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FÜR ANGEWANDTE
WISSENSCHAFTEN
MÜNCHEN

H2 HYDRO MOTION

# Case study of simulation driven designed components in use for a hydrogen-powered prototype vehicle

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# Agenda

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- Aim: How we try to think before we build
- Introduction Team
- General Information
- Composites
- Topology Otimisation
- Aerodynamics

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# The Team

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# The Mission

Hydrogen fueled

33,5 kg light

Continous development


603 km/m³Hydrogen => 1849 km/l gasoline

=> 3rd Place Shell Ecomarathon 2015

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# Fuel Cell

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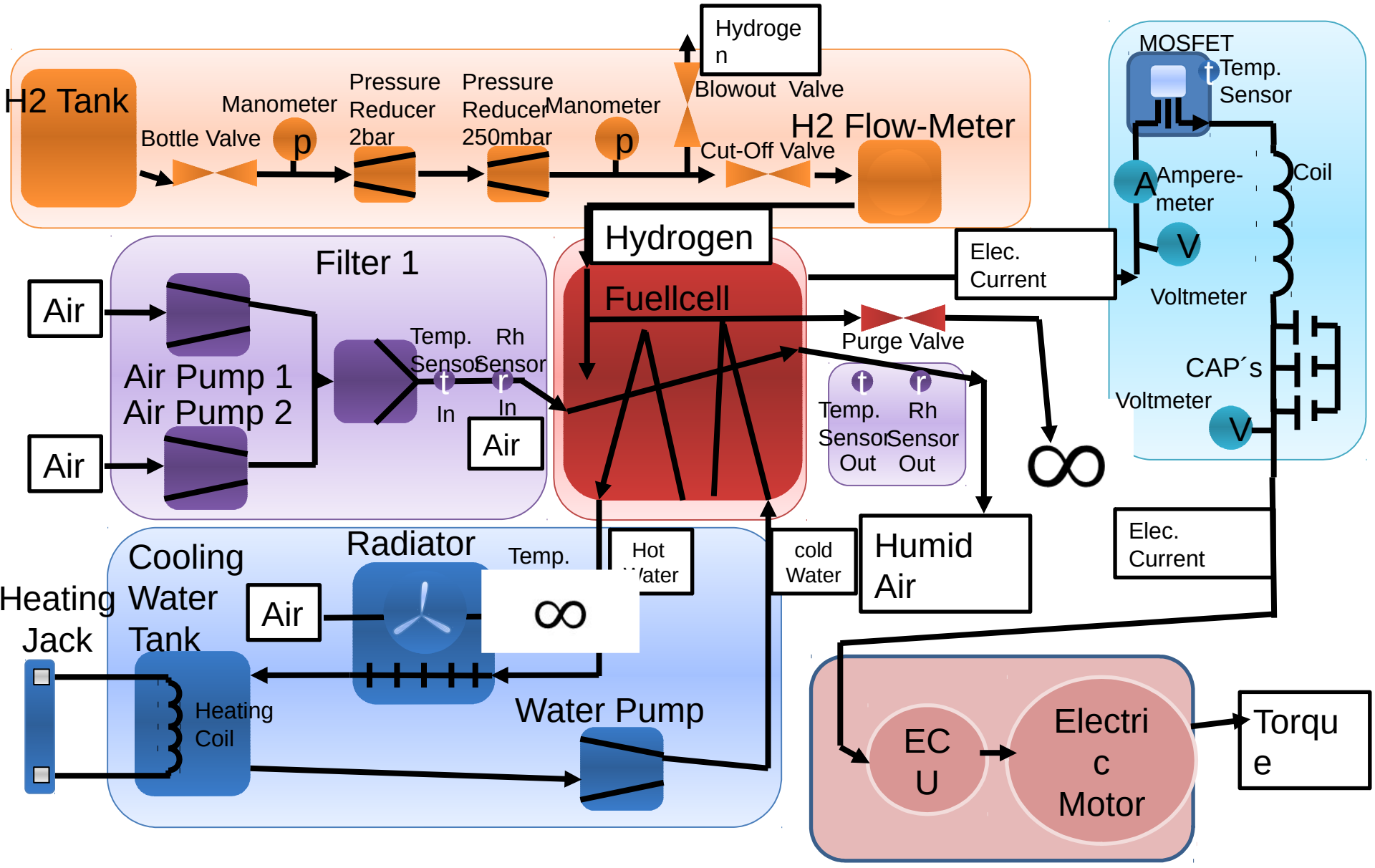

