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Aero Additive Manufacturing

The impact of AM in Formula 1 Aerodynamic applications

Alberto Maggioni

Abstract

The introduction and the continuous development of Additive Manufacturing in the last 2 decades have been propelled by the motorsport industry and particularly from the constant push for innovation driven by the most critical aspect of a modern Formula One Vehicle: it's very complex Aerodynamics.

This quick presentation aims to give a couple of practical examples on how the AM technology is used on daily business in the aerodynamic development of the racecar as well as for aerodynamic applications on the racetrack.

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Stake F1 TEAM | KICK SAUBER

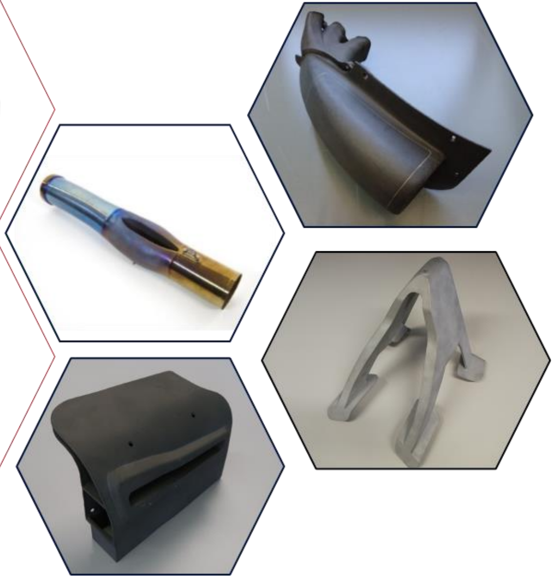
SAUBER Technologies

- *Additive Manufacturing*
- *Engineering Services*
- *Aerodynamic Services*

Additive Manufacturing at Sauber

Customer Projects

Formula 1™ Applications



Additive Manufacturing at Sauber
Available and used technologies

Plastic AM

- 7 x ProX 800 (SLA)
- 1 x EOS P500 (SLS)
- 2 x EOS P770 (SLS)

Metal AM

- 4 x MetalFAB1 (DMLS)
  - Titanium (2 Cores)
  - Aluminium (4 Cores)
  - Scallmaloy (1 Core)
  - Stainless Steel (1 Core)

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Aero Development

AM for Windtunnel Application

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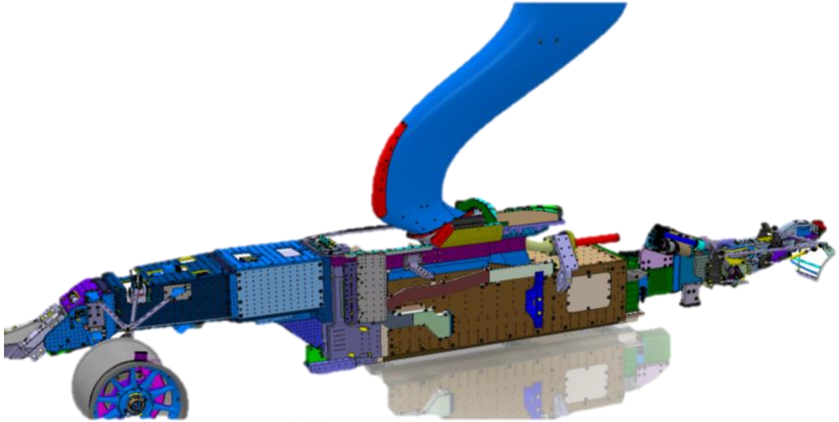
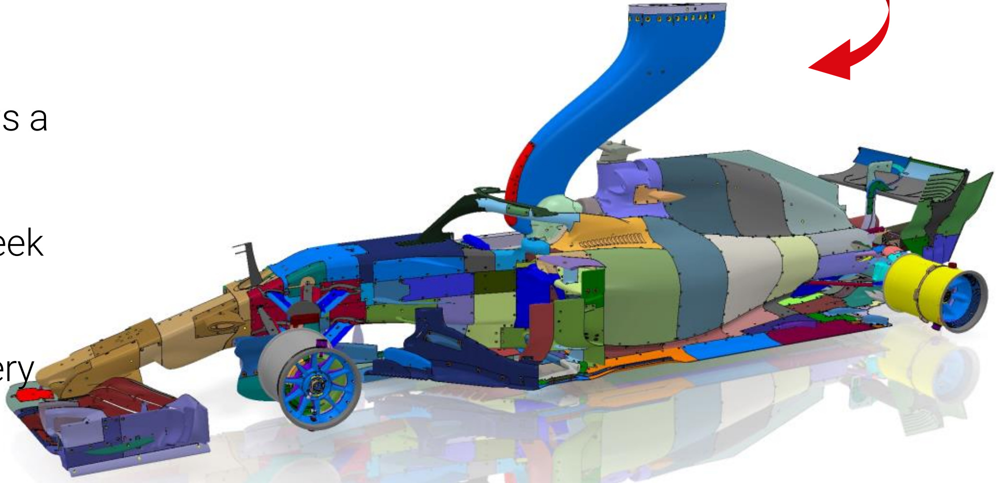
WT model architecture

