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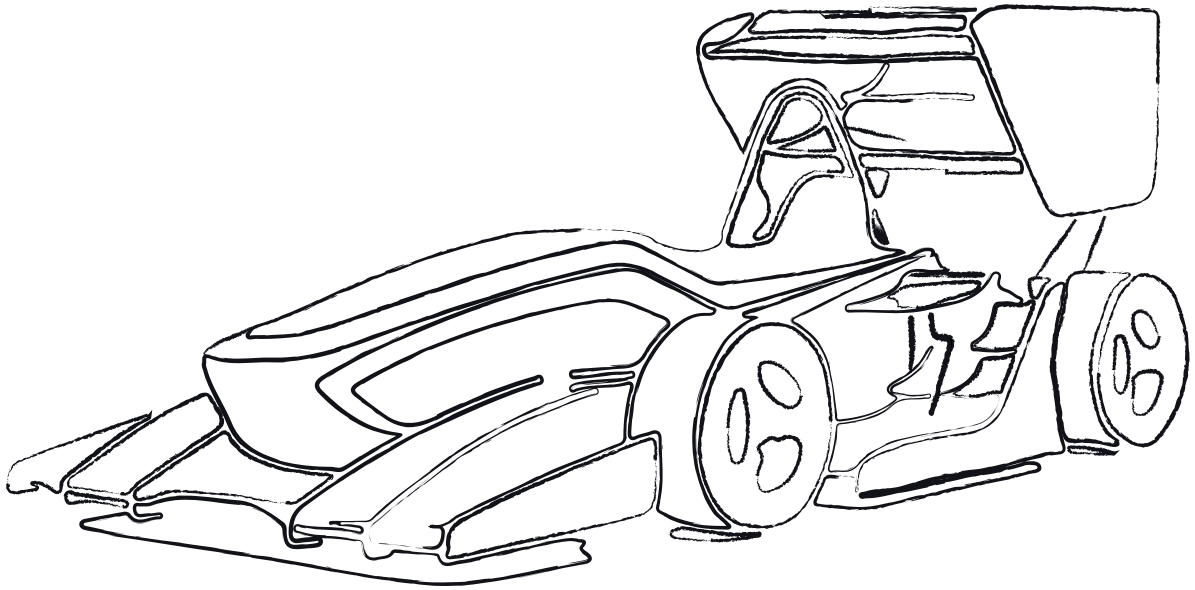

Structural Simulation @ joanneum racing graz

Torsional Stiffness Optimization of a Formula SAE Chassis

Content

- Formula Student
  - General
  - Competitions
- *joanneum racing graz – "The Weasels"*
- jr18
- Torsional stiffness analysis of chassis
- General topics about structural simulation at joanneum racing graz

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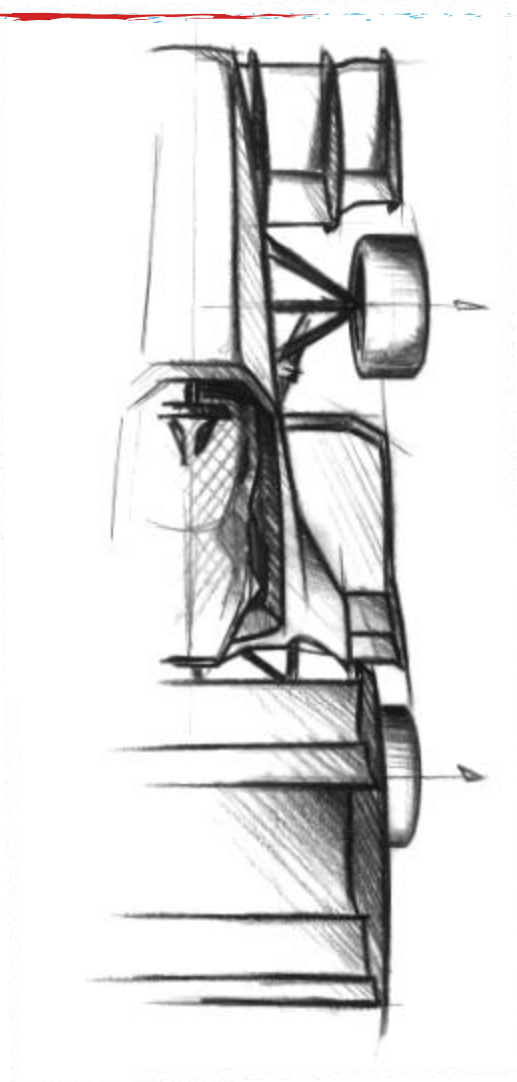
Formula Student

- Objective: designing, fabricating, testing and demonstrating a single seater prototype vehicle
- International design competition
- Regalement by SAE (Society of Automotive Engineers)
- Almost 700 teams worldwide