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# Live Telemetry

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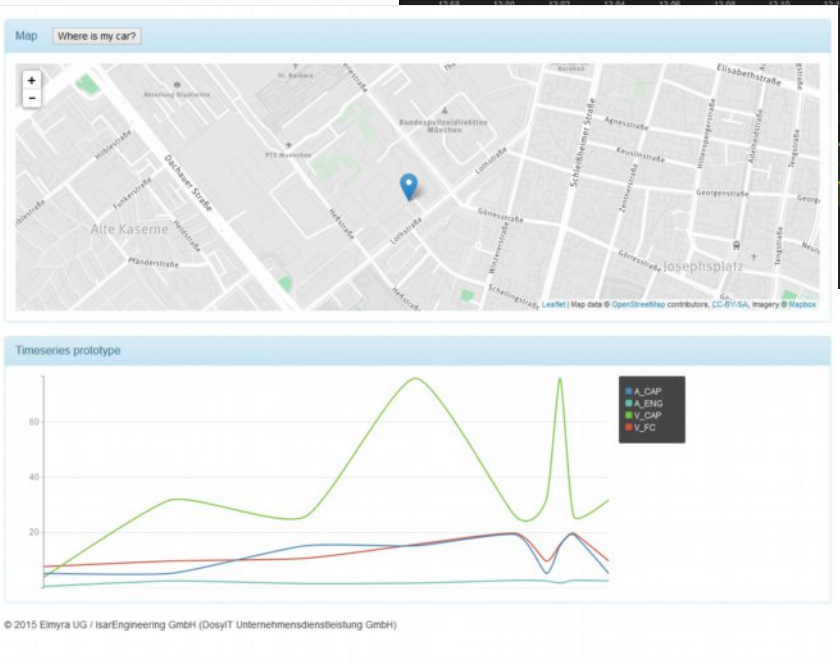
- Live data stream
- Preset options
- Average speed
- Visualisation online

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# Composites

