainability

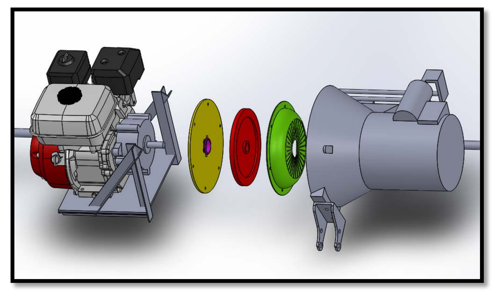
- Team will travel to Cameroon to reproduce the design in the future using locally available resources
- The MiniPUP II will be used on a day-to-day basis by ACREST hauling food, water, supplies, and other utility needs

- The vehicle will reduce small-holder farmer labor challenges and improve productivity and food security
- Reproducing this design locally on a micro-factory scale creates sustainable employment opportunities
- Creation of this vehicle within Purdue ABE brings awareness to the challenges faced by the people of Africa's developing countries

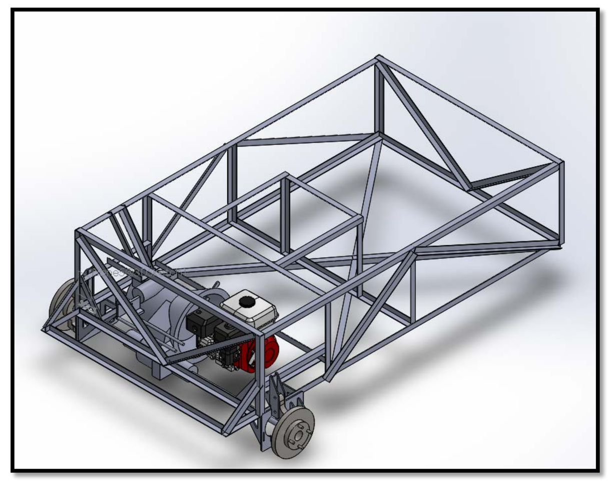
Final Design



- ¼" steel plate weldment designed to replace angle iron spindle mounts reduces build time, provides more consistent wheel alignment, and improves mount strength
- Parts mirrored to allow for assembly in both left and right wheel configurations
- Laser cut to maintain dimensional accuracy



- Direct drive powertrain utilizing 6:1 reduction gearbox eliminates all chains and sprockets
- Compact layout reduces engine bay area, reducing vehicle size

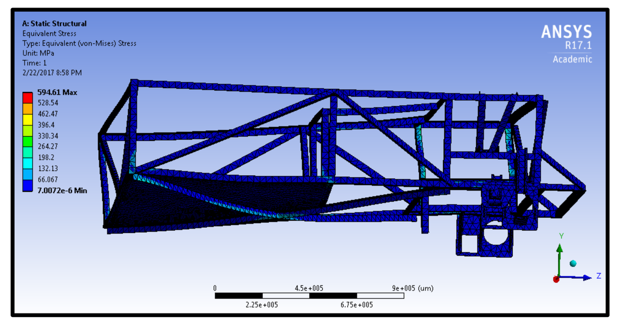


- Placement of all drivetrain components ahead of rear axle and below driver lowers center of gravity, improves front/rear weight distribution
- Reduced cargo area minimizes opportunity for overloading, maintains short wheelbase to ensure nimble handling
- Center driver placement allows for easier use in row crop applications

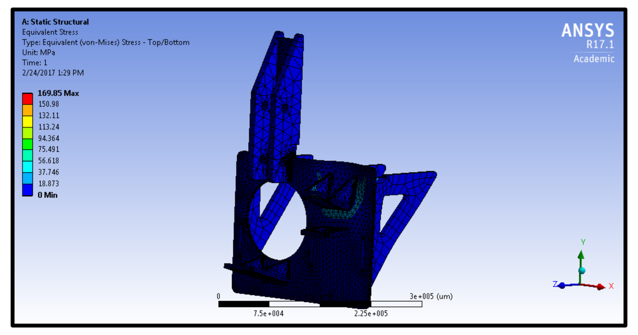
ANSYS

- Structural analysis using ANSYS Workbench allowed for substantial weight reduction of frame components without a decrease in strength
- Analysis of frame utilizing a 1000 lb. payload at 2G's showed factors of safety approaching 2 throughout the entire frame
- Separate analysis of spindle mounts shows similar factors of safety for 1000 lb. loading on spindle mounting points
- Multiple renditions using different loading orientations provided similar results

