UNIVERSITÀ DEGLI STUDI DI PADOVA

DIPARTIMENTO DI INGEGNERIA INDUSTRIALE

raceup

Università degli Studi di Padova – Dipartimento di Ingegneria Industriale
Corso di Laurea in Ingegneria Aerospaziale

Relazione per la prova finale
«Aerodynamics Design of FSAE Car MG18.23»

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FSAE & RACE UP TEAM

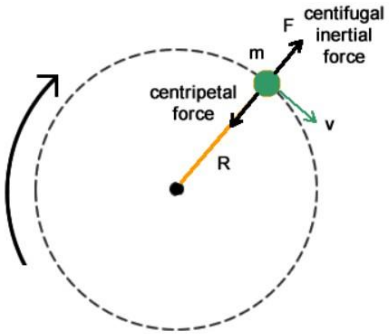
International University competition about the design and manufacturing of formula-type race cars, tested on circuit in dedicated events.

Events are divided in:

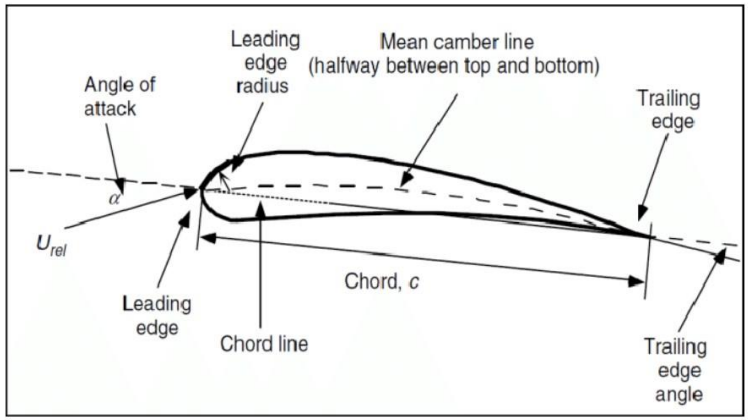
- Static events (325 points)
- Dynamic events (675 points)

Race UP Team is the UniPD Team since 2003, in which 90 students design and build 2 cars: combustion and electric.

RACE CAR AERODYNAMICS



$$m\frac{v^2}{r} = \mu(mg + DF)$$

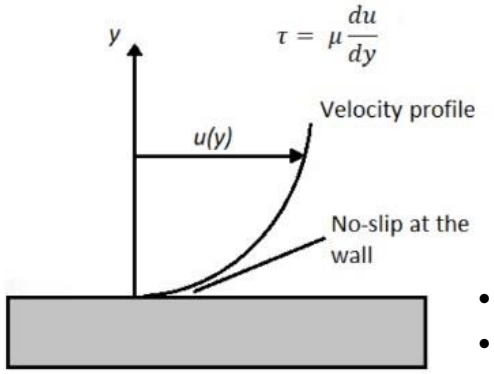


Net forces on an airfoil:

- Lift (Downforce)
- Drag

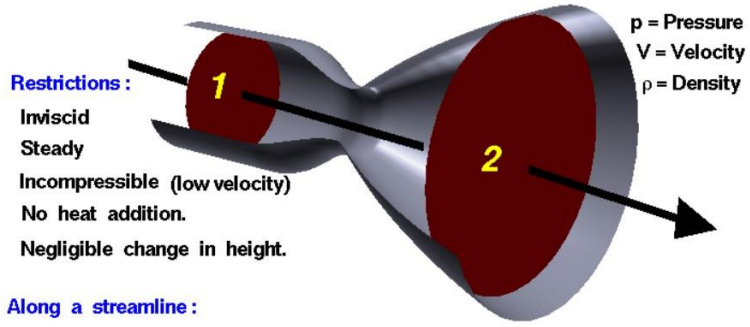
$$DF = \frac{1}{2}\rho C_L A v^2$$

$$D = \frac{1}{2}\rho C_D A v^2$$



$$Re = \frac{\rho v l}{\mu}$$

- Low Re: laminar flow
- High Re: turbulent flow



$$\int\int_S pV \cdot dS = 0$$

$$A_1 V_1 = A_2 V_2$$

STARTING POINT

T8.2 Restrictions for Aerodynamic Devices

T8.2.1 Height restrictions:

- All aerodynamic devices forward of a vertical plane through the rearmost portion of the front face of the driver head restraint support, excluding any padding, set to its most rearward position, must be lower than 500 mm from the ground.
- All aerodynamic devices in front of the front axle and extending further outboard than the most inboard point of the front tire/wheel must be lower than 250 mm from the ground.
- All aerodynamic devices rearward of a vertical plane through the rearmost portion of the front face of the driver head restraint support, excluding any padding, set to its most rearward position must be lower than 1.2 m from the ground.

