Engineering Portfolio

MYRON ONG

IMPERIAL COLLEGE LONDON - MECHANICAL ENGINEERING

Gimbal Rig Upgrades

Xtrac Gimbal Rig – Actuator Accuracy & Response Improvement

During my summer internship at Xtrac, I worked on improving the accuracy and responsiveness of actuators on the gimbal rig, which is used for dynamic validation of gearboxes and differentials. I evaluated various actuation methods, from hydraulic rack-and-pinion systems to electric motors with strain wave gearing.

- **Engineering Applications:**
- **Fluid Mechanics:** Assessed hydraulic flow and accumulator requirements
- **Mechanics:** Performed kinematic modelling of the rig
- **Mechatronics:** Developed control and electrical system solutions
- **Outcome:**
  Proposed an electrically actuated gimbal rig capable of simulating higher G-forces, enhancing testing capabilities for future motorsport gearboxes and differentials.

- Previous calculations used:
  - Convert between measured acceleration (accelerometer), and representative acceleration
- 1) $Rig\ angle = \sin^{-1}(measured\ acceleration)$
- 2) $Representative\ acceleration = \tan(rig\ angle)$
- 3) $\therefore Representative\ acceleration = \tan(\sin^{-1}(measured\ acceleration))$

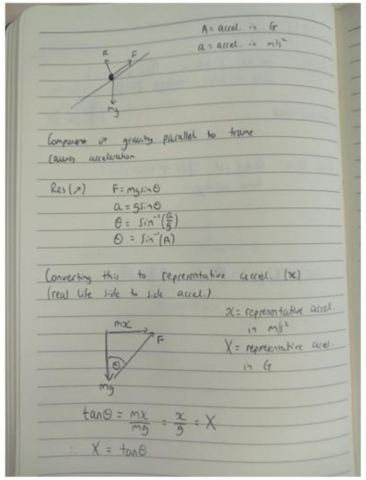
$$X = \tan[1.571 - \mathrm{acos}(x)]$$

Convert from radians to degrees

Inverse function to produce rig angle

where X= representative/simulated acceleration, x = filtered acceleration

Gimbal work instruction



Measured vs Representative acceleration

Total Torque [Nm]	0.1	8878.511	8487.828	8121.248	7789.93	7503.939	7271.956
Distance [m]		0.1	0.1	0.1	0.1	0.1	0.1
Rotation angle		10	20	30	40	50	60
G force [G]		4	4	3.999996	3.999996	4	4.000004
Angular velocity [rev/s]		1.8218	2.519092	3.017885	3.412931	3.745073	4.03861
Total Torque [Nm]	0.2	5151.505	4924.822	4712.135	4519.897	4353.953	4219.346
Distance [m]		0.2	0.2	0.2	0.2	0.2	0.2
Rotation angle		10	20	30	40	50	60
G force [G]		3.999996	3.999996	4	4	4	4
Angular velocity [rev/s]		1.288207	1.781266	2.133968	2.413308	2.648167	2.855727
Total Torque [Nm]	0.3	4225.74	4039.789	3865.32	3707.624	3571.502	3461.085
Distance [m]		0.3	0.3	0.3	0.3	0.3	0.3
Rotation angle		10	20	30	40	50	60
G force [G]		4.000004	4	4	3.999996	3.999996	3.999996
Angular velocity [rev/s]		1.051817	1.454398	1.742378	1.970456	2.162218	2.33169
Total Torque [Nm]	0.4	4000.27	3824.245	3659.077	3509.803	3380.944	3276.415
Distance [m]		0.4	0.4	0.4	0.4	0.4	0.4
Rotation angle		10	20	30	40	50	60
G force [G]		4.000004	4.000004	3.999996	4	4	3.999996
Angular velocity [rev/s]		0.910901	1.259547	1.508943	1.706466	1.872537	2.019303

Too high angular velocity (>2 rev/s)

Too small rig angles (10 degrees)

Ideal Operating range:
20 to 30 degrees max rig angle
200 to 300mm gearbox position

Gearbox positioned too high

Xtrac Gimbal Rig (kinematic calculations)

Item	Nominal Positions r vertical	r horizontal	Mass (kg)	Load Torque	MomI
1306 Gearbox	0.02	0.00	126.5	0.000	0.0387
6*Rig frame mounting runner	-0.03	0.00	72.0	0.000	0.0648
ERD brake 1	0.00	0.67	15.4	-102.251	6.9131
Motor	0.11	0.50	37.0	-183.335	9.7141
Inner frame (No torque since symetrical)	0.00	0.47	46.4	0.000	19.359
Outer frame (No torque since symetrical	0.00	0.52	52.1	0.000	29.362
Electric actuator 1	0.00	-0.77	27.5	210.989	16.483
			Instantaneous angle torque	0	
			Total	74.598	81.935

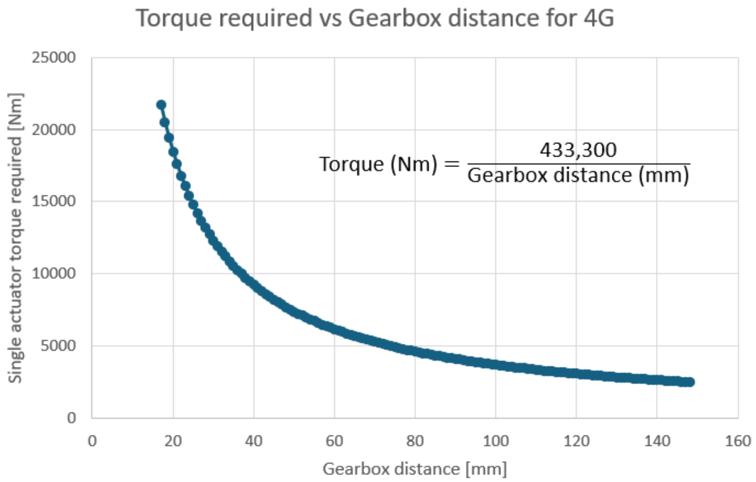
Item	Nominal Positions r vertical	r horizontal	Mass (kg)	Load Torque	MomI
1306 Gearbox	0.02	0.00	126.5	21.938	0.0387
6*Rig frame mounting runner	-0.03	0.00	72.0	-21.406	0.0648
ERD brake 1	0.00	0.67	15.4	0.000	6.9131
Motor	0.11	0.50	37.0	41.067	9.7141
Inner frame (No torque since symetrical)	0.00	0.47	46.4	0.000	19.359
Outer frame (No torque since symetrical	0.00	0.52	52.1	0.000	29.362
Electric actuator 1	0.00	-0.77	27.5	0.000	16.483
			Instantaneous angle torque	90	
			Total	-41.600	81.935

