



Power Unit Cooling System Simulation of a Formula 1 Car

Dominic Riderer

Introduction



Sauber Group:

- Sauber Motorsport competes in Formula 1 for over 30 years.
- Since 2018 as Alfa Romeo Racing F1 Team.
- The chassis is designed and developed in Hinwil (Switzerland) with a team of approximately 500 people.
- In 2022 the team showed strongly, finishing in 6th position in the 2022 World Championship.

Dominic Riderer:

- **Sauber Technologies AG** (Since February 2023): Power Unit Integration Team Formula 1 for 2026.
- **Sauber Motorsport AG** (July 2018 – January 2023): Heat Management Group as Senior Thermodynamicist.
- **Audi AG** (November 2013 – June 2018):
 - Engineer Thermal Management and Aerodynamics in Motorsports
- **KLK Motorsport GmbH** (May 2012 – October 2013): CFD Engineer for the DTM racing car.
- **Technical University of Munich** – Diploma in Automotive Engineering (2012).



General Development Challenges in Formula 1

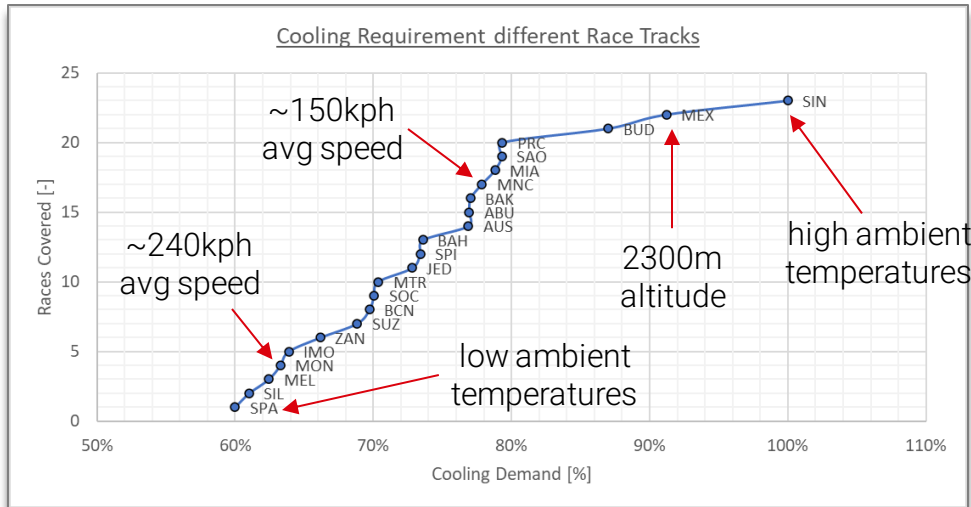
- Very limited track and testing time – only 3 fixed days of preseason testing for all teams:
 - Main objective is to get a reliable and fast car in a very short time.
 - Preseason tests are very close to the season start – short reaction time.
- Regulation limits CFD and Aerodynamic testing Resources:
 - Limitation on CPU hours for CFD simulations.
 - Limited number of geometries to be tested.
- Financial limitation due to budget cap of currently \$135 million per season.
 - Fine balance between system functionality and lap time potential needed.
- Very high Competition – complete grid often within ~2% lap time.

→ Crucial to use accurate and reliable simulation tools!



Cooling System Development Challenges

- Complex power units with various cooling circuits for charge air cooling, MGU, battery and combustion engine.
- Tight packaging to allow highest flexibility for aerodynamic development.
- Objective to minimize cooling air requirements to maximize aerodynamic potential.
- Crucial to extract all lap time potentials on the different circuit characteristics of the Season:
 - Differences in altitude, car speed, ambient conditions, energy strategies,....



Race Weekend Structure

- During normal race weekends 3x60min track time are available to setup the car.
- Sprint race weekends only have 1x60min of free practice before the cooling configuration must be frozen for the Qualifying.
- Within the sessions, configuration changes must be proceeded within a few minutes to not lose too much track time (e.g., bodywork or aero configuration changes).
- Bigger changes could be proceeded between the session (e.g., changes in radiator configuration).
- Due to the limited track time, very detailed preparation is crucial to make fast decisions within the sessions and not lose time.

