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

Front Suspension
- 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.

Rear Suspension
- 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.

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.
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Production & Materials:

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Arms & rods loads:

- Applying Castiglione’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 performed, 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.

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

- 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.

Geometry:

- Fully adjustable, using Lotus Suspension Analyzer® and SolidWorks® CAD model.
- Adjustable, negative Camber angle along entire suspension travel.
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Weights & Results:

<table>
<thead>
<tr>
<th>Weight distribution (with driver)</th>
<th>Front</th>
<th>Rear</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>51%</td>
<td>49%</td>
</tr>
<tr>
<td>Motion ratio</td>
<td>0.86</td>
<td>0.9</td>
</tr>
<tr>
<td>natural frequency</td>
<td>3.5 Hz</td>
<td>4.1 Hz</td>
</tr>
<tr>
<td>Rebound Damping ratio</td>
<td>84%</td>
<td>79%</td>
</tr>
<tr>
<td>Compression Damping Ratio</td>
<td>63%</td>
<td>60%</td>
</tr>
</tbody>
</table>

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- Mr. Nimrod Meller, Prof. Reuven Katz, Leah stern & the Faculty of Mechanical Engineering.
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- Itai Groag and MR. Nimrod Meller, Prof. Reuven Katz, Leah stern & the Faculty of Mechanical Engineering.

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