IFR Powertrain DMT Group 10A

Imperial College London

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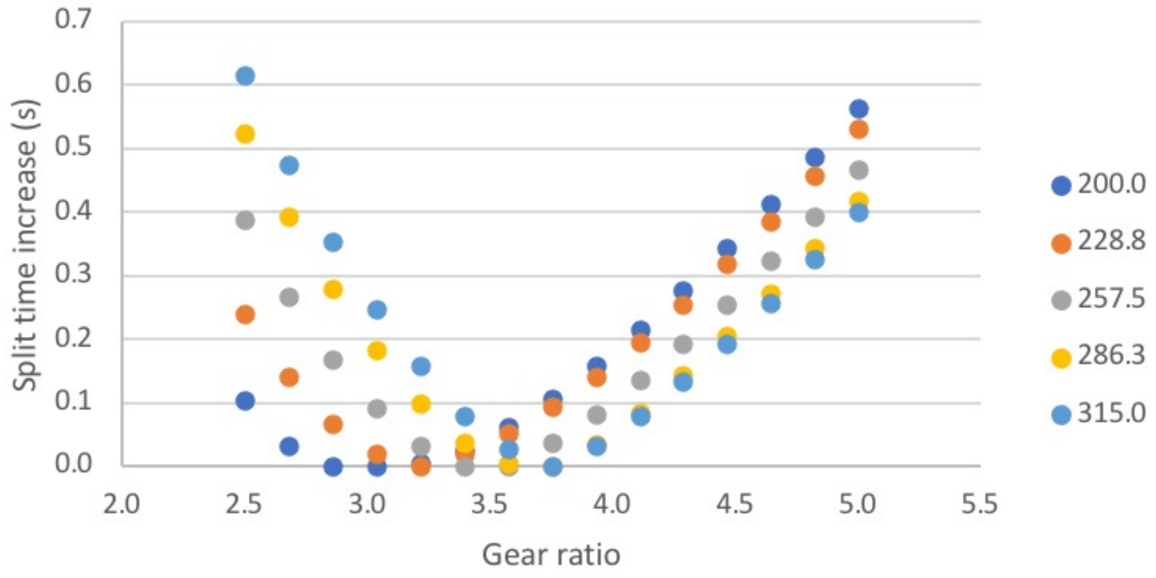
Imperial Formula Racing

Introduction

The project specification was to design a Formula Student (FS) drivetrain with the following legacy components: EMRAX 228 **motor**, Drexler **differential** and Bamocar D3 **motor controller**.

In line with research conducted across various FS teams, a chain drive transmission was selected. Using lap simulation data to optimise for acceleration, a transmission ratio of **3.53** was selected.