$$T_{required} = T_{Inertial} + T_{frictional} + T_{load}$$

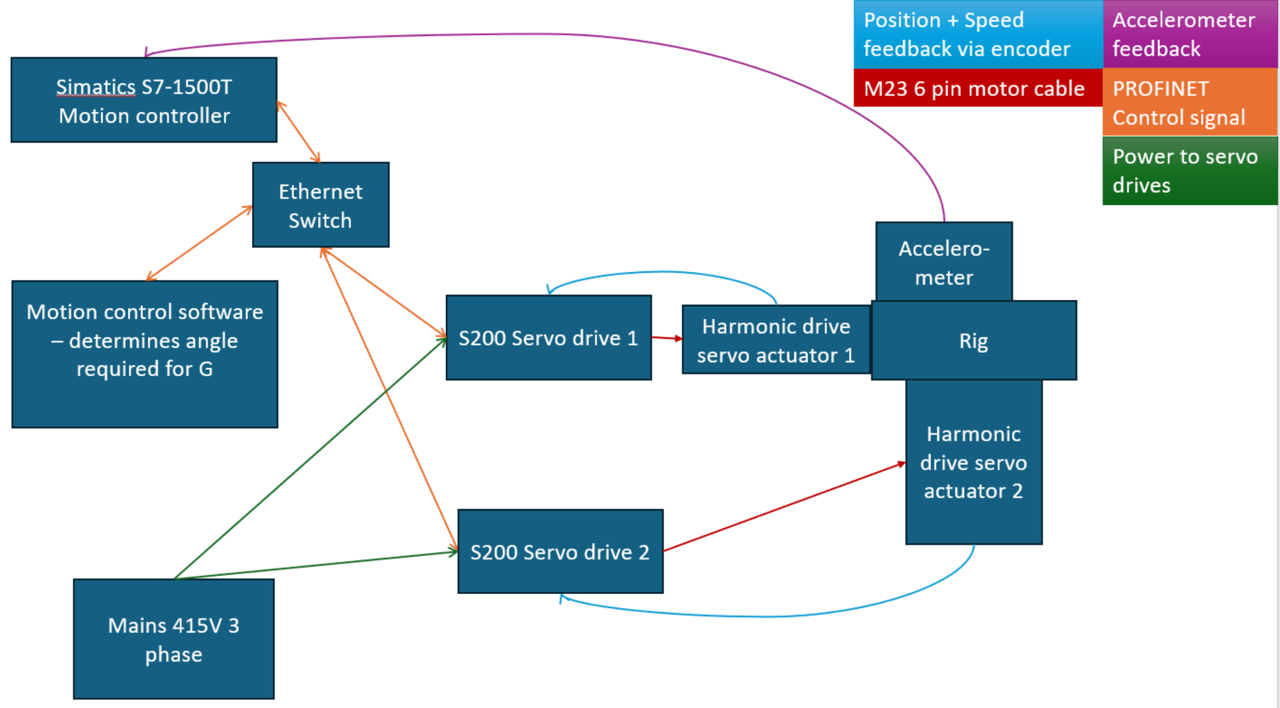
$$T_{Inertial} = Moment\ of\ Inertia\ \times\ \alpha$$

