UW FORMULA X BOEING

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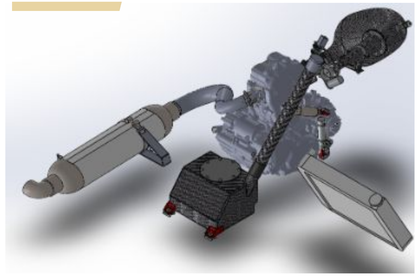
INTRODUCTION & MOTIVATION

Formula SAE powertrains have evolved from internal combustion engines to inboard electric motors to outboard planetary systems. We seek to take the next step by beginning the development of a direct drive motor with an emphasis on mass reduction, power density, and efficiency.

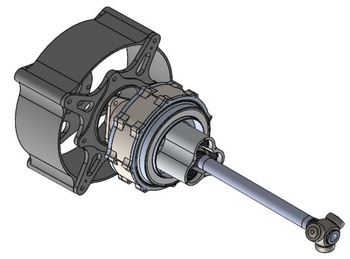
PROBLEM STATEMENT:

Simplify the powertrain architecture through the use of a direct drive motor. Develop the groundwork for future teams by establishing top level architecture and relationships between motor characteristics.

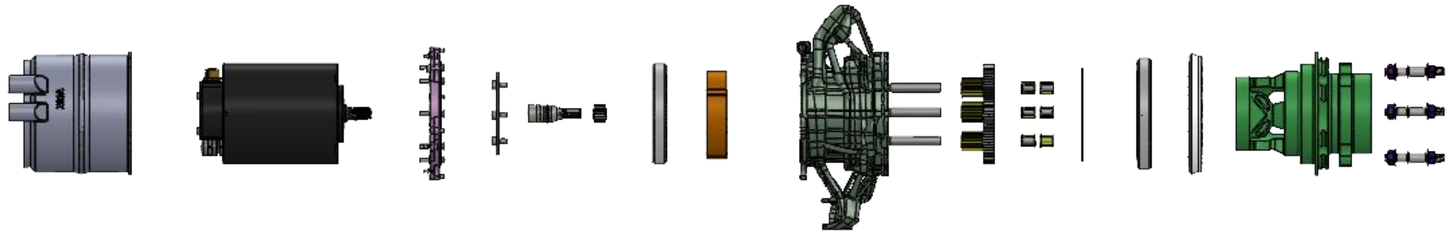
EVOLUTION OF THE DRIVETRAIN



2015: Internal Combustion Engine - 100 hp, gasoline powered



2019: Central Motor and Gearbox with Half Shafts - 92N-m, single-stage planetary gearbox



2023 (**Current**): In-Wheel Motor and Gearbox - 21 N-m, compound planetary gearbox

CONCEPT GENERATION

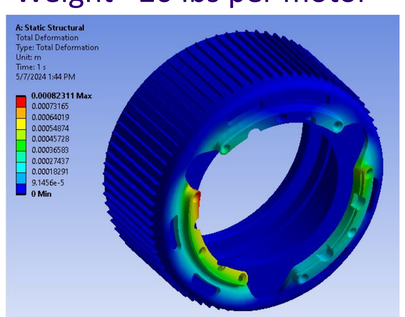
Rankings	Manufacturing	Weight	Design Effort	Performance
Compound Planetary	2	3	**3**	1
Single Planetary	1	2	1	2
Direct Drive	**2**	**3**	2	**3**

Initial concept generation had three options: Keeping the existing systems, simplifying the gearbox, or fully removing the gearbox. Ranking each option showed that direct drive yielded the best results with the lowest complexity.

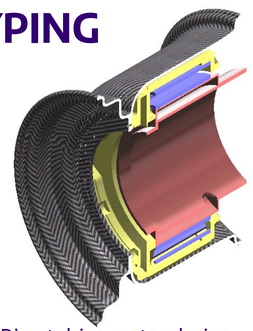
SPECIFICATIONS & PROTOTYPING

Current Requirements:

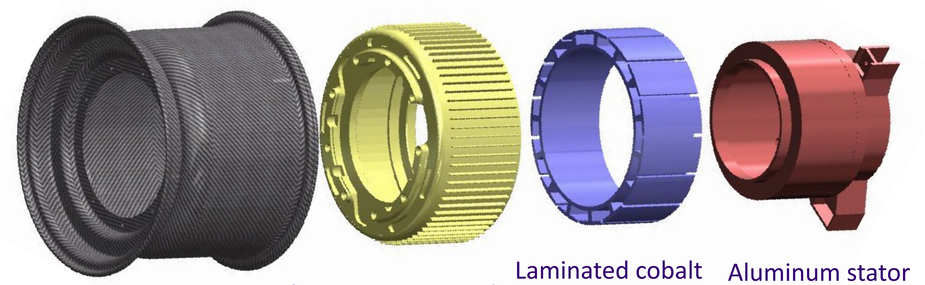
- 280 N-m of torque
- Maximum speed of 1600 rpm
- Weight ~20 lbs per motor



Simulation of forces exerted on the rotor from the wheel



Direct drive motor design packaged within a wheel



Carbon Fiber Wheel Shell | Aluminum rotor and magnet assembly | Laminated cobalt steel stator core + copper windings | Aluminum stator mount and suspension upright

2024 (**Proposed Design**): Exploded view

BENEFITS OF NEW DESIGN

- Fewer individual components
- Reduced complexity in the manufacturing process requiring less sponsors
- 7% projected increase in efficiency
- Longer life cycle
  - Current gearboxes only last 50 hours
- Parametric design allows future teams to adjust values based on iterative car design

FUTURE WORK

Future work will validate the design to ensure it fulfills project and vehicle requirements. This will primarily focus on an in-depth analysis of electromagnetic, themal, and structural properties.
From speaking to experts and through our research, we expect that thermal performance will be the primary limiting factor in the design of the motor.
Beyond design, physical dynamometer testing will be required prior to vehicle-level testing and integration.

ACKNOWLEDGEMENTS

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In memory of our late faculty advisor, Professor Ashley F. Emery.

Mechanical Engineering Capstone Exposition
May 29th 2024, Husky Union Building, University of Washington, Seattle

MECHANICAL ENGINEERING
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