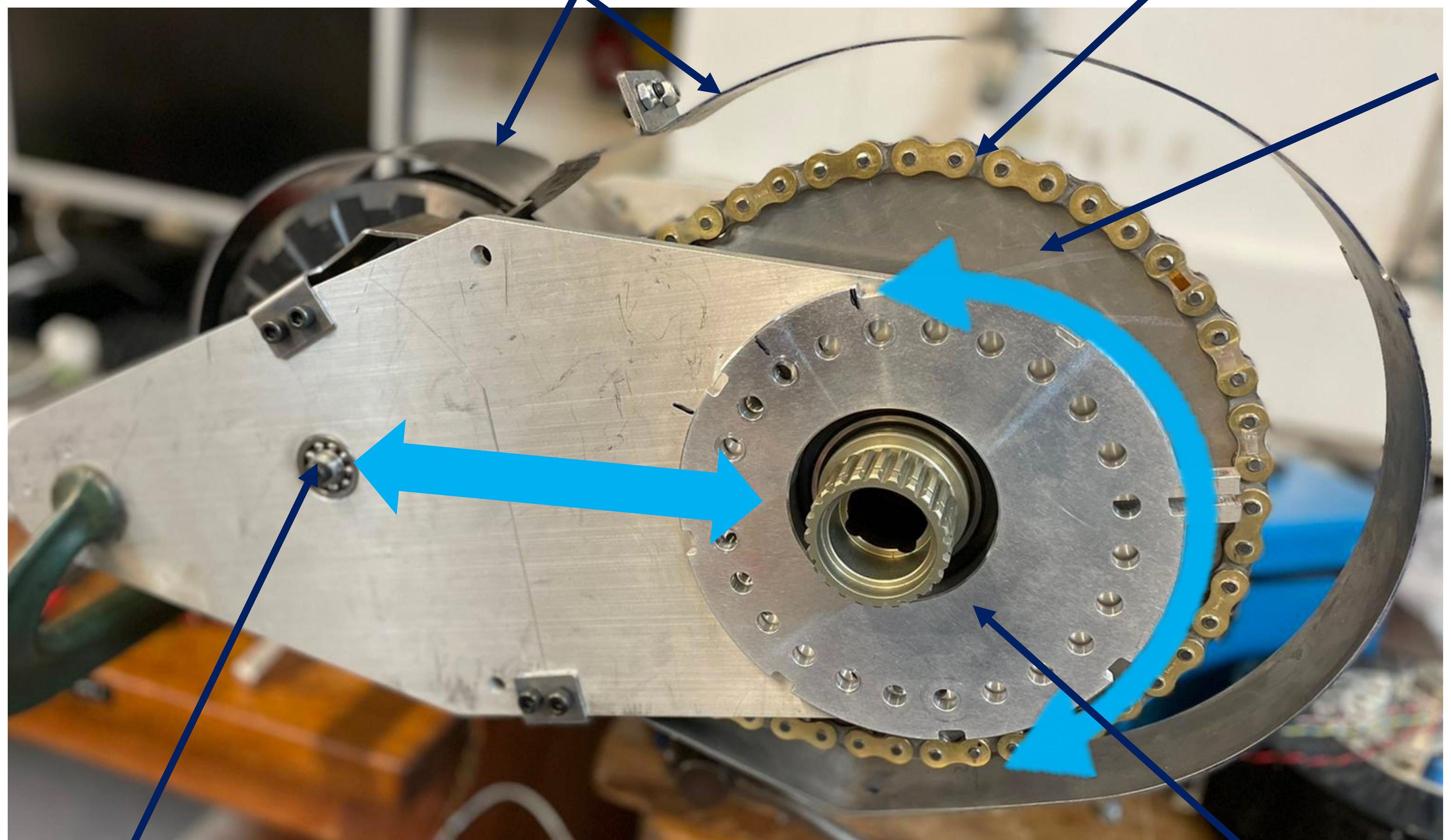
Impact of gear ratio on increase of acceleration event time using a Quasi Static lap simulator

Mounting & eccentric mechanism

A multifunctional two plate design was designed to support both the motor and differential. This had the required stiffness to prevent a misalignment of **<0.35mm** [1]. It allowed for adjustable chain tensioning through an eccentric bearing housing. This means the housing rotates, causing translational motion of the rear axle and effectively tensions the chain. This allows for torque transmission to drive the rear wheels.

Technical Specifications

Dry mass	35.9kg
Dimensions (mm)	540 x 600 x 310
Sprocket ratio	3.53 : 1
Service life	<30 hrs
Project cost	£2025.71
Safety factors	1.5 for non critical parts 2 for critical parts



