The hepia Moto2 Aerodynamic Program - From CFD to the Track

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Haute Ecole Spécialisée de Suisse occidentale

www.cmefe.ch

L'avenir est à créer

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Haute école du paysage, d'ingénierie et d'architecture de Genève

SWISS UNIVERSITIES OF APPLIED SCIENCES AND ARTS

hepia
(Geneva)

- 7 Universities
- + 2 private
- 80' 000 Students

MOTORSPORTS AT HEPIA

- Egli Motorradtechnik (1985) Bachelor thesis
- Motos ROC Annemasse (1992) Bachelor Thesis
- ASM Formula 3 (2006)
- Eco-marathon Shell : Consomini (2003-05), Biomobile.ch (2005 - actual)
- Motostudent PoliTo Turin (2011-12)
- Moto2 NCS Rapid Inside Modena (2011)
- Audit of the Formula 1 teams (2010 – 2013)
- MotoGP Akira (2014 - actual)
- Moto2 Tech3 (2014)
- Moto2 Technomag CarXpert Suter and Kalex (2014 - actual)

MOTORSPORTS AT HEPIA

Moto2 Tech3 Guy Coulomb

Motostudent PoliTo

ASM Formula 3

MotoGP Akira

THE TRADITIONAL WORKING METHOD

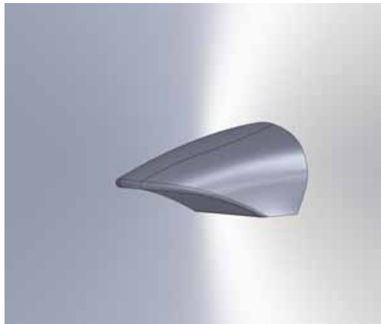
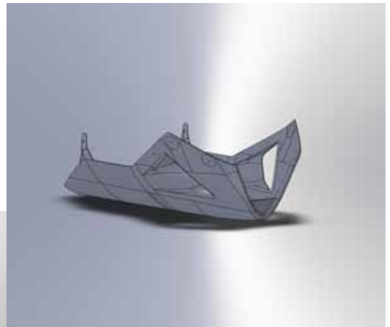
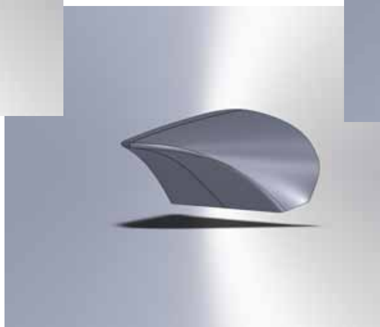
- Experimental analysis of the moto2 Ri211 from Rapid Inside NCS (Modena) in 2011
- Development of the air inlet and air box

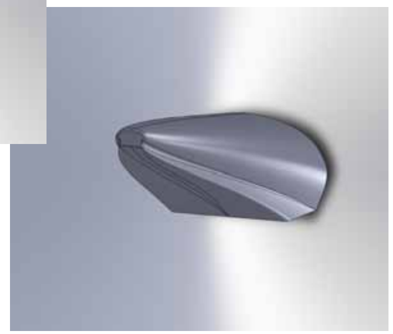
Subsonic wind tunnel hepia-cmefe in Geneva

THE TRADITIONAL WORKING METHOD

- Based on experience and feeling, production of parts in rapid prototyping
- Use of a rigid support and a 6 component balance
- Rotation of the front wheel using a rolling belt

CAD of the motorcycle



Production of parts in rapid prototyping

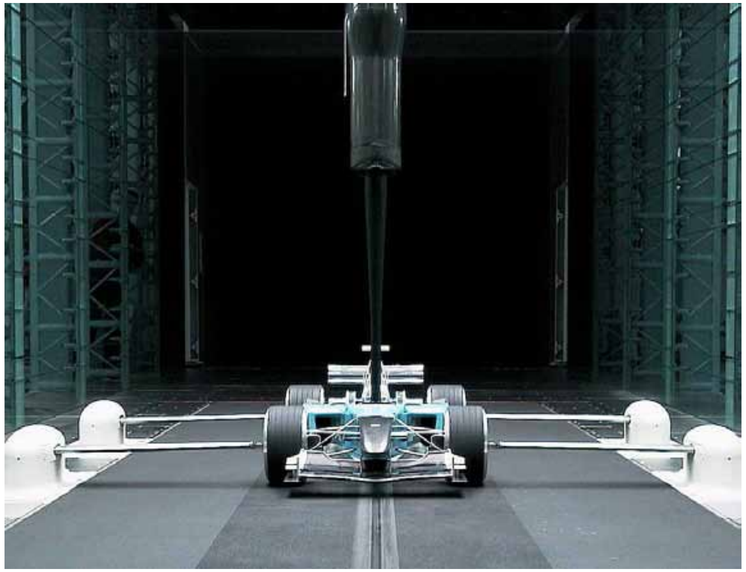
FORMULA 1 TEAMS WORKING METHOD

Formula One Teams Association

- From 2010 to 2013 hepia worked as partner of the Formula One Teams Association (FOTA)
- Roberto Putzu and Patrick Haas are team auditors in charge of the « *Aerodynamic testing and CFD simulation Regulation »*

Force India

FORMULA 1 WIND TUNNELS



Some Formula 1 wind tunnels

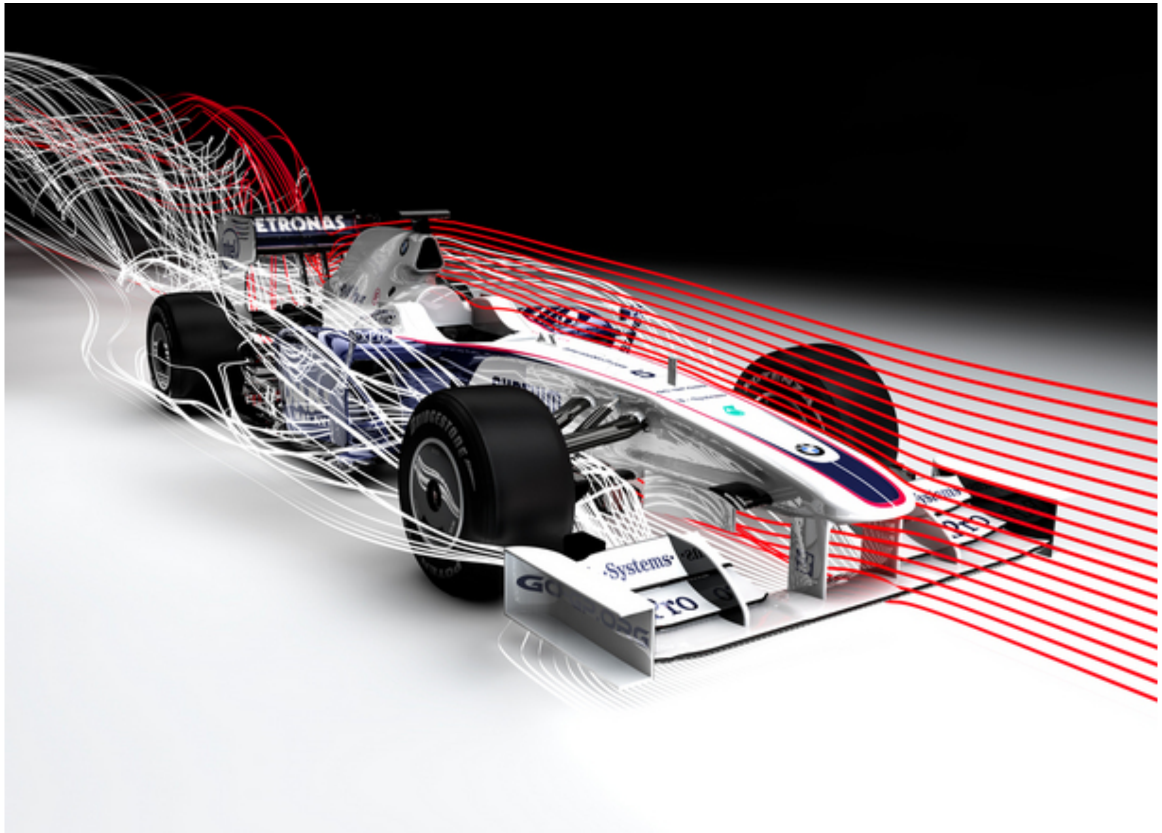
FORMULA 1 WIND TUNNELS

« Aerodynamic Testing Restrictions (FOTA) »