- The WT model is built on purpose to be as rigid as possible (quasi static test, deflection monitored or imposed)
- The model spine is mainly produced out of metal (machined).
- The full bodywork is then built using rapid prototyping: plastic, ceramic, metal. This allows a easy and cheap turnover parts.
- Over 250 model test parts are designed per week in a normal F1 development cycle.
- The 60% model represents the Race car in every detail (external skin) and is built of 2500 parts.



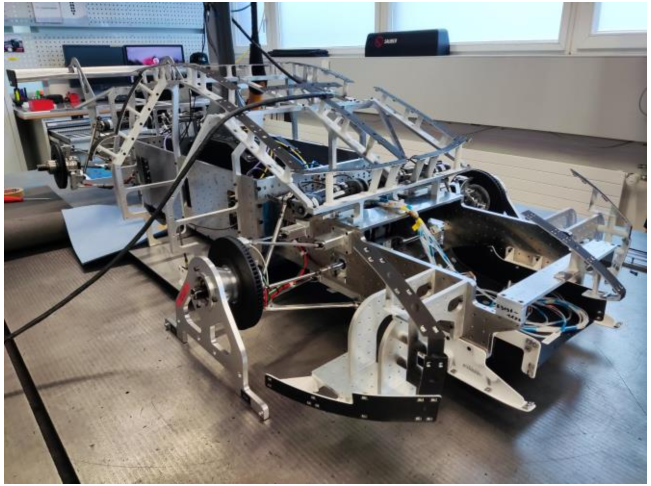
60% model spine



60% model with aero parts

WT model architecture

- The WT model is modular, allowing rapid geometry change in the WT (not the same with a race car): normally a series of options are tested around a basic shape (the so-called baseline).
- Geometrical inputs come from CFD for ALL the test options (Development is CFD driven, not Wind Tunnel Test driven).
- Model parts (rapid proto) are quite cheap, fast and easy to produce with the modern techniques: different materials are used in the different areas of the car depending on the loading and stiffness requirements
- Thousands of parts can be produced, tested and binned in a very short time: in F1 the geometries to be tested in WT are now limited while they are not in other categories.



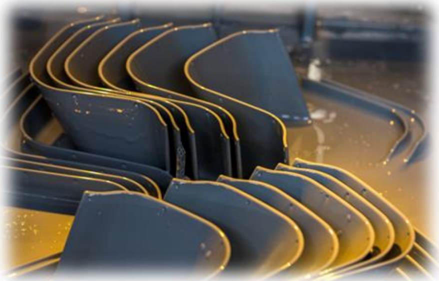
WT model architecture

- In these pictures other racecars categories models are shown.

- F1 is normally running more than one model to allow quicker preparation of big geometrical changes (like rule changes e.g.)