Points distribution

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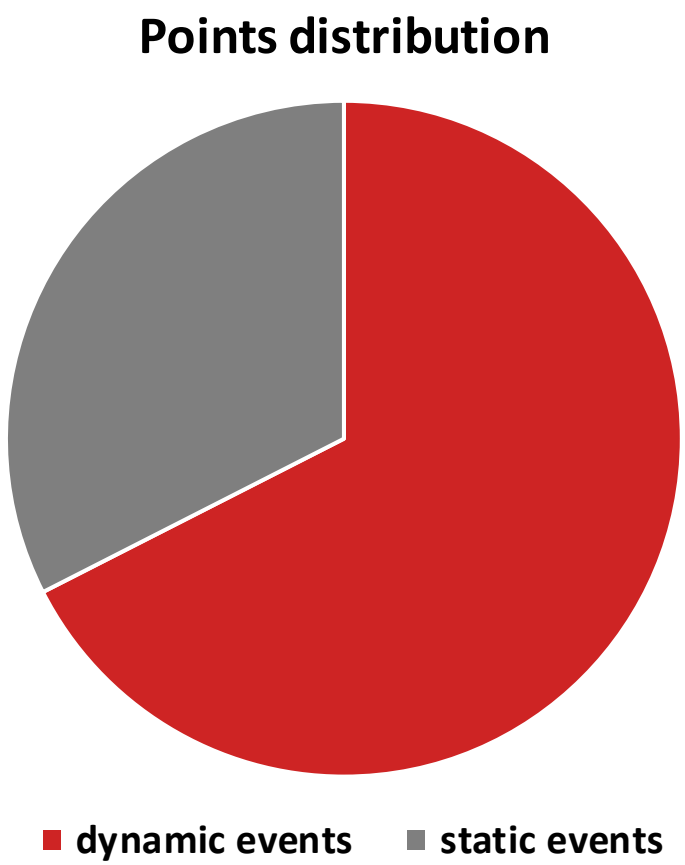
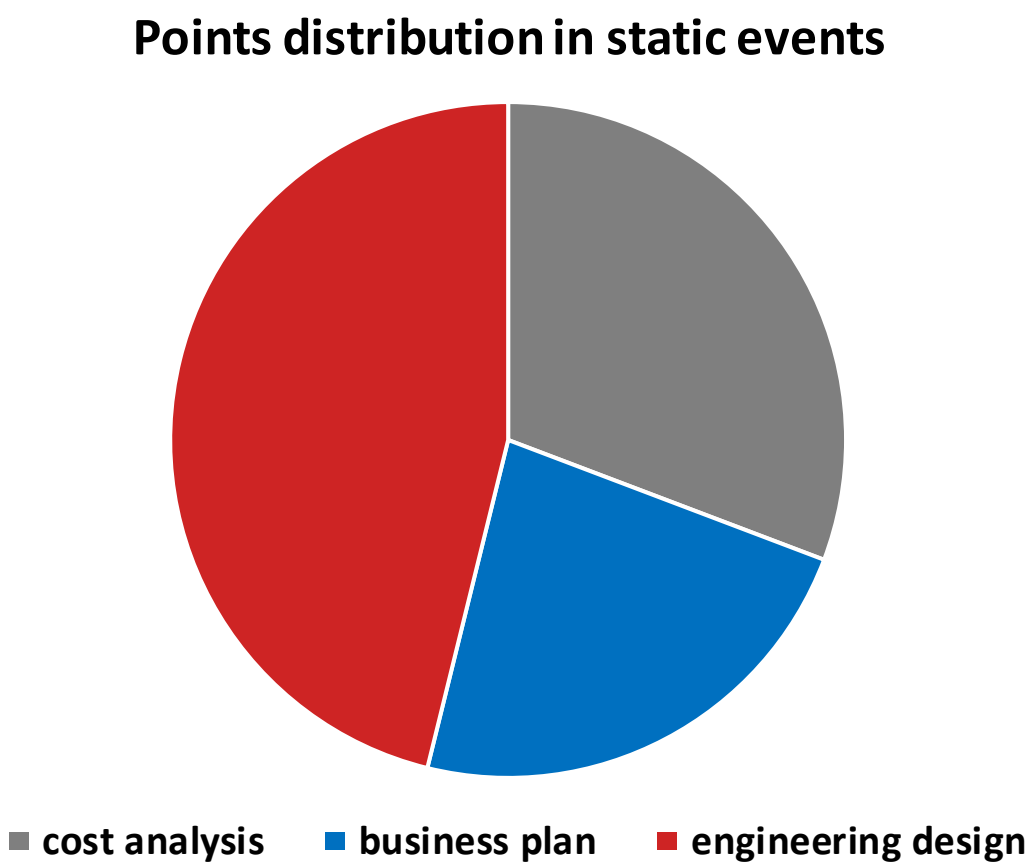
- 1000 points maximum score
- Static events
  - Performance depends on team and knowledge
- Dynamic events
  - Performance depends on racecar and driver



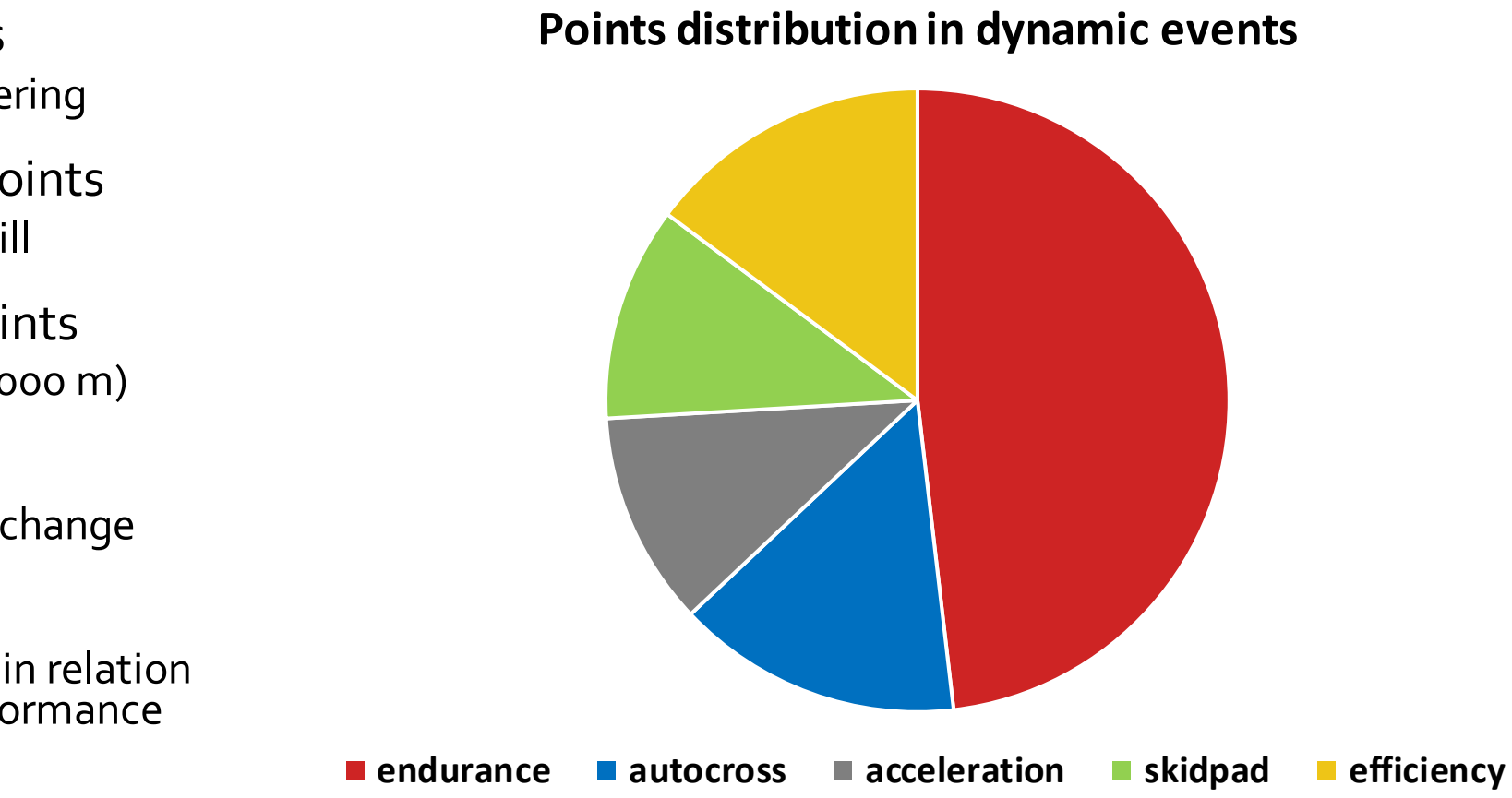
Static events

- Cost analysis: 100 points
  - Cost itemisation: cheapest car wins
  - Accuracy & real case
- Business plan: 75 points
  - Idea & elaboration
- Engineering design: 150 points
  - Engineering decisions & reasoning
  - Basic technical knowledge



