FORMULA TECHNION 2015

Suspension & Steering Teams

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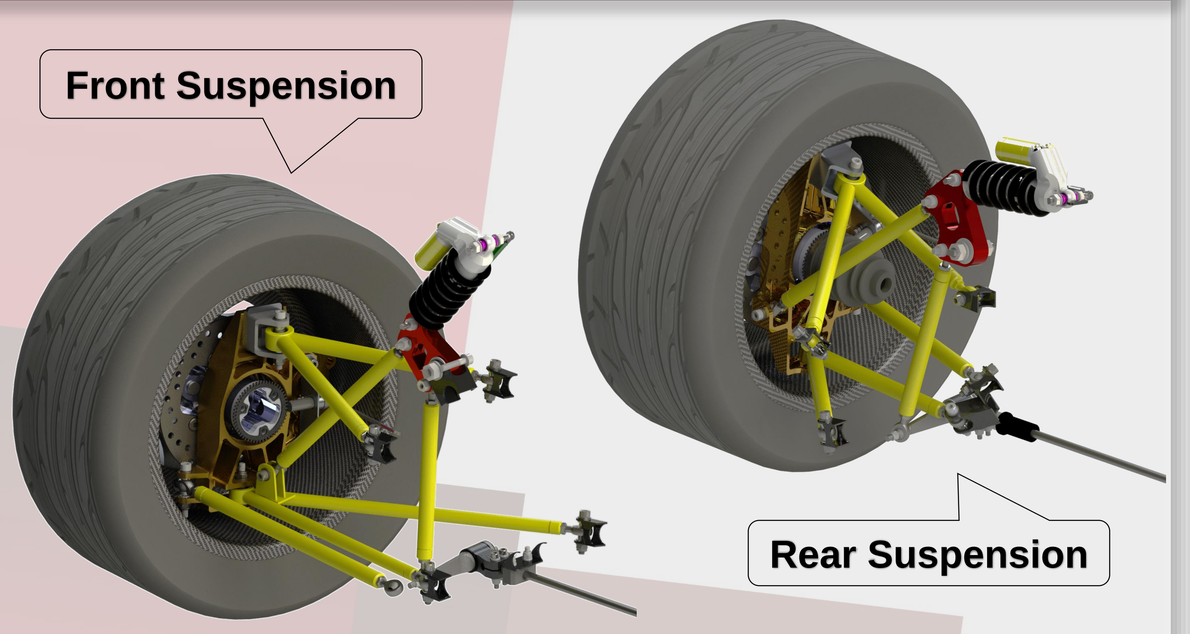
Objectives & Requirements

- Design of a suspension system for a high-downforce FSAE car.
- Increasing the maintainability, and reliability of critical components that failed in 2014.
- Conducting dynamic experiments on the 2014 car, in order to revise old design guidelines, and verify new design goals via experiments on the 2015 car.
- Reduction of the total production costs.
- High adjustability for all the dynamic parameters, to allow tuning the car for different race courses and dynamic events.
- Suspension geometry suited for high lateral-acceleration (~1.4 g's), and tight tracks.

Sub-System Description



Components:

- Non-parallel double A-arm suspension with Push-rods, @ front and rear suspension.
- Front and rear rockers (bell cranks), designed to achieve high motion ratios.
- 4-way adjustable Ohlins TTX25 MKII dampers, with linear springs and 57mm travel.
- Anti-Roll mechanism, consisting of torsion bars and adjustable blades.

Production & Materials:

- Unique ultra-light Magnesium (ZM21-F) tube profiles used for most arms and rods. Lower front A-arms are 4130 steel.
- Weldments at rods and A-arms are jig-based, to ensure precision while welding.
- Rockers and Anti-Roll bars' housings and blades are CNC fabricated.
- A-arms' inserts, ball-joints' housings and spacers are turned on a lathe, therefore significantly reducing the production costs.

Experimentation & Validation

Dynamic performance experiments, with aid from 'Magal Automotive Engineering' :

- On the 2014 car, to measure key parameters (damping ratio, ride frequencies, roll resistance, load transfers, forces along the suspension, tire friction, and downforce).
- On the 2015 car, to compare it's performance & parameters with those of 2014's car.

Finite elements and static analysis:

- Finite elements analysis using SolidWorks® simulation, to achieve adequate factor of safety. A design study has been conducted to reduce components' weight.
- Forces of multiple scenarios were calculated and introduced to the simulations.