Extensive usage for Aero-Dev

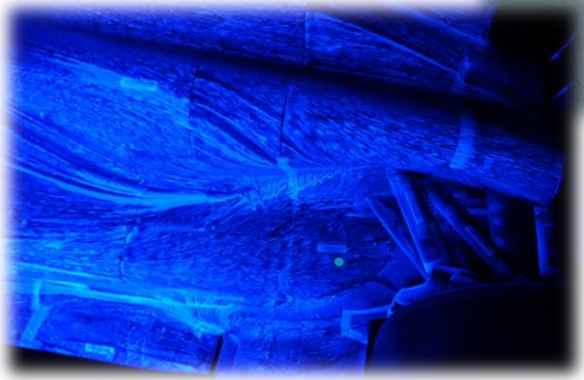
Requirements for Wind Tunnel



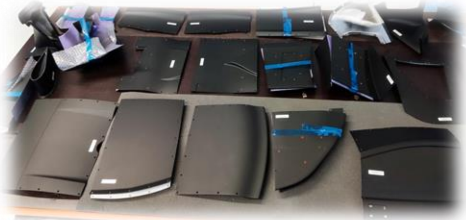
Repeatability

Surface Quality

Accuracy & Stiffness



>25’000 Options/Year *(50’000 Parts)*

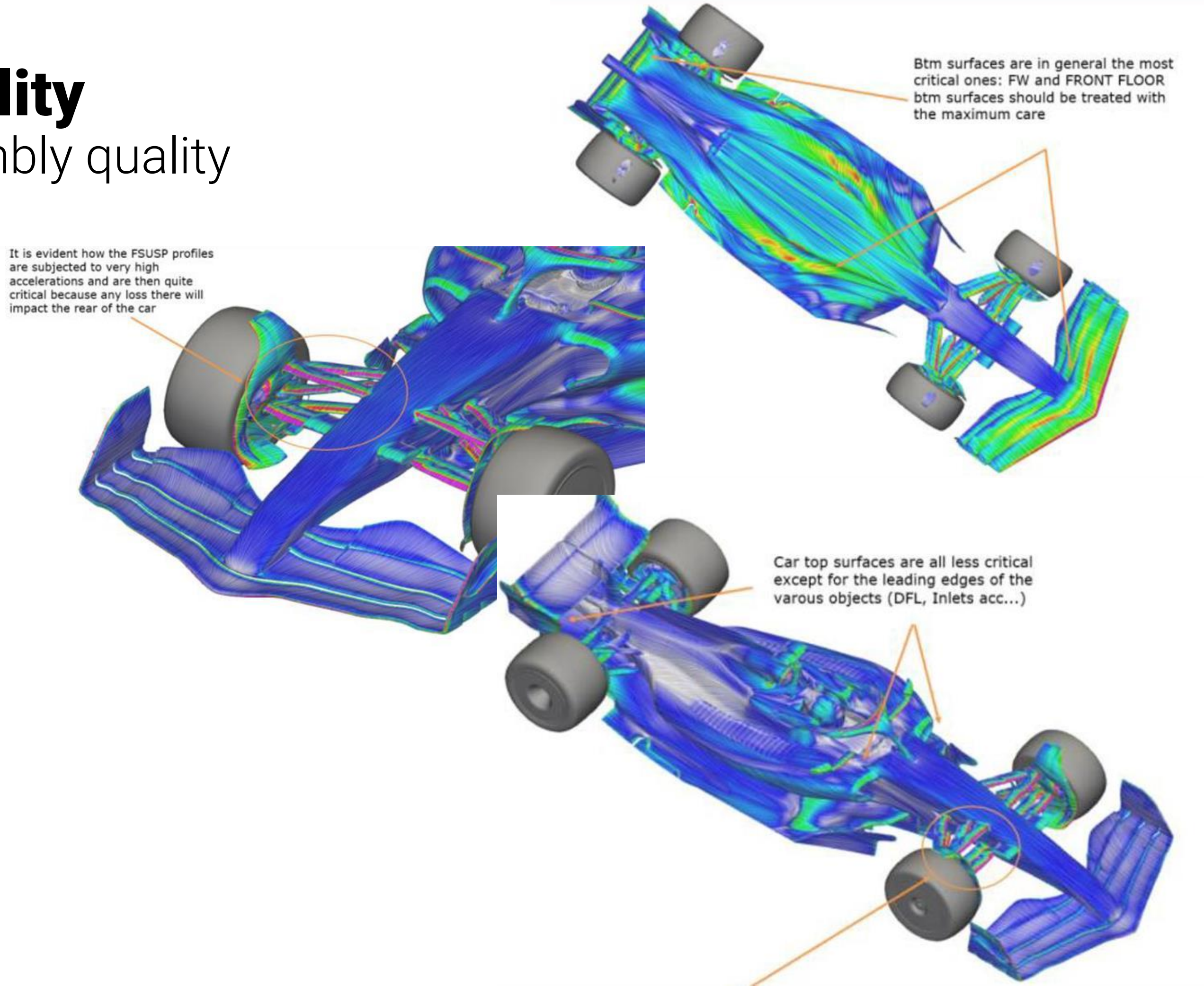


Importance of quality

Surface quality & assembly quality

- Not all the car areas are aero-sensitive in the same way so clearly floor and wings are the areas where more attention is needed