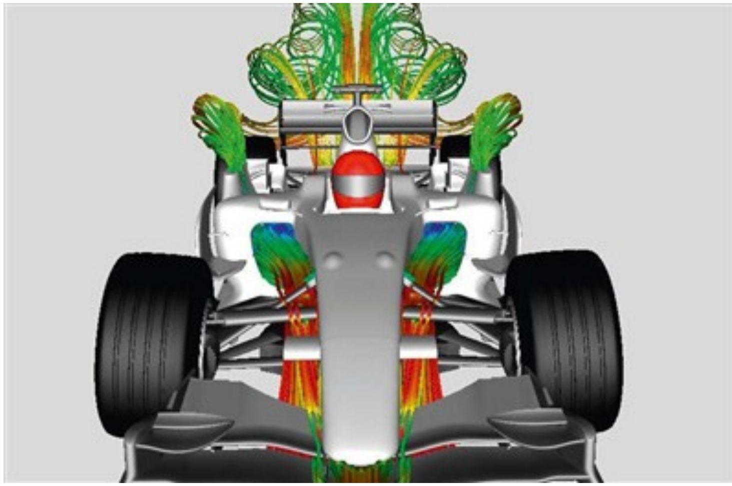
- Regulation adopted to reduce costs!
- 60% max. model scale
- 50 m/s max air speed
- Rolling belt
- Boundary layer succion
- Tests for several angles (pitch, yaw)
- More than 500 complete tests a month (all angles) in addition to CFD

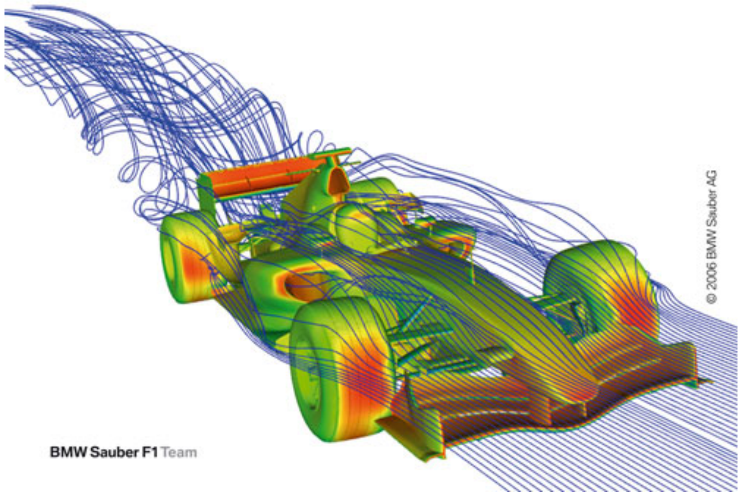
A test every 30 minutes !

FORMULA 1 CFD METHOD



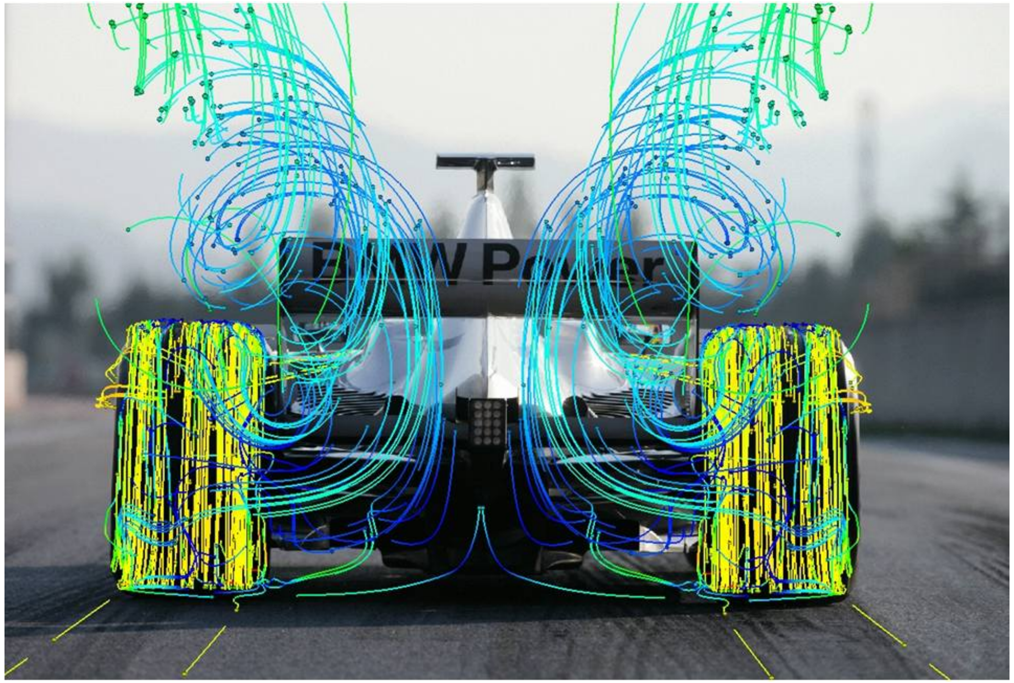
Sauber





FORMULA 1 CFD METHOD

« Aerodynamic CFD Restrictions (FOTA 2013) »



Sauber

- The number of operations in a period of 2 months is limited
- Up to 18 h CPU time on a server of hunderth of cores per simulation
- Up to 1'500 CFD simulation per month

Up to 50 simulations full car per day !

CFD CAPABILITIES OF THE FORMULA 1 TEAMS

Albert HPC server, Sauber

- Commercially available codes (Fluent, Star CCM+)
- Finite volume approach
- Highly parallelized computer of 64 bits processors
- Servers with up to 6'000 cores
- Up to 18'000 Gb RAM
- Infiniband DDR 48 Gbit/s interconnections or better
- Approx. 100 kW electrical suply
- Approx. 150 kW cooling tower (condenser)

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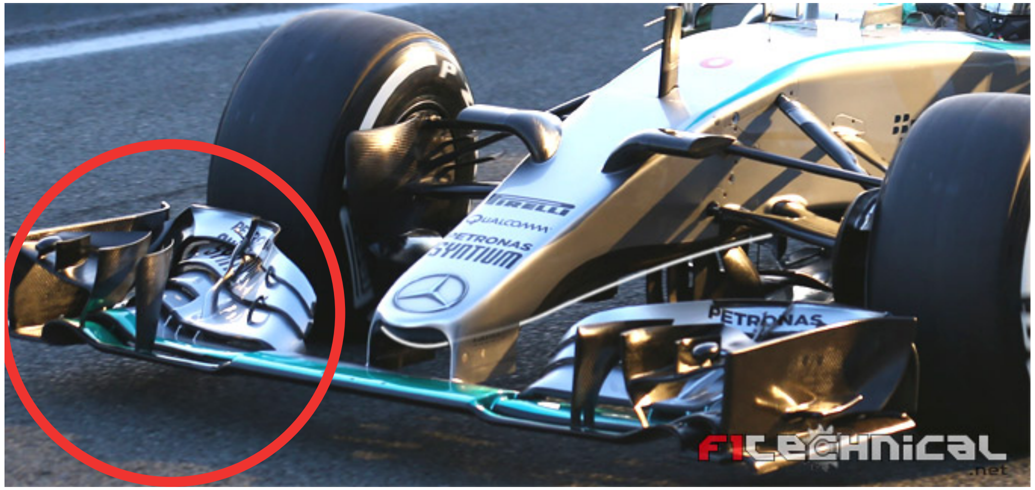
WHAT CAN BE LEARNED FROM THE FORMULA 1 TEAM WORK?