Dynamic events

- Skidpad: 75 points
  - Steady state cornering
- Acceleration: 75 points
  - 75 m from standstill
- Autocross: 100 points
  - Single fast lap (~1000 m)
- Endurance
  - 22 km with driver change
- Efficiency
  - fuel consumption in relation to endurance performance



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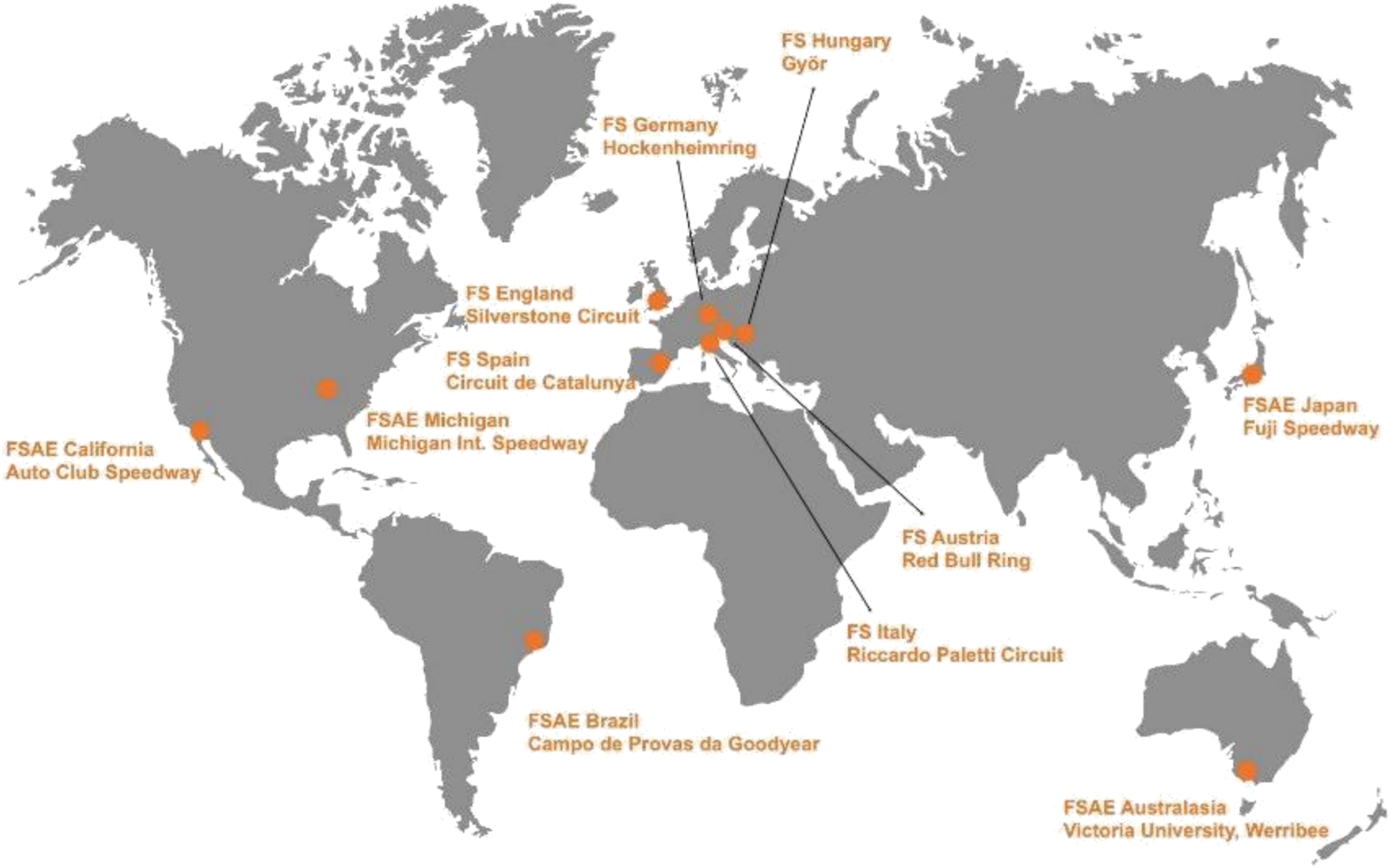
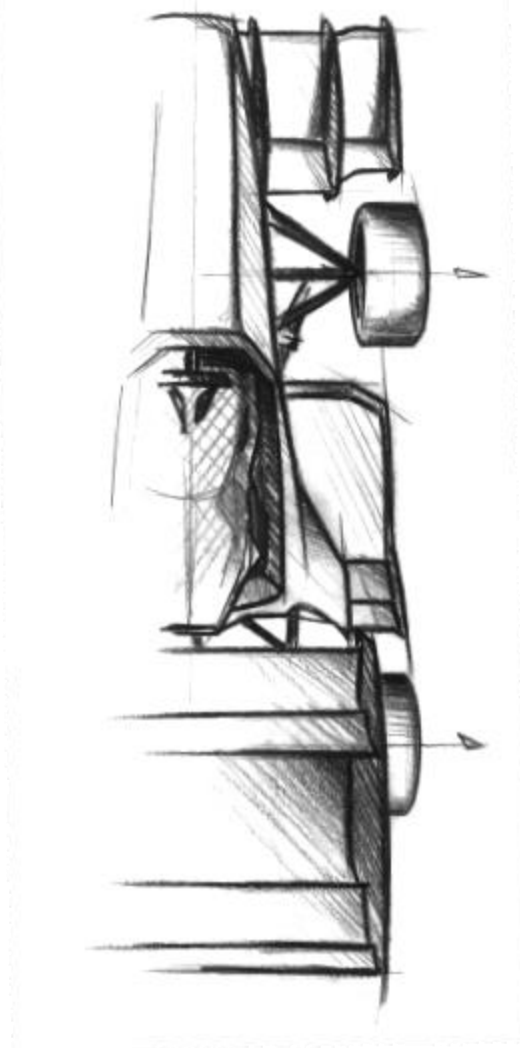
Formula Student – Competitions





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- Since 2003
- ~30 automotive engineering students
- Team changes every year
- Top 3 in world ranking in 2016

jr18

- 2-cylinder turbo engine
  - Modified 2-cylinder BRP Rotax engine
- CFRP monocoque
- Self-developed CFRP gearbox housing
- CFD optimized aerodynamics
- Multi-functional steering wheel
- Power: 63 kW / 127 Nm
- Weight (dry): 205 kg

FSAE Italy (47 teams)

1st engineering design
4th place skidpad
3rd place autocross

13th place overall

FSA Spielberg (30 teams)

3rd place cost-report
5th place engineering design
7th place skidpad

8th place overall

FSG Hockenheim (58 teams)