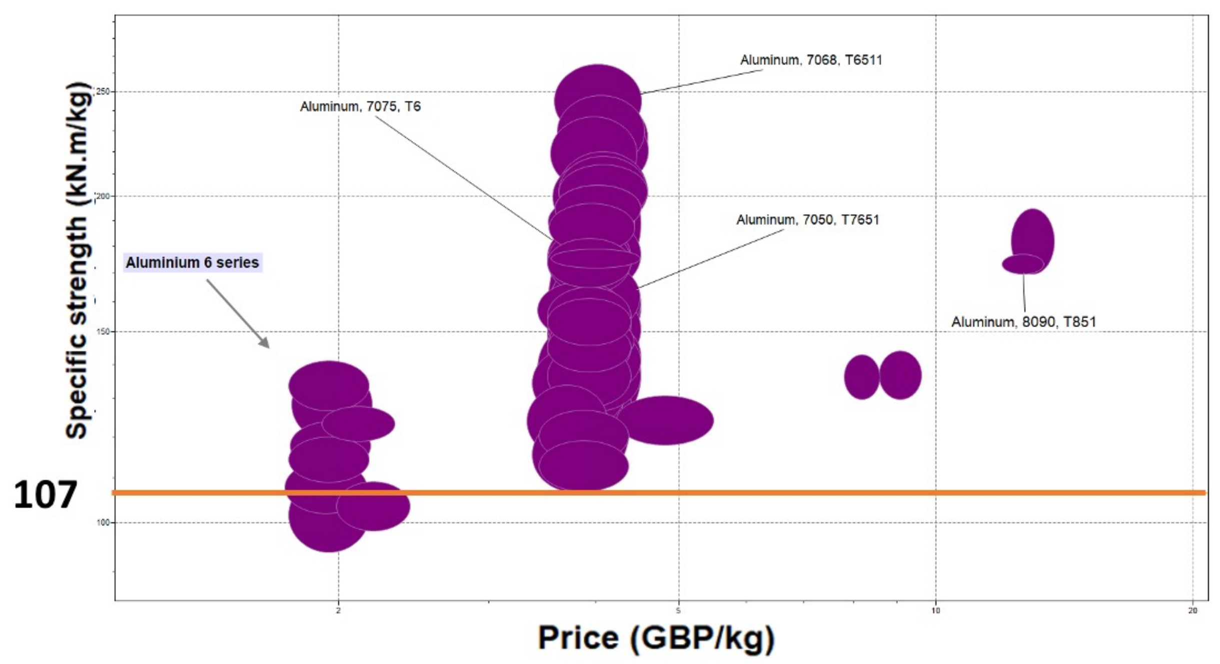
Final manufactured powertrain unit

Material selection

Minimum material requirements:

- Yield strength: **250 MPa**
- Specific strength **107 kPa/kg**

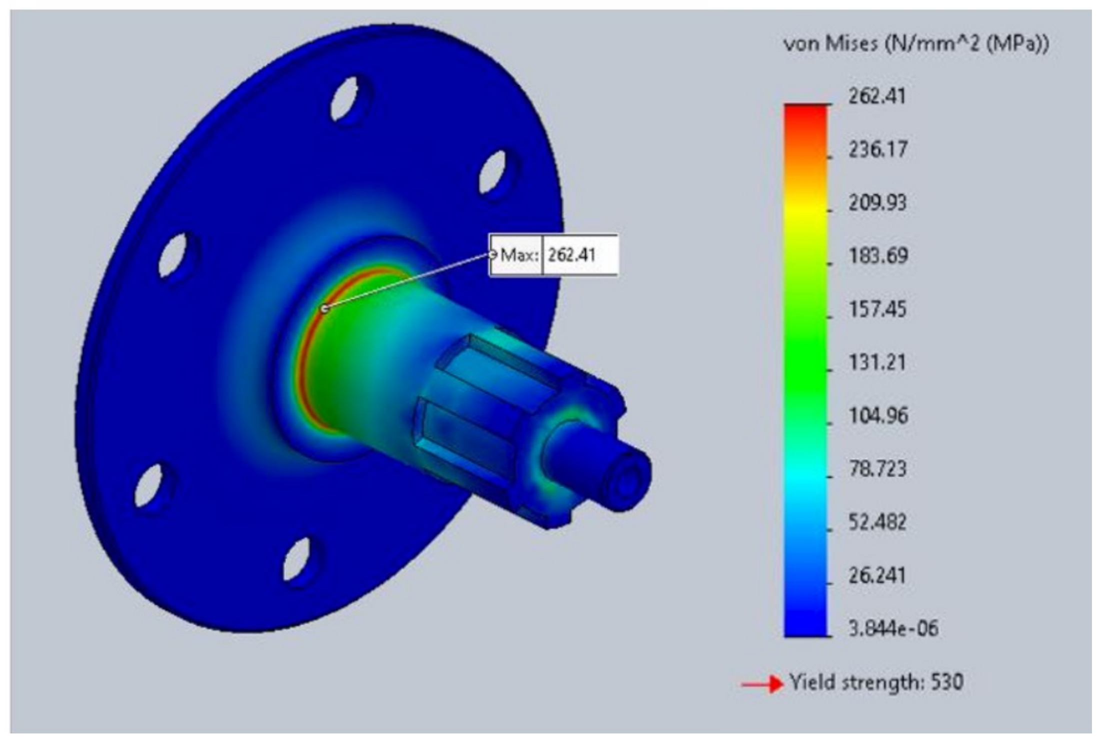
An appropriate Performance Index (PI) was used: $E^{1/3}/\rho$ [2]. Aluminium 7075 T6 was chosen with a **80% increase in yield strength** over 6 series alloys which were used in the previous EV3 iteration.



