CAPSTONE/DESIGN EXPERIENCE 2016

Purdue Utility Project:
MiniPUP Frame

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Problem Statement and Background

- A new, lower priced design needs to be developed to reach smallholder farmers and extend the PUP project into new markets
- The team has been tasked with designing a frame for this new vehicle
- Purdue has partnered with ACREST to provide an affordable utility vehicle for local transportation of water, crops, and supplies while being able to power attachments
- The PUP design has been finalized at a build cost of $1500-$2000 USD
- This price is higher than what a typical smallholder farmer in Sub-Saharan Africa can afford
- The new design, a MiniPUP, needs to have many of the qualities of the PUP such as carrying heavy loads, traversing rough roads, and being manufactured locally

Impact on Society and Sustainability

- Team will travel to Cameroon to reproduce the design in the future using only locally available resources
- The MiniPUP will be used on a day-to-day basis by ACREST hauling food, water, supplies, etc.
- 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
- The MiniPUP can also run attachments such as a maize grinder or a water pump which will turn it into a mobile power unit

Project Goals

MiniPUP Constraints:

- Develop vehicle with a total parts cost that is equal to or less than $750
- Utilize an engine that is between 3.5 and 6.5 horsepower, a front wheel drive transmission, and other parts that are locally available in Sub-Saharan Africa
- Have the vehicle be able to obtain a speed of approximately 20mph on flat ground while unloaded while also being able to handle traveling on rough roads
  - Devise a bed that can carry a payload of up to 1000 lbs and have space for carrying two 55 gallon drums

Senior Design Goals:

- Design a frame for this new vehicle using 1/2 to 1/3 of the angle iron needed for the PUP
- Manufacture a prototype for testing at Purdue and for use in future MiniPUP iterations

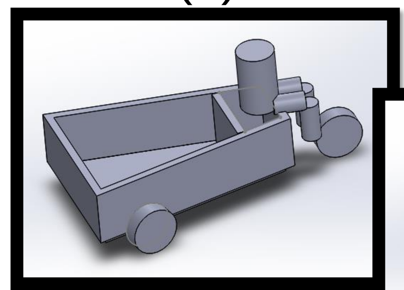
Alternative Solutions

Component Layout Decision

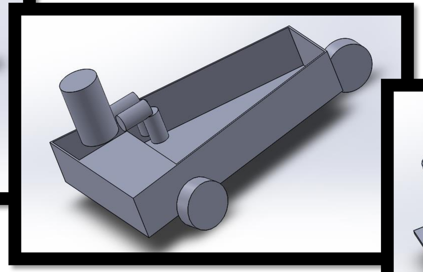
- Four ideas for the general layout were developed
- These included placement of the engine, driver, number of wheels, direction of driving, suspension options, and steered wheels
- The four options are as follows: Traditional (1), Person in Back(2), Person Standing in Back(3), Car-Like(4)
- A weighted decision matrix was developed and eventually eliminated (4), convinced us to further investigate (1), and then eliminate (1)
- The final chosen layout was a combined (2) and (3)

	design	1	2	3	4
Weight	Front	5	9	9	3
	Back	5	3	3	9
	Frame	9	5	5	3
	Suspension	9	9	9	3
	Bed	9	9	9	3
Weight Total		7.4	7	7	4.2
Stability	CG Height	9	5	3	1
	CG Fore to Aft	9	9	3	9
	Torque Frame	9	9	9	5
Visibility	Front	9	3	5	9
	Back	3	5	9	3
Accessibility	Engine	5	3	5	9
	Attachments	5	5	9	3
Design Implementation	Linkages	1	9	9	3
	Steering	9	5	5	3
Cost	Extra Strut	9	9	9	5
	Extra Wheel	9	9	9	5
	Extra Frame	9	5	3	1
	Import Cables	5	9	9	9
Cost Total		8	8	7.5	5
Security	Engine	1	5	9	3
	Total	256	224	238	183

(1)



(2)