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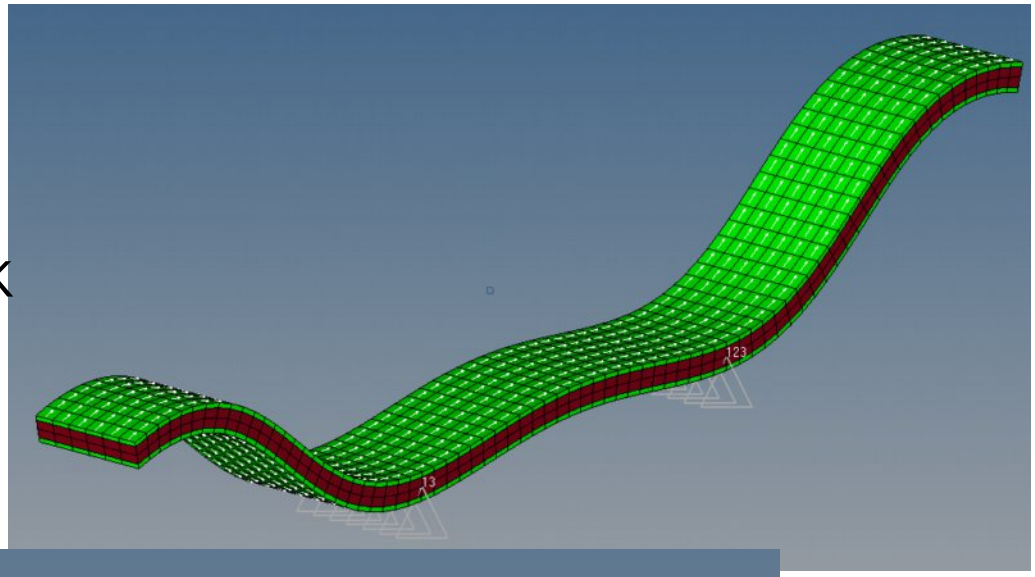
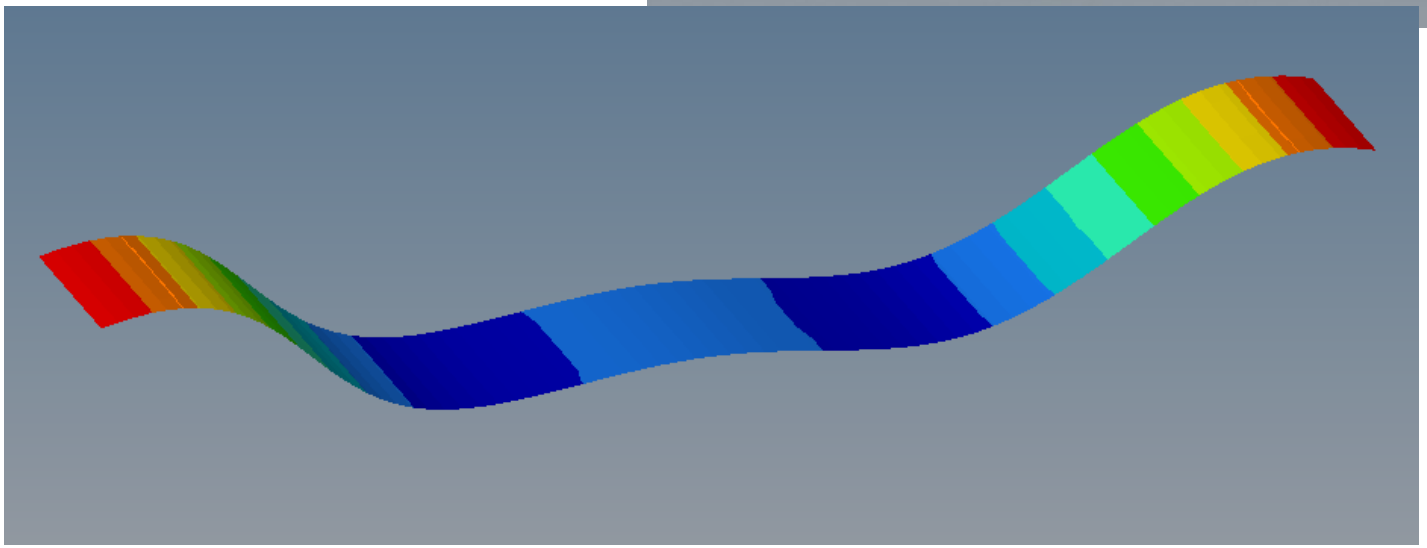
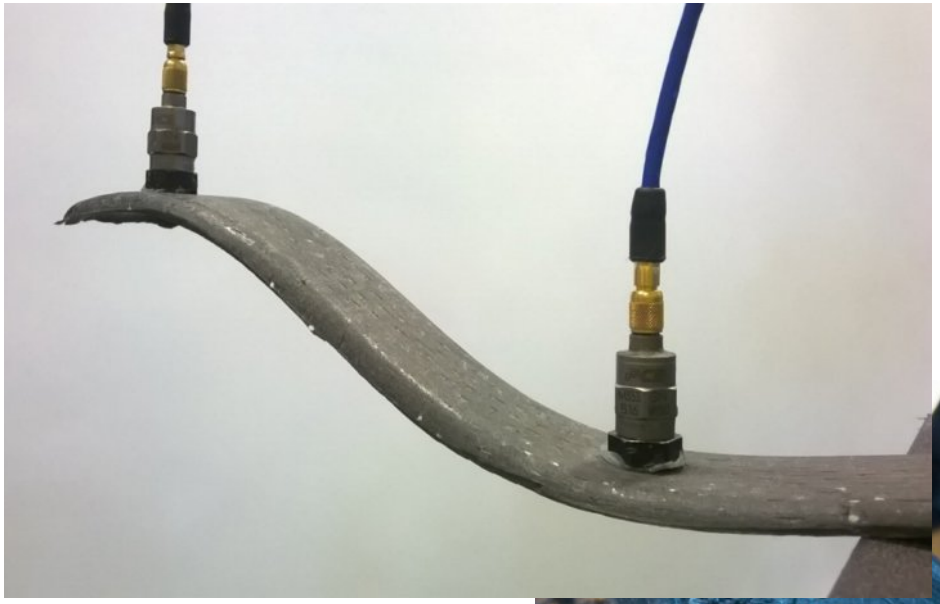
- Easy Part for experimentation
- Hybrid: GFK Core CFK Cover Layer
- Easy load step

