An Educational Experience with Generative Design

Elizabeth Bishop

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AUTODESK. UNIVERSITY

About me

Elizabeth Bishop

- 2012 MEng Mechanical Engineering
- 2016 - 2017 UAV Group Project
- 2017 Started a PhD in Large-Scale 3D Printing
- Maker in Residence at Warwick Engineering Build Space

@LizBish94

@WEDesignMake

Elizabeth Bishop

The Build Space Team

Who are we?

Dr Simon Leigh
Associate Professor
Build Space Lead
Maker in Residence

Dr Chris Purssell
Research Fellow
Maker in Residence

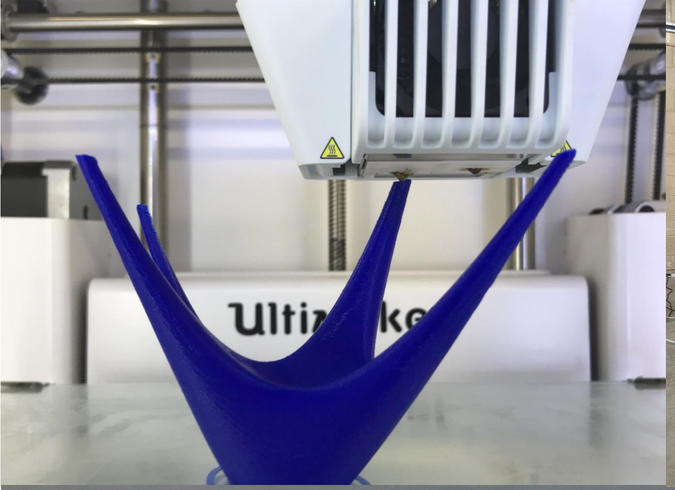
Elizabeth Bishop
PhD Student
Maker in Residence

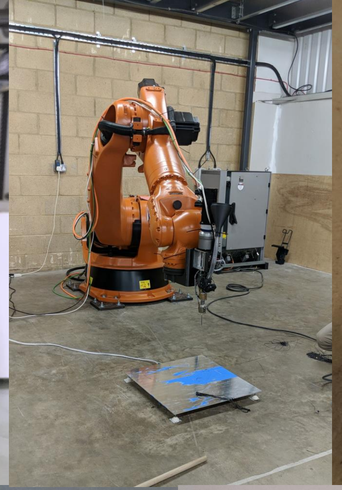
Elliott Griffiths
PhD Student
Maker in Residence

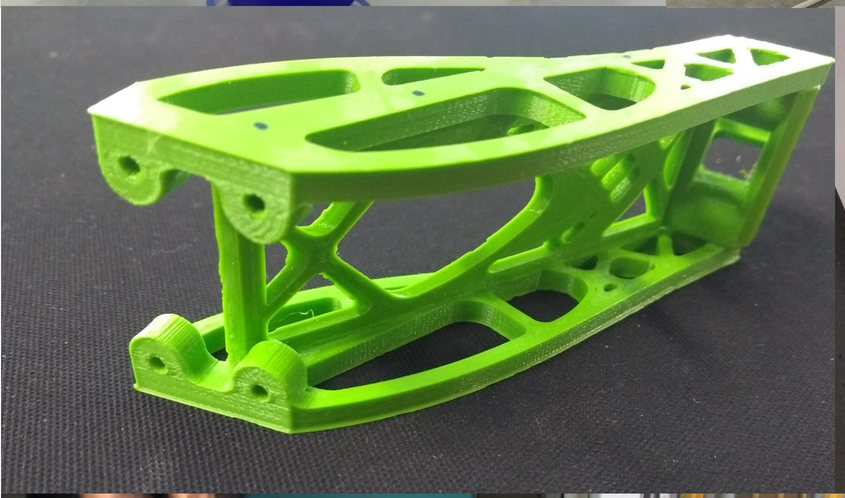
ENGINEERING BUILD SPACE

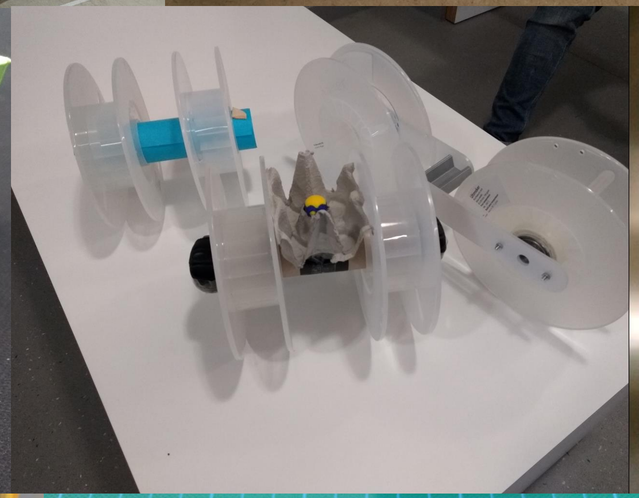
WARWICK ENGINEERING DESIGN+MAKE

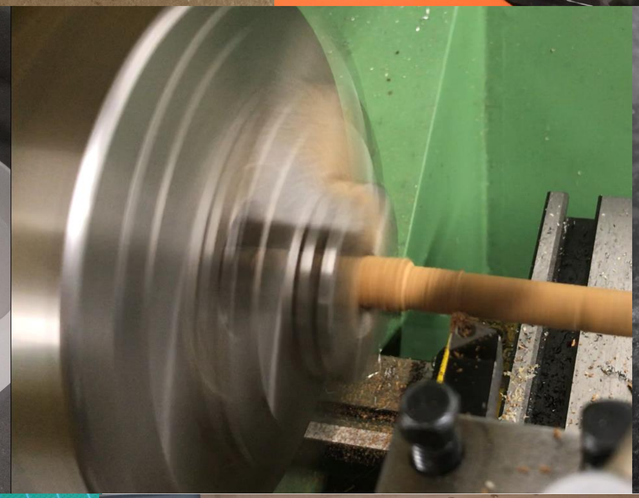
Powered by AUTODESK

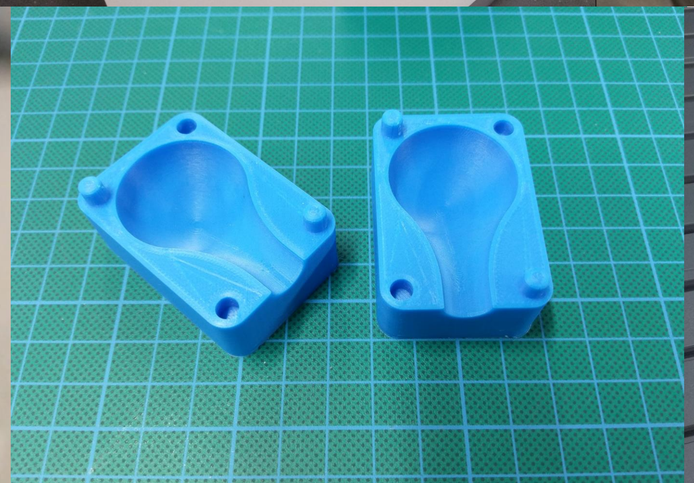




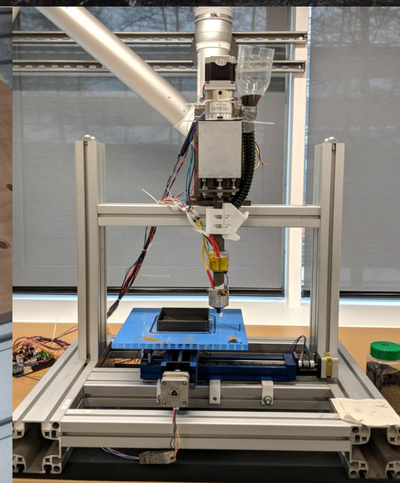


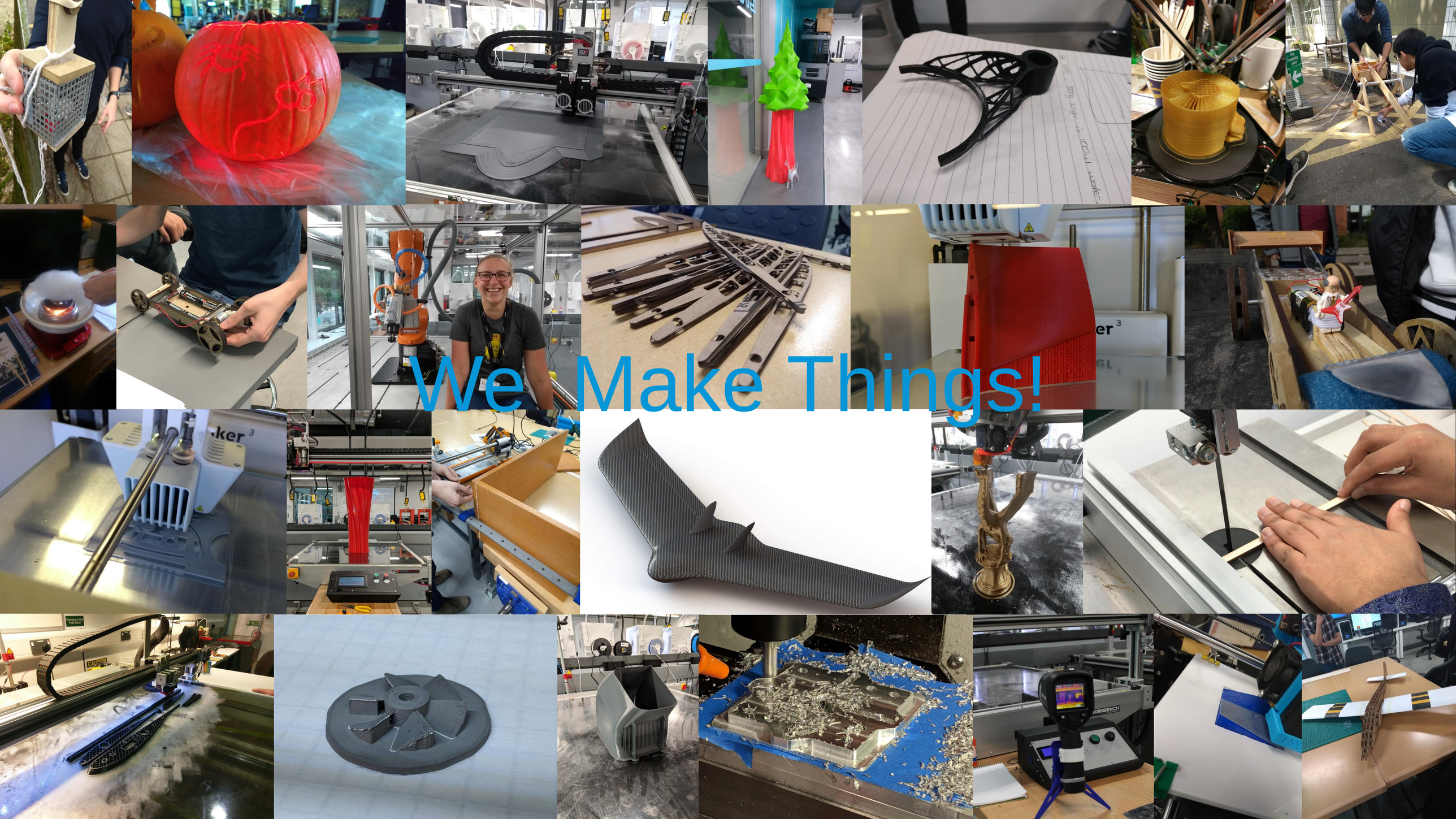







SET WORK ZERO




We Make Things!