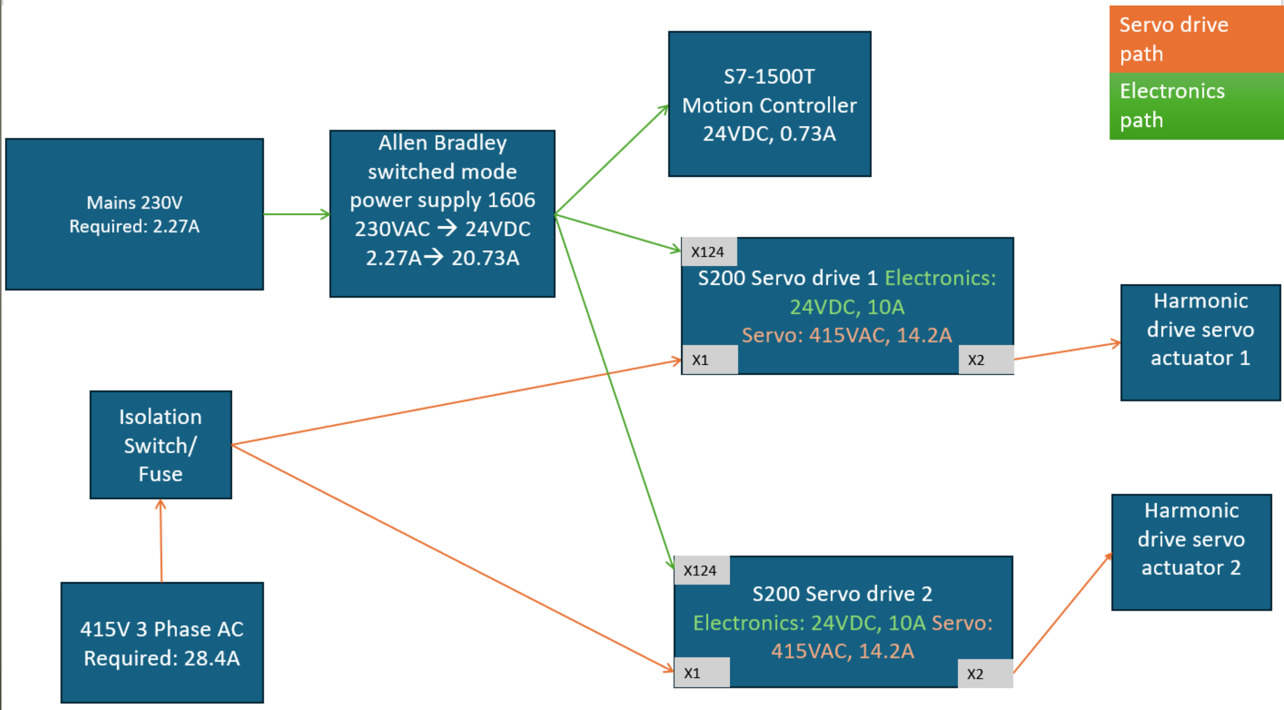
Assumptions

- Negligible Frictional torque
  - Frames are supported by bearings
- Actuator has negligible Moment of Inertia

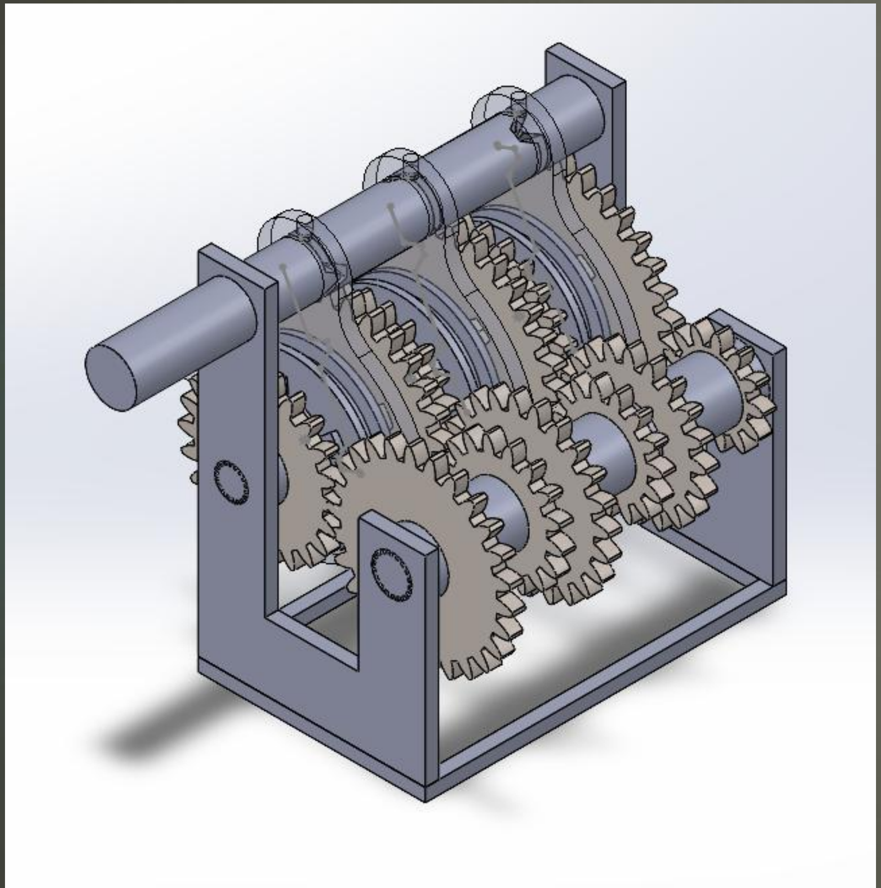


Xtrac Gimbal Rig (Control and electrical power systems)