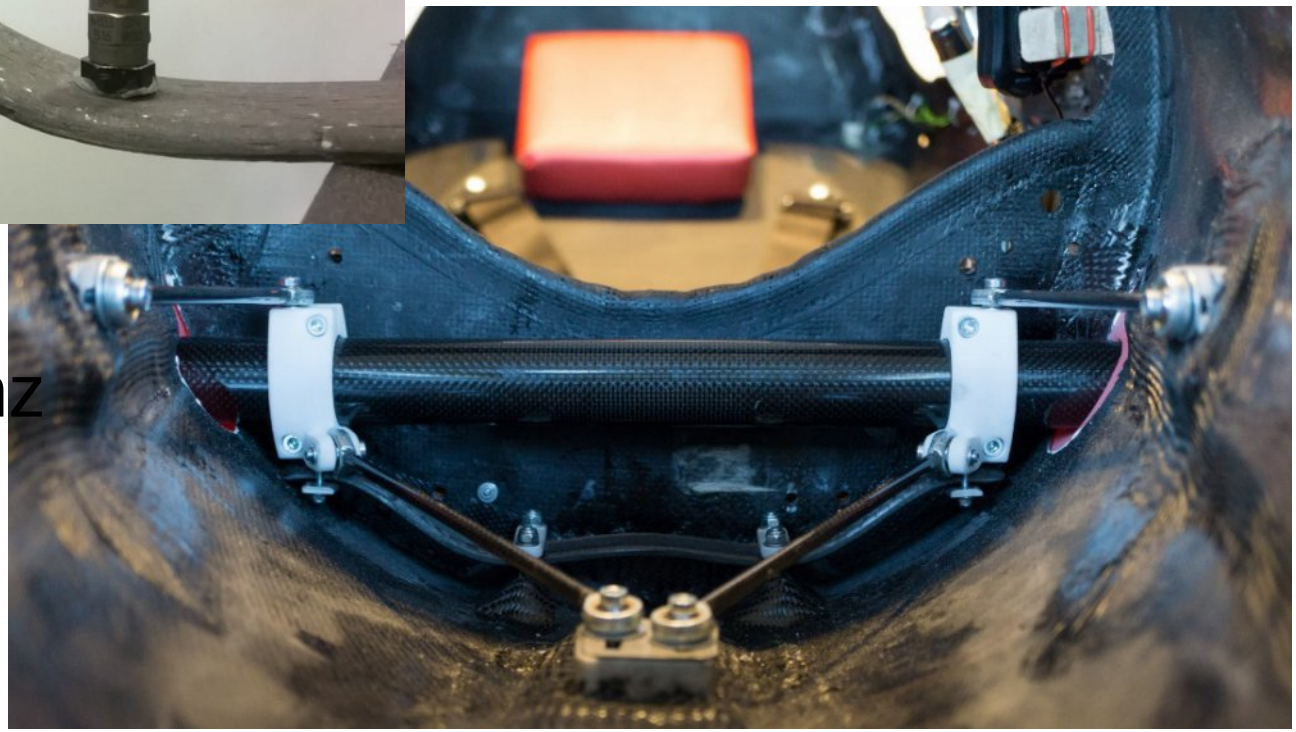




# Measuring



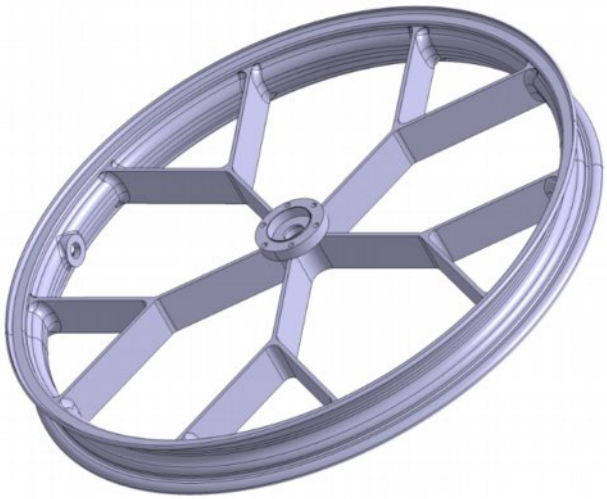
- Spring mounted in car

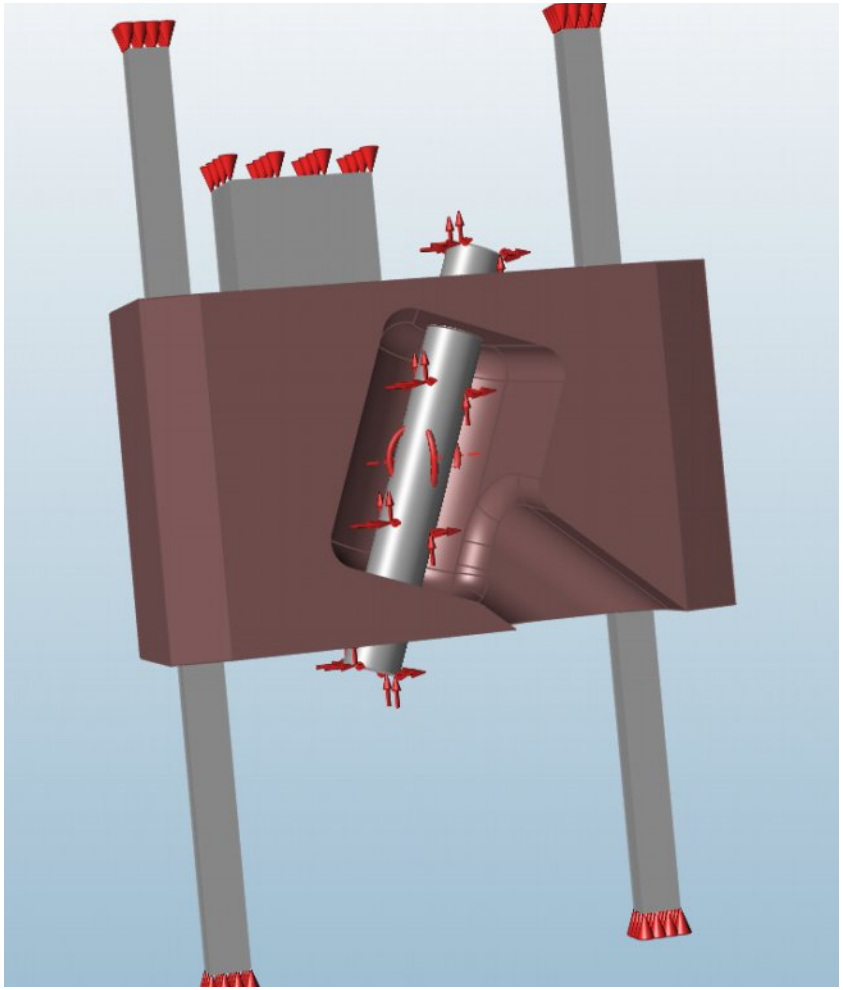


- Eigenfrequenz analysis

# Topology Optimisation

- Boundary conditions
- Load and deformation requirements
- Design follows topological optimization