You may remember us from…

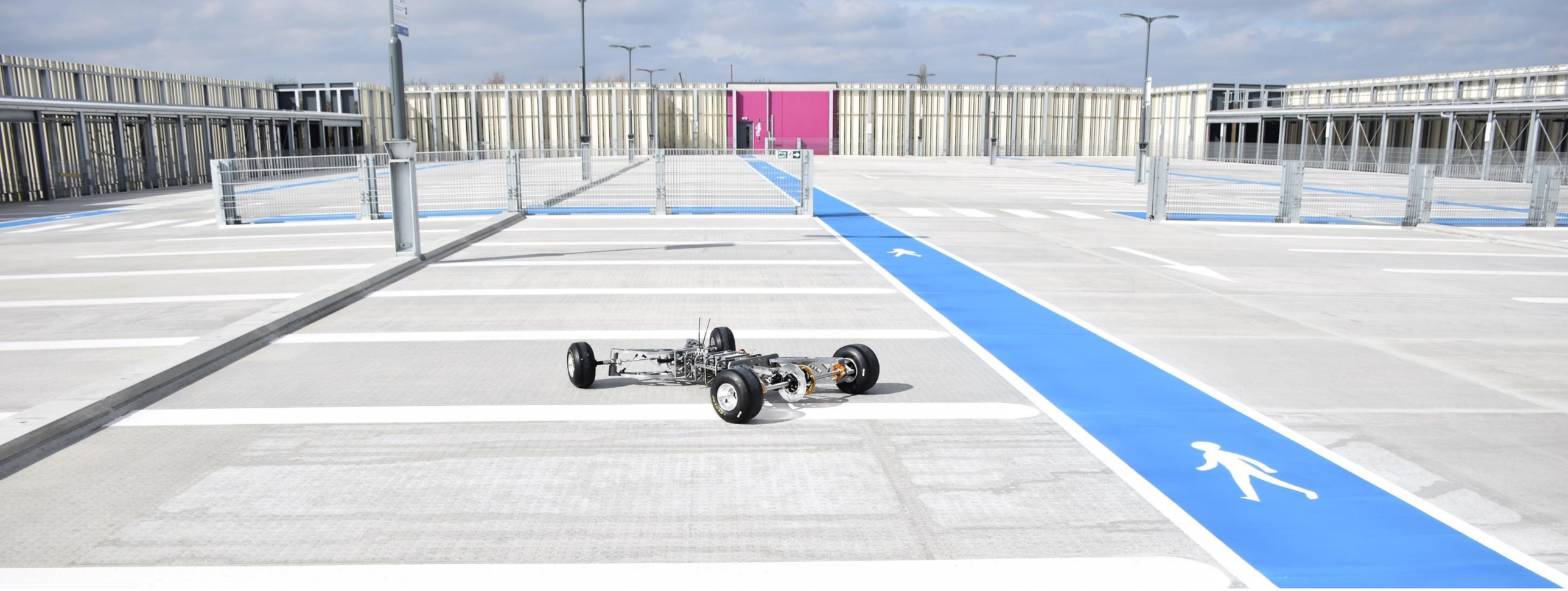
WARWICK
SCHOOL OF ENGINEERING

DMTL
Digital and Material Technologies Laboratory

GKN AEROSPACE

AUTODESK.

Warwick Autonomous Electric Racing Series (AERS) Project



warwick aero

DMTL
Digital and Material Technologies Laboratory

SCALED
IDEAS MADE BIG

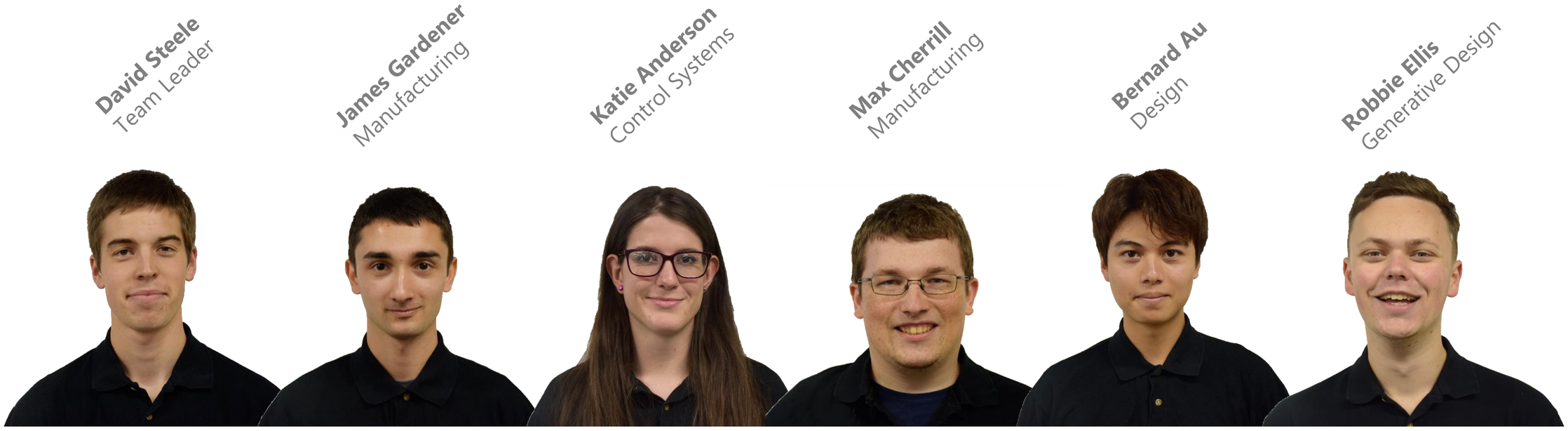
FILAMENTIVE
Sustainable 3D Printing

AUTODESK.

3DP
3D PLATFORM


DUNLOP

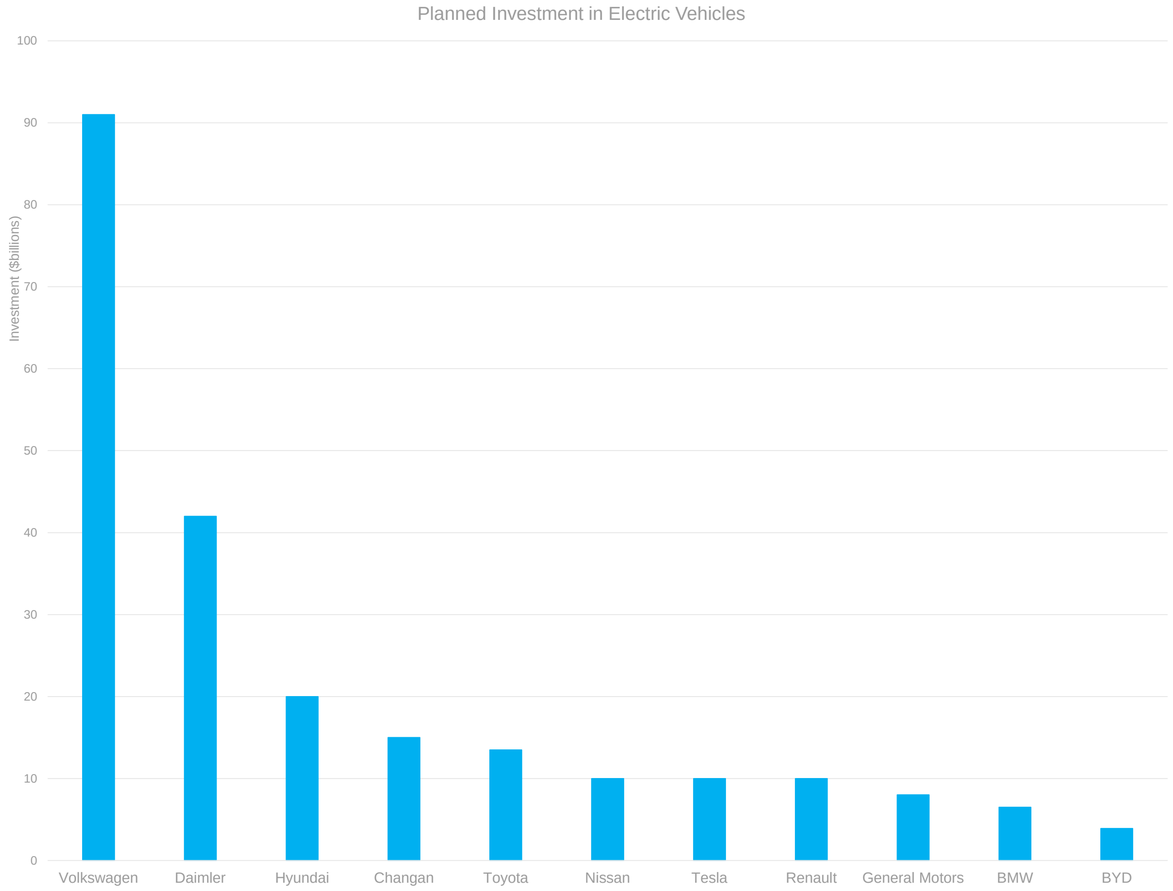
The Student Team



Overview

“To demonstrate the feasibility of a new student-focused, semi-autonomous, electric vehicle racing series”

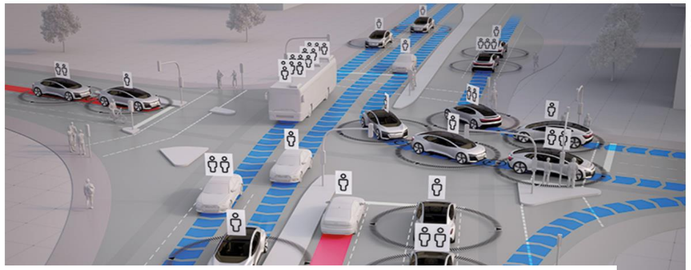
Project Context



- Intelligent mobility skill gap
- Increased push for autonomous mobility solutions
- Multi-disciplinary requirements for implementation

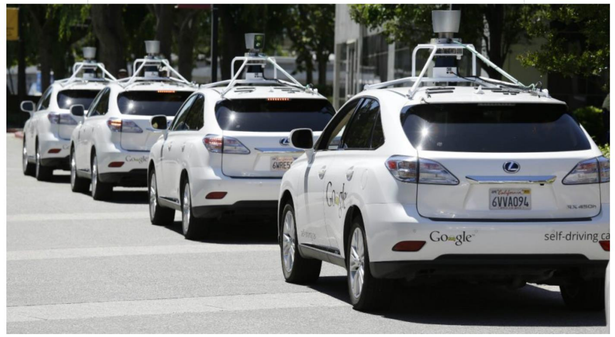
Data obtained from: https://graphics.reuters.com/AUTOS-INVESTMENT-ELECTRIC/010081ZB3HD/index.html
Research from: Deloitte (2018), *New market. New entrants. New challenges. Battery Electric Vehicles,* Retrieved from https://www2.deloitte.com/content/dam/Deloitte/uk/Documents/manufacturing/deloitte-uk-battery-electric-vehicles.pdf

Driverless or autonomous cars will alienate petrolheads



Consumers Don't Really Want Self-Driving Cars, MIT Study Finds

May 25, 2017 | By Zeninjor Enwemeka



An MIT study finds that consumers are increasingly growing uncomfortable with the idea of fully autonomous cars. Pictured: A row of Google self-driving Lexus cars at the Computer History Museum in Mountain View, California. (Eric Risberg/ AP)

Tech companies and car manufacturers are spending billions to get self-

Bloomberg

Technology

Don't Worry, Petrolheads. Driverless Cars Are Still Years Away

By David Welch and Gabrielle Coppola
9 January 2018, 01:44 GMT *Updated on 9 January 2018, 13:15 GMT*

- Lyft cautions human drivers will be needed 'a very long time'
- Toyota sees 'long journey' before drivers let go of the wheel

Search | The Guardian | UK edition

The end of cars is coming, so what will happen to the petrolheads?