6-Speed Gearbox

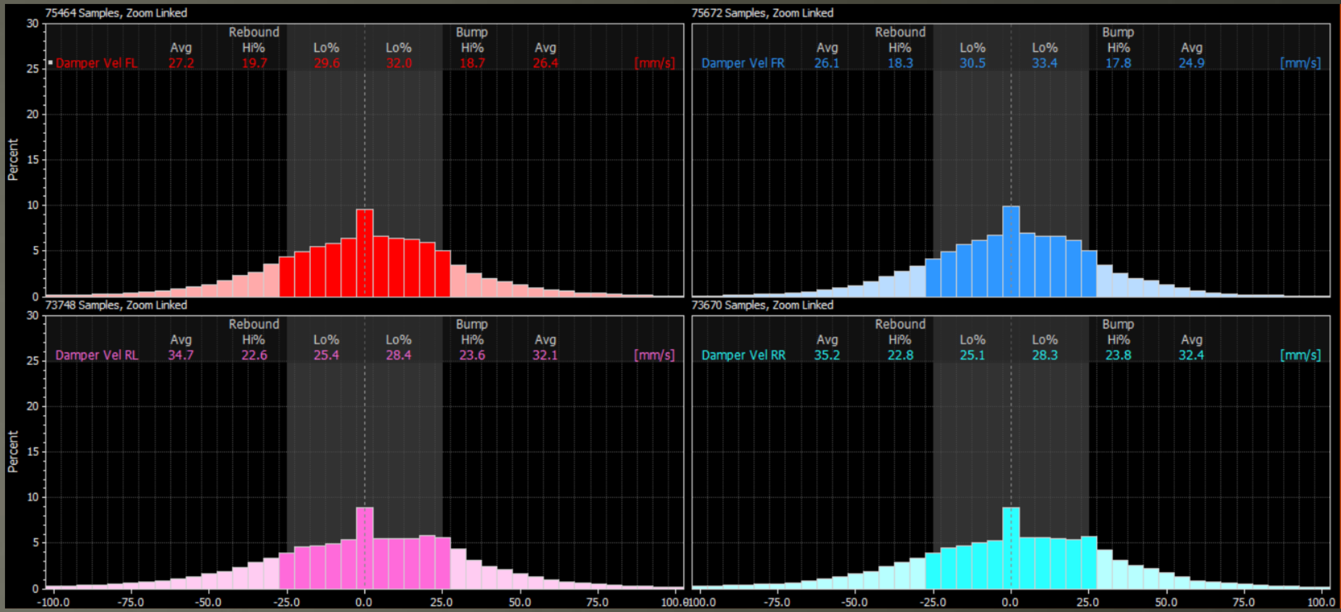


			Gear 1	Gear 2	Gear 3	Gear 4	Gear 5	Gear 6
module	10	Layshaft	13	15	17	20	23	26
		Mainshaft	35	33	31	28	25	22
		Centre distance [mm]	240	240	240	240	240	240
		Ratio	2.69231	2.2	1.82353	1.4	1.08696	0.84615

6-Speed Sequential Open-Cluster Gearbox
Inspired by my internship at Xtrac, I modelled a 6-speed sequential gearbox in CAD with the long-term goal of creating a fully 3D-printable prototype.

Key Design Considerations:
•Designed back-tapered dog teeth to ensure reliable dog clutch engagement
•Optimised gear-change barrel geometry to control clutch movement accurately

GT3 Damper Investigation: ACC and MoTeC i2 Telemetry



Suspension Dynamics Investigation
This project combined my interests in sim racing, vehicle dynamics, and race car setup. I focused on analysing damper behaviour, which is independent of driver input, and used suspension histograms to consistently evaluate performance across multiple laps.

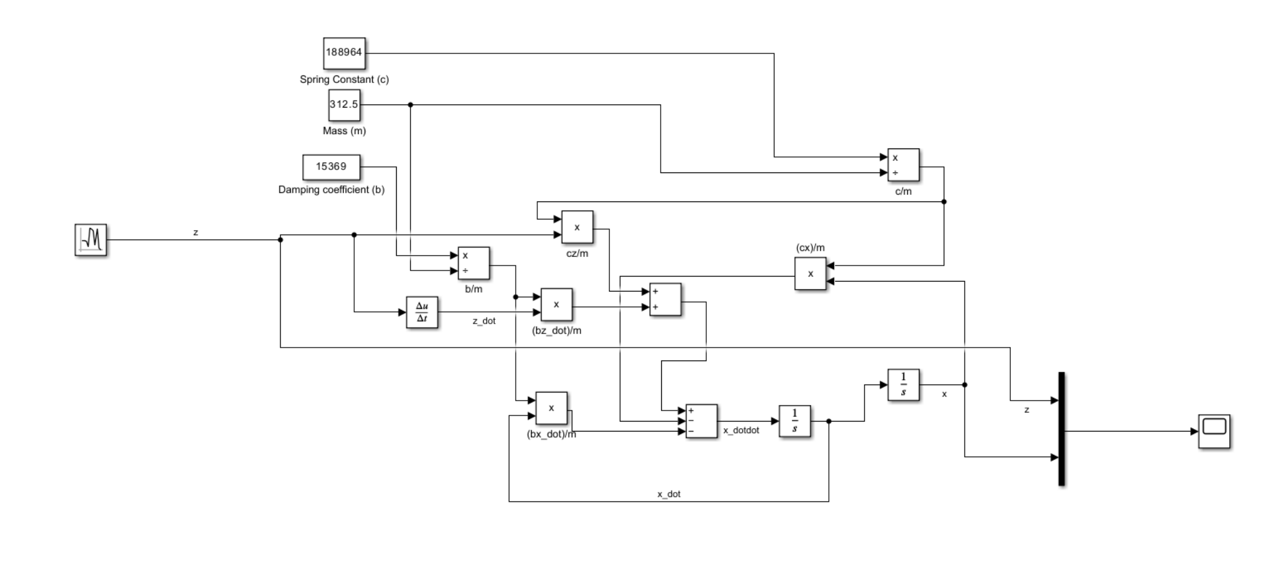
Engineering Applications:
•Collected and analysed MoTeC i2 telemetry data and correlated it to suspension characteristics in an engineering report
•Researched how motorsport teams optimise suspension setup to identify the 'ideal' suspension histogram

Run	Slow Bump	Fast bump	Slow Rebound	Fast rebound
Baseline	Baseline	Baseline	Baseline	Baseline
1	Soft	Baseline	Baseline	Baseline
2	Stiff	Baseline	Baseline	Baseline
3	Baseline	Soft	Baseline	Baseline
4	Baseline	Stiff	Baseline	Baseline
5	Baseline	Baseline	Soft	Baseline
6	Baseline	Baseline	Stiff	Baseline
7	Baseline	Baseline	Baseline	Soft
8	Baseline	Baseline	Baseline	Stiff

GT3 Damper Investigation: SIMULINK

Quarter-Car Suspension Simulation

To explore the theoretical aspects of dampers, I built a quarter-car model in MATLAB Simulink, visualising sprung mass displacements under different damping ratios and coefficients.