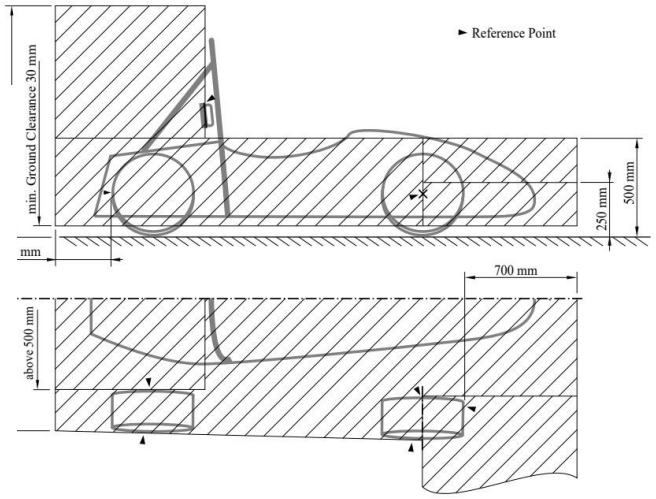
T8.2.2 Width restrictions:

- All aerodynamic devices lower than 500 mm from the ground and further rearward than the front axle, must not be wider than a vertical plane touching the most outboard point of the front and rear wheel/tire.
- All aerodynamic devices higher than 500 mm from the ground, must not extend outboard of the most inboard point of the rear wheel/tire.

T8.2.3 Length restrictions:

- All aerodynamic devices must not extend further rearward than 250 mm from the rearmost part of the rear tires.
- All aerodynamic devices must not extend further forward than 700 mm from the fronts of the front tires.

T8.2.4 All restrictions must be fulfilled with the wheels pointing straight and with any suspension setup with or without a driver seated in the vehicle.



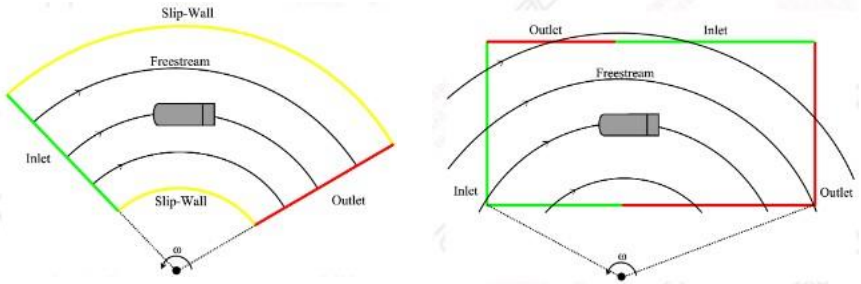
Car needs to be rule compliant or a disqualification may occur

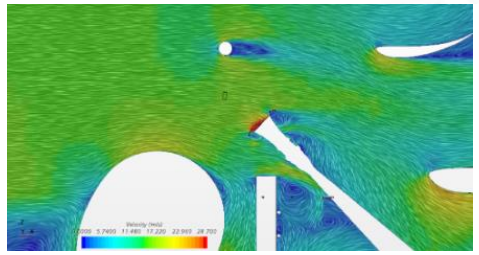
MG17.22:

- Good cooling system
- Heavy loss of downforce in cornering conditions
- High pitch sensitivity
- Low downforce front wing

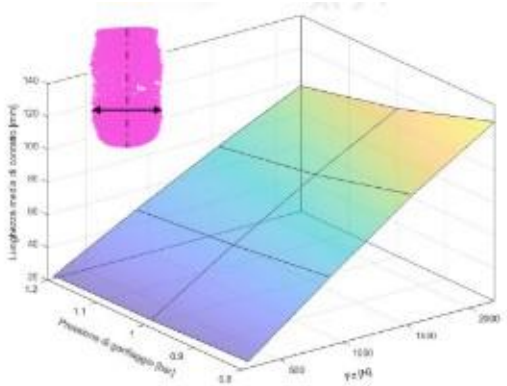
CFD IMPROVEMENT

- New cornering simulation (MRF), with pitch, roll and steering angle parametrization;
- Curved domain: better accuracy, easier boundary conditions, better understanding of results
- Engine intake modelling