3rd place engineering design
6th place cost-report
7th place endurance

9th place overall

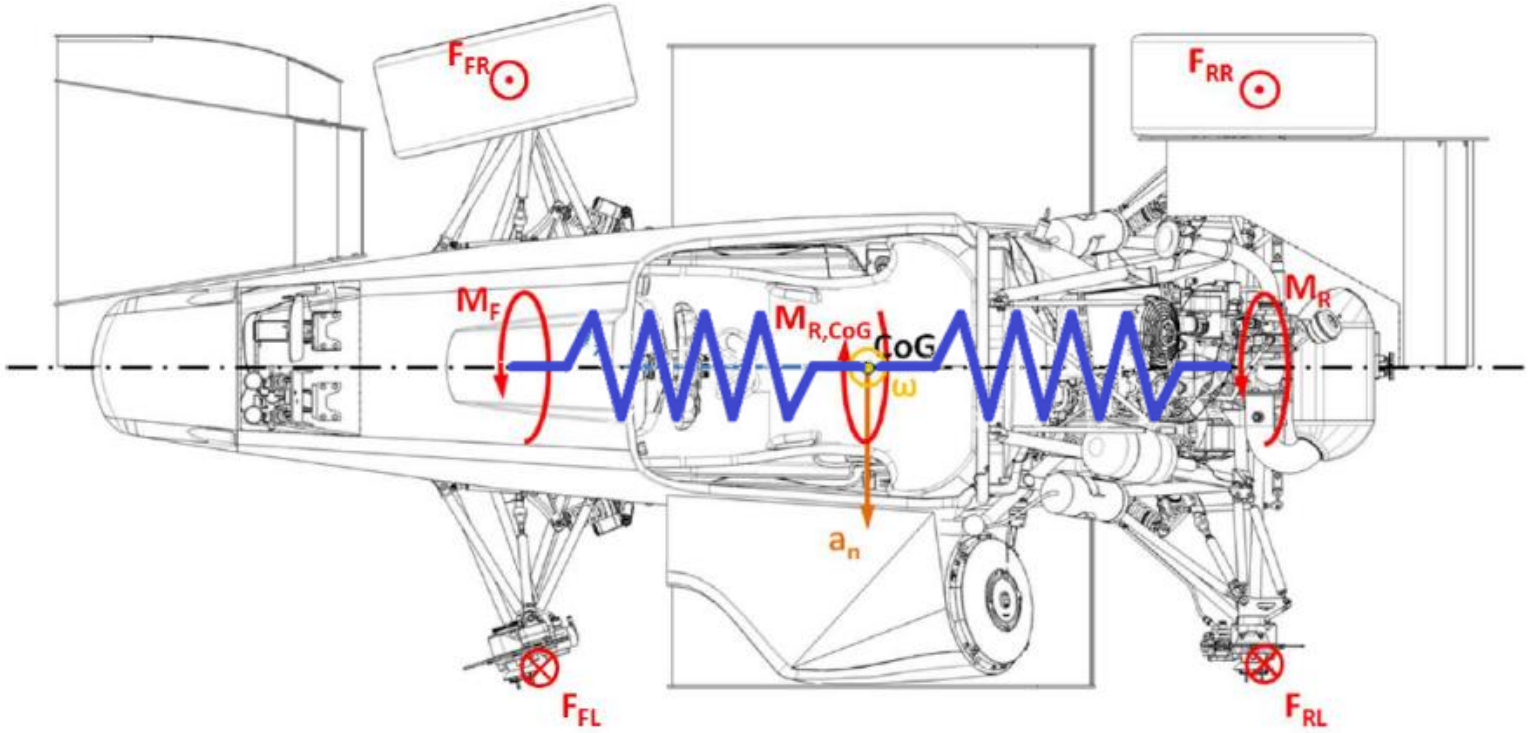
SFJ Japan (86 teams)

1st place engineering design
1st place skidpad
3rd place autocross

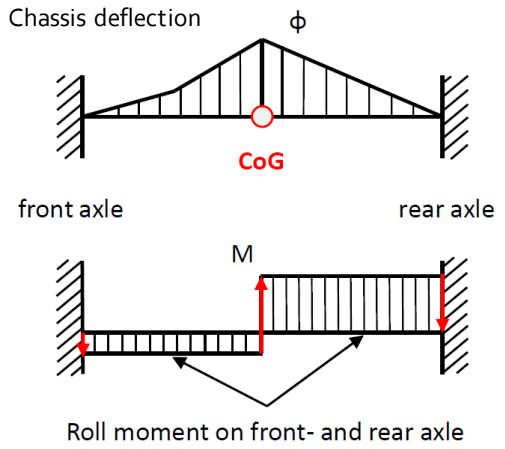
5th place overall

Special Awards:
CAE award

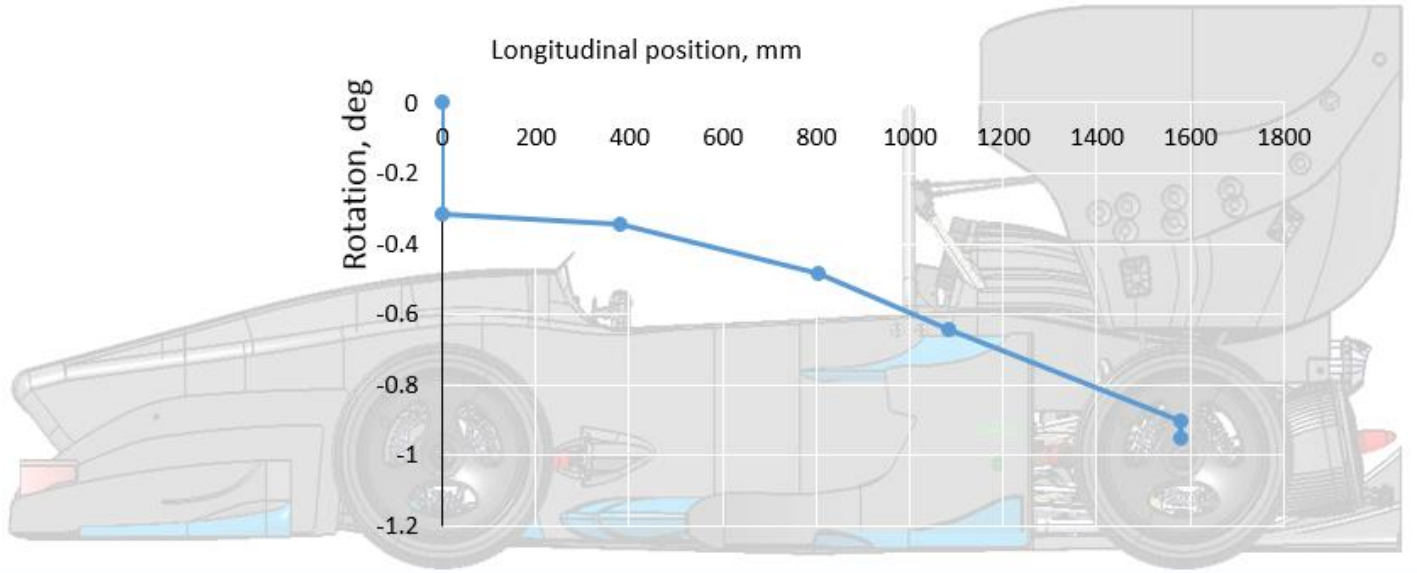
Why torsional stiffness?