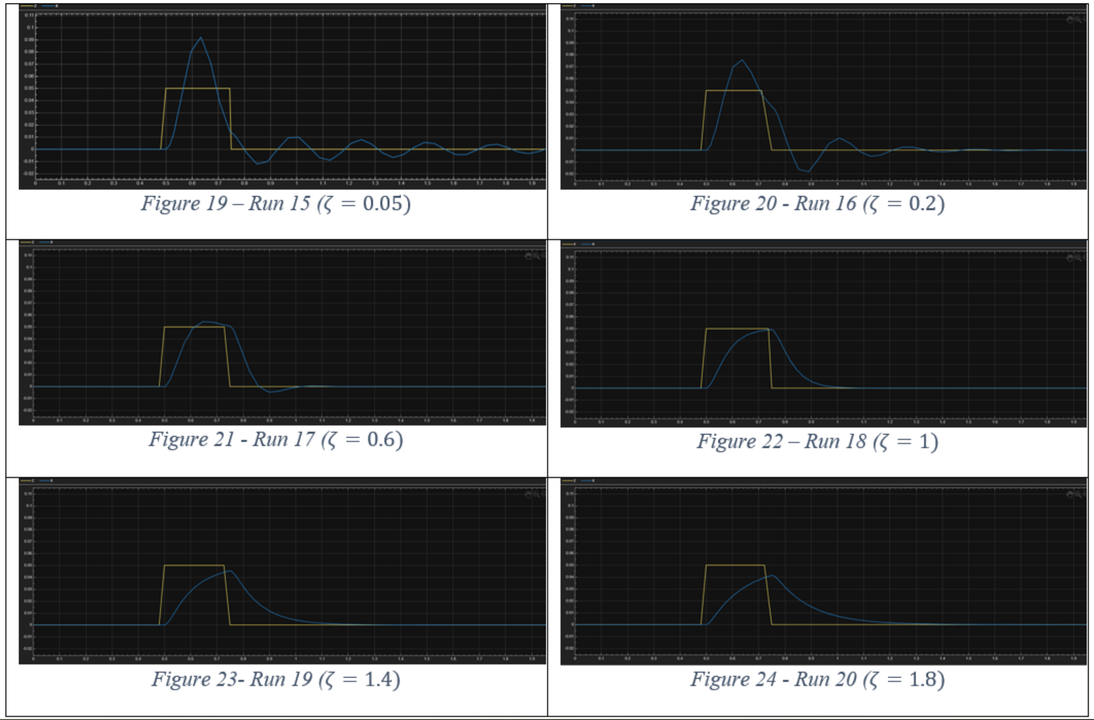


Figure 19 – Run 15 ($\zeta = 0.05$)

Figure 20 - Run 16 ($\zeta = 0.2$)

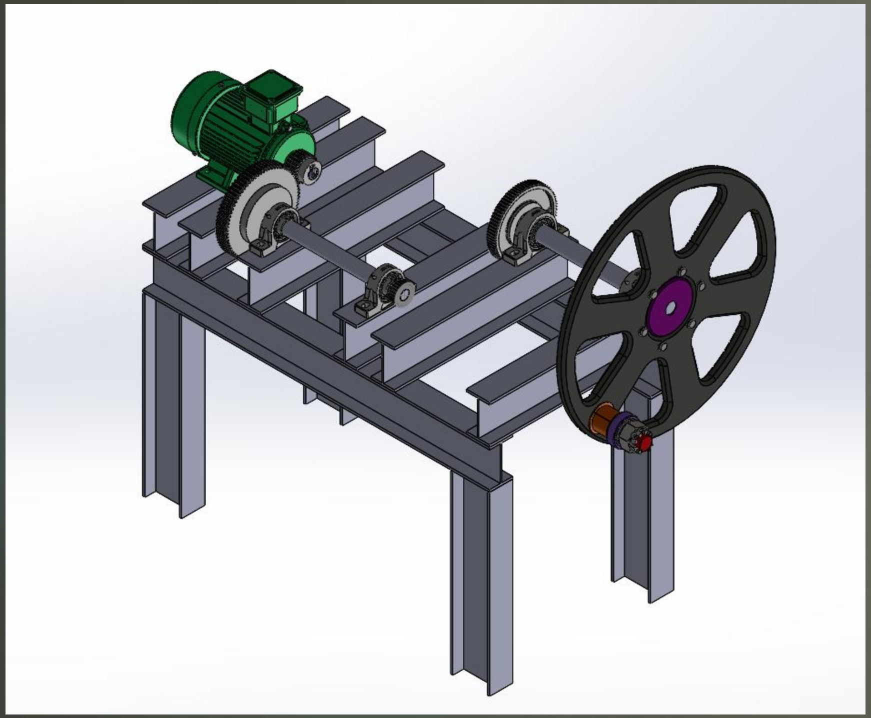
Figure 21 - Run 17 ($\zeta = 0.6$)

Figure 22 – Run 18 ($\zeta = 1$)

Figure 23- Run 19 ($\zeta = 1.4$)

Figure 24 - Run 20 ($\zeta = 1.8$)