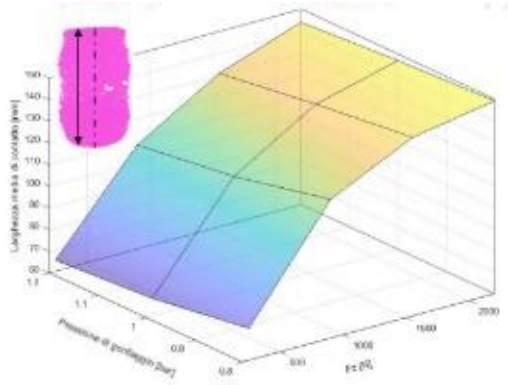




- Acquisition of contact patches under static load and reimporting in CAD and CFD



Lunghezza media di contact patch [mm]		Carico verticale [N]			
		250	900	1550	2200
Pressione di gonfiaggio [bar]	0.8	24.1	62.1	98.7	129.6
	1	22.1	54.2	83.6	110.2
	1.2	21.6	48.4	73.4	96.6



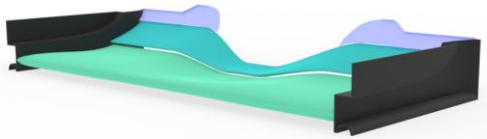
Larghezza media di contact patch [mm]		Carico verticale [N]			
		250	900	1550	2200
Pressione di gonfiaggio [bar]	0.8	74.9	124.1	142.5	149.0
	1	68.1	114.1	137.1	147.0
	1.2	65.1	108.0	130.8	144.0

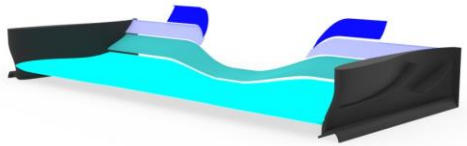
FRONT WING AND SIDEPODS

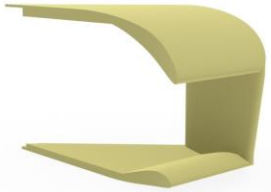
- 3 to 4 elements setup
- Profiled Endplates
- Less pitch/roll sensitivity

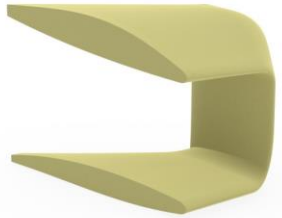
Old vs. new configuration:

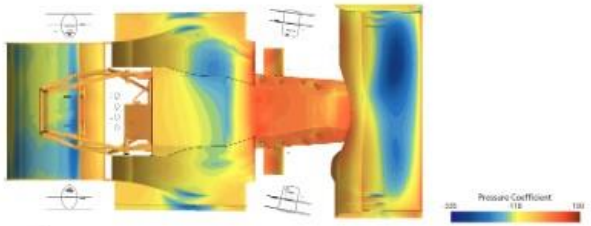
- High DF Front wing leads to worse air to radiators
- Conservative divergent to avoid separation zones
- Bigger intake