Driverless cars are on their way but how will Australia's car-obsessed culture give way to shared ownership, automated traffic and H plates?

Driverless cars will END the joy of driving, warns Nick Freeman

THE moment I set eyes on her I was smitten. And my response was primitive. I had to possess her and make her mine. Apologies if this sounds like the corny romanticism of some dribbling old fool.

By NICK FREEMAN
PUBLISHED: 11:01, Thu, Feb 8, 2018 | UPDATED: 11:08, Thu, Feb 8, 2018

SHARE TWEET 3

It's in the news…

The Project Objectives

DESIGN A NEW RACE SERIES

Design a new race series for students to compete, manufacturing a vehicle which must have some autonomous functionality, combined with remote control and no on-board driver.

EXPLORE THE USE OF GENERATIVE DESIGN

Use Autodesk Fusion 360 to explore the use of Generative Design in a design and make project.

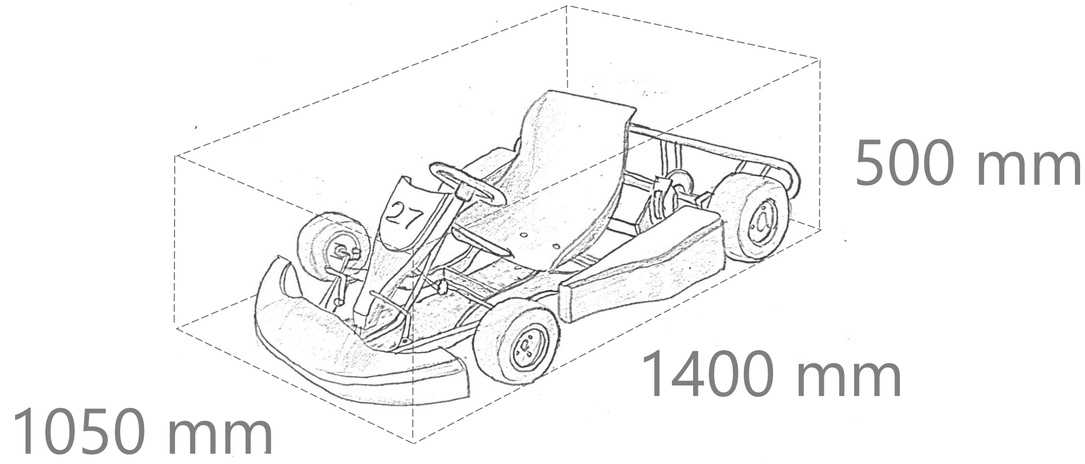
MANUFACTURE A VEHICLE FOR THE RACE

Demonstrate the feasibility of the new race series by manufacturing a working vehicle which could compete in the series.

The Race Series

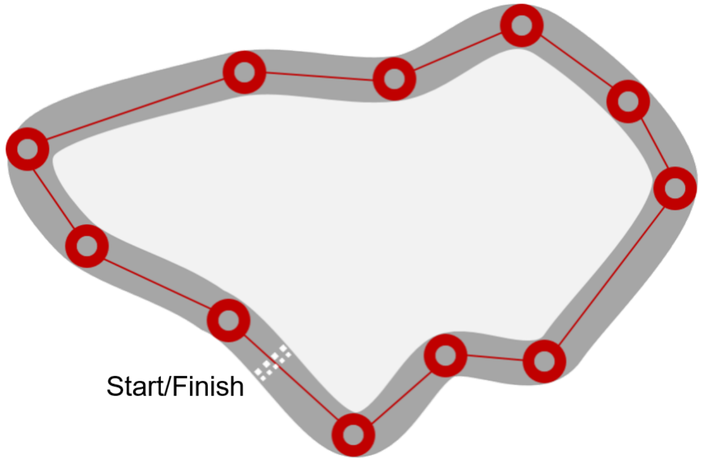
VEHICLE SPECIFICATIONS

- Dimension Limit: 1400 mm x 1050 mm x 500 mm
- Weight Limit: 40 kg

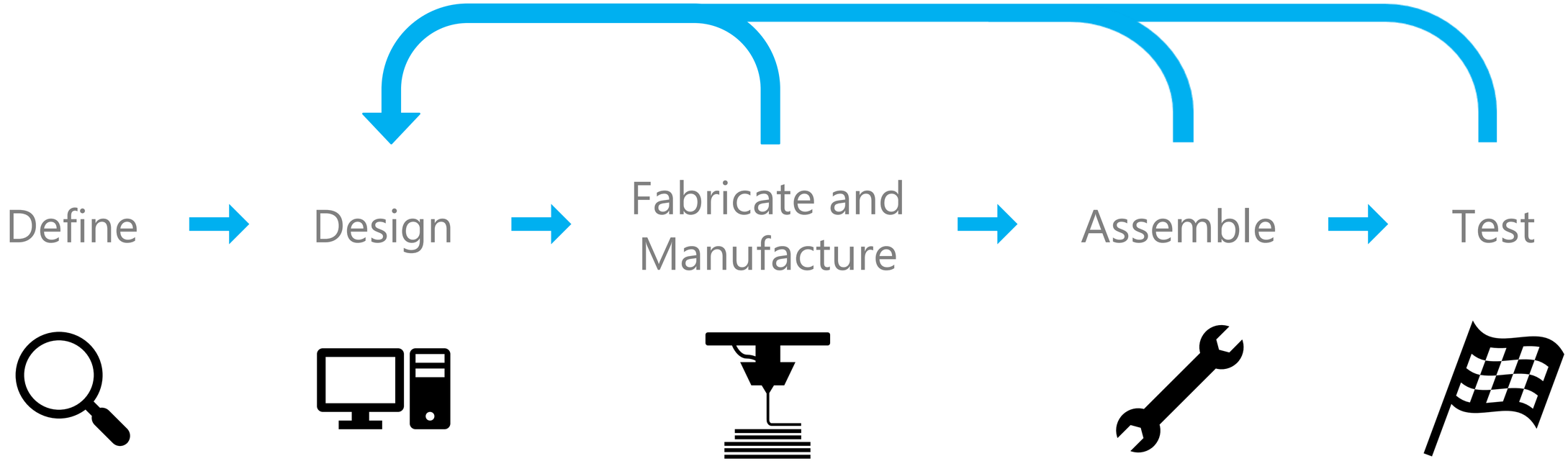


RACE SERIES PLAN

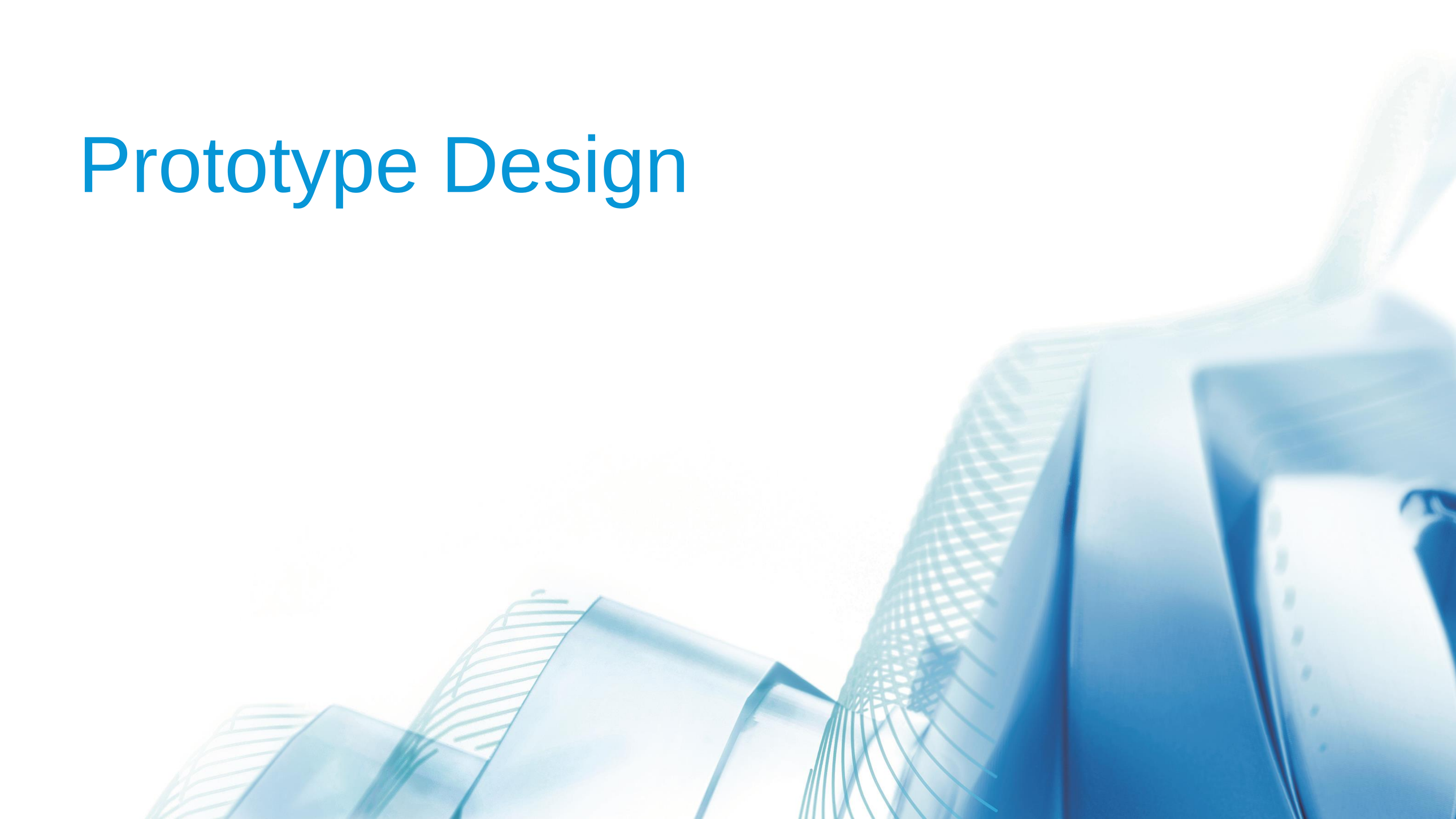
- Timed laps for semi-autonomous vehicles (follow pre-set GPS waypoints)
- Design and racing aspects