Drive Transmission Project

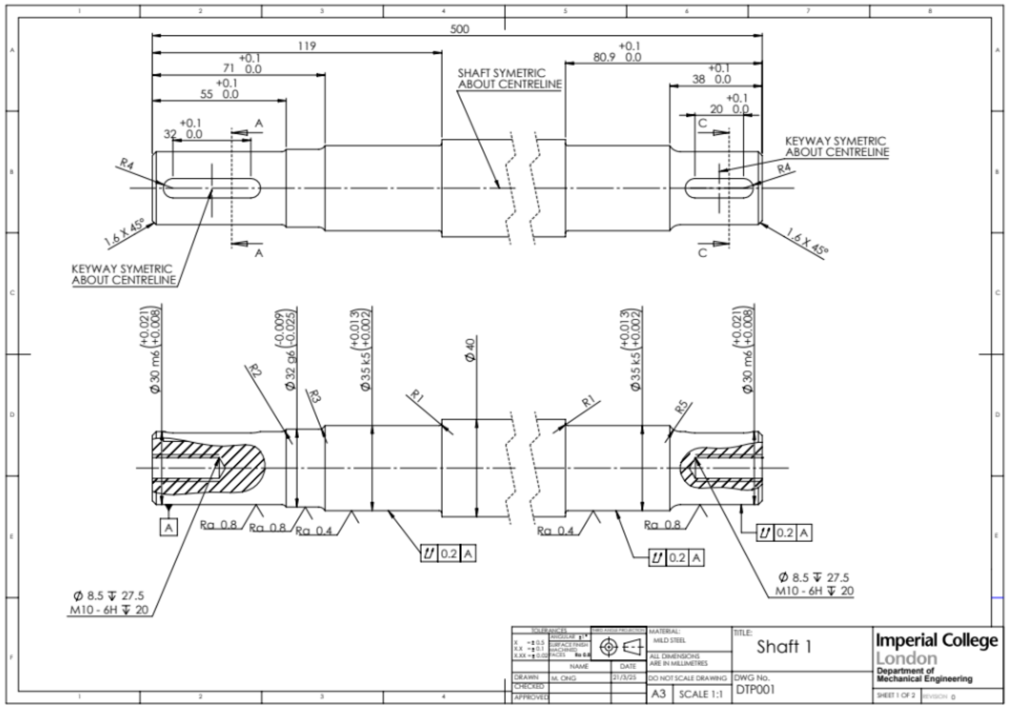


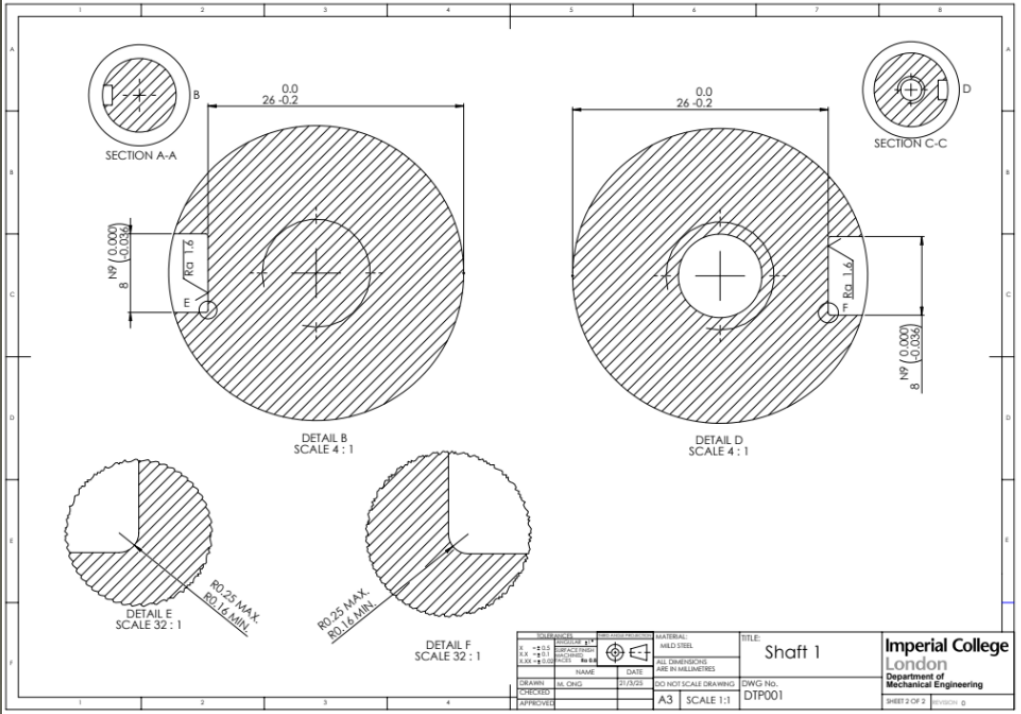
2-Stage Transmission Design (Imperial Design & Manufacture Module)
As part of my module, I designed a 2-stage transmission system using gears and pulley belts, constrained by standard industry parts and power requirements.

Key Considerations:

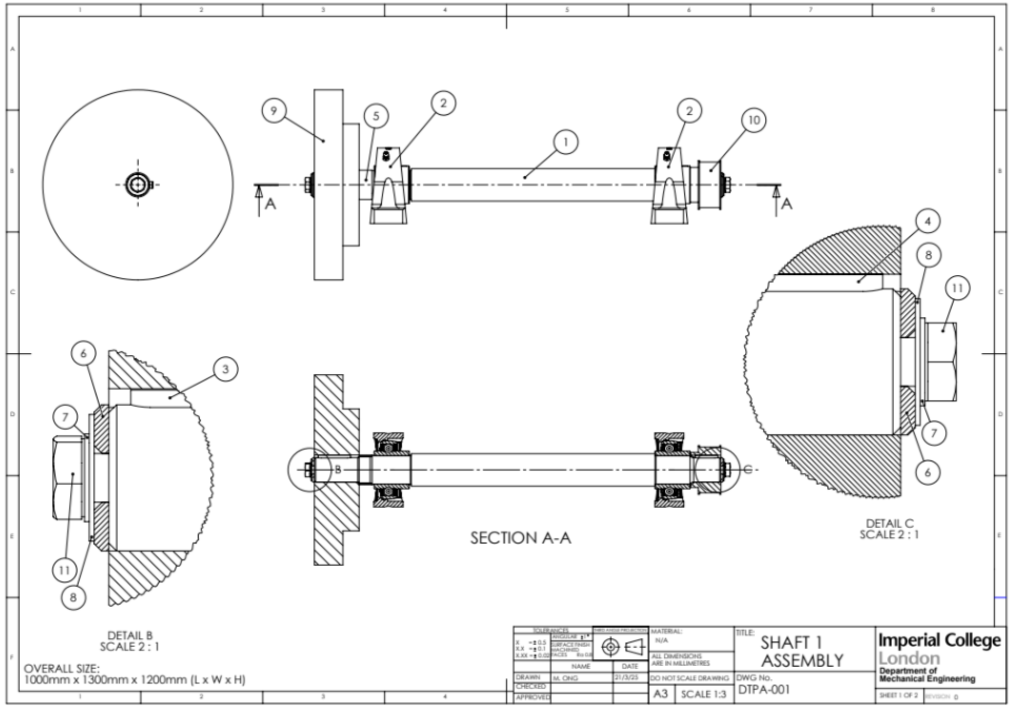
- Applied safety factors and stress concentration reduction methods
- Designed radial and axial locking mechanisms (keys, bolts & nuts, taper locks)
- Followed BS888 standards for engineering drawings (GD&T, BOM)

Outcome:
Produced a CAD model and engineering drawings, earning a **Grade A** and demonstrating a strong understanding of power transmission and design practices.