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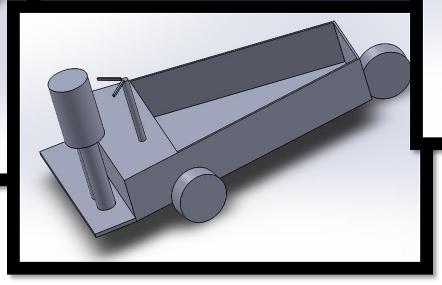
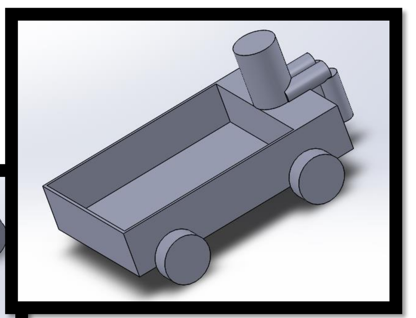


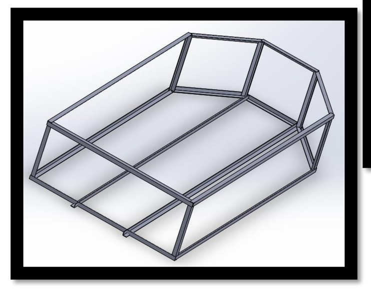
(4)

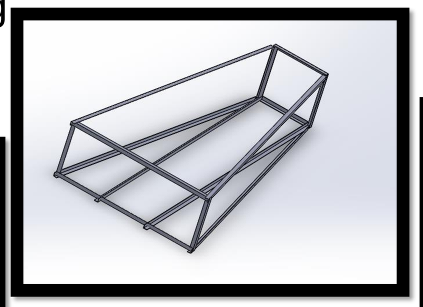


Frame Choice

- For the frame, there were three ideas
- They are: triangular, trapezoidal, box
- The final decision was to combine the trapezoidal and the box due to cost and ease of building

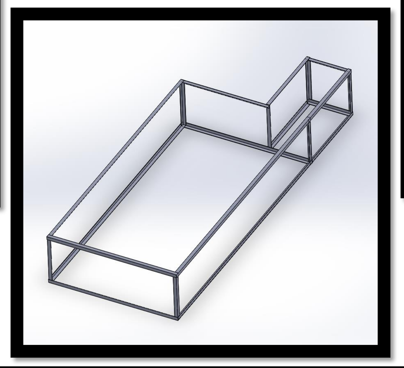
Trapezoidal

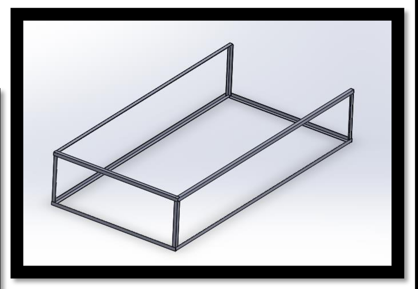




Triangular

Box



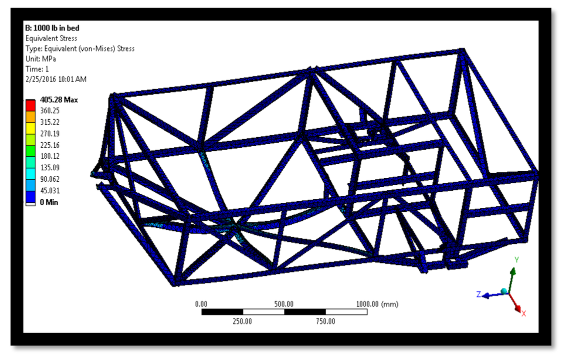


Final

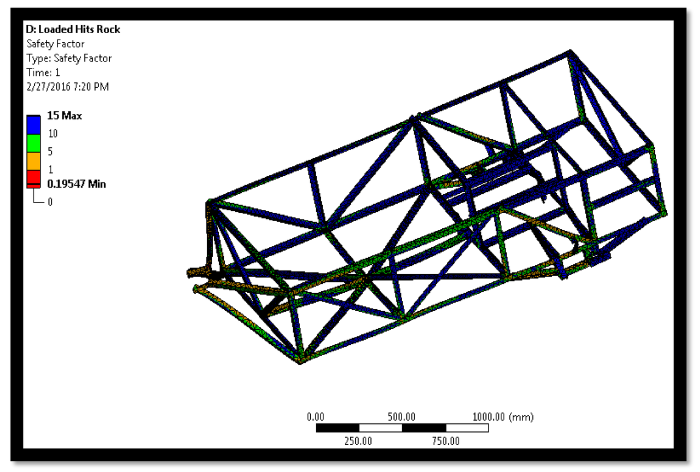
ANSYS

- For initial testing, ANSYS simulations were ran to see how the designed frame would work under different situations
- The only worrisome results were for the wheel supports, which were modified and retested.