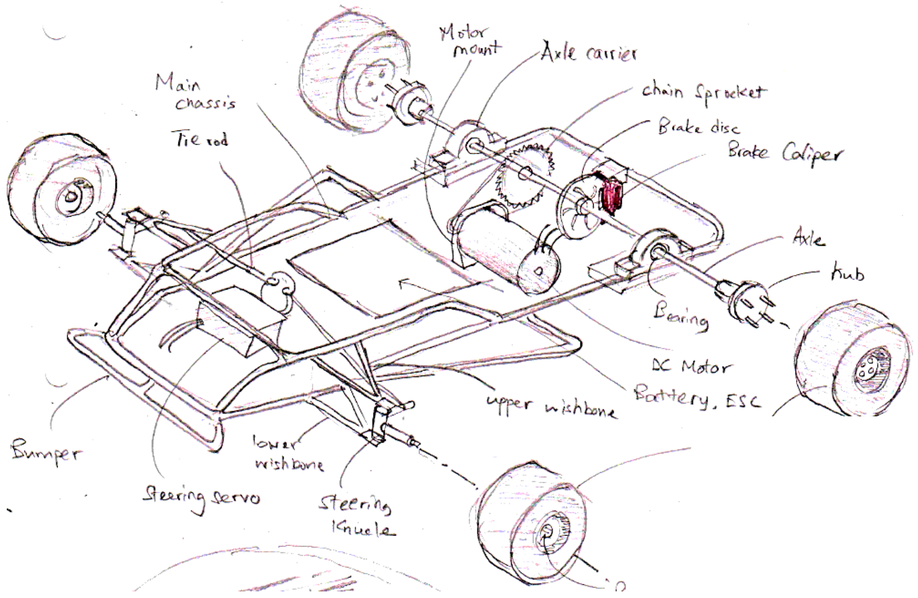


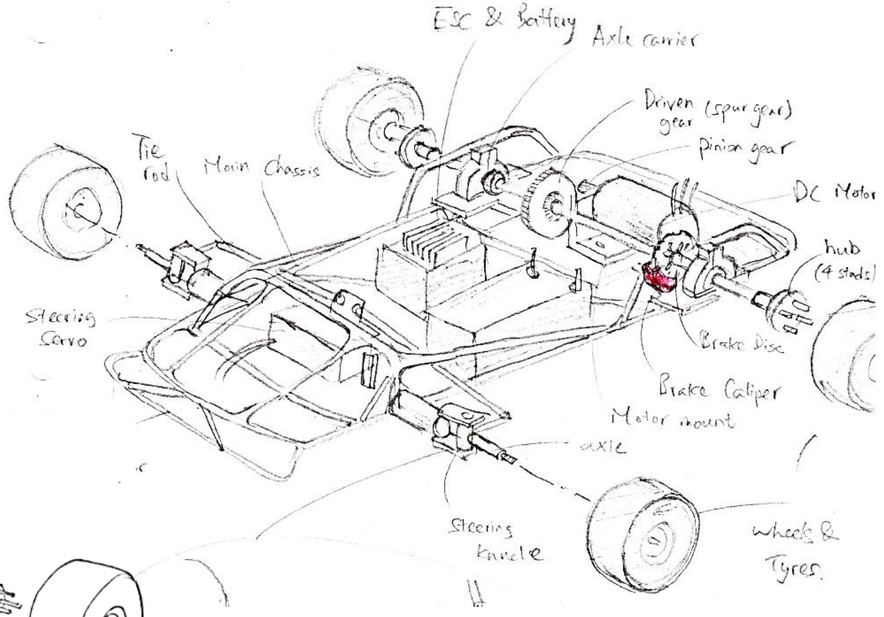
Project Workflow

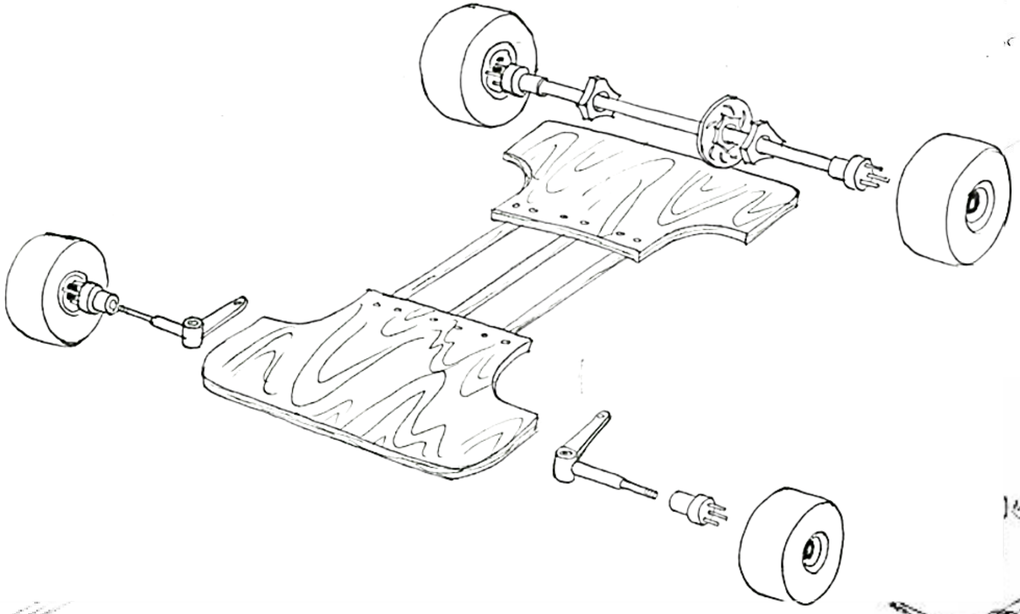


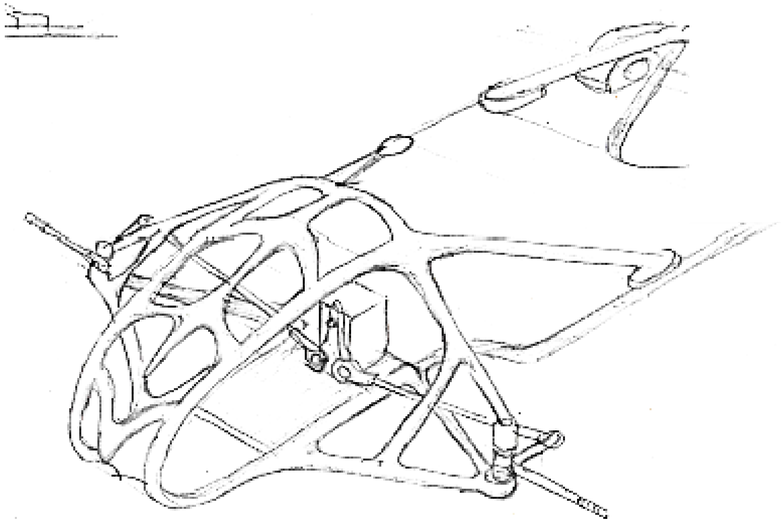
Prototype Design

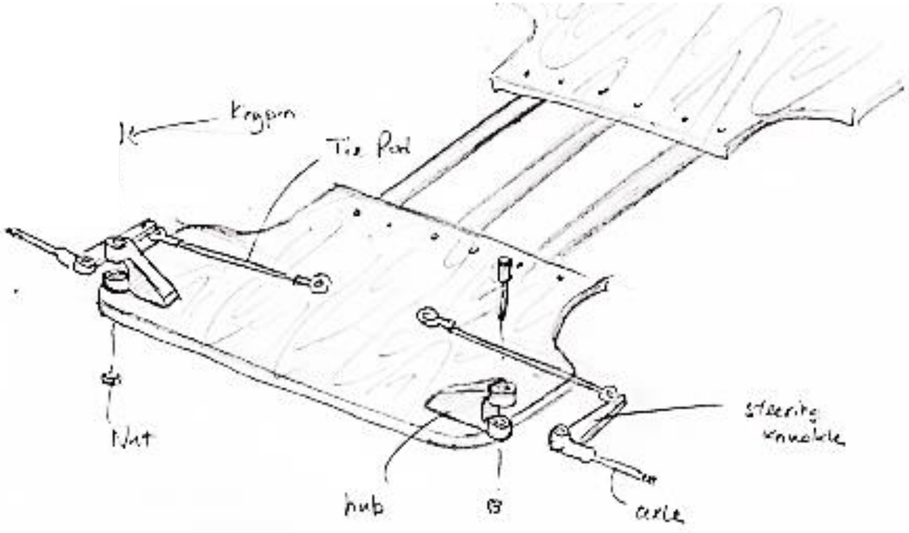


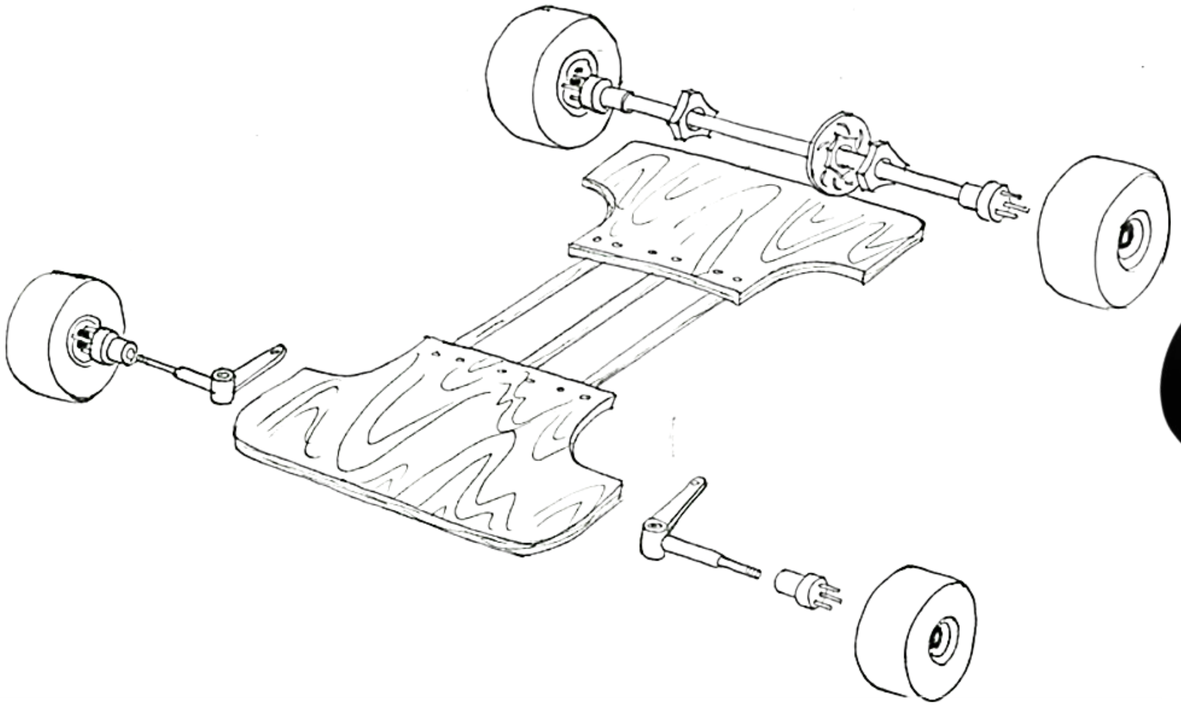

Motor mount
Axle carrier
Main chassis
chain Sprocket
Tie rod
Brake disc
Brake Caliper
Axle
hub
Bearing
DC Motor
Battery, ESC
upper wishbone
Bumper
lower wishbone
Steering servo
Steering knuckle


ESC & Battery
Axle carrier
Driven (spur gear)
pinion gear
Tie rod
Main Chassis
DC Motor
hub (4 studs)
Steering Servo
Brake Disc
Brake Caliper
Motor mount
axle
Steering knuckle
wheels & Tyres