Design Process & Primary Characteristics

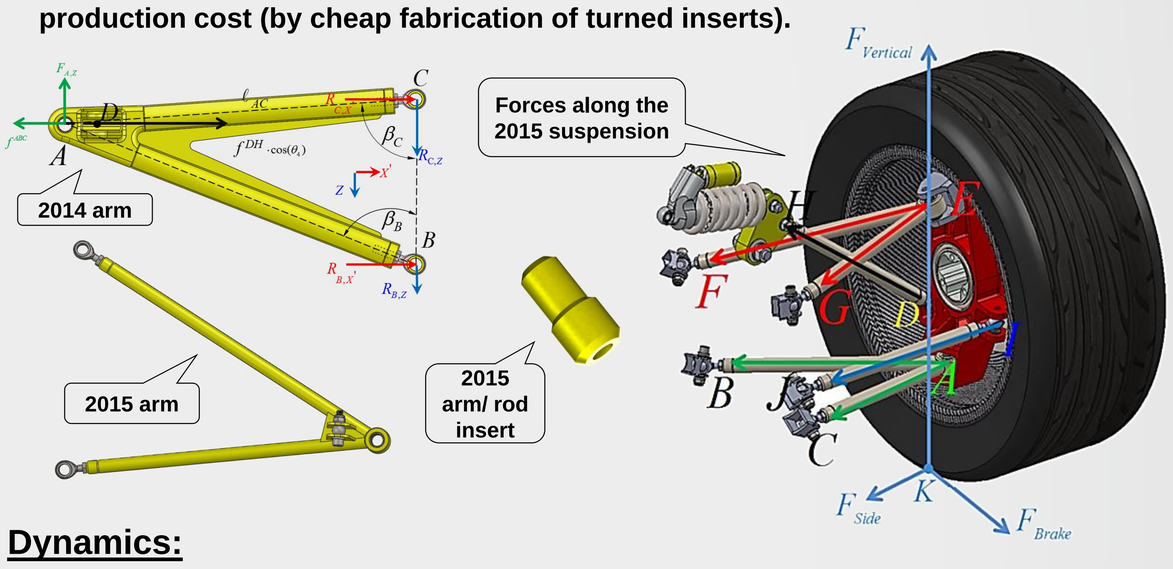
Geometry:

- Iterative design, using Lotus Suspension Analyzer® and SolidWorks® CAD model.
- Adjustable, negative Camber angle along entire suspension travel.
- Significantly lower Roll centers, compared to the 2014 car.
- Geometry parameters were partially compromised in order to lighten peak loads on the A-arms and rods.

	Front	Rear
Roll center height (from ground)	15 mm	45 mm
Center of gravity (from ground)	305 mm	
Static toe-in	-0.2°	+0.2°
Static camber	-1°	-2°
Mechanical trail	29.5 mm	35 mm
Caster angle	7.9°	7.7°

Arms & rods loads:

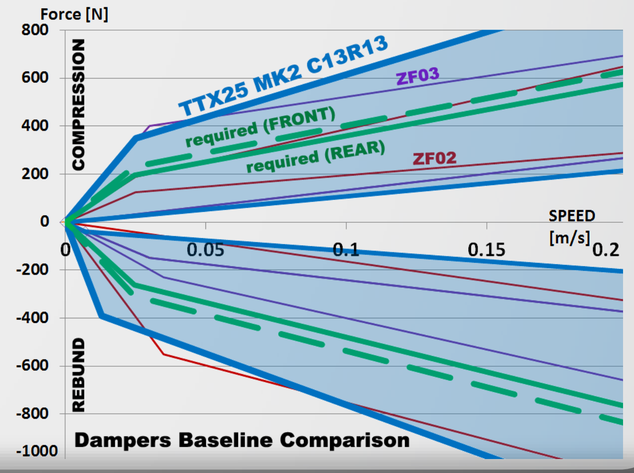
- Applying Castigliano's second theorem, we proved that the A-arms can be designed to act as a truss, which enabled the use of circular cross section tubes for the suspension's A-arms and rods.
- Achieved weight reduction of more than 12%, and significant reduction in production cost (by cheap fabrication of turned inserts).



Dynamics:

- Following conclusions from experiments on the 2014 car, a much stiffer shock absorbing system was designed.
- Quarter-car dynamical Analysis was preformed, to determine and achieve the desired dynamical parameters, using guidelines by Kaz-Technologies®.
- Dampers were chosen and valved to fit specific requirements, and allow high range of adjustable parameters, (high-speed and low-speed damping, in rebound and compression).
- Simplification of Anti-Roll bars' components resulted in 14% cost reduction.

	Front	Rear
Weight distribution (with driver)	51%	49%
Motion ratio	0.86	0.9
natural frequency	3.5 Hz	4.1 Hz
Rebound Damping ratio	84%	79%
Compression Damping Ratio	63%	60%



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Design by Lucy Berry & Shahar Yehezkel