

Eric Kong (AE-Machine Systems), Tom Heinz (AE-Machine Systems), Nate Purk (ASM), Jake Steinke (ASM)

Background

The American Society of Agricultural and Biological Engineers (ASABE) has been hosting the International 1/4 Scale Tractor Student Design Competition for 21 years. Each team must design and build a pulling tractor that utilizes a Briggs & Stratton 31 horsepower Vanguard engine and a set of Titan tires.

At the annual competition, the teams' tractors compete in various events that evaluate the pulling performance, maneuverability, and durability. The competition gives students an opportunity to implement the design process, apply classroom knowledge, and gain hands-on fabrication experience.



Project Information

The team must design and build a compact utility tractor that excels in the categories of:

- Performance
- Safety
- Manufacturability
- Affordability

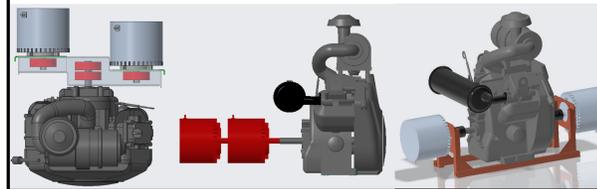
Performance in these categories will provide validation that the eTrain possesses the fundamental attributes of a compact utility tractor.

Alternative Solutions

During the initial brainstorming phase, three possible configurations were developed to attach the engine to the generators.

- Offset belt-driven (left)**
 - Complex shielding
 - Generators wider than frame rails
- Tandem coupled generators (middle)**
 - Untested coupling method
 - High precision machining

- Dual-shaft driven (right)**
 - Proven, reliable configuration
 - Simple shielding



Impact & Factors

The market is currently dominated by mechanical and hydrostatic drivetrains. Success in this competition will validate the feasibility of an electric drivetrain for practical consumer use. Many factors impacted the design process of the tractor:

- Public health - sound level
- Public safety - shielding and hazard warnings
- Environmental - emissions and soil compaction
- Economic - product cost



Constraints

- Total weight under 900 pounds
- Stock engine
- Proper shielding
- Rear kill switch

Criteria

- Durable
- Manufacturable
- Maneuverable
- Serviceable
- Ergonomic controls

Final eTrain Design

The key features of the 2019 Purdue eTrain are:

- Electric powertrain
- Rear-mounted engine
- Drive-by-wire
- 4-link/air ride suspension
- Independent rear brakes
- Safety interlocks
- Electronic locking differential
- Preset operation modes

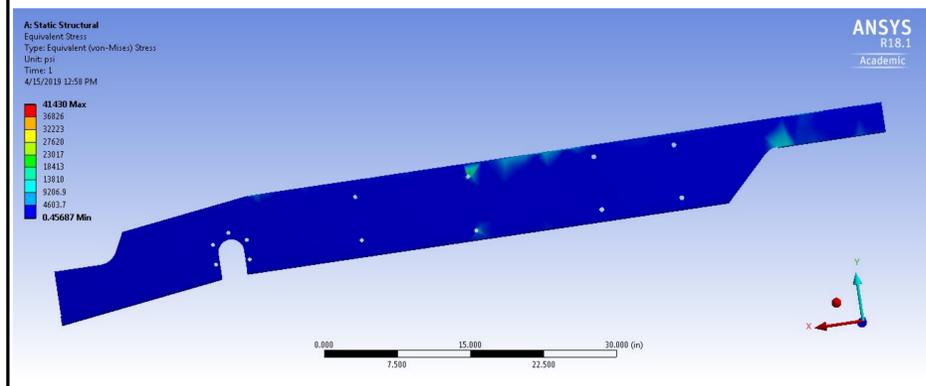
Economic Analysis

The team began the year with the intent of lowering the adjusted manufacturing cost of the 2019 tractor model without forfeiting the durability, affordability, and performance that the team is known for.