Mercedes AMG F1 WA06, 2015

Ferrari SF15T, 2015

1. CFD intensive computations:

- CFD shows all quantities everywhere without perturbing the flow at the time scale you want!
  Complete and detailed flow understanding → New ideas!

- Complex geometry optimisations – Parameter studies

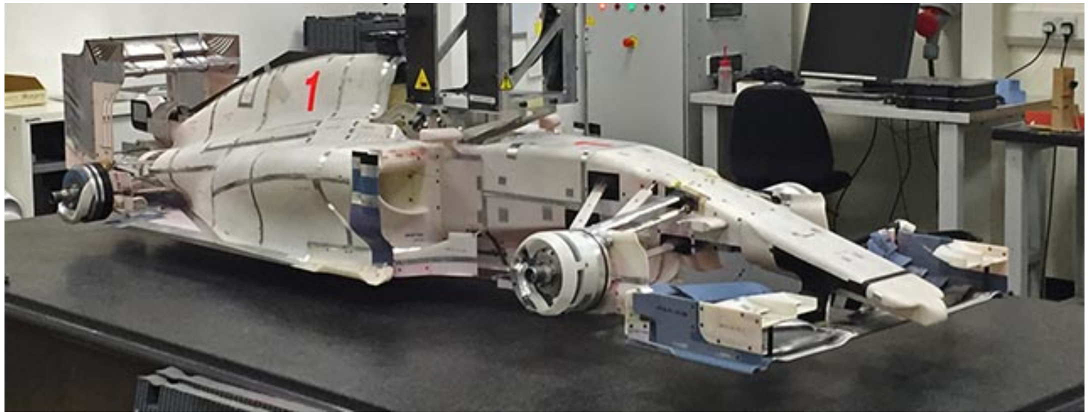
WHAT CAN BE LEARNED FROM THE FORMULA 1 TEAM WORK?

2. Wind tunnel tests:

- Instrumented models (balances, PSI, motorized wheels, suspensions, ecc.)
- Rapid prototyping parts on a steel body
- Exceptional methodology and work organization

3. Tests on track:

- Aspect ratio and size effects
- Hypothesis validation



Marussia 2015

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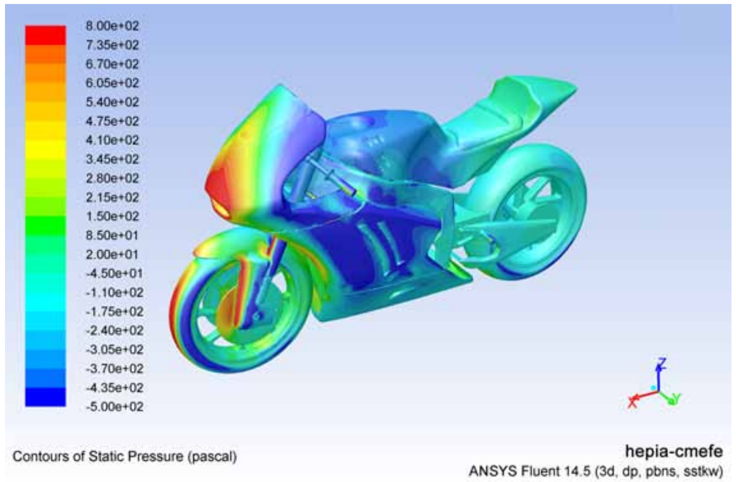
THE HEPIA MOTO2 AERODYNAMIC PROGRAM

1. **Wind tunnel tests with 50% scale models**
   - Difficulties having the bike for a long time in the wind tunnel (no second bike allowed in moto2 regulation)
   - Aspect ratio (front area / test section)
   - Costs

2. **Wind tunnel tests at full scale**
   - Pilot training and position, seat definition
   - Validation of CFD results
   - Continuity with the past (known results and effects)

3. **Simulation CFD**
   - Flow understanding
   - New ideas, aerodynamic program definition
   - Motor cooling and thermal analysis



THE HEPIA MOTO2 AERODYNAMIC PROGRAM

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4. On track aerodynamic drag evaluation

- Full scale
- Complete motorcycle (the true one!)
- Made by torque measurement on gearbox shaft
- Job done using a motoGP to investigate the effect of the aspect ratio

5. Race results analysis

- ECU logger data analysis

Italy Grand Prix 2015

→ The objective is a real increase of performances during the races, i.e. on track !

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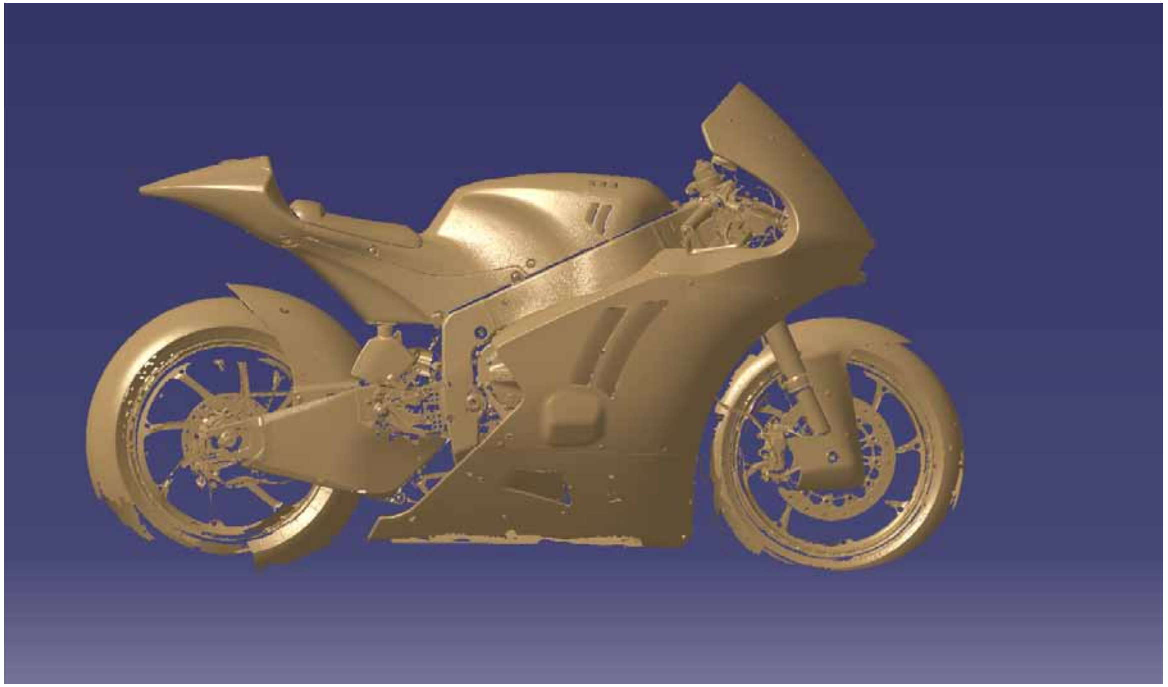
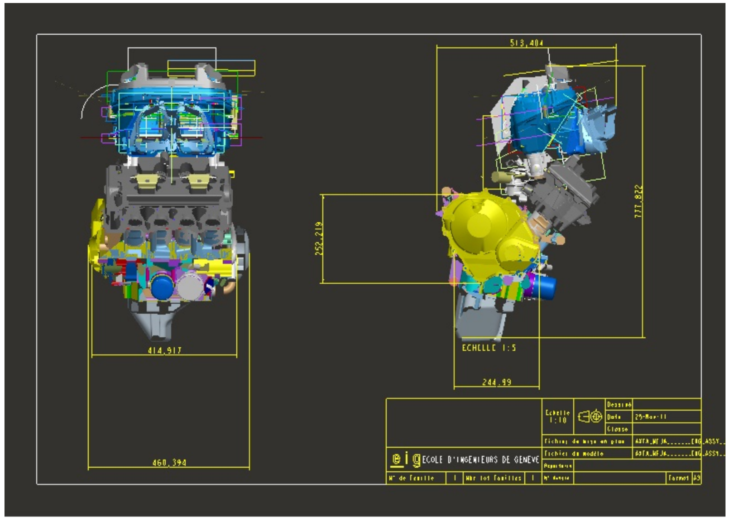
WIND TUNNEL TESTS WITH 50% SCALE MODELS