Drive Transmission Project (Engineering Drawings)

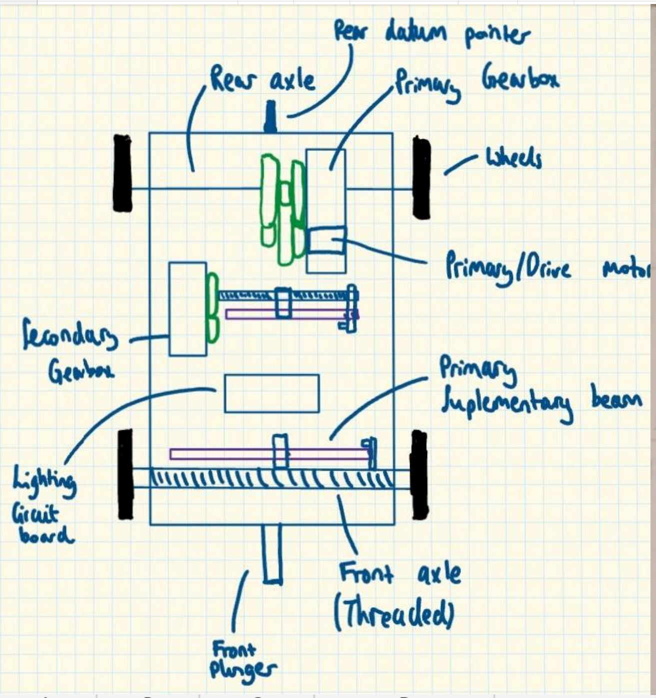


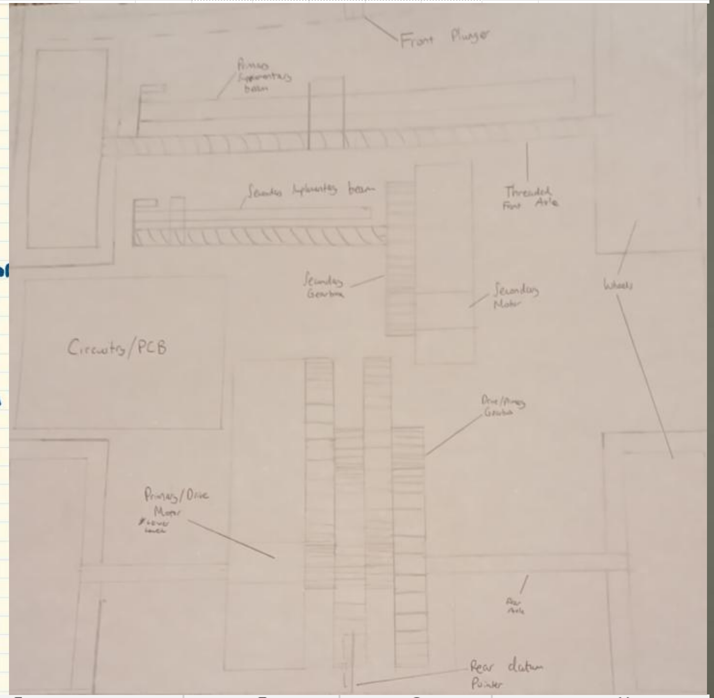
ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	DTP01	SHAFT 1	1
2	DTP02	BALL BEARING	2
3	DTP03	8mm x 7mm x 32mm KEY	1
4	DTP04	8mm x 7mm x 20mm KEY	1
5	DTP05	SPACER	1
6	DTP06	ENDCAP	2
7	DTP07	SPRING WASHER	2
8	DTP08	WASHER	2
9	DTP09	SPUR GEAR	1
10	DTP10	PULLEY	1
11	DTP11	HEX SCREW M10x30-N	2

SHAFT 1 ASSEMBLY
Imperial College London
Department of Mechanical Engineering
DTPA-001
A3 SCALE 1:3

IMechE Design Challenge

				Week Commencing	6/1/2025	13/1/25	20/1/25	27/1/25	3/2/2025	10/2/2025	17/2/25	24/2/25	3/3/2025	10/3/2025	17/3/25	24/2/25
2				**Status**	WEEK 1	WEEK 2	WEEK 3 (Design Gateway)	WEEK 4	WEEK 5	WEEK 6	WEEK 7	WEEK 8	WEEK 9	WEEK 10	WEEK 11	WEEK 12 (Last week of Spring)
3	Brainstorm Initial Ideas	Week 1	Week 2													
4	Design Gateway Preperation	Week 1	Week 2													
5	Logic Circuit Design	Week 3	Week 5													
6	Material Selection, Accuracy Considerations	Week 3	Week 4													
7	Chassis design	Week 5	Week 6													
8	Procurement	Week 3	Week 7													
9	Manufacturing	Week 5	Week 9													
10	Test run 1/ First design completition	Week 10	Week 10													
11	Final Design Changes/ Improvements	Week 10	Week 10													
12	Test run 2	Week 11	Week 11													
13	Internal Competition	Week 11	Week 12													
14	Competiton	Week 16	Week 16													





Quantity	Store	Code	Name	Description	Price (Exc VAT)	Price (Inc VAT)	Included in ImechE BOM
1	RS	RS 397-4954	Datum Pointer	Datum Pointer for the rear of the vehicle	1.18	1.42	☑
1	RS	RS 238-9709	Motor	Power for vehicle	2.22	2.66	☑
1	RS	RS 183-701	Button Tactile Switch	Pressure Sensor for the plunger	0.514	0.618	☑
1	Amazon	N/a	Plexiglass Sheet	610x610mm baseplate	13.75	16.5	☑

Autonomous Robotic Charging Device (Team Project)

Worked as part of a team to design and build an autonomous robotic charging device, creating initial sketches and CAD prototypes. Although our team was not selected for the university-level competition, the project provided valuable experience in project planning and teamwork.

