Lukács Eszter
Vehicle Aerodynamics, 2011.11.24.

High-performance cars

Introduction

High-performance cars: high accerelation, high deceleration, excellent maneuverability, high top speed

- Sports cars: designed for „public transport", high power/weight ratio, center of gravity close to the ground, design

- Racing cars: very special regulation extremely big downward acting force, good steering abilities, safety

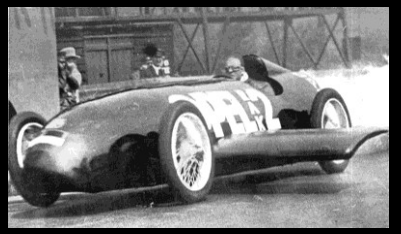
- Record braking cars: designed for extreme velocities, low drag and high directional stability is extremely important

Historical milestones – record breaking cars

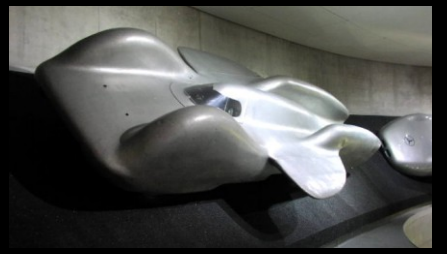
- 1899: Camille Jenatzy (belgian race car driver)
  first to exceed the 100km/h limit with his electric car,
  named: La Jamais Contente (never satisifed)
  cigar-shape inspired by airship

- 1929: Henry Segrave (english fighter pilot)
  beats the 200 mph record with the Golden Arrow
  record on land and water

- 1928: Fritz con Opel (alias Rocket Fritz)
  OPEL-RAK 2 rocket-car; the first car with horizontal wings



- 1930: T80 designed by Ferdinand Porche,
  streamlined body, horizontal and vertical wings
  never put on track because of WW2



Historical milestones – record breaking cars

- 1947: John Cobb passes 634 km/h, record not tied till the 60's

- 1970: Gary Gabelich reaches 1001.6 km/h with the rocket driven Blue Flame

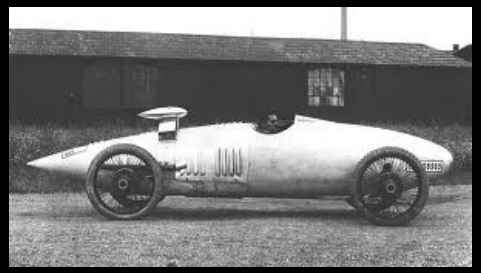
- 1979: Stan Barret passes the speed of sound with Budweiser Rocket
  velocity record of 1190 km/h never became official

- 1983: Richard Noble designes the Thrust SSC-t, record-holder till today with 1228 km/h (1997). Consumption: 5500 l/100 km

Historical milestones – racing cars

- 1887: the first car race, distance of 2km, the winner: Georges Bouton (the only racer…)

- 1914: open passenger compartment, uncovered wheels
  Lautenschlager Mercedes Cd = 0.65



- 1923: Benz Tropfenwagen, teardrop shaped car
  Streamlined cars gain importance before WW2

- 1955: Mercedes-Benz 300 SLR, retractable flap increases the drag coefficient from 0.44 to 1.09, Le Mans 24h-race

- 1967: Chaparral 2F; the first racing car with wings to reduce the lifting force

Historical milestones – racing cars

- 1969: Chaparral 2J,
  two fans at the rear of the car, increased downforce
  Banned.

- 1975: Ken Tyrrell (first served in the Royal Air Force, than timber merchant)
  Six-wheeled car. Banned.
  Strange record: his team was punished the most.

- 1977: Lotus 79 first race car using the „ground effect". Diffuser and sliding skirts at the bottom of the car and wing-shaped side pods reduce the lifting force.
  Banned.

Historical milestones – racing cars

- 1978: Brabham BT46B, „vacuum-cleaner"
  Response of Bernie Ecclestone to the diffuser.
  Niki Lauda won everything with it, but it was:
  Banned.
  http://forma1-f1.hu/index.php/forma1/olvas/639
- 1987: active suspension in Lotus – to sustain optimal ground clearance, intelligent system.
  Banned….. however, in 1991 allowed again, today even in passanger cars
- 2009: double decker diffuser. Not straightforward.
  Banned.
- 2010: the F-duct introduced by Mclaren .
  Flow rate towards the rear wing can be controlled.
  Banned.

Requirements

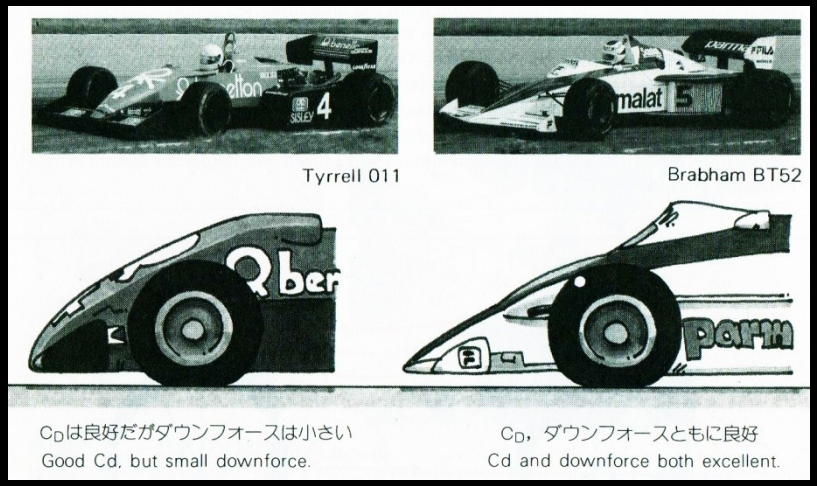
- Same motor power, the highest possible final speed:
  - reduction of the cross-section: almost impossible; huge exposed wheels are the major problem
  - reduction of Cd
- High negative lift/drag ratio: large Cl or small Cd
- Good maneuverability: zero or positive lift on front axle, large negative lift on rear axle – experience of driving tests
- Stability: low sidewind sensitivity with vertical axis
- Cooling and ventilation for motor area and driver's comfort