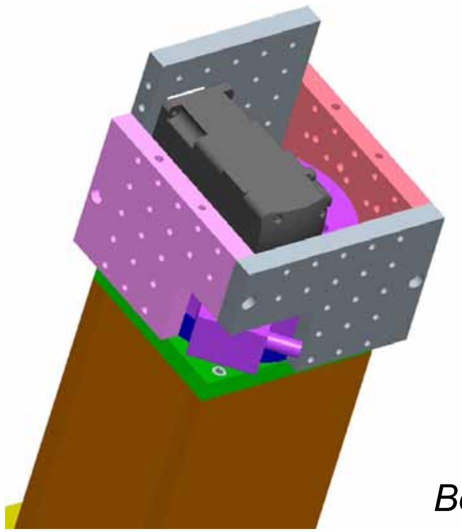
Model development



Scan 3D, CAD, ecc.



Motor Honda 600 cm3



Body

WIND TUNNEL TESTS WITH 50% SCALE MODELS

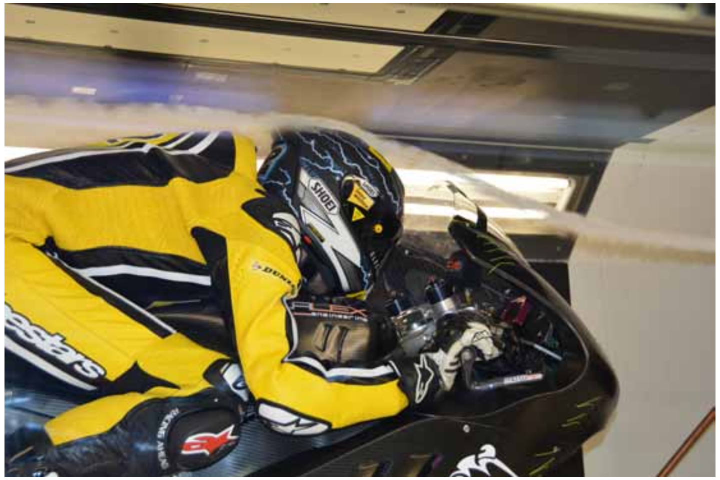
Model production and instrumentation

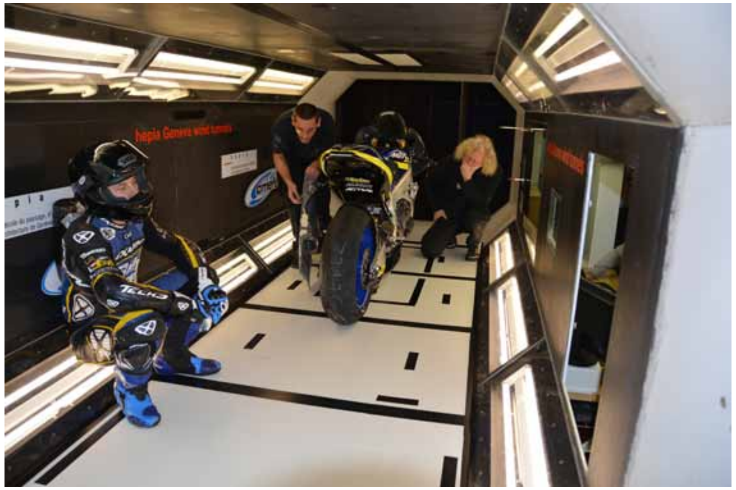
Fairing

Motorized wheel

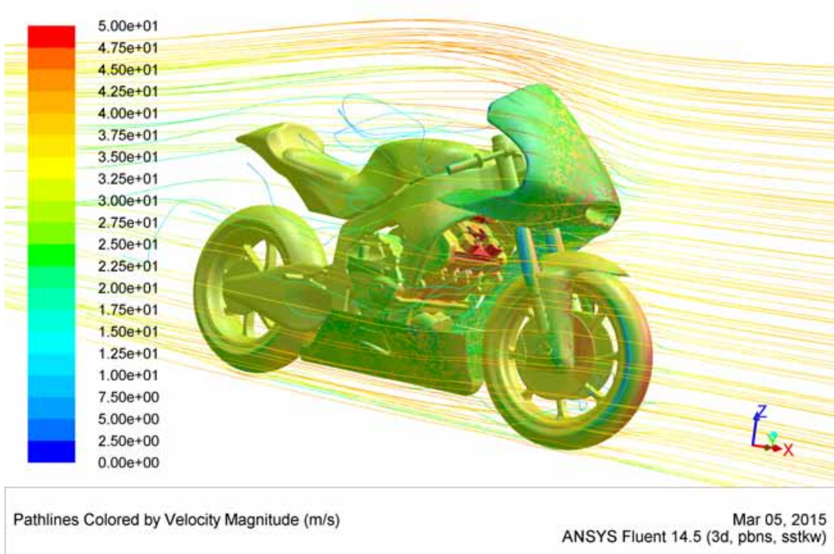
Model assembly

WIND TUNNEL TESTS AT FULL SCALE





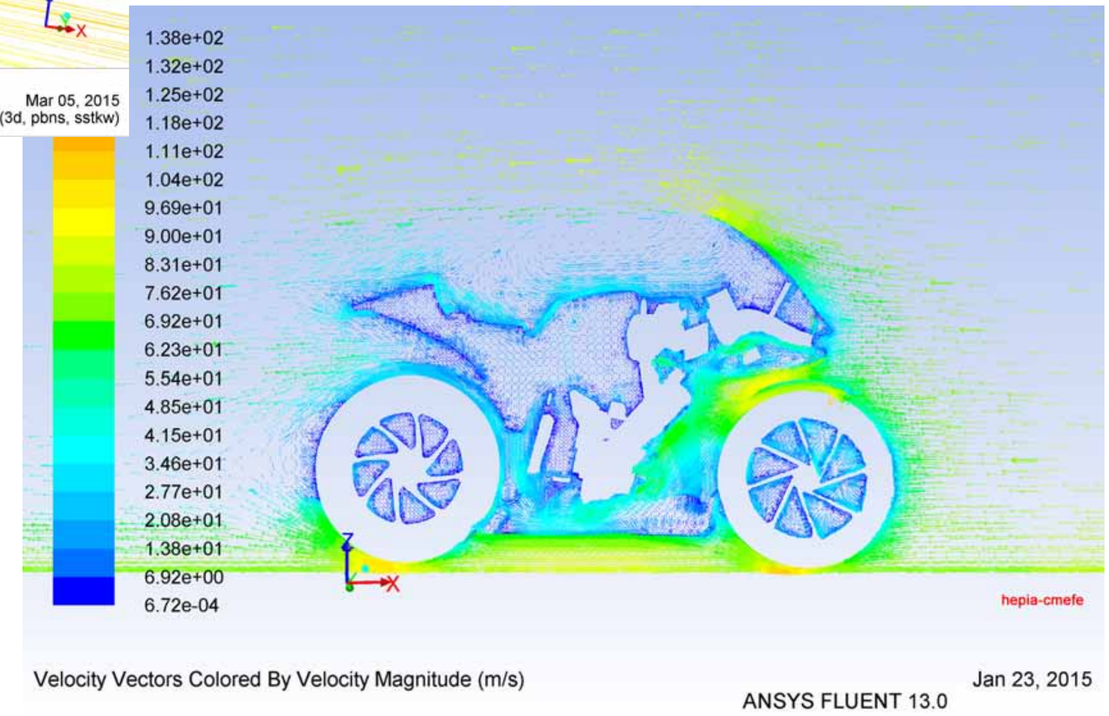
CFD SIMULATIONS



Objectives

