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.

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.

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.

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

Criteria
- Durable
- Manufacturable
- Maneuverable
- Serviceable
- Ergonomic controls

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
- 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

Final eTrain Design
The key features of the 2019 Purdue eTrain are:

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

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.

<table>
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<tr>
<th>Category</th>
<th>Purchased</th>
<th>Fabricated</th>
<th>Total Cost</th>
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<tr>
<td>Engine System</td>
<td>1,593.87 $</td>
<td>9.35 $</td>
<td>1,603.22 $</td>
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<td>Transmission / Transaxle</td>
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<td>Drive Train</td>
<td>2,506.71 $</td>
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<td>Tires &amp; Wheels</td>
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<td>700.00 $</td>
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<td>845.96 $</td>
<td>12,892.11 $</td>
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</table>

Sponsors:
ADM
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2019 PQS Team Members