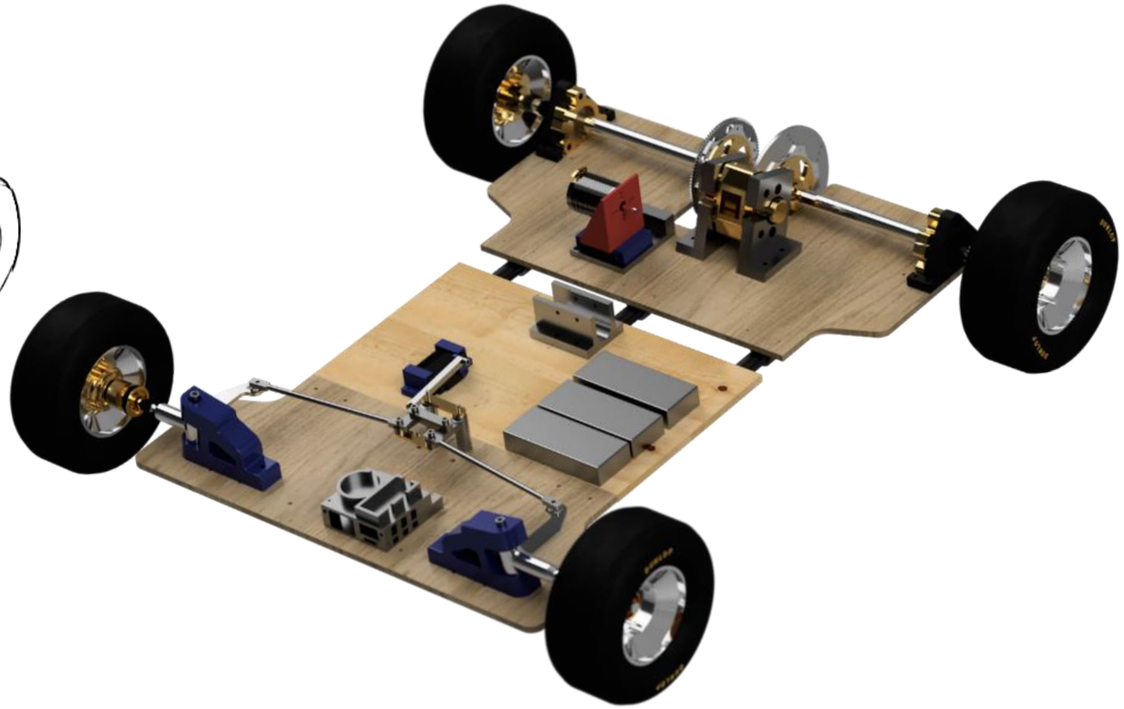





Kingpin
Tie Rod
Nut
steering knuckle
hub
axle

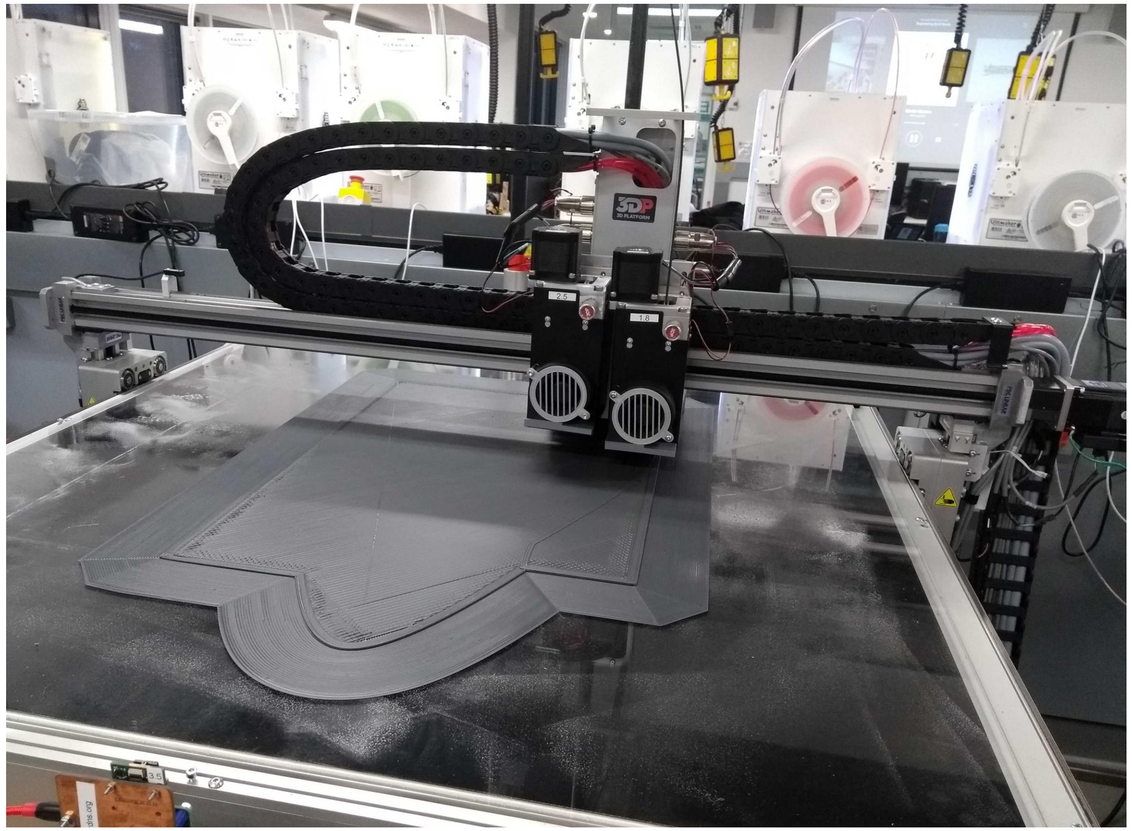


CONCEPT



CAD MODEL

Using Large-Scale AM



FEATURES

- Bigger build volumes – 1 m x 1 m x 0.7 m
- Bigger nozzles – 2.5 mm
- Faster flow rates – 70 mm^3s^{-1}

ADVANTAGES

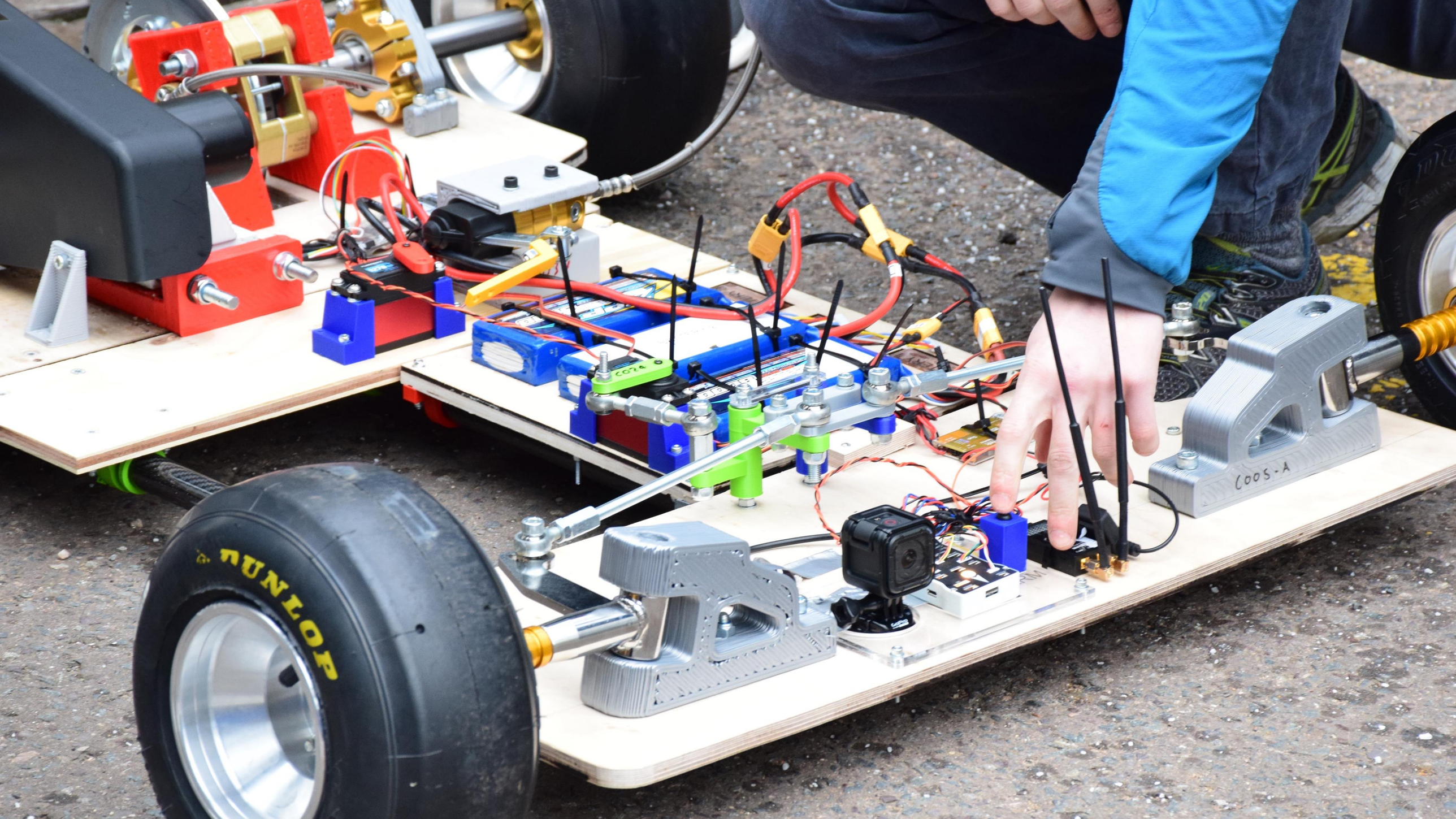
- Build bigger parts
- Build parts faster

DISADVANTAGES

- Minimum feature size is much larger
- Support cannot be removed easily
- Overhang staircase is more pronounced

3D PLATFORM


DUNLOP
C005-A

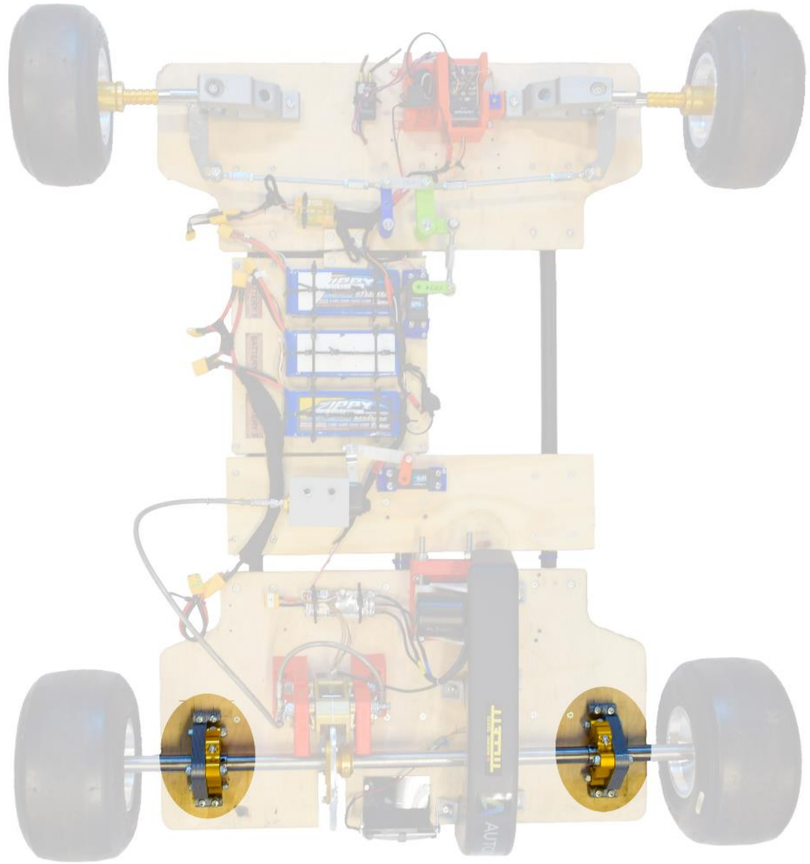

DUNLOP

Fail Fast, Fail Often…?