- Some mm gaps (or even worse fwd facing steps) must be avoided to avoid unintended separations or flow spillage caused by a bad assembly quality

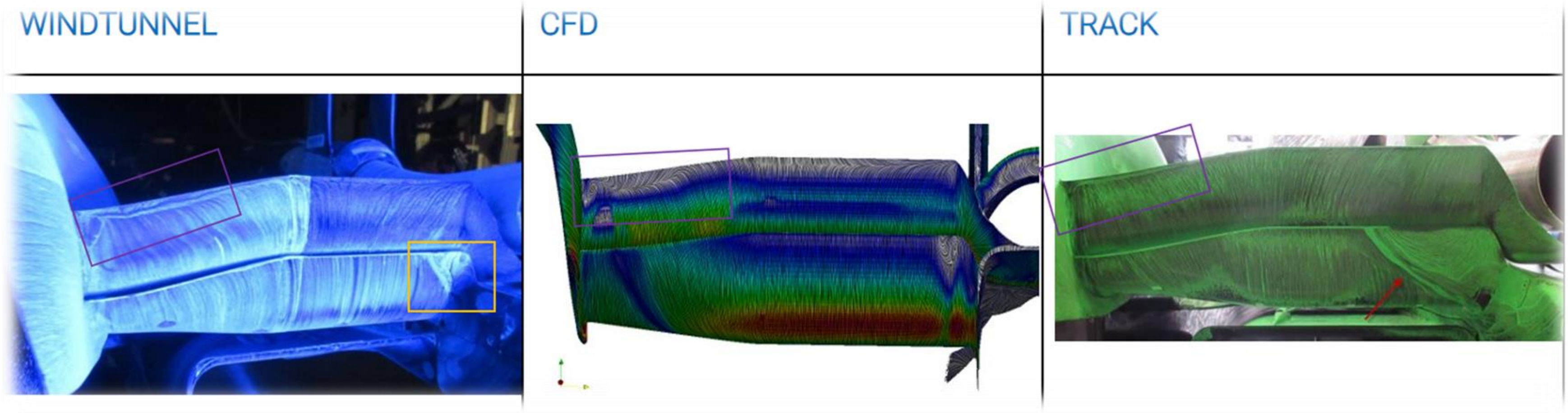


Example of bad quality

Consequences of poor parts quality and assembly quality

- Here below is an example showing how the quality in wind tunnel model (metal RP part coupled with a ceramic RP part) was not sufficient to give flow stability in a very critical area.

- Track (carbon parts) then behaved even worse.