2h between Sessions

 FIA Formula 1 World Championship™

2022 Start Time Information

RACE DATE	GRAND PRIX	FRIDAY		SATURDAY			SUNDAY		
		PRACTICE 1	PRACTICE 2	PRACTICE 3	QUALIFYING				
		LOCAL	LOCAL	LOCAL	LOCAL	GMT	LOCAL	GMT	SUNSET
20-Mar	Bahrain	15:00 - 16:00	18:00 - 19:00	15:00 - 16:00	18:00 - 19:00	15:00 - 16:00	18:00	15:00	17:48
27-Mar	Saudi Arabia *	17:00 - 18:00	20:00 - 21:00	17:00 - 18:00	20:00 - 21:00	17:00 - 18:00	20:00	17:00	18:36
10-Apr	Australia	13:00 - 14:00	16:00 - 17:00	13:00 - 14:00	16:00 - 17:00	06:00 - 07:00	15:00	5:00	18:00
24-Apr	Emilia Romagna	FP1 13:30 - 14:30	Qualifying 17:00 - 18:00	FP2 12:30 - 13:30	SPRINT 16:30	14:30	15:00	13:00	20:08
8-May	Miami	14:30 - 15:30	17:30 - 18:30	13:00 - 14:00	16:00 - 17:00	20:00 - 21:00	15:30	19:30	19:55

Normal Race Weekend

Sprint Race

Cooling System Setup

- To maximize race car performance, different cooling specifications are available for tracks with high or low cooling demands.
- Various aero or cooling system configurations are used to setup the car (15 - 25 configurations) to transfer cooling potential into aero or weight advantage .



Different
Bodywork
Exit Areas



Different
Louver
Panels

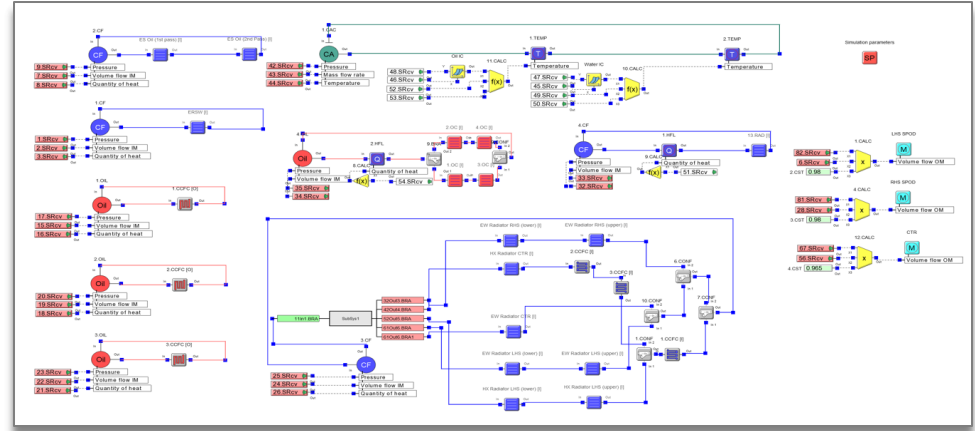
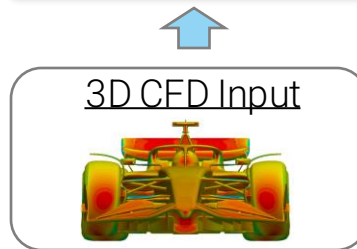
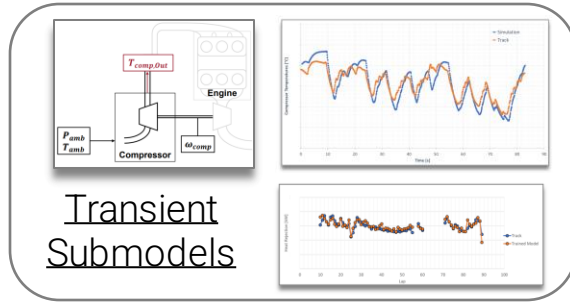


Simulation Environment Requirements

- Data handling of large input and output files.
 - Big matrices to be calculated to evaluate best configurations for specific conditions.
- Possibility to model exhaust energy recovery systems, different charge air cooling circuits, multiple electric engines, batteries, internal combustion engine, heat exchangers and radiators.
- Possibility to model and modify air paths quickly.
- Moderate simulation times to run big data matrices.
- Numerical stable algorithms to run complex cooling arrangements with thermal interaction between circuits.
- Moderate license costs.
- Flexibility to model potential new technologies in an easy and flexible manner.