Large-scale AM - Rapid Part Iteration

Using Large-scale AM meant that large structural parts could be tested and iterated in less than an hour in some cases.

Bearing Carrier Mounts



Generative Design

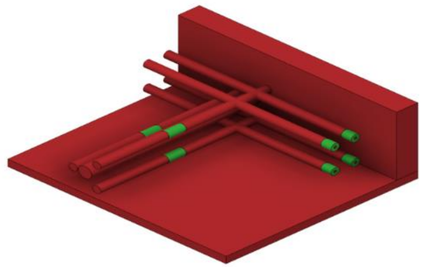
“Generative design mimics nature’s evolutionary approach to design. Designers or engineers input design goals into generative design software, along with parameters such as materials, manufacturing methods, and cost constraints. Unlike topology optmization, the software explores all the possible permutations of a solution, quickly generating design alternatives. It tests and learns from each iteration what works and what doesn’t.”

Autodesk

TRADITIONAL DESIGN PROCESS

Concept → Design → Simulate → Manufacture

GENERATIVE DESIGN PROCESS

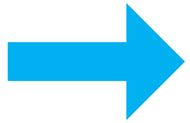


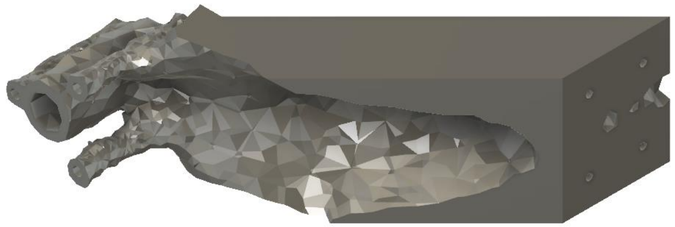
Define

Generate

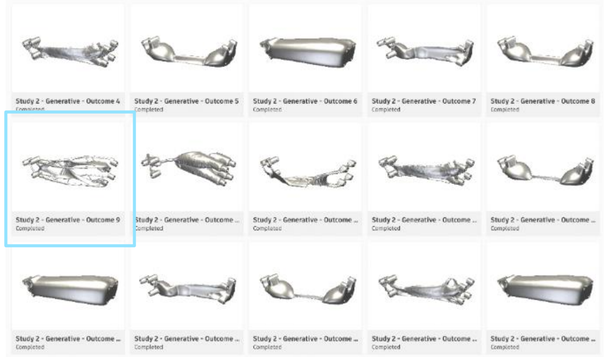
Promote

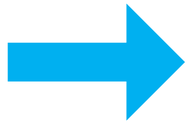
TOPOLOGY OPTIMISATION

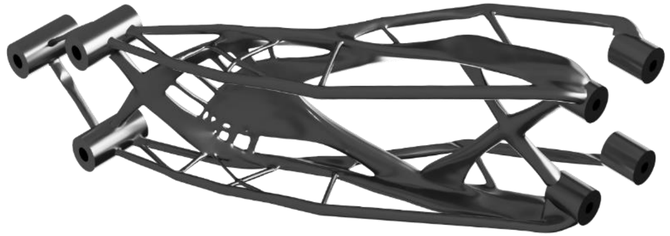


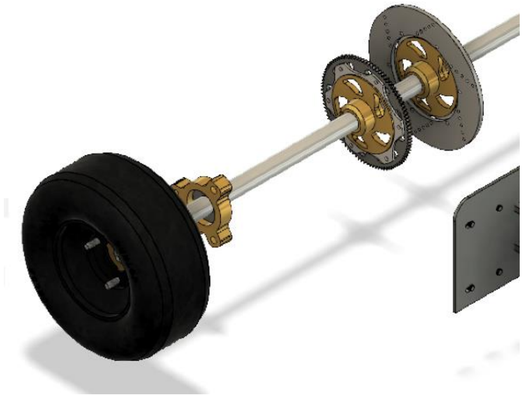


GENERATIVE DESIGN

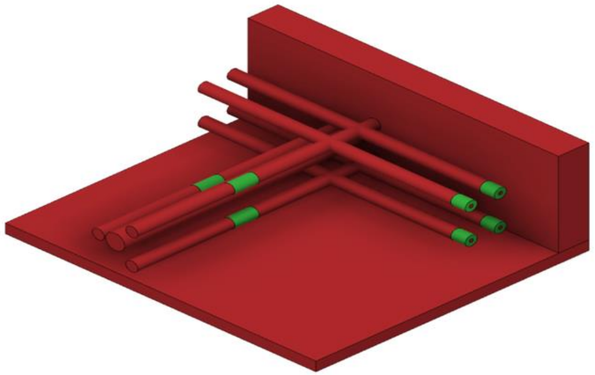




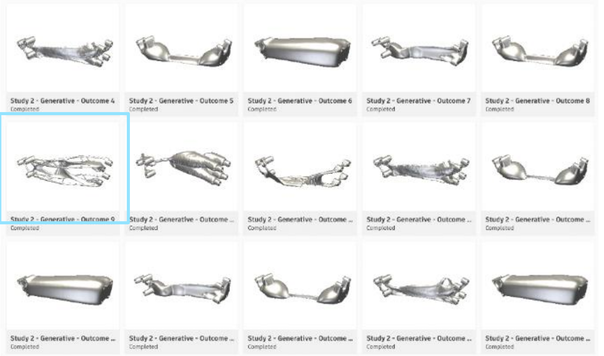




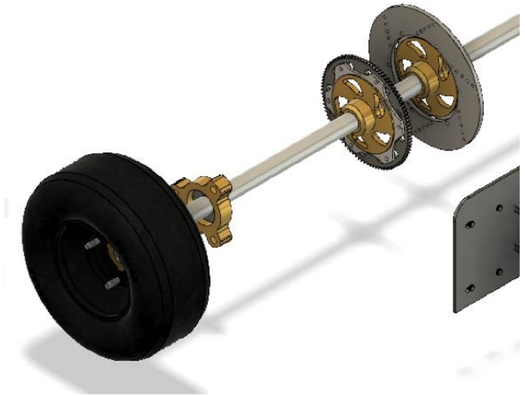
Stage 1: Design Space



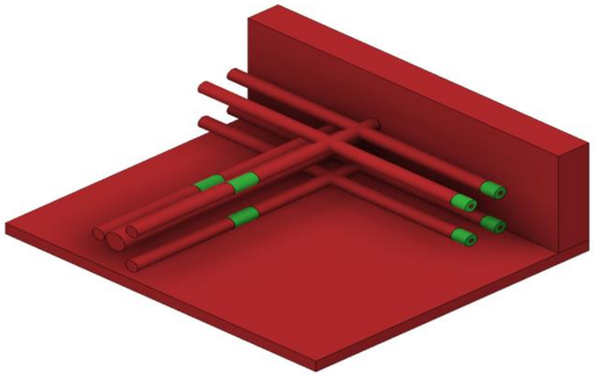
Stage 2: Set-up



Stage 3: Results



Stage 1: Design Space



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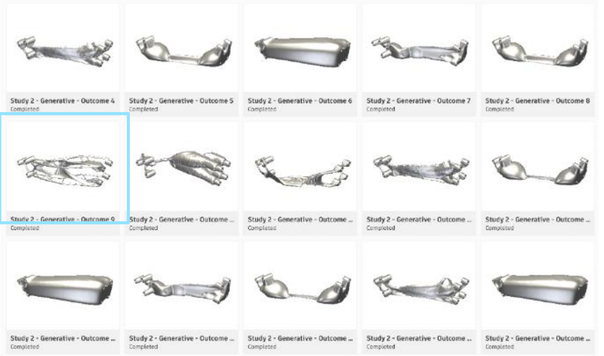
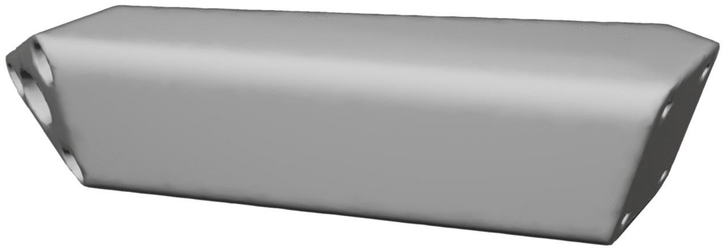
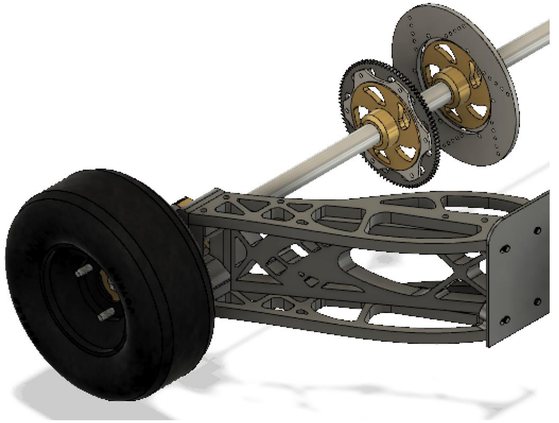