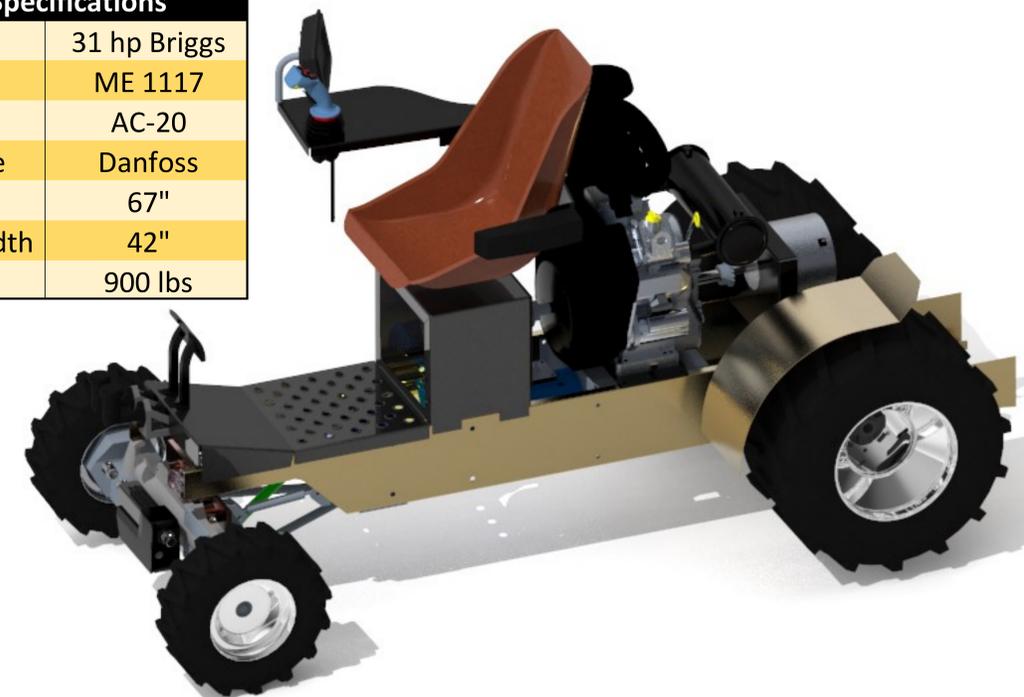
Category	Purchased	Fabricated	Total Cost
Engine System	\$ 1,593.87	\$ 9.35	\$ 1,603.22
Transmission / Transaxle	\$ 1,985.23	\$ -	\$ 1,985.23
Drive Train	\$ 2,506.71	\$ -	\$ 2,506.71
Tires & Wheels	\$ 288.44	\$ -	\$ 288.44
Steering	\$ 731.92	\$ 116.88	\$ 848.80
Frame	\$ 492.22	\$ 207.78	\$ 700.00
Body	\$ 36.00	\$ 94.36	\$ 130.36
Brake System	\$ 273.97	\$ 34.89	\$ 308.86
Electrical System	\$ 4,017.90	\$ -	\$ 4,017.90
Fasteners	\$ 68.10	\$ -	\$ 68.10
Safety Equipment	\$ 18.33	\$ 7.07	\$ 25.40
Trim	\$ 8.10	\$ 191.88	\$ 199.98
Miscellaneous	\$ 25.35	\$ -	\$ 25.35
Final Assembly	\$ -	\$ 183.75	\$ 183.75
TOTAL	\$12,046.15	\$ 845.96	\$12,892.11

Structural Analysis

To aid in design, finite element analyses (FEA) were run on key structural components of the eTrain. The components in question were the frame rails, wheelie bars, and driveline mounts. The results of the frame rail FEA are shown below. For this analysis, a 1600 pound load was placed on the top of the rail. The frame was constrained at the front/rear axles and the cross member bolt holes.



eTrain Specifications	
Engine	31 hp Briggs
Front Motor	ME 1117
Rear Motor	AC-20
User Interface	Danfoss
Wheelbase	67"
Rear track width	42"
Weight	900 lbs



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