Graph of Specific strength against price [2]

Stress analysis

Finite Element Analysis of critical parts was carried out in SolidWorks and verified in ABAQUS. The motor shaft was modelled by applying dynamic loads and boundary conditions. The step down to the spline was the likely point of failure, so an additional step was used. The final SF of **2.09** met the PDS criterion for critical parts.

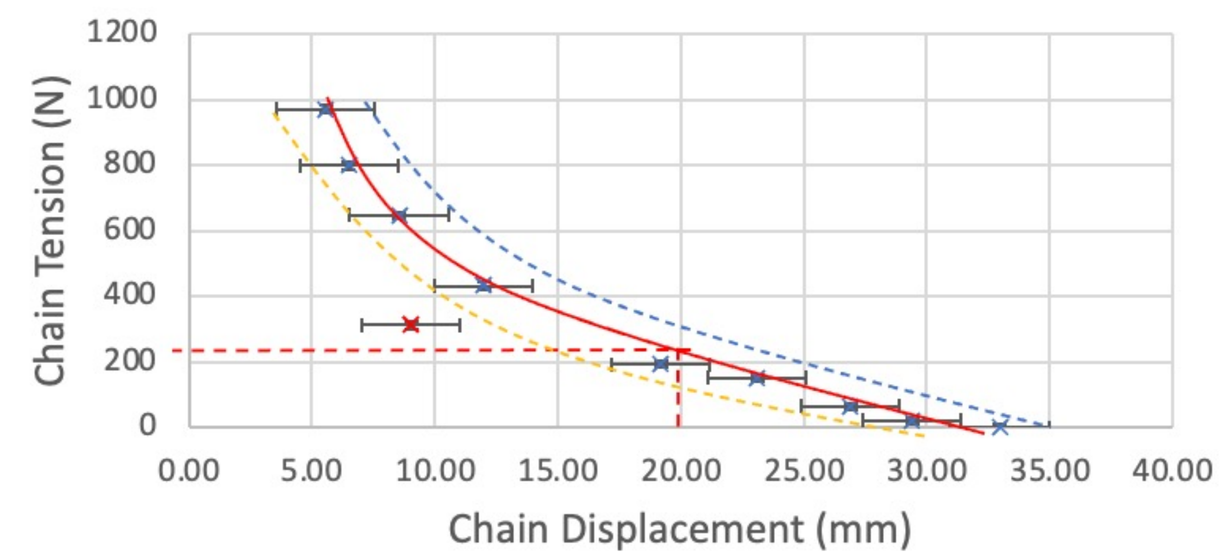


FEA motor shaft model in SolidWorks Simulations

Testing & Redesign

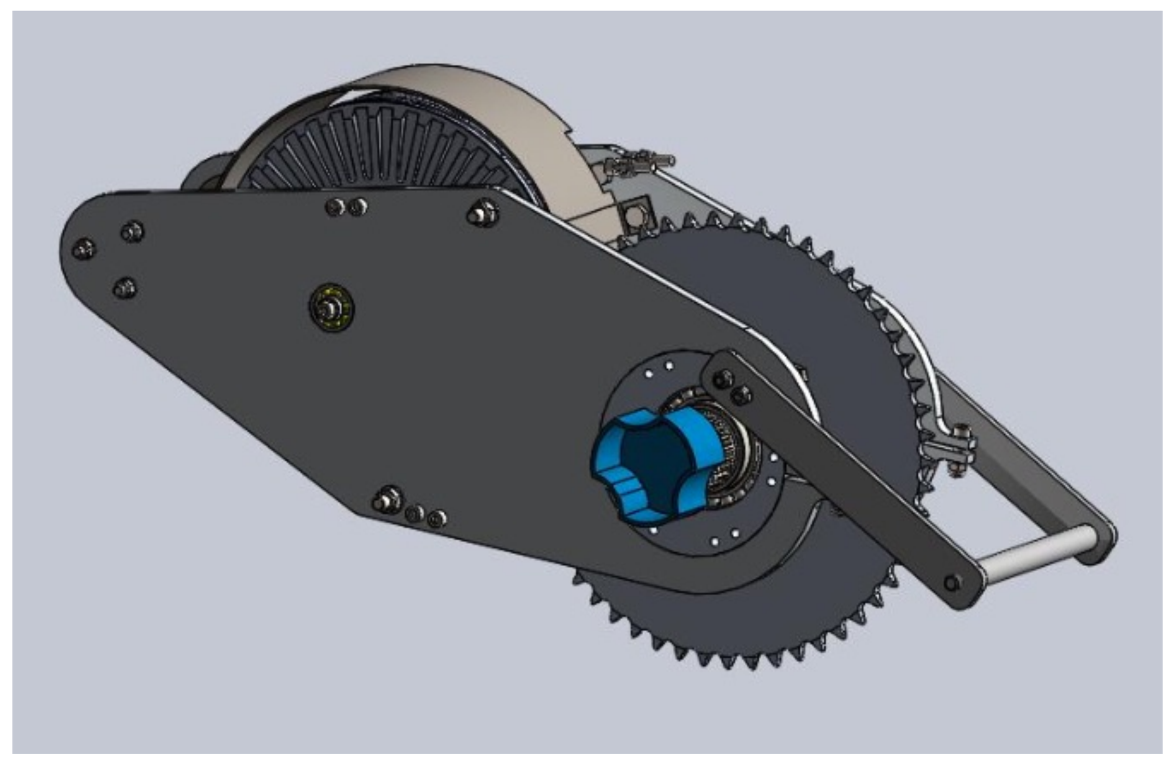
Strain gauge data was used to correlate the rough estimate of 'slack' distance with a numerical force. It was found that **250 ± 10.8N** of chain force was required to correctly tension the chain, equating to 20mm of slack distance. It was also found that ~4° of rotation was required to tension, rather than the 180° designed for.

Chain tension against slack displacement



Redesign changes included:

- Reducing the eccentricity of the housing
- Smooth teeth – based on preload mechanism – allows incremental tensioning
- Custom tensioning tool for synchronised rotation of housings



Redesigned powertrain unit and tensioning tool

References:
[1] Neale, M. J. The Tribology Handbook. s.l. : Elsevier, 2016
[2] CES EduPack 2020