Stage 3: Results



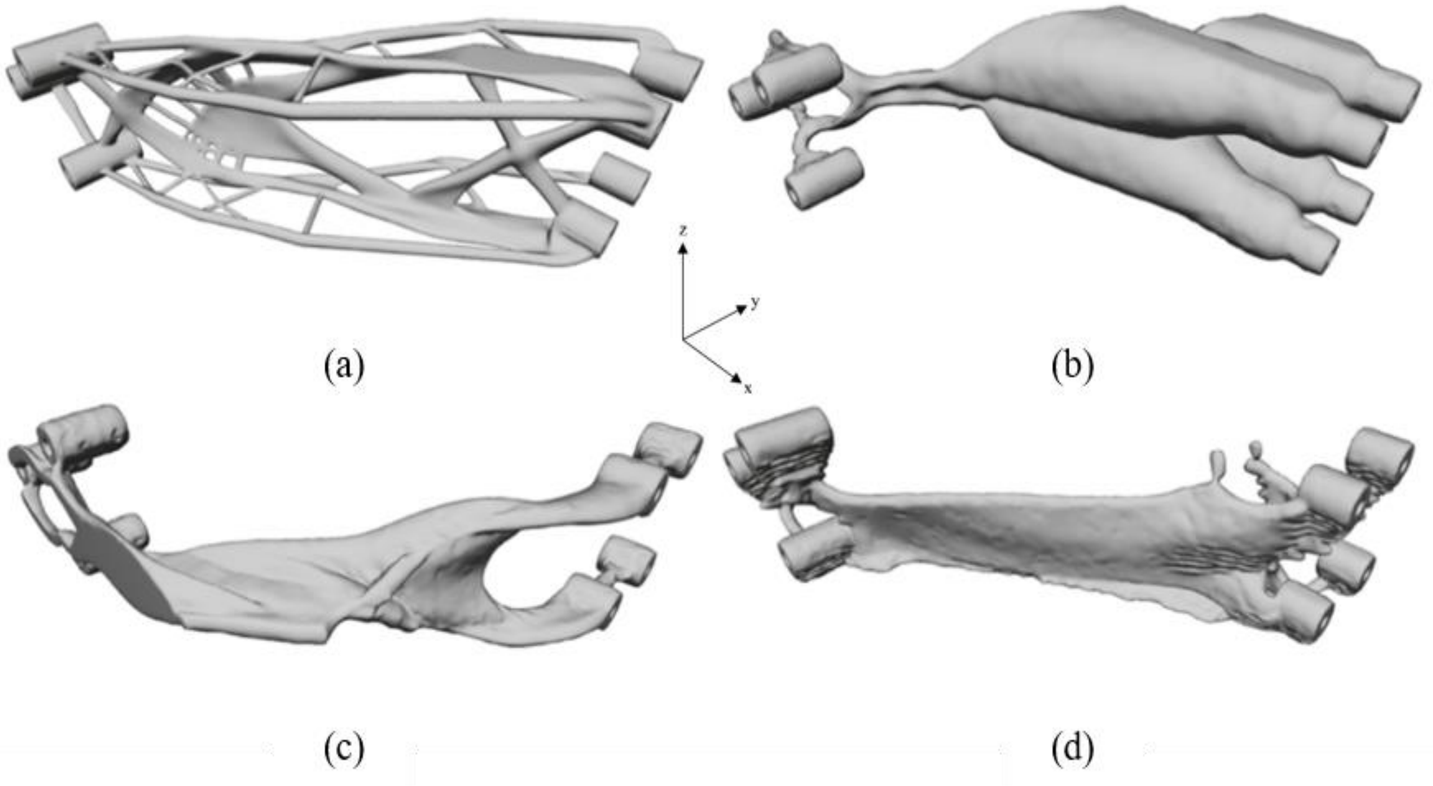
Stage 4: Selected Design

Stage 5: DFM



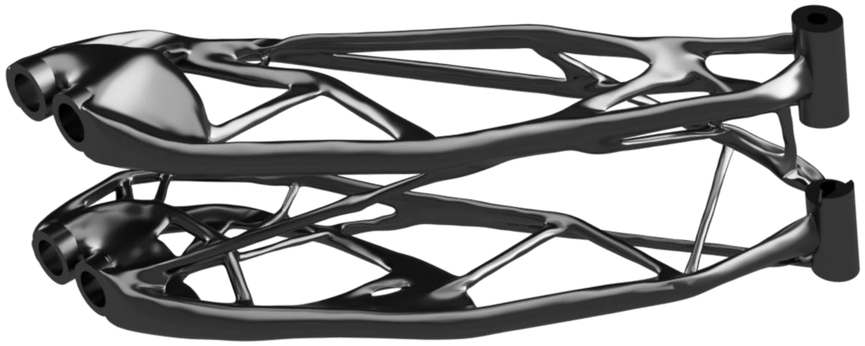
Stage 6: Implementation

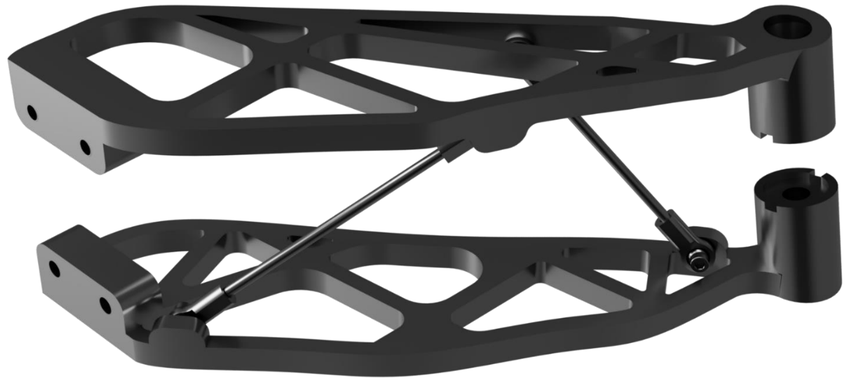
Selection of Candidate Design

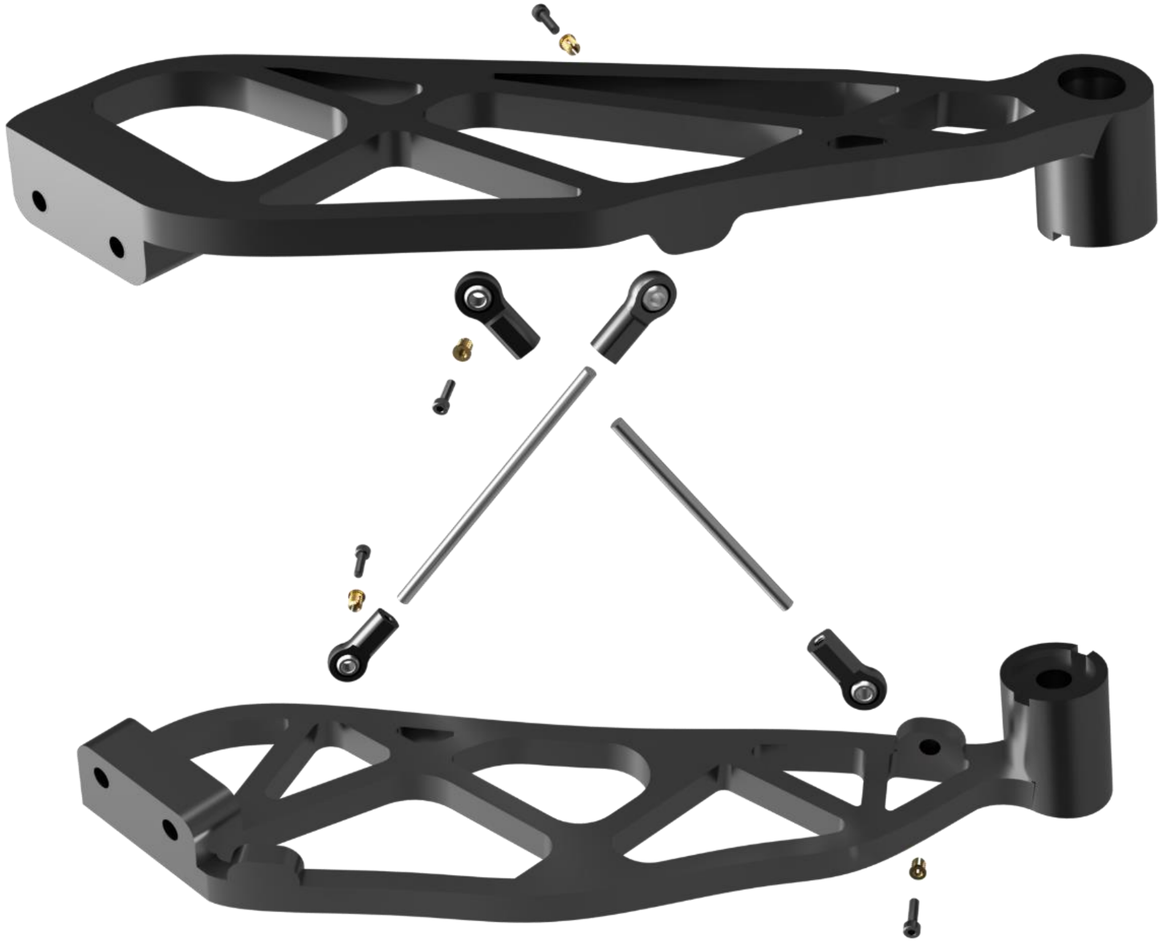


Rear right arm generative output optimised for (a) unrestricted manufacturing, (b) AM x+ manufacturing, (c) AM y+ manufacturing, and (d) AM z+ manufacturing