- Has influence on driving behaviour
- Compromise between reasonable stiffness and weight

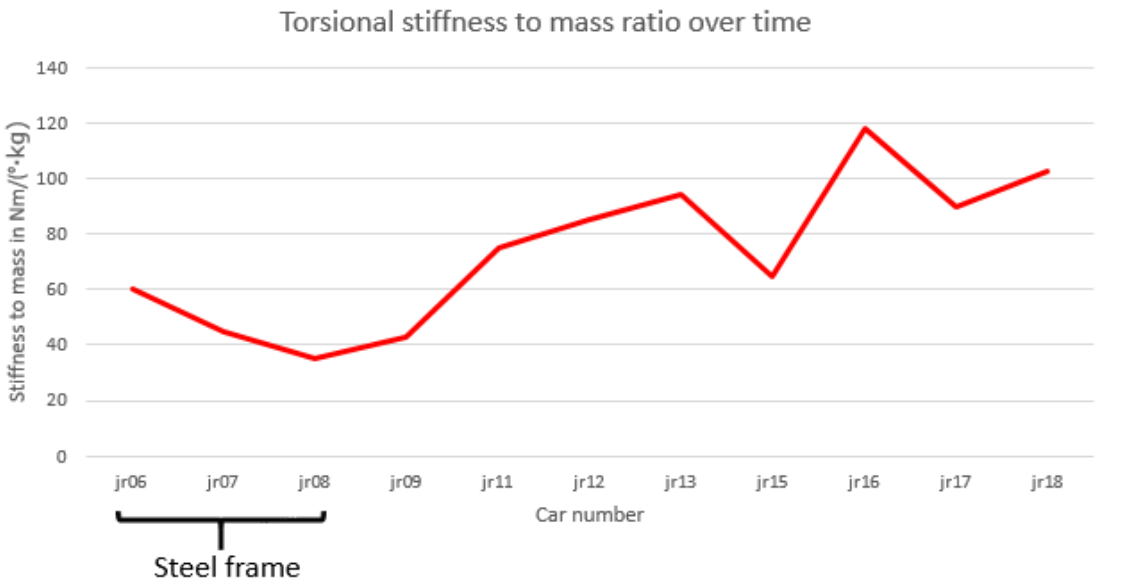


Chassis stiffness distribution



- Target: a linear stiffness distribution over chassis → most compliant sections have biggest influence on overall stiffness
- Design scope limited by structural requirements due to the rules

Internal benchmark



Overall: Stiffness/Mass ratio is better with monocoques

- Torsional stiffness of jr17 was satisfying → target for jr18 was to keep stiffness level and reduce chassis weight
- Weight reduction of 5 kg by minimal loss of stiffness realized from *jr17* to *jr18*

Evaluation of the 3-point bending test with a analysis benchmark

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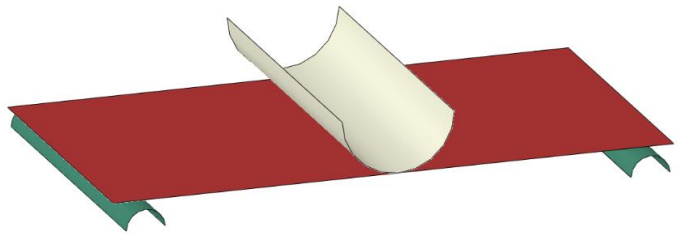
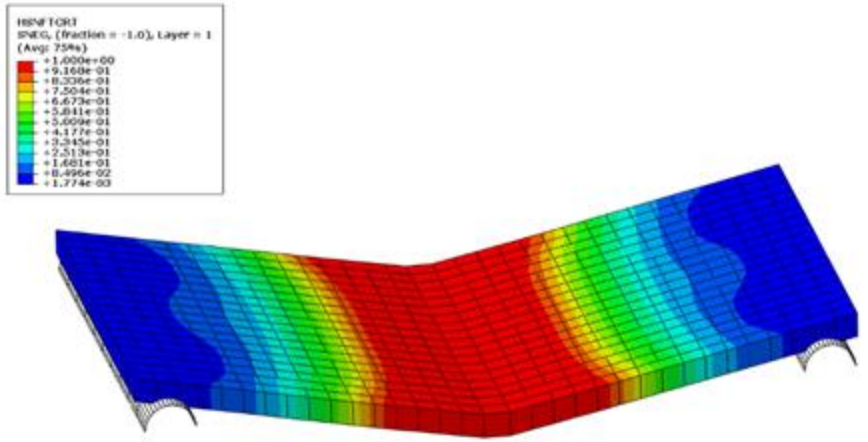
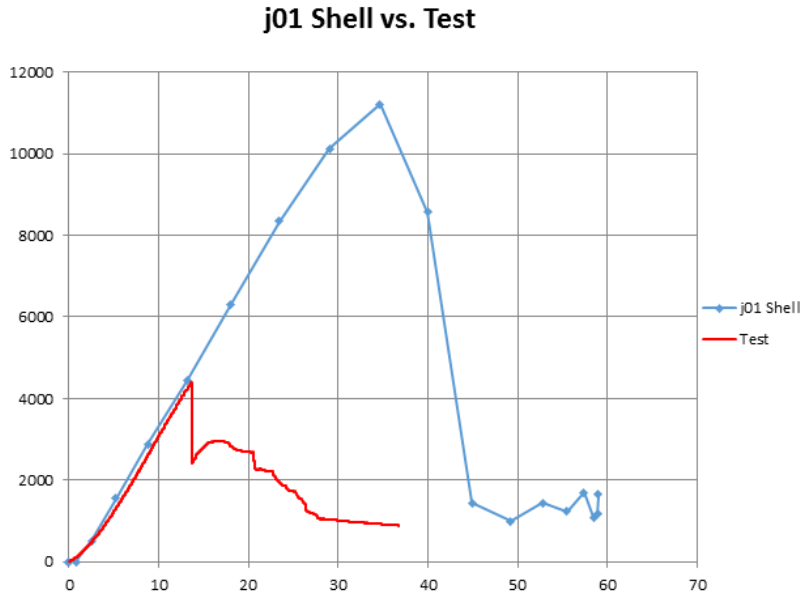
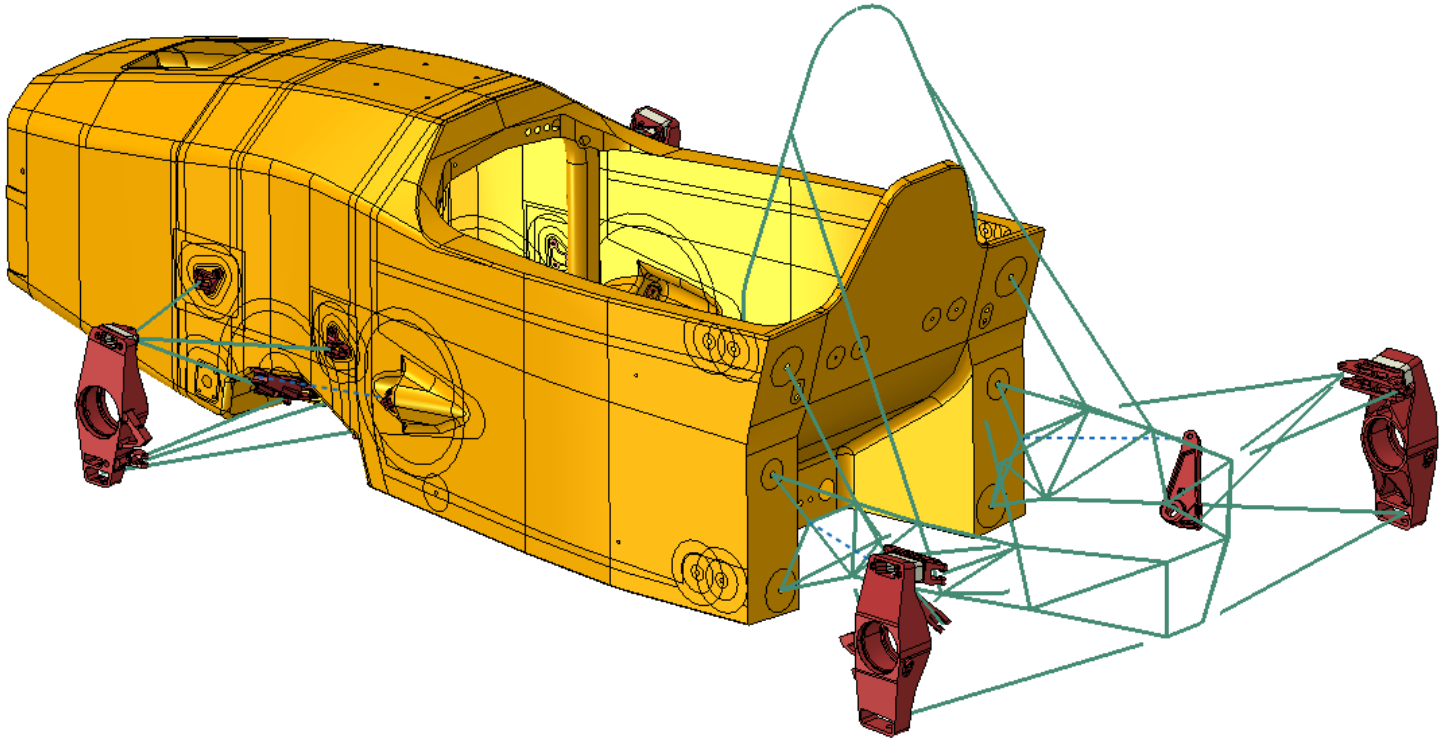
- Force vs. deflection plot of analysis and test
- Good correlation in stiffness between test and analysis