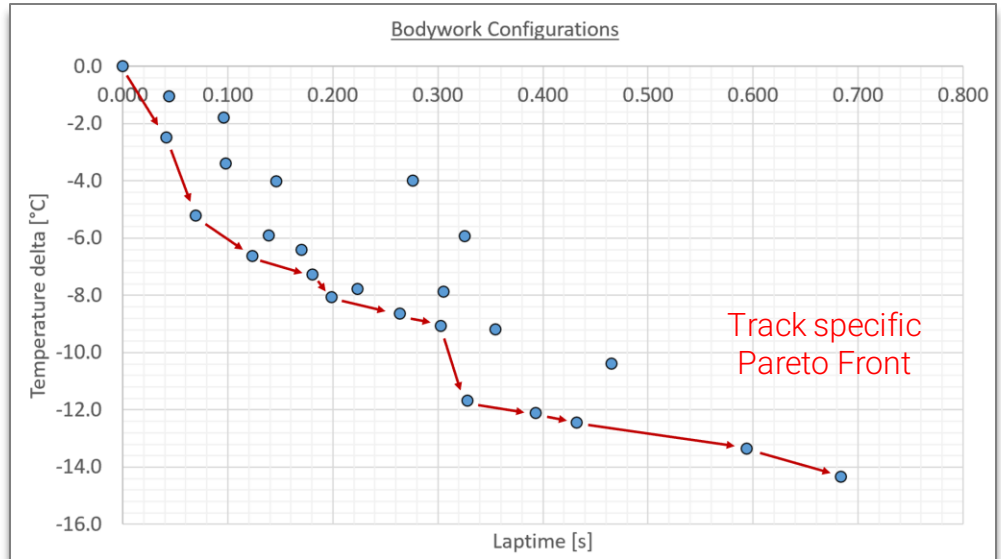
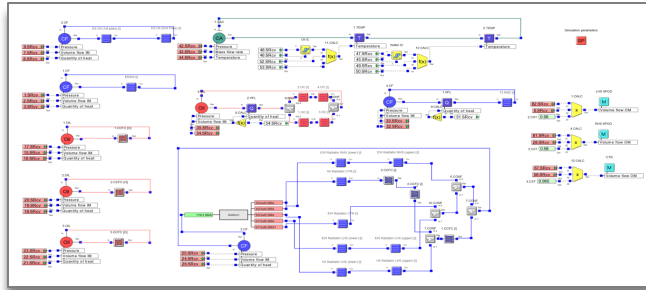
1D Simulation - Modelling Approach

- Sauber is using a semi-transient simulation approach.
 - The model is fed by the outputs of various sub-models.
 - The heart of the temperature prediction is a Kuli model.
- The semi-transient approach allows to benefit from repeating patterns in temperature behavior and reduces simulation times significantly.



1D Simulation - Race Weekend

- With the input from wind tunnel measurements and race car performance simulation, the 1D cooling simulation gives us the possibility to create a relationship between lap time and temperature effect for each cooling circuit.
- In preparation for each individual race, we are creating a pareto front considering the performance relevant configurations.
- The track specific pareto front gives the possibility to define the strategy during the free practice sessions and allows to adjust the cooling configuration if boundary conditions are changing or correlation is on the lower side.





Sauber Motorsport AG
Wildbachstrasse 9
CH-8340 Hinwil
Switzerland

www.sauber-group.com



Dominic Riderer
Senior Thermodynamicist



Office +41 78 267 87 42
Mobile



dominic.riderer@sauber-group.pu26.ch

Get in Touch