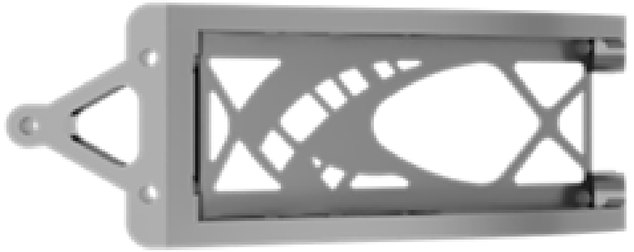
Front Arm DfAM

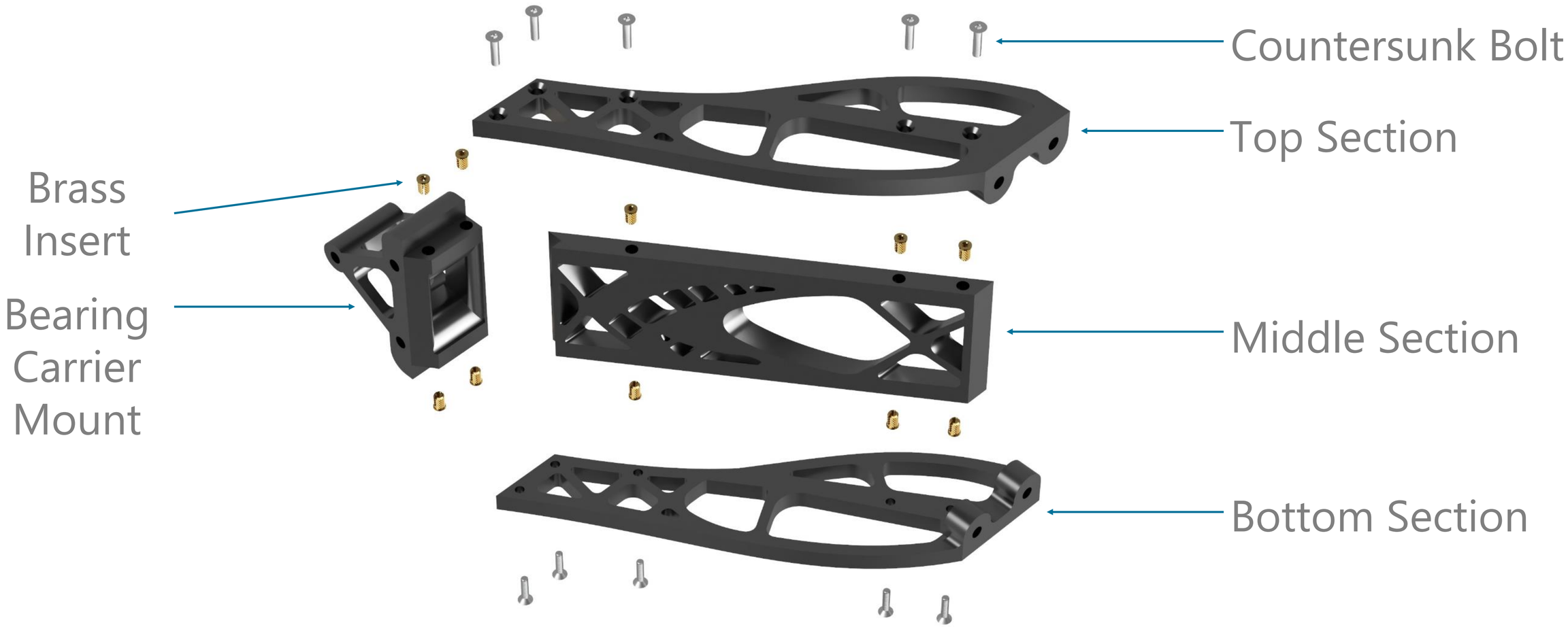




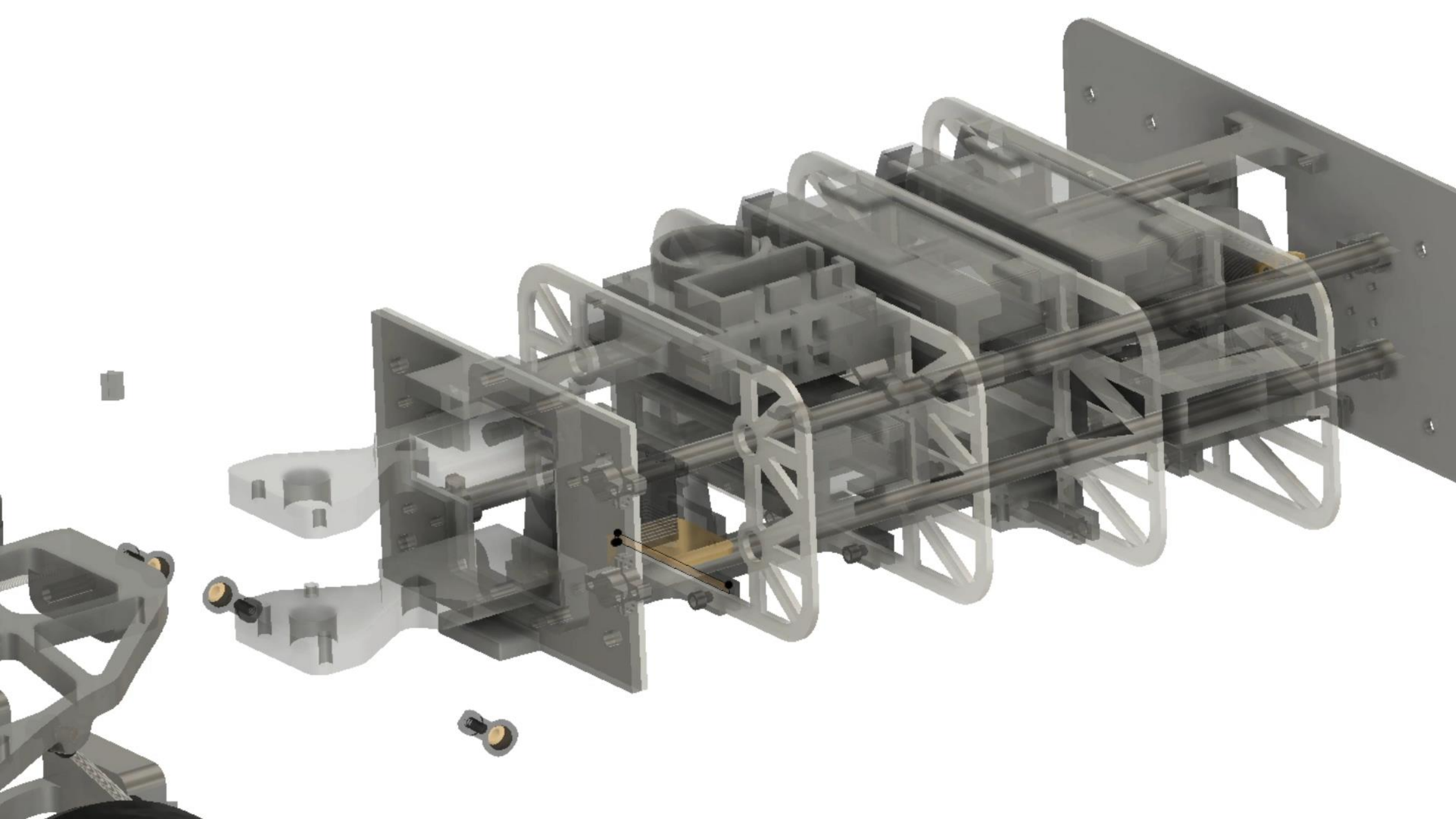


Rear Arm DfAM

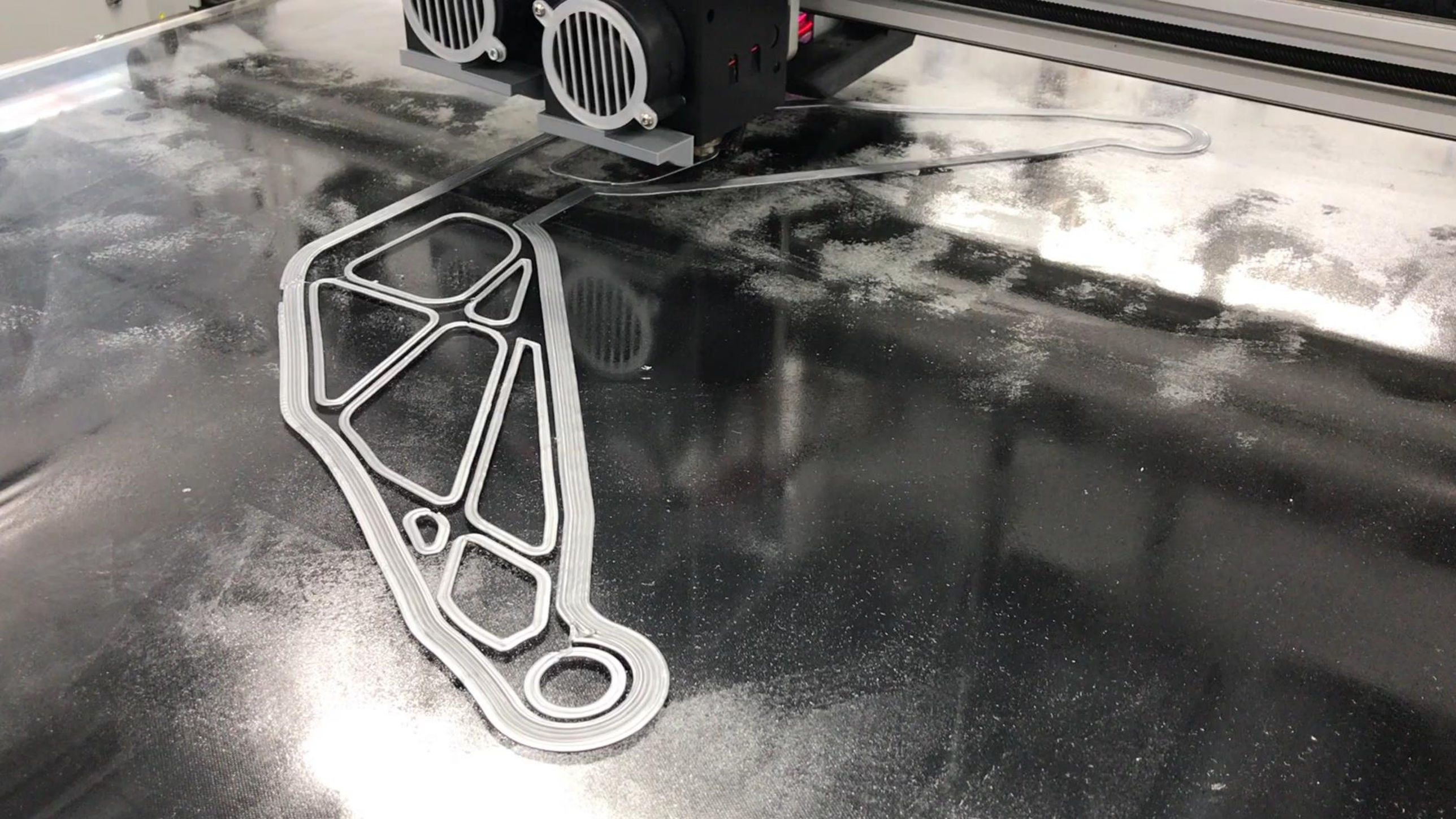


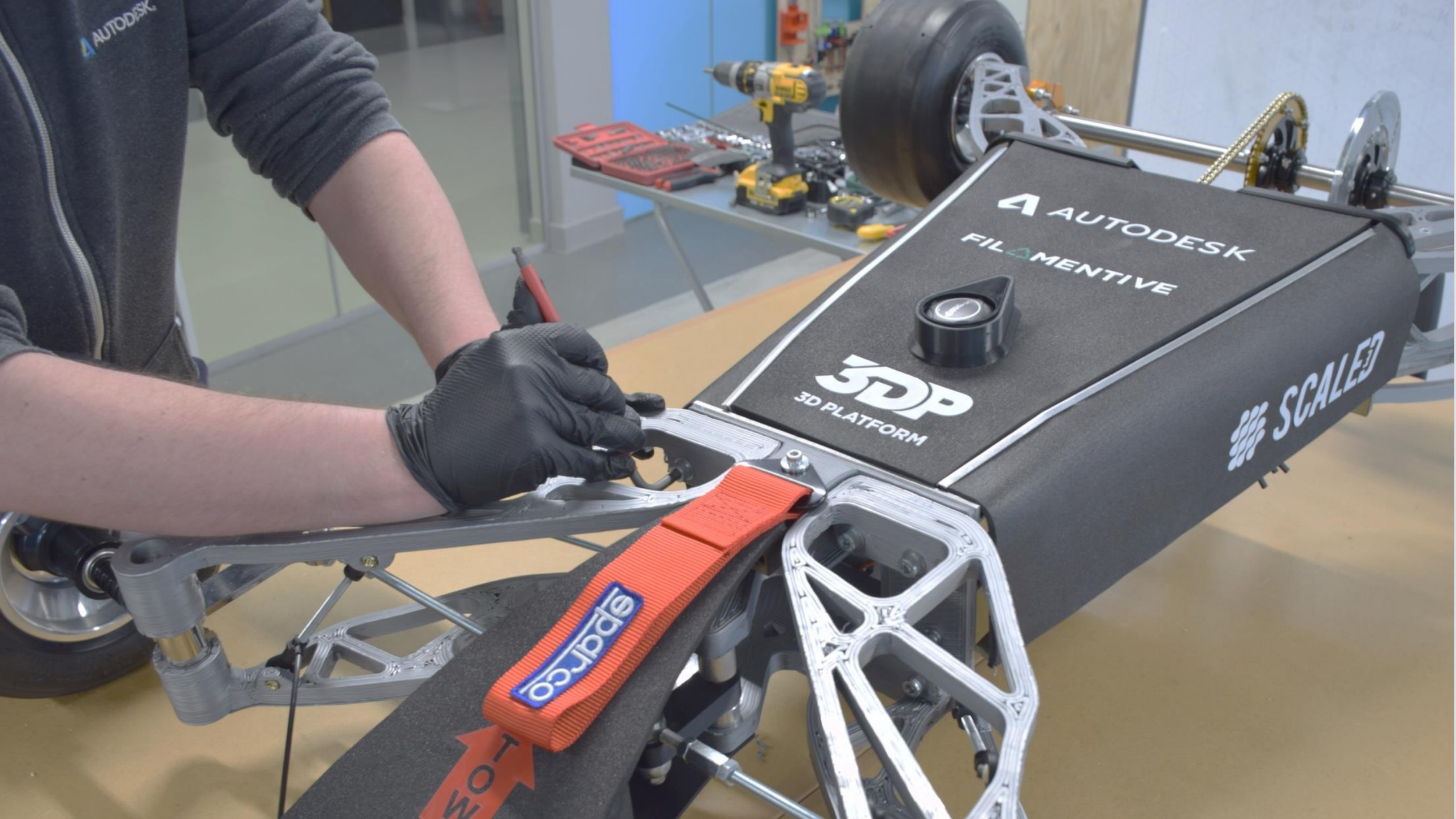


Rear Arm Exploded View



Manufacturing

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Learning Points

What We've Learnt From the Process for Education

- Intelligent selection of load cases and problem definition is obviously key
  - *actually a great tool for complementing the taught theory*
- Knowing the key constraints of your manufacturing process in advance is important
  - *sometimes it's actually easier to use the unrestricted output*
- Shape Optimisation in Fusion is a great 'onboarding' tool before students get into Generative but obviously no substitute as Generative requires a very different 'mindset'
- No 'hard and fast' rules about how long it takes someone to pick up Generative
- Still requires core competency in Fusion to work properly (*i.e. how to create assemblies properly*)


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What’s Next?

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