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# Weight and stiffness

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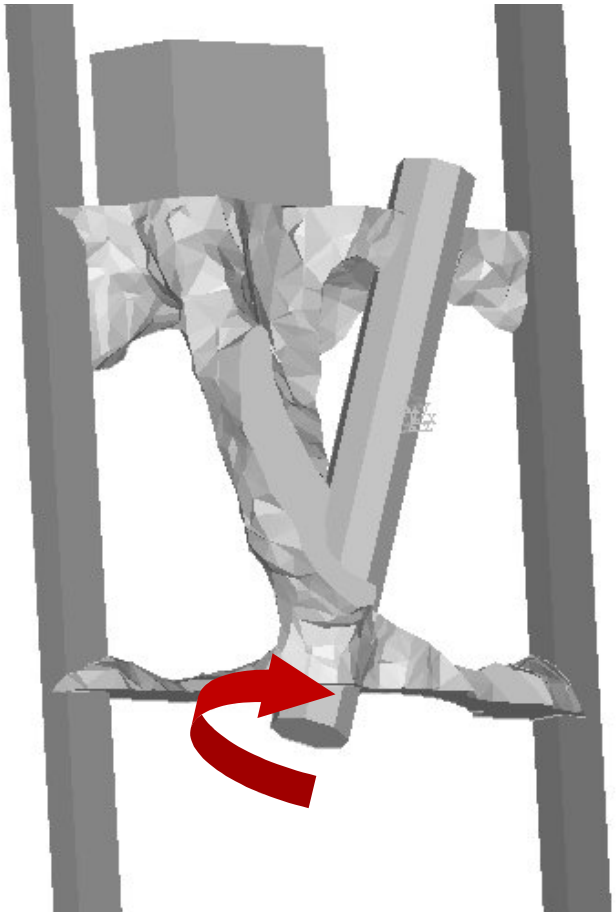
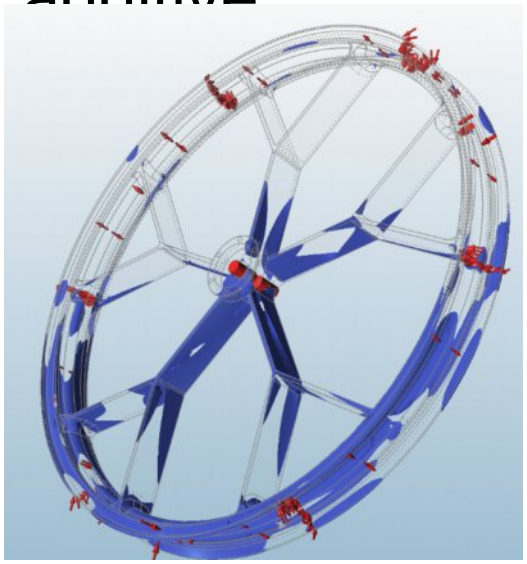
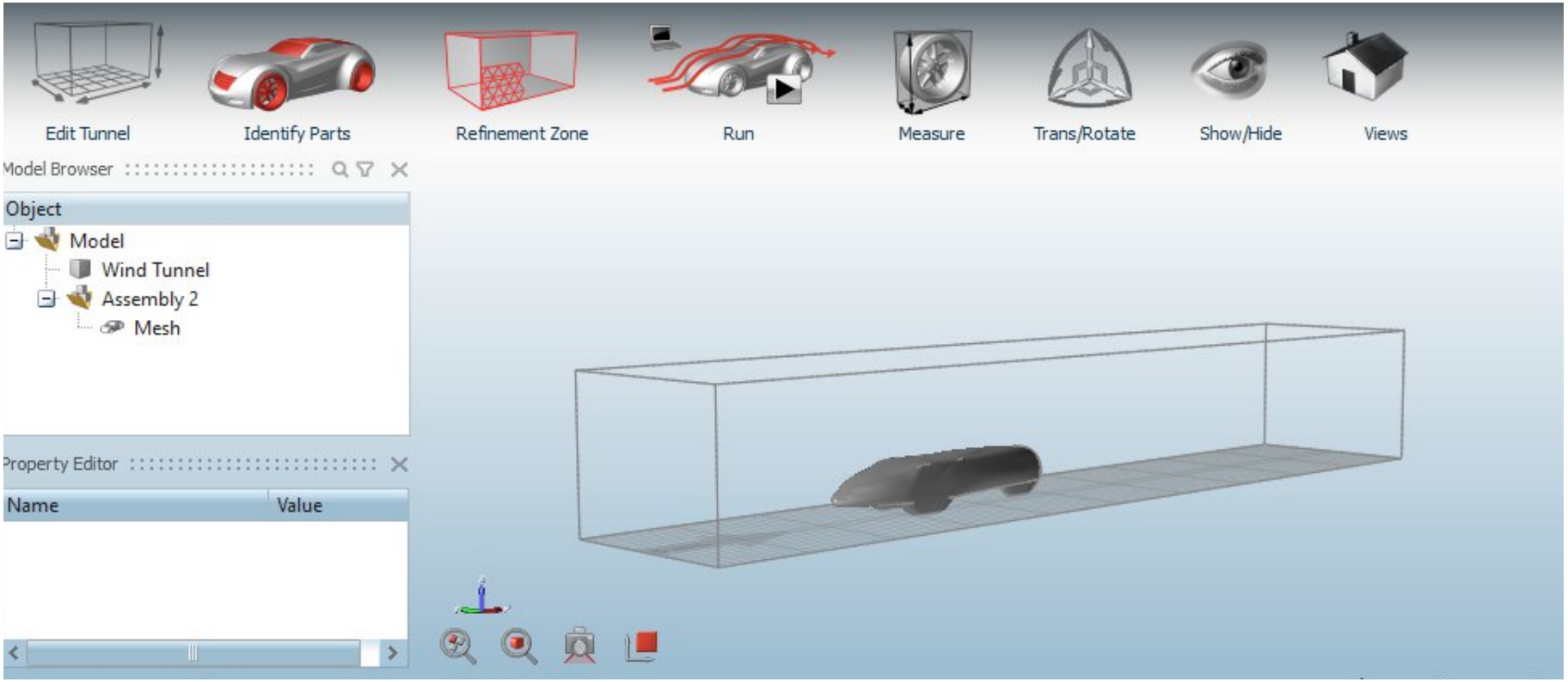
- Designed parts result with concrete loadpaths
- Inspiration for design process
- Productionally by additive manufacturing