Frame Analysis – 2000lb Payload



Spindle Mount Analysis – 1000lb Load on Mount Points



Cost Analysis

- The MiniPUP II used 56% of the angle iron the MiniPUP I prototype used, and only 27% of the angle iron of a full size PUP vehicle to save cost on frame materials
- Reduction in frame materials alone saves 71 lbs. from the prototype MiniPUP I (MiniPUP II frame of 89 lbs. vs. MiniPUP I frame of 160 lbs.)
- Reduction in power transfer components (shafts, bearings, sprockets) maintains comparable drivetrain costs to MiniPUP I vehicle
- The cost of a single MiniPUP II prototype is $897, but cost will decrease as production begins in country

Developing Country Vehicle Cost

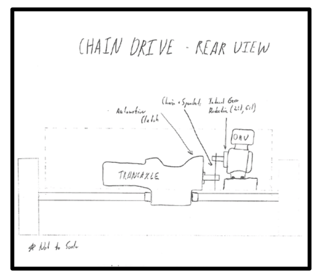
		Quantity	Unit Cost ($)	Total Cost ($)
Chassis	30mm x 30mm x 3mm Angle Iron (6m)	5	40	200
	Sedan Front Strut	1	20	20
	4' x 8' x 1/2" Plywood	1	7	7
	4' x 8' x 3/8" Plywood	2	5	10
Steering	Steering Column (Steel Tube)	1	15	15
	Ball Joints	2	5	10
	Tie Rods	1	10	10
	Handlebar	1	10	10
Drivetrain	Rear Spindles	2	10	20
	Half Shafts	2	10	20
	Transaxle	1	175	175
	Shift Cables	1	20	20
	Clutch	1	15	15
	Flywheel	1	10	10
	Alignment Spacer	1	15	15
	Engine	1	230	230
	Wheels & Tires	3	15	45
	Clutch Master Cylinder	1	10	10
Brakes	Brake Master Cylinder	2	10	20
	Rotors, Calipers	1	25	25
	Brake Line & Fittings	1	10	10
		Total Cost $ (USD)		897

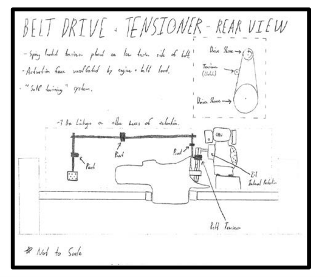
Alternative Solutions

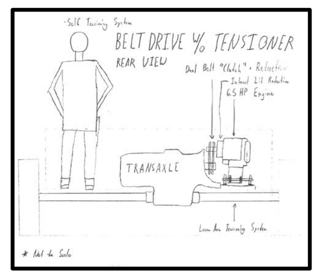
- Four ideas were generated for the vehicle driveline
- The potential solutions were direct drive (1), belt drive (2), chain drive with a reduction (3), and a chain drive without a reduction (4)
- Considerations were based on the merits of cost, manufacturability, performance, ergonomics, and durability
- A weighted matrix helped highlight the strong areas of each design, as well as a best power transfer solution for the MiniPUP II

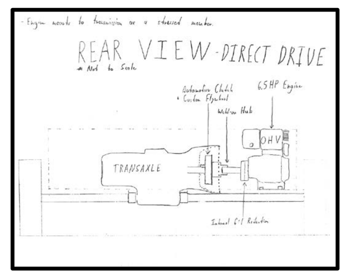
Drivetrain Decision Matrix

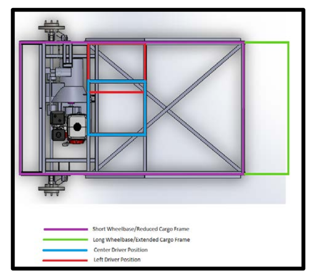
		#1. Direct Drive	#2. Belt Drive	#3. Chain Drive with Reduction	#4. Chain drive without Reduction
Cost (25%)	Parts & Materials	3	5	4	3
	Labor	4	4	3	3
Manufacturability (15%)	Required Tools	2	5	5	5
	Ease of Manufacture	4	5	2	2
Performance (25%)	Handling (Unloaded)	5	4	5	5
	Handling (Loaded)	4	5	5	5
	Climbing	5	4	5	5
	Braking	4	5	5	5
	Towing	5	3	4	3
	Implement Accessability	2	5	5	3
	Weight Distribution	5	5	5	3
	Payload Capacity	4	4	5	5
	Final Drive Variability	2	4	4	3
	CG	5	4	4	3
Ergonomics (10%)	Driver Fitment	5	5	5	5
	Control Operation	5	3	5	5
	Control Implementation	5	4	4	4
Durability (25%)	Wear Items	5	2	3	2
	Required Adjustment	5	3	3	1
Weighted Total		4.1	3.975	3.79166667	3.116666667











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