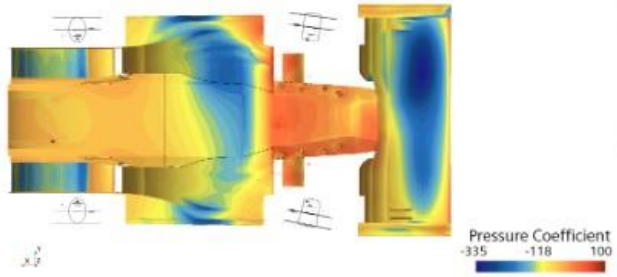


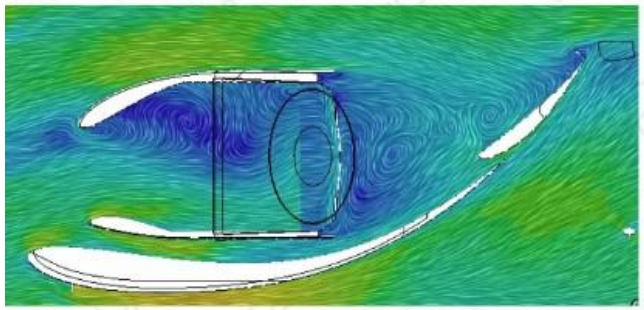


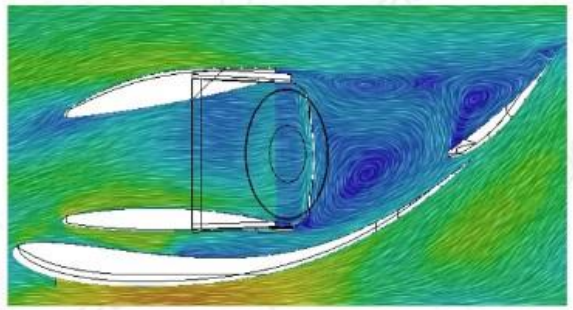






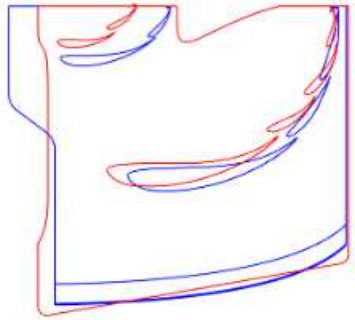


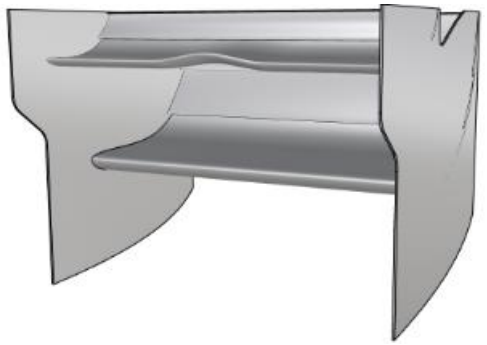


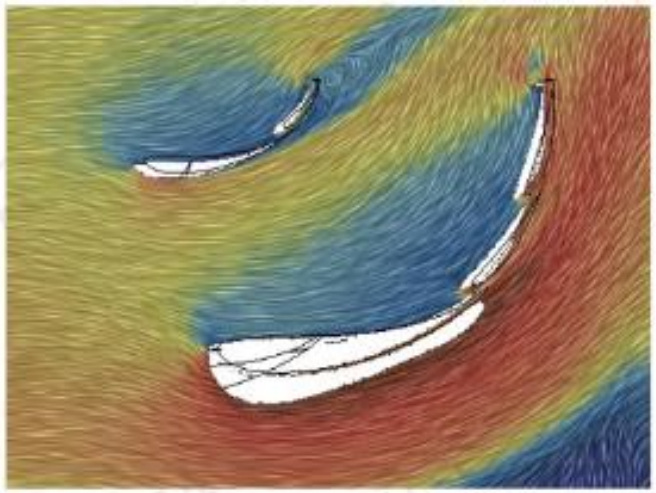


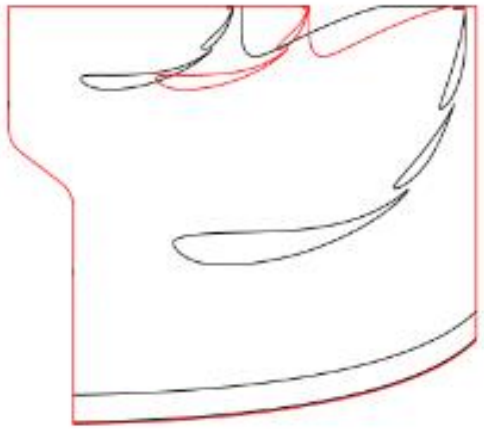
REAR WING

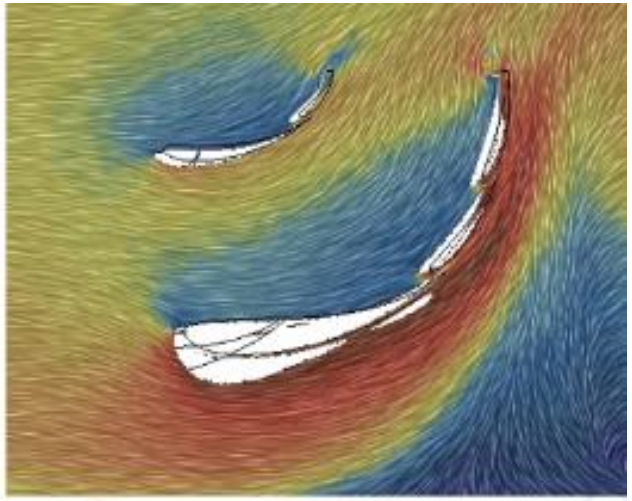
- 4 elements to 3 elements
- Optimised upper flaps to avoid flow detachment, using high pressure from main plane
- Redesign of endplates, to better isolate the flow coming from sidewings
- Swept upper flap main plane due to engine intake downwash