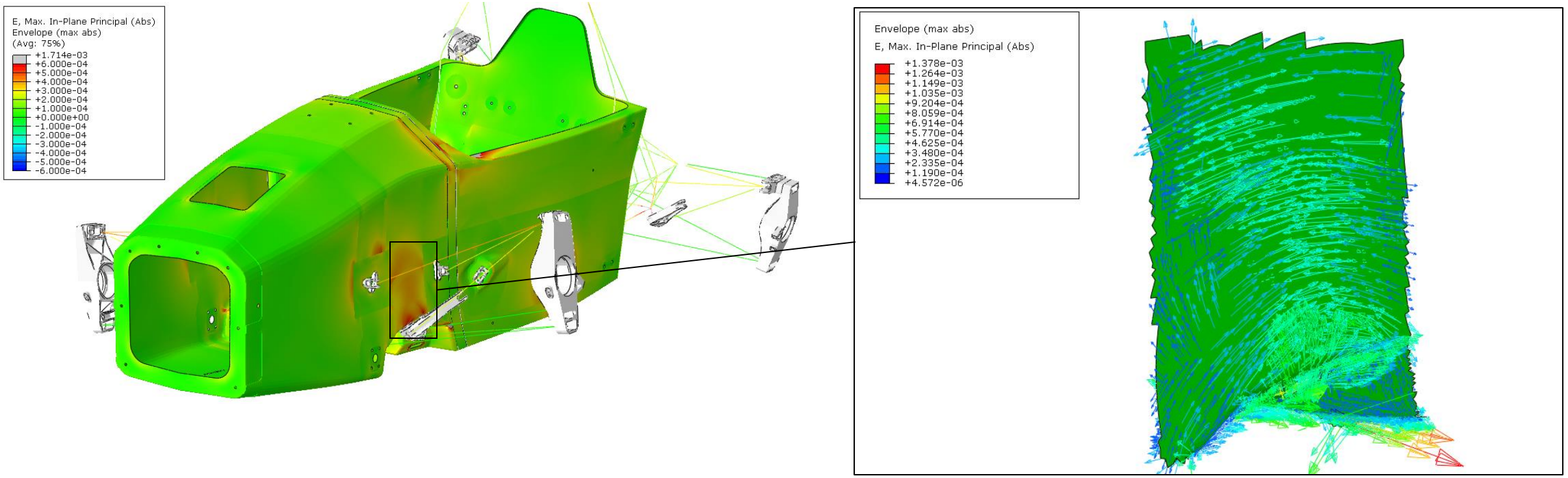


Analysis model



- Linear static analysis
- 5 load steps for main loads during driving
- Usage of Composite Manager (135 composite layups)
- Mesh info:
  - Approx. 360 000 Nodes
  - Linear elements
  - Mainly hexahedral and tetrahedral elements

Analysis results



Investigation of principal strains and directions

→ Optimization with variation of type and amount of plies, fiber direction and core thickness