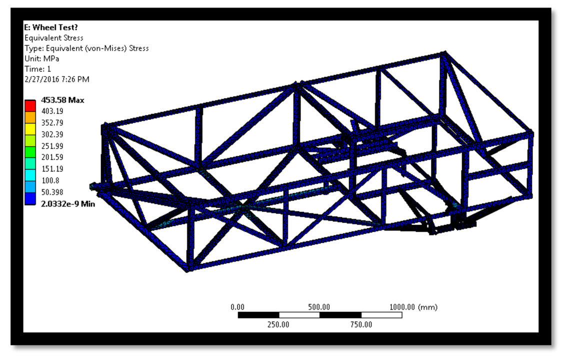
1000 lb Loaded Bed



Loaded Bed Hitting a Rock



Wheel Support Test



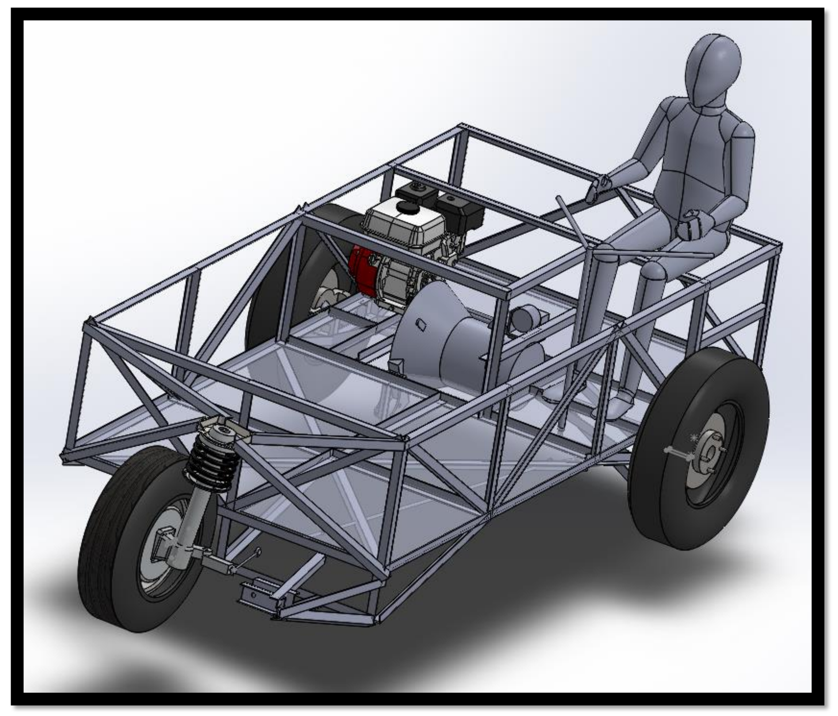
Cost Analysis

- The prototype was made for less than what the goal price was
- The design has less than ½ of the amount of angle iron of the full PUP (363 vs 170)
- For this prototype the team didn't need to find rims, tires, the strut, transaxle, driver controls, or pedals which will increase the cost in the future unless the team obtains most of the those parts off of one car
- The price of making 20 will be much lower than the prototype cost due to the discount for buying many parts at once (eg. buying 10 engine for $50/engine)

Items	Cost
Frame	
Angle iron (9 pieces, 6 meters each)	$180.00
Plywood	$79.92
Drivetrain	
-Transaxle Assembly (1993 Corolla)	$19.49
6.5 HP Diesel Engine	$100.00
Chains, sprockets, hubs, bearings, pully etc	$91.65
Wheels	
Front Strut – 1986 Toyota Corolla	$ -
Rims & Tires	$ -
Driver Ergonomics	
Brake cylinder and lines	$39.87
Steering system (tubes, rod ends, joints, handlebars)	$118.34
Driver controls, pedals	$-
Miscellaneous	
Misc. Components/Tools/Supplies	$50
Total	**$652.27**

Final Design

- Both of the senior design goals were met
- The prototype frame uses 46.8% of the angle iron that the original PUP does
- The team completed a prototype of the frame and has the needed parts to finish the prototype for testing
- The team spent less than $750 on the prototype
- The ANSYS analyses that were made can be used as a tool to further develop the MiniPUP frame design in the future



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