My Responsibilities:

- Project management and coordination
- Procurement, cost analysis, and material selection
- Prototyping and ensuring vehicle accuracy

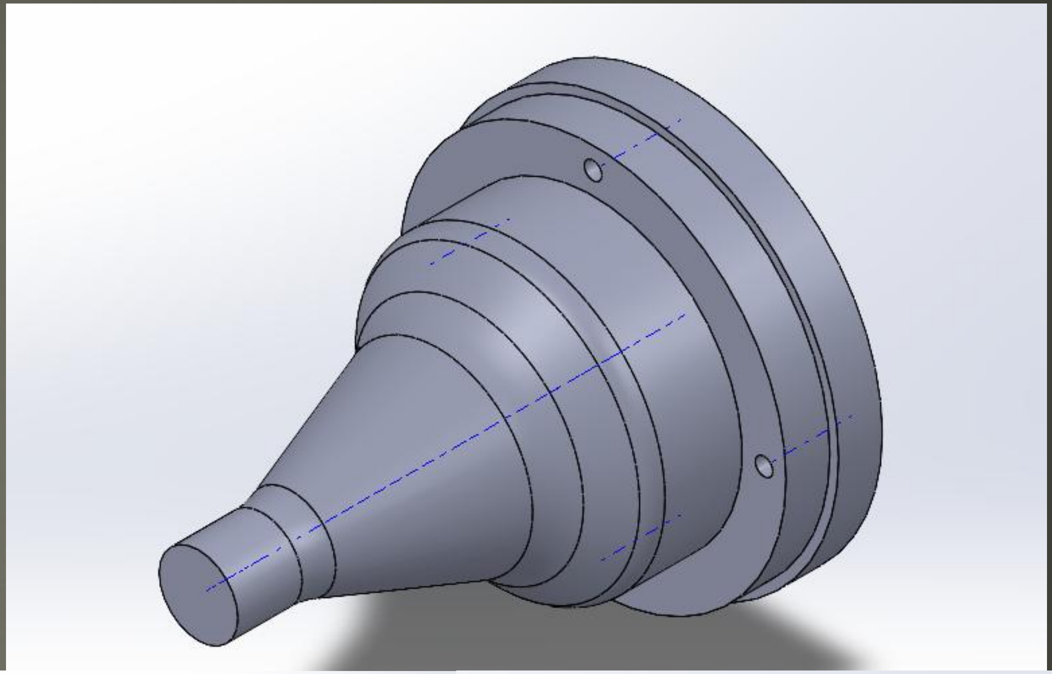
Formula Student

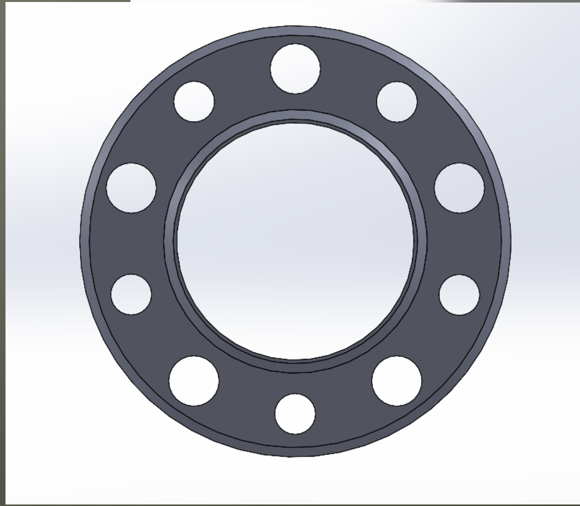
Imperial Formula Racing – Drivetrain Team
Contributed to the design of drivetrain components, including the CV boot and sprocket adaptor, and performed sprocket stress calculations to determine safety factors.

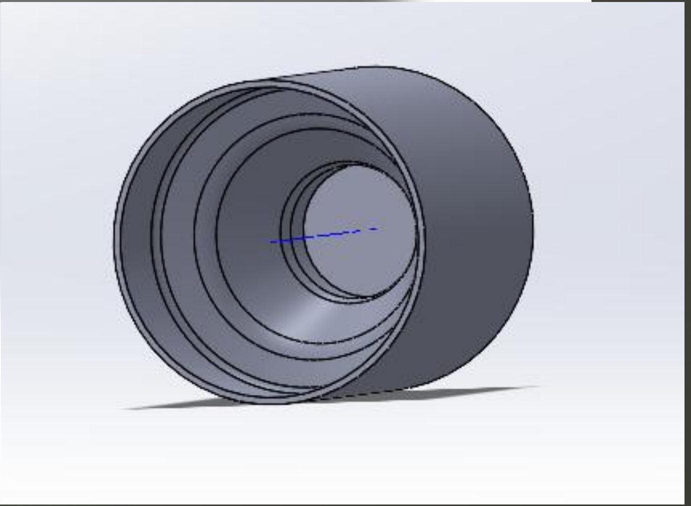
Hands-On Experience:

- Participated in silicon moulding of the CV boot using a 3D-printed mould
- Supported drivetrain maintenance and assembly

Outcome:
Imperial Formula Racing achieved **6th place at FSUK**, combining engineering design with practical application.







Workshop Machining

Imperial Workshop Machining Sessions
Gained hands-on experience with machining processes, reinforcing the importance of designing parts with manufacturability and tolerancing in mind. Applied these insights to later projects, including a 6-speed gearbox and a 2-stage drive transmission system.

Techniques Explored:

- Drilling, forming, boring, turning, milling