- External and internal aerodynamics
- Drag optimisation
- Thermal exchange

- Radiator as an anysotropic porous media
- Rotating wheels with mesh interfaces



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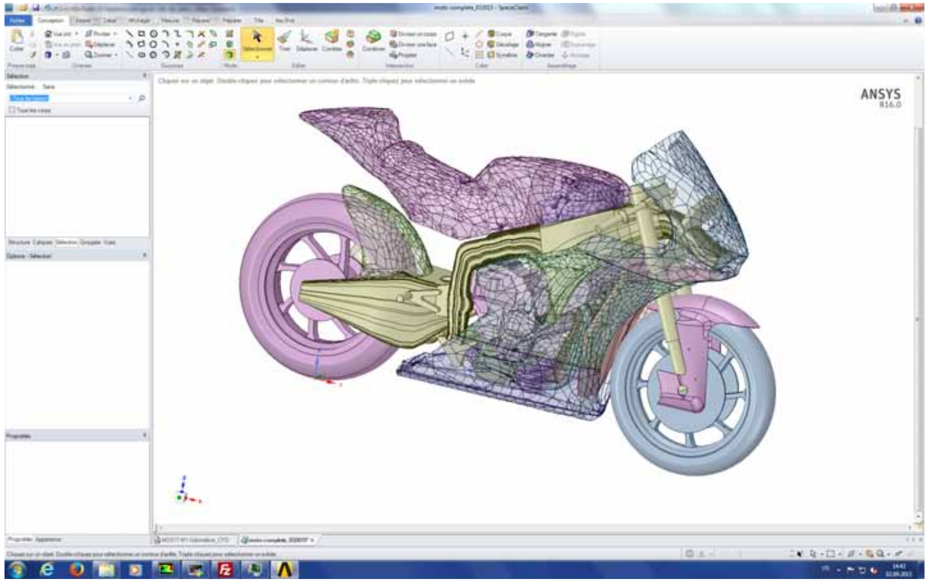
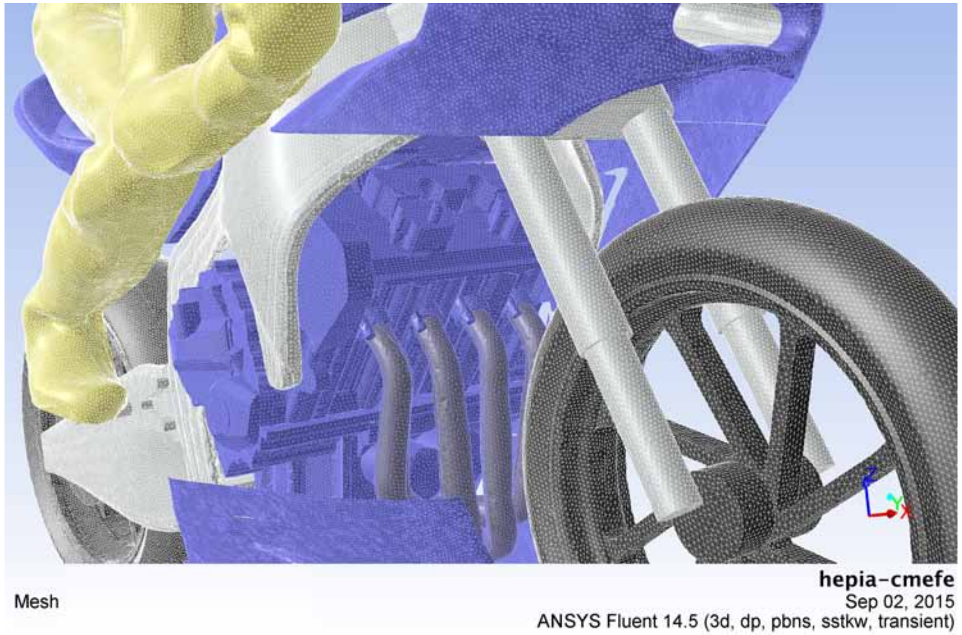


Modeler

- Catia V5
- ANSYS SCDM (Space Claim Design Modeler)

Mesher

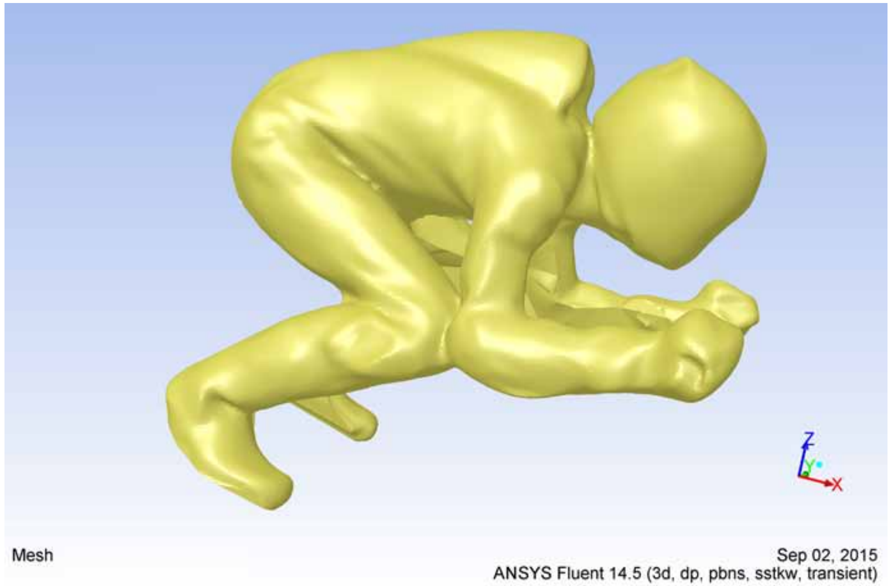
- ANSYS ICEM
- Workstation 16 cores, 126 Gb RAM
- 30 millions cells