Race Car Application

AM for Formula 1 Track Aerodymics

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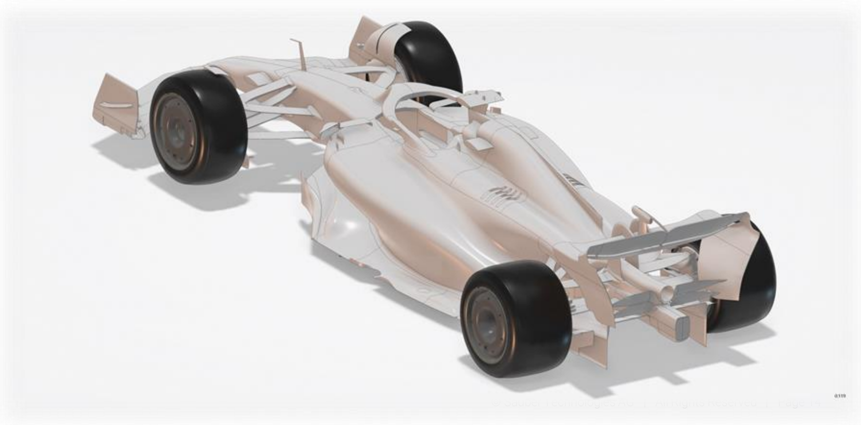
Total pressure measurements on track

Metal AM application on track

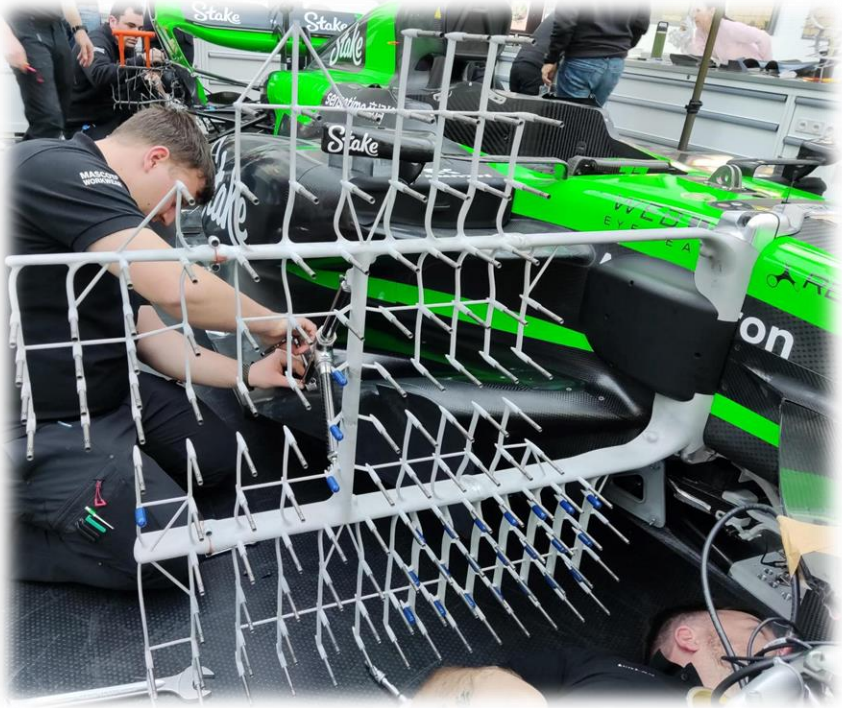
- The use of so-called Pressure Rakes is quite common during track testing to measure the total pressure around the car in some predefined planes.
- They consist in a rake of total pressure probes distributed properly to capture the main flow features, in particular the tyre wakes.