# Aerodynamics

- CFD - Simulation 25 km/h – 30 km/h
- Mutating the geometry



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# Aerodynamics

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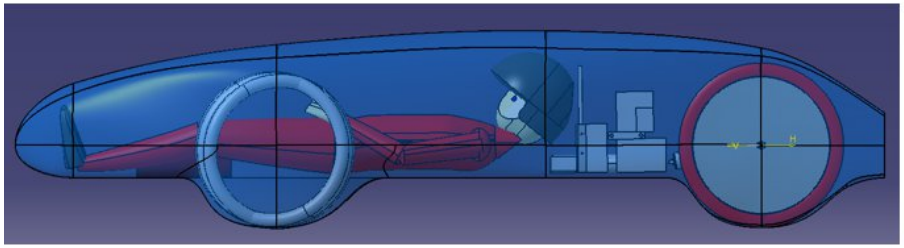
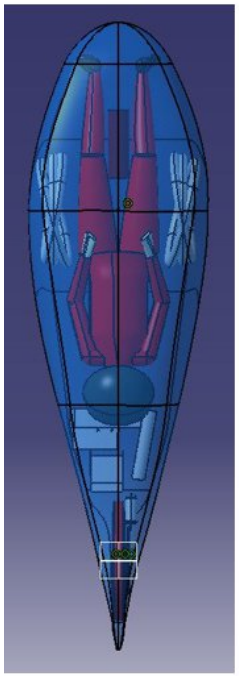
## TEST-020

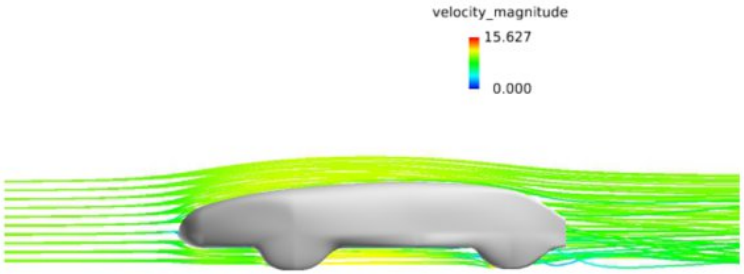
## 20150807_Schal_v_0-2-1.igs

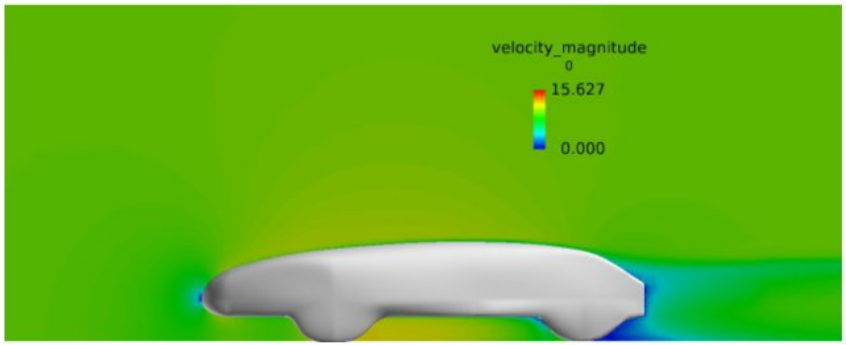


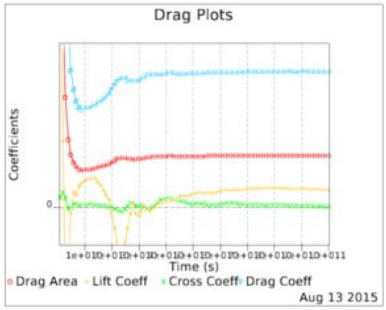
| | |
|---|---|
| Simulation type | steady |
| Element count | 2432871 |
| Run time ( Elapse time ) | 0.636 h |
| Wind_Tunnel_Inlet | 9.72 0.00 0.00 m/s |
| Drag coefficient, Cd | 0.246 |
| Lift coefficient, Cl | 0.033 |

| | |
|---|---|
| Wind tunnel, bounding box | [ 0.000, 10.000], [-2.000, 2.000], [ 0.000, 3.000] |
| Body, bounding box | [ 1.993, 4.673], [-0.385, 0.385], [-0.009, 0.603] |
| Wind tunnel dimension | 10.000 m x 4.000 m x 3.000 m. |
| Body dimension | 2.680 m x 0.770 m x 0.612 m. |
| Frontal ref. area, Aref | 0.382 $m^2$ |
| Blockage ratio % | 3.18333333333 |
| Distance inflow - body | 1.993 m |