CFD SIMULATIONS

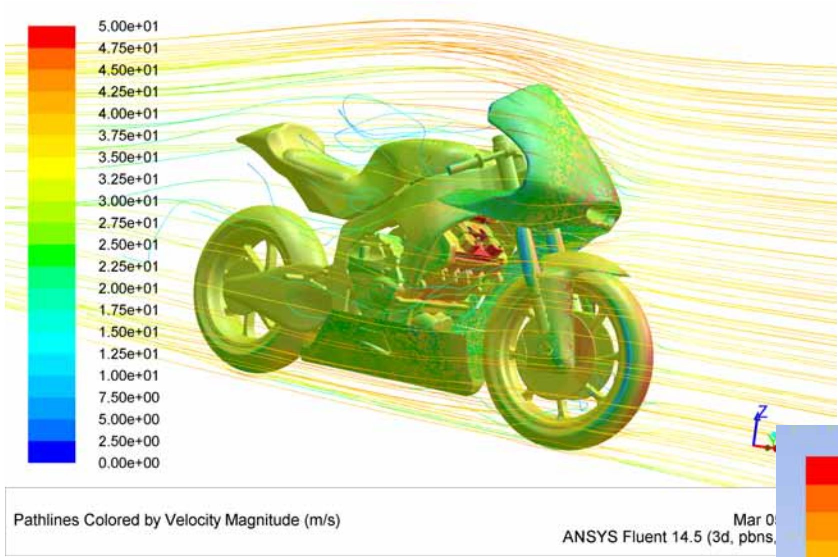
Scan of the pilot

- Hand scanned (fast)
- Dominique Aegerter
- Correct positions
- All suit and helmet details!



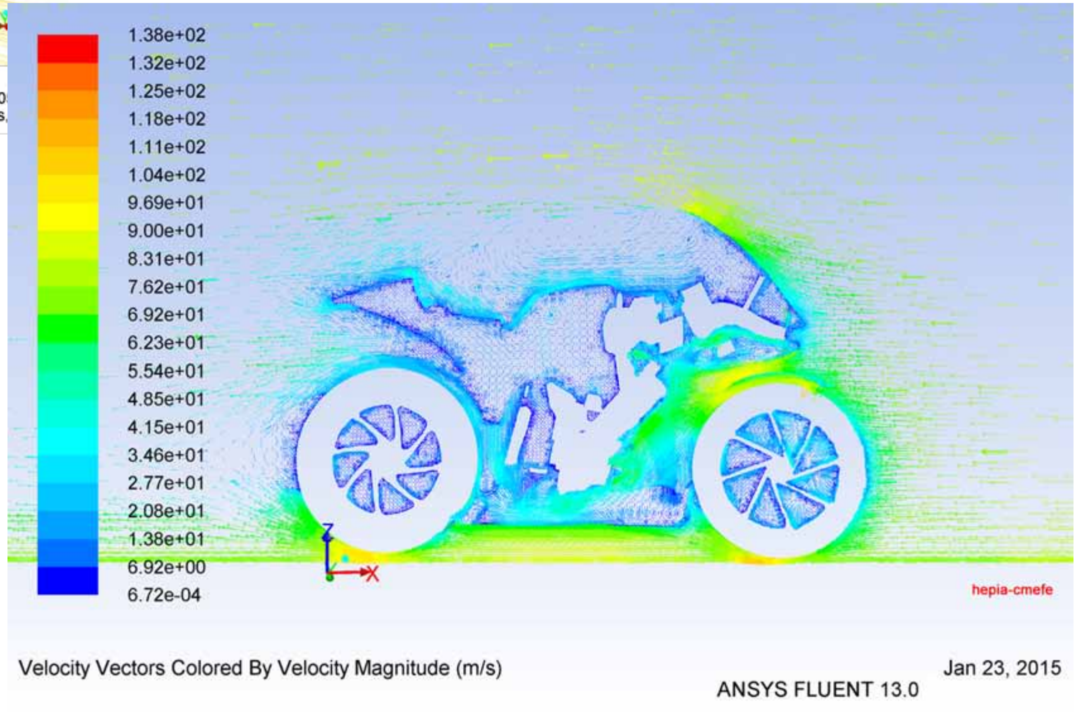
Dominique Aegerter 77 and Kalex Moto2

CFD SIMULATIONS



Solver

- ANSYS CFD Fluent
- Server 224 cores, 3 GHz
- Pressure based solver
- Turbulence SST – kw



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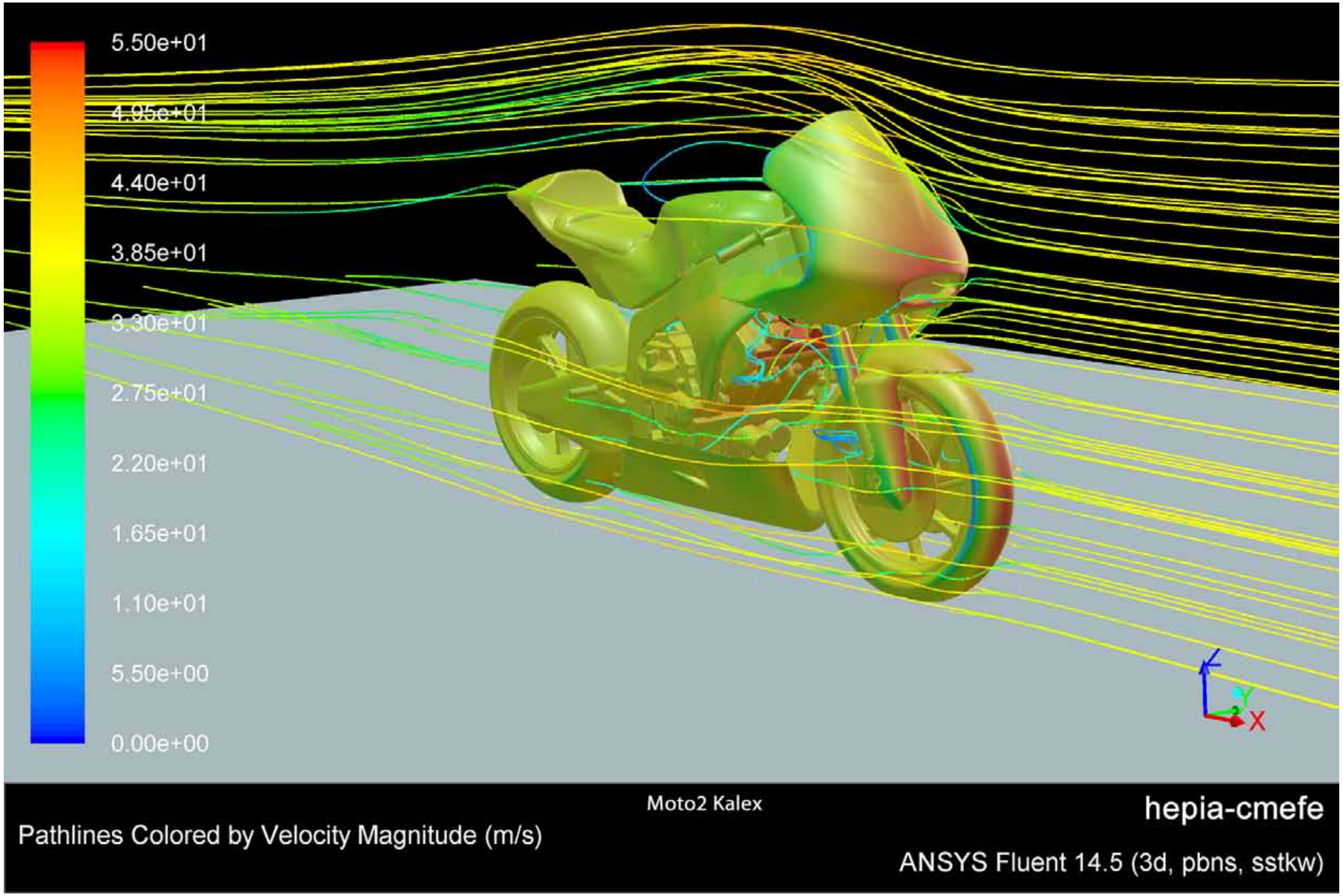