Stake F1 front rake 2024

Metal AM fully printed rake

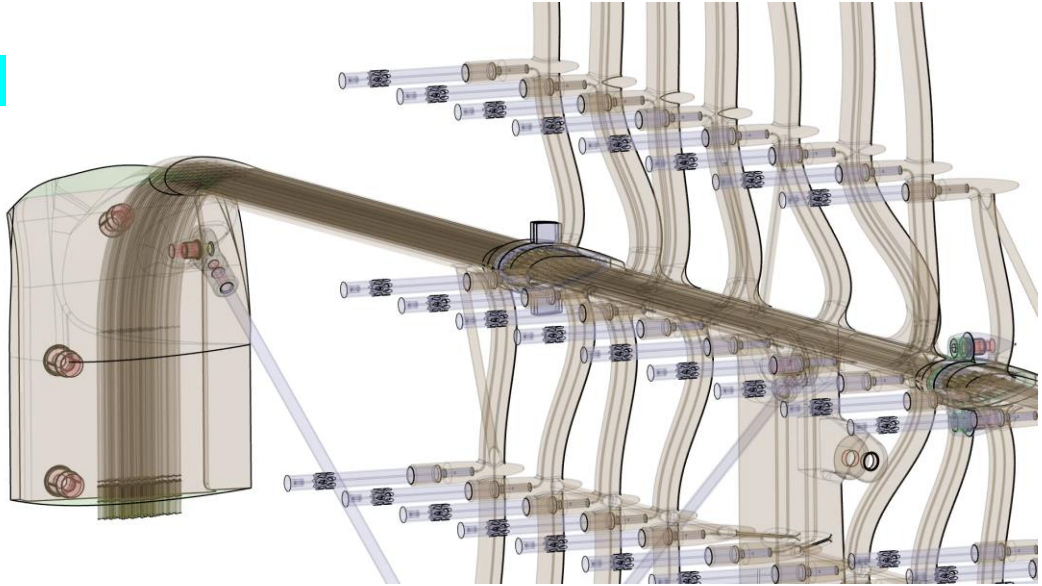
- Here beside an image of the 2024 front rake which was redesigned and rebuilt this year.
- It's a fully printed rake with 128 probes per side (glued in) and covering the full region where the front tyre wake develops
- 4 modules printed and glued together with a quick release clamping system around the chassis



Design and production details

Importance of the metal printing

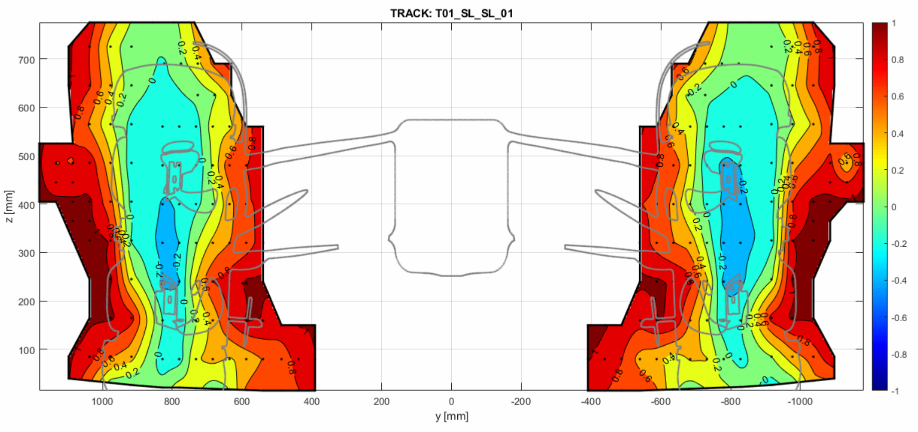
- The picture here shows the detail of the internal design: the 256 pressure tubes (1.2mm diameter) are designed one by one.
- They get grouped together in the main beams to bring the pressures to the sensors
- These parts with the full internal tubing is then printed in Aluminium



Improvements using metal printing

Huge steps in turnover time and measurement quality

- The use of metal AM reduced the fitting time of the front rake from about 30 minutes to less than 7 minutes! (Crucial track time!)
- Measurement quality has been significantly improved because the channels are monitored and checked in house and they don't get damaged during transportation or fitting.
- Coupling structural and aero requirements, the metal printing made the rest of the magic



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