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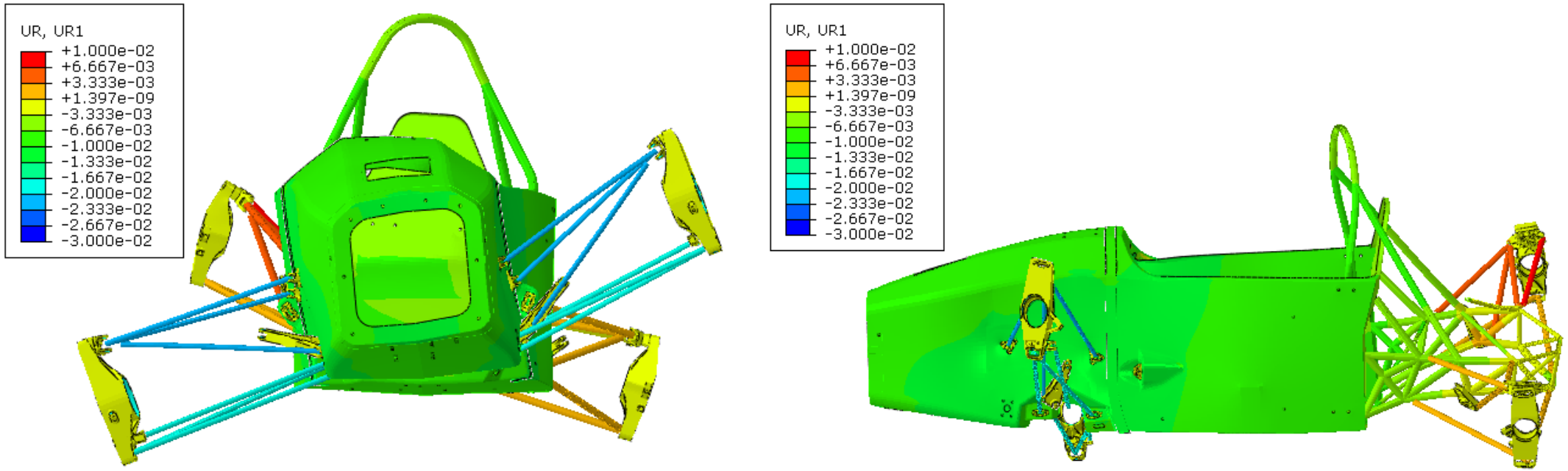
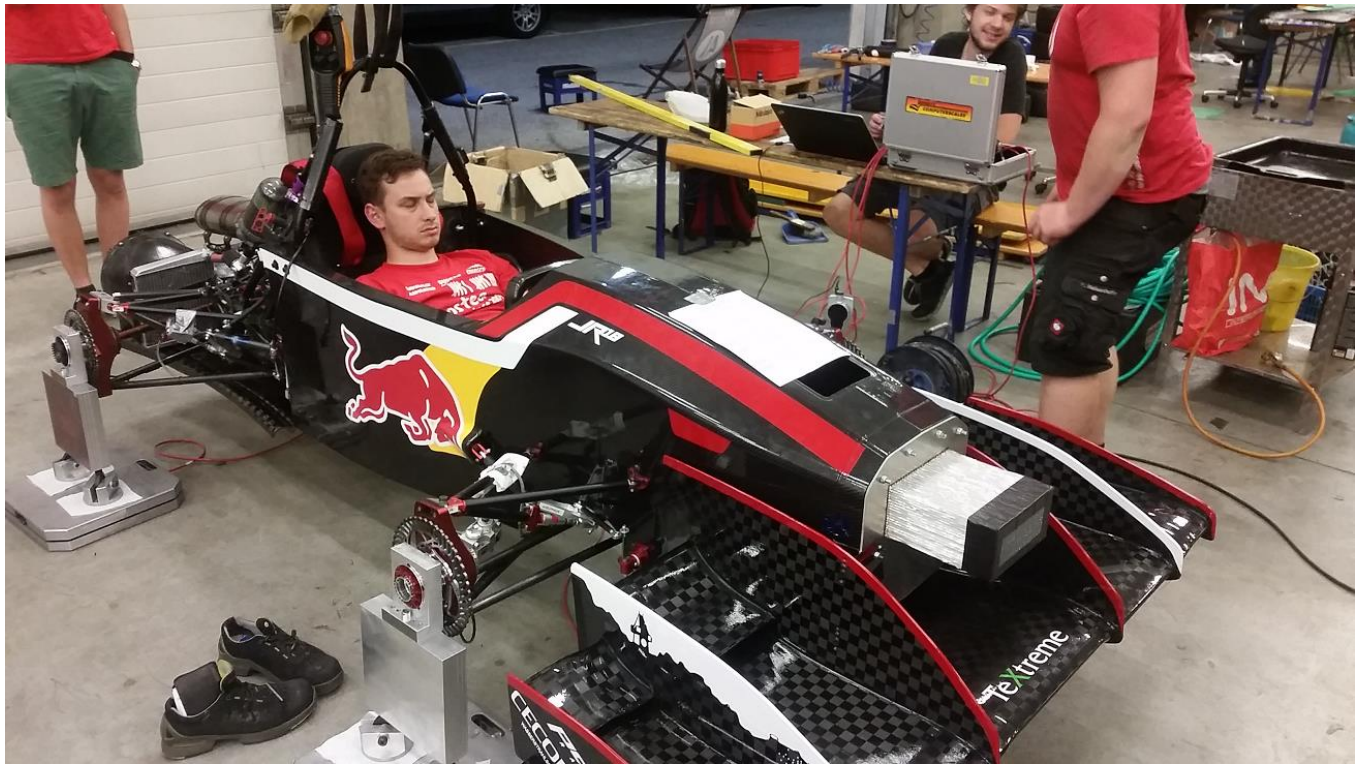
Analysis results



- Hub-to-hub stiffness: 1511 Nm/°
- Stiffness-split: 51/49

- Stiffness-to-weight ratio of chassis increased by ~15%

Validation of torsional stiffness



- Total deviation of 16 % of measurement and simulation
- Deviation of measurement and simulation reduced by 50 % compared to last year due to more detailed ply stack in analysis model