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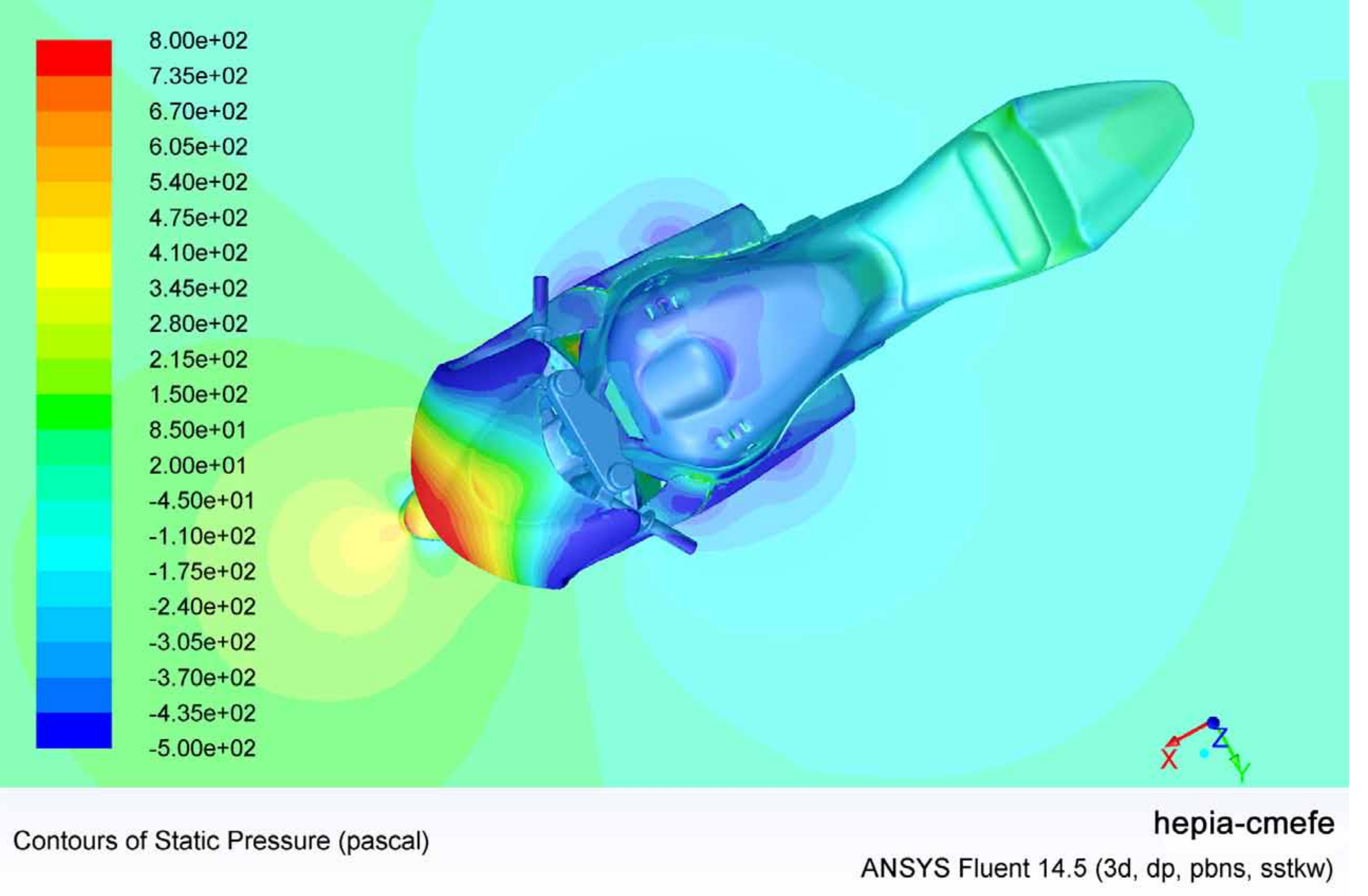