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# Aerodynamics

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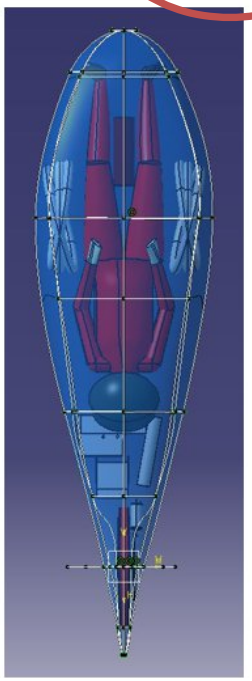
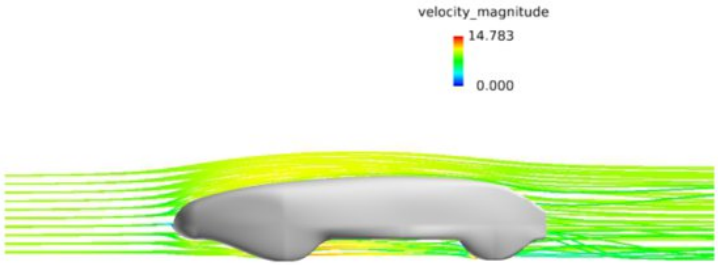
TEST-028
20150819_Schal_v-0-4-1.igs

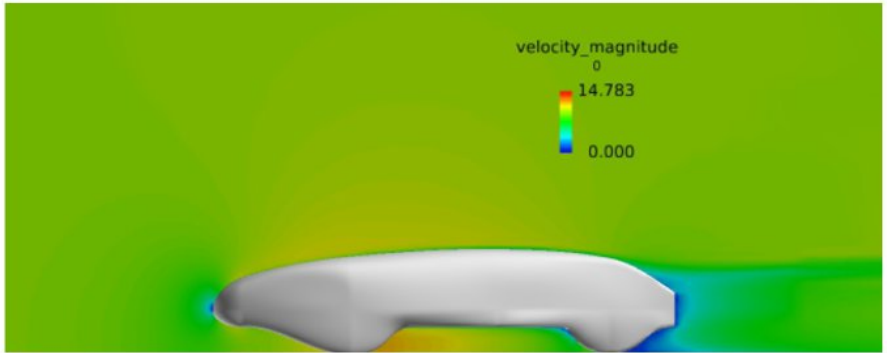
9.72 m/s

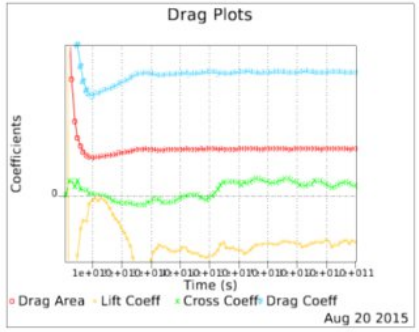
| | |
|---|---|
| Simulation type | steady |
| Element count | 2424763 |
| Run time ( Elapse time ) | 0.674 h |
| Wind_Tunnel_Inlet | 9.72 0.00 0.00 m/s |
| Drag coefficient, Cd | 0.197 |
| Lift coefficient, Cl | -0.073 |

| | |
|---|---|
| Wind tunnel, bounding box | [ 0.000, 10.000], [-2.000, 2.000], [ 0.000, 3.000] |
| Body, bounding box | [ 1.993, 4.673], [-0.385, 0.385], [-0.009, 0.603] |
| Wind tunnel dimension | 10.000 m x 4.000 m x 3.000 m. |
| Body dimension | 2.680 m x 0.770 m x 0.612 m. |
| Frontal ref. area, Aref | 0.382 $m^2$ |
| Blockage ratio % | 3.18333333333 |
| Distance inflow - body | 1.993 m |



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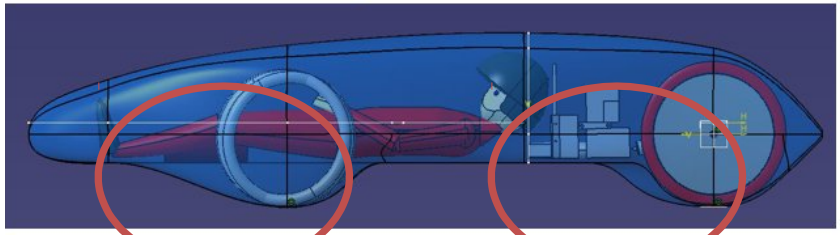
# Aerodynamics