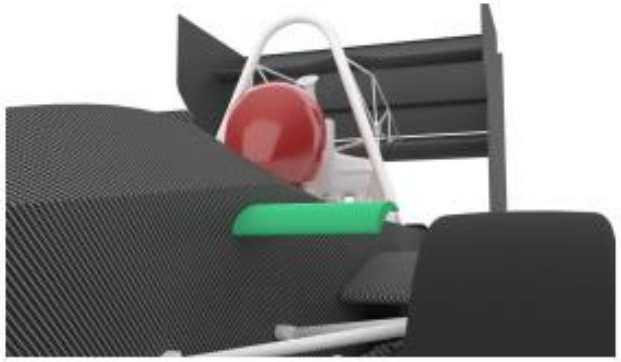


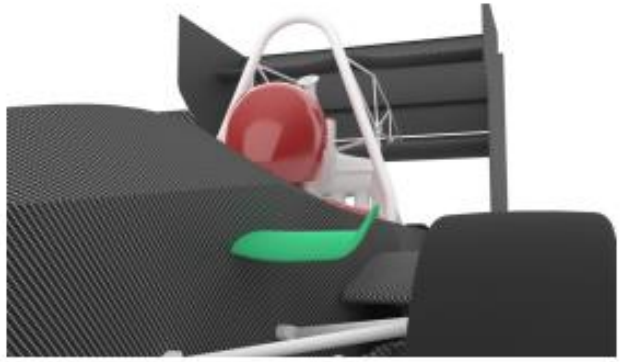
BULL WINGS AND DIFFUSER

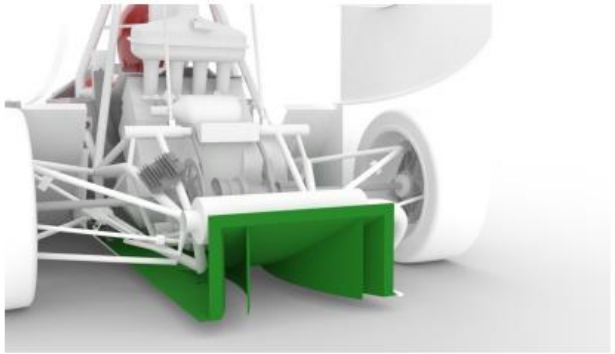
Bull wings redirect the front wing upwash down:

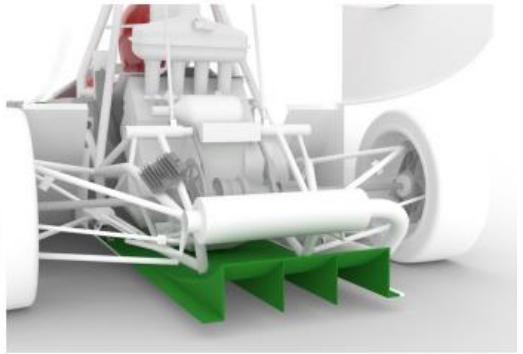
- Rear wing cleaner air
- Vortex shedding for better wake control

- More conservative diffuser
- No lateral expansion = less tyre wake influence
- Overall downforce increment in pitch conditions









AEROPACK DATA AND EVENTS

	CLA TOT [m^2]	DF TOT [N]	CDA TOT [m^2]	CLA DIFF [m^2]	CLA FW [m^2]	CLA RW [m^2]	CLA SIDE [m^2]
MG17	3,9086	160,709	1,813	0,0901	1,6978	1,4219	0,6603
MG18	5,003	187,464	1,759	0,1235	1,7893	1,5292	0,9191
GAIN (pts)	109,44		-5,353	3,35	9,15	10,73	15,052
GAIN (%)	27,99	16,65	2,95	37,148	5,389	7,546	59,255

FSAE Italy:

- P1 Design
- P1 Cost
- P2 Business plan
- P3 Acceleration
- P1 Skidpad
- P1 Autox
- P1 endurance
- P1 overall

FSAE Hungary

- P1 Design
- P4 Cost
- P1 Business plan
- P2 Acceleration
- P5 Skidpad
- P3 Autox
- P1 endurance
- P1 overall

BIBLIOGRAPHY

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