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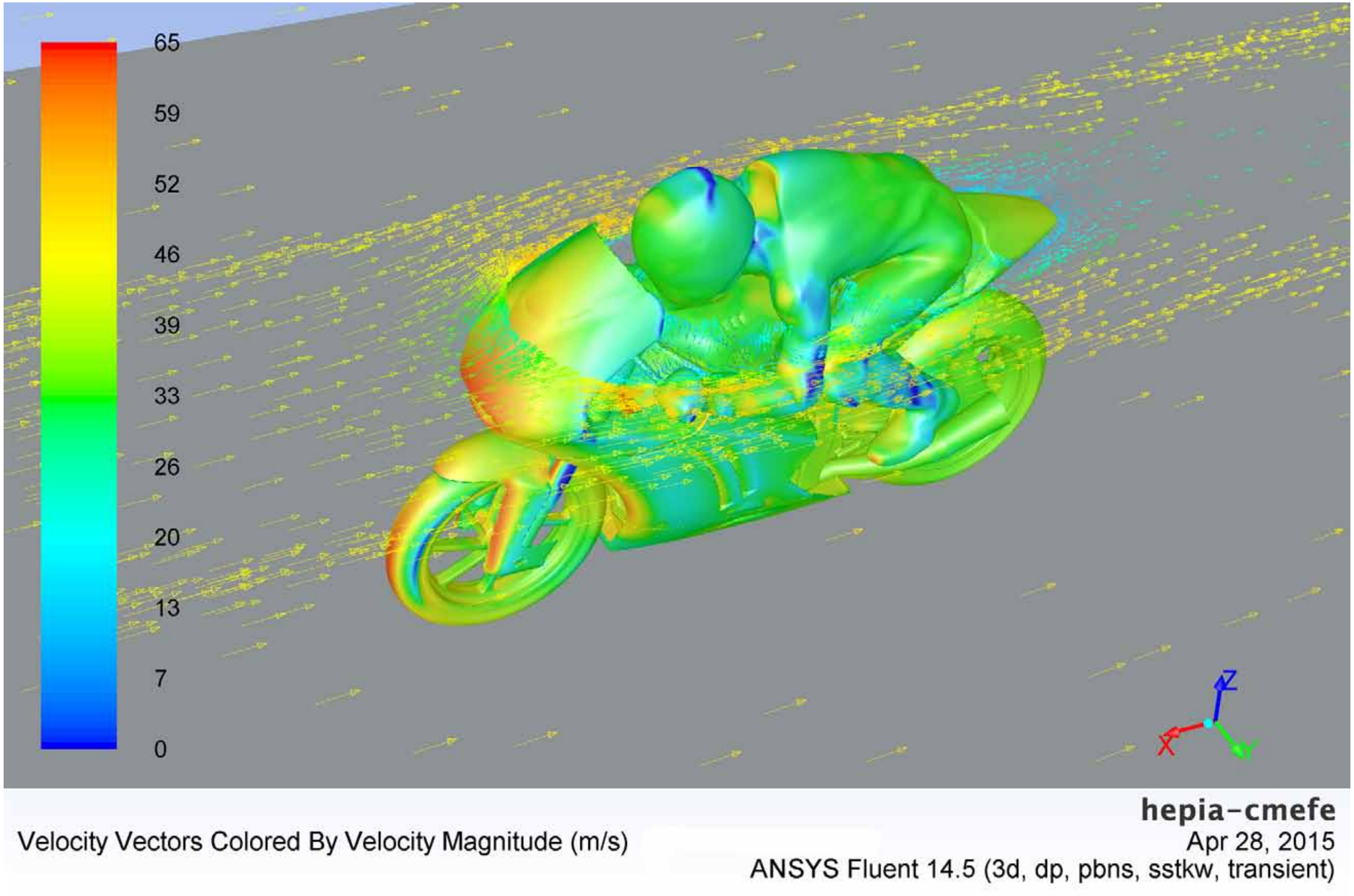
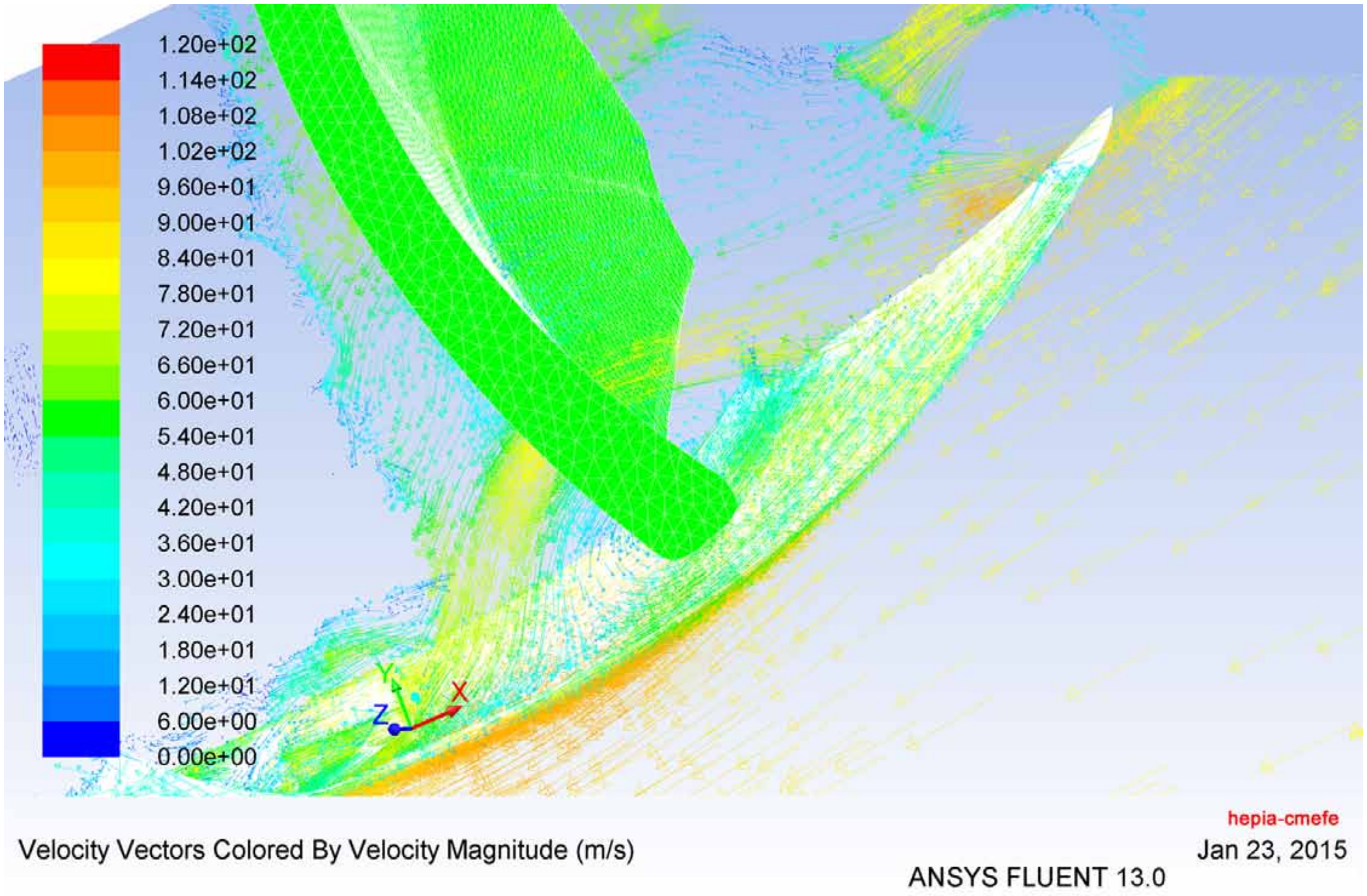


CFD SIMULATIONS

Understanding of side fairing and radiator interactions



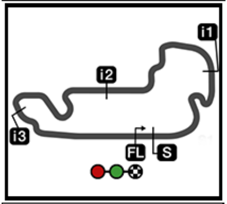
RESULTS

		SCx values
Moto2 Kalex Aegerter 2015 (with our work)		
CFD simulations	:	0.230
Wind tunnel full scale (corrected for aspect ratio)	:	0.250
Moto2 Suter Aegerter 2014 (with our work)	:	0.270
Moto2 NCIS 2011	:	0.320
Ducati 1098 S 2007 (including all components for road use)	:	0.380

RESULTS

- In the top speed of all moto2 riders from the beginning of the 2015 championship

anapolis Motor Speedw Results and timing service provided by TISSOT



4170 m.

Moto2

RED BULL INDIANAPOLIS GRAND PRIX

After the **Race**

Event Best Maximum Speed

33

	Rider	*Nation*	*Team*	*Motorcycle*	*Km/h*	
12	**Thomas LUTHI**	**SWI**	Derendinger Racing Interwetten	KALEX	**290.0**	Race
77	**Dominique AEGERTER**	**SWI**	Technomag Racing Interwetten	KALEX	**289.3**	Free Practice Nr. 1
25	**Azlan SHAH**	**MAL**	IDEMITSU Honda Team Asia	KALEX	**288.7**	Race
11	**Sandro CORTESE**	**GER**	Dynavolt Intact GP	KALEX	**287.6**	Free Practice Nr. 3
73	**Alex MARQUEZ**	**SPA**	EG 0,0 Marc VDS	KALEX	**286.9**	Race
21	**Franco MORBIDELLI**	**ITA**	Italtrans Racing Team	KALEX	**286.8**	Race
1	**Tito RABAT**	**SPA**	EG 0,0 Marc VDS	KALEX	**286.8**	Race
39	**Luis SALOM**	**SPA**	Paginas Amarillas HP 40	KALEX	**286.3**	Qualifying
40	**Alex RINS**	**SPA**	Paginas Amarillas HP 40	KALEX	**286.0**	Race
36	**Mika KALLIO**	**FIN**	Italtrans Racing Team	KALEX	**285.9**	Race
97	**Xavier VIERGE**	**SPA**	Tech 3	TECH 3	**285.9**	Race

RESULTS

Illustration of the top speed gain achieved : Mugello 2015

Tito Rabat (1) not able to pass Dominique Aegerter (77) instead of speed gain obtained by aspiration.

CONCLUSIONS

- Gain on the aerodynamic drag of about 20%
- Selection of the best pilot position, seat design (thicknesses)
- Suit design (back) and helmet choice (deflector). Interaction between these two elements.
- Better design of several bike parts
- Definition of a correlation between the wind tunnel (with high aspect ratio) and the track
- All conclusions done in the wind tunnel, even with a high aspect ratio, are confirmed on track. The small size of the wind tunnel appears in this study as a cost advantage and offers the possibility to work more. This will be increased by the use of 50% models.
- CFD simulations correlate well with experimental results for such body (high Reynolds numbers, no zones with unclear separation regions)

→ CFD simulations gives us understanding of the flow and will lead to new ideas in a way to progress quickly hepia

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THANKS, QUESTIONS?

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Christophe Balistreri, Assistant de recherche
Christophe Cerutti, Assistant technique