Topology optimization of front upright

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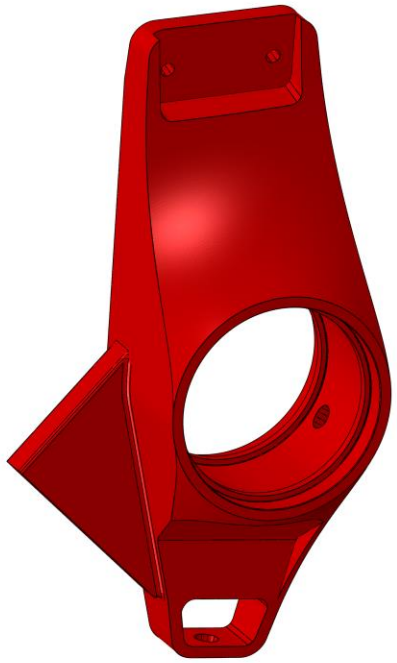
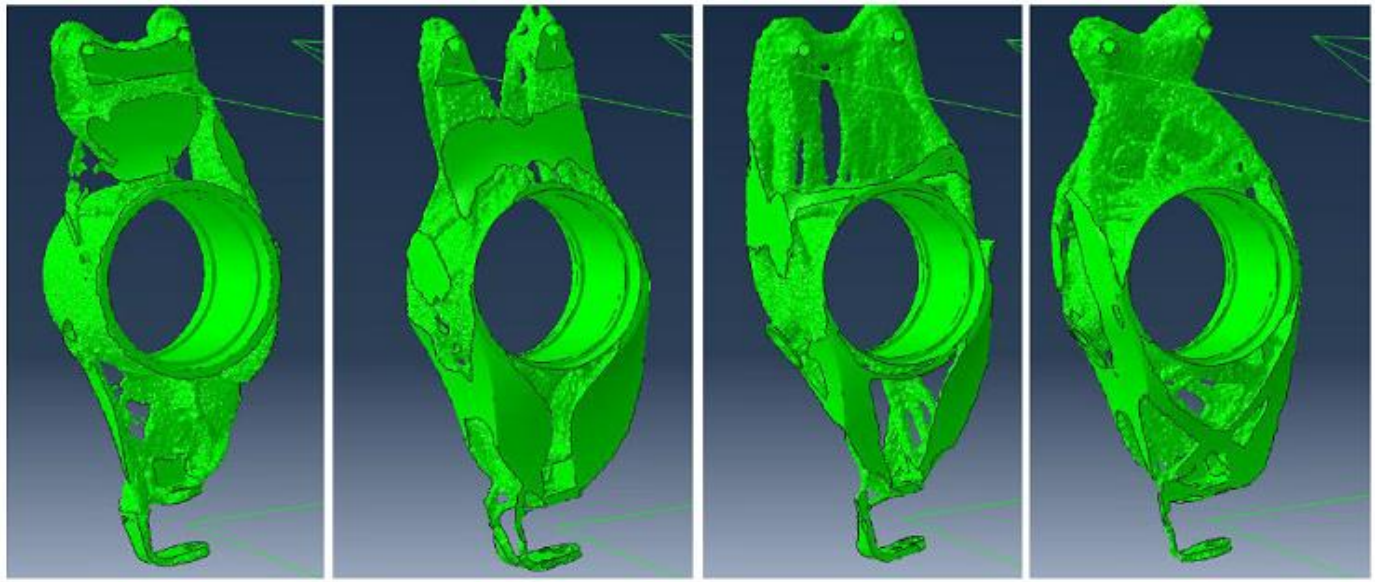
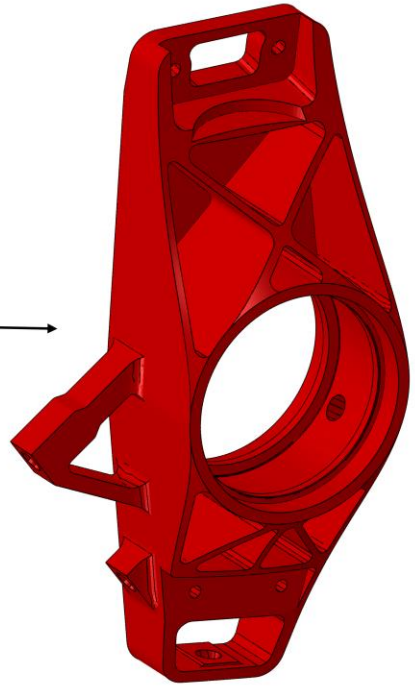


Design space





Final design

- Approach:
  - Topology optimization for each load case
  - Combining results at final design
- Weight reduction of ~10% compared to last year

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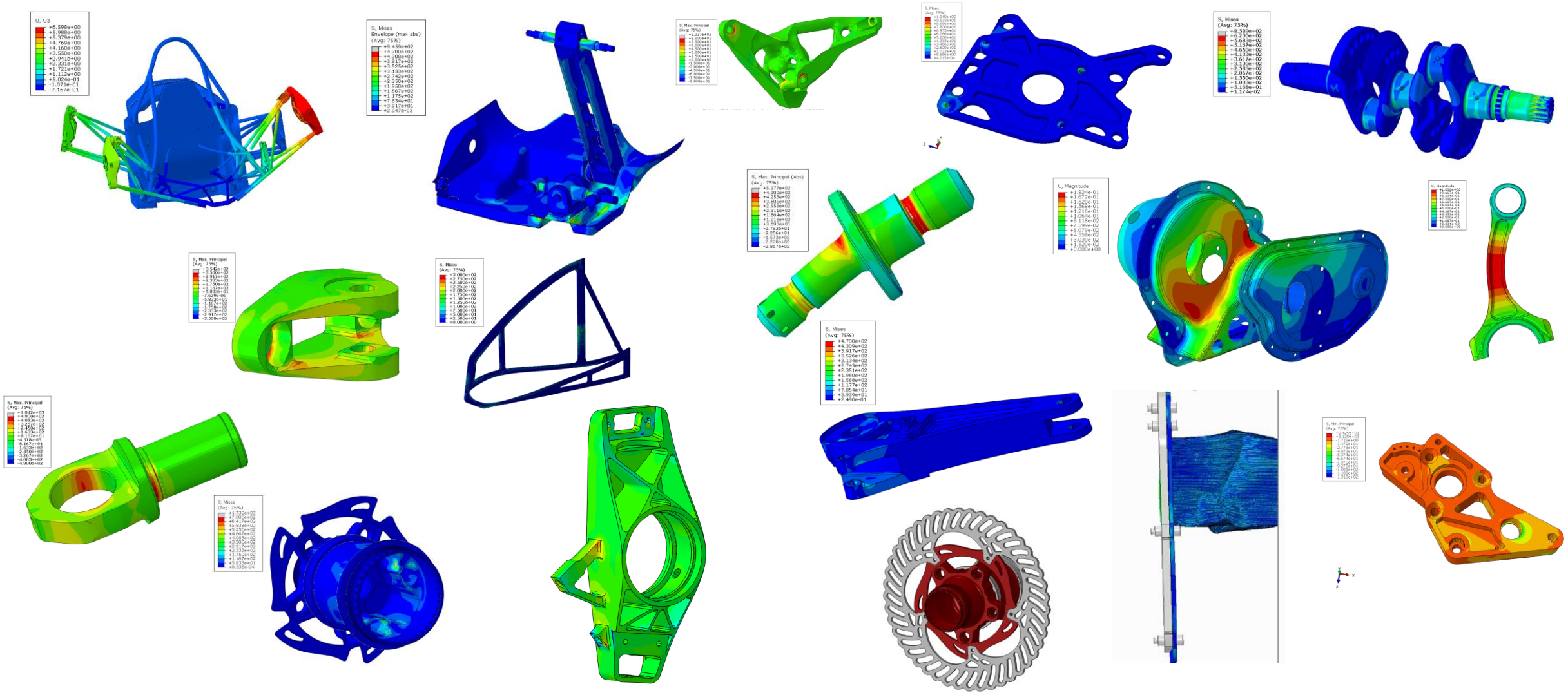
Thank you SIMULIA!



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Thank you for your attention