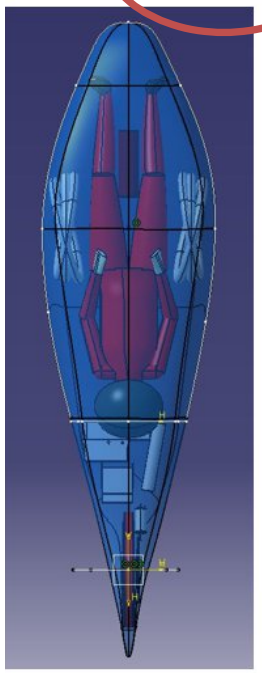
H2YDRO MOTION

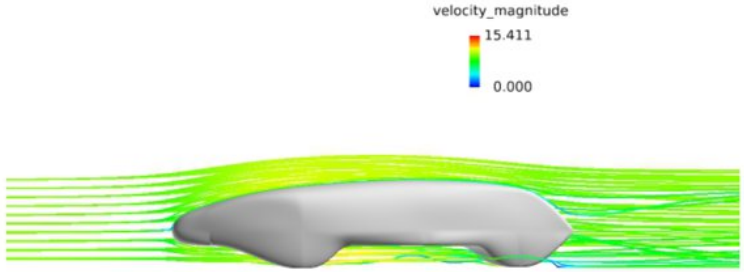
TEST-044
20150825_Schal_v_1-0-0.igs

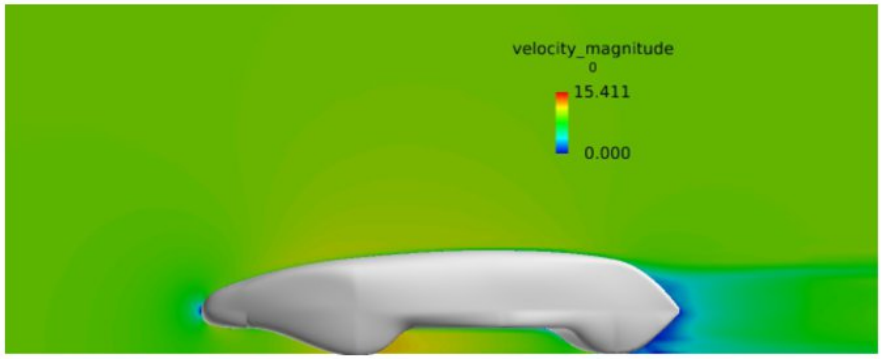


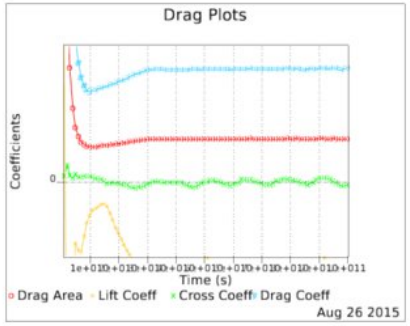
| | |
|---|---|
| Simulation type | steady |
| Element count | 2406405 |
| Run time ( Elapse time ) | 0.635 h |
| Wind_Tunnel_Inlet | 9.72 0.00 0.00 m/s |
| Drag coefficient, Cd | 0.170 |
| Lift coefficient, Cl | -0.121 |

| | |
|---|---|
| Wind tunnel, bounding box | [ 0.000, 10.000], [-2.000, 2.000], [ 0.000, 3.000] |
| Body, bounding box | [ 1.943, 4.723], [-0.385, 0.385], [-0.009, 0.603] |
| Wind tunnel dimension | 10.000 m x 4.000 m x 3.000 m. |
| Body dimension | 2.780 m x 0.770 m x 0.612 m. |
| Frontal ref. area, Aref | 0.382 $m^2$ |
| Blockage ratio % | 3.18333333333 |
| Distance inflow - body | 1.943 m |



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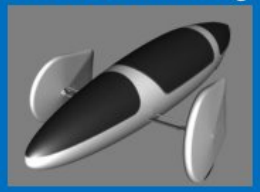
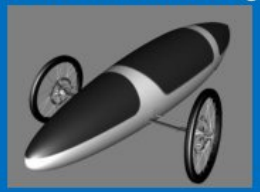
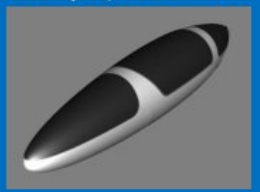
# Aerodynamics

H2 HYDRO MOTION

## ZEITGEMITTELTE KRAFTANTEILE.

| Simulation / Kräfte | mit Radverkleidung  | ohne Radverkleidung  | nur Rumpf (mit Hinterrad)  |
|---|---|---|---|
| Stirnfläche | $A_X$ = 0,286 m² | $A_X$ = 0,265 m² | $A_X$ = 0,209 m² |
| Rumpf mit Hinterrad | $C_X*A_X$ = 0,019 m²<br>$C_X$ = 0,068<br>$C_Z$ = -0,066 | $C_X*A_X$ = 0,020 m²<br>$C_X$ = 0,076<br>$C_Z$ = -0,088 | $C_X*A_X$ = 0,020 m²<br>$C_X$ = 0,095<br>$C_Z$ = -0,114 |
| Vorderräder mit Aufhängung | $C_X*A_X$ = 0,009 m²<br>$C_X$ = 0,032<br>$C_Z$ = -0,021 | $C_X*A_X$ = 0,047 m²<br>$C_X$ = 0,177<br>$C_Z$ = -0,006 | - |
| Radverkleidung | $C_X*A_X$ = 0,012 m²<br>$C_X$ = 0,041<br>$C_Z$ = 0,036 | - | - |
| **Gesamtfahrzeug** | **$C_X*A_X$ = 0,040 m²<br>$C_X$ = 0,141<br>$C_Z$ = -0,051** | **$C_X*A_X$ = 0,067 m²<br>$C_X$ = 0,253<br>$C_Z$ = -0,095** | **$C_X*A_X$ = 0,020 m²<br>$C_X$ = 0,095<br>$C_Z$ = -0,114** |

# Aerodynamics Summary

- Status quo with covered front wheels
  c * Ax = 0.040 m²
- New concept for completly covered front axle
  c * Ax = 0.065 m²

- Conclusion: Why build a new car? Let‘s get rid of the problematic sections and build new wheel covers.

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# Outlook

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- Collaboration with more faculties
- Comparision of different software tools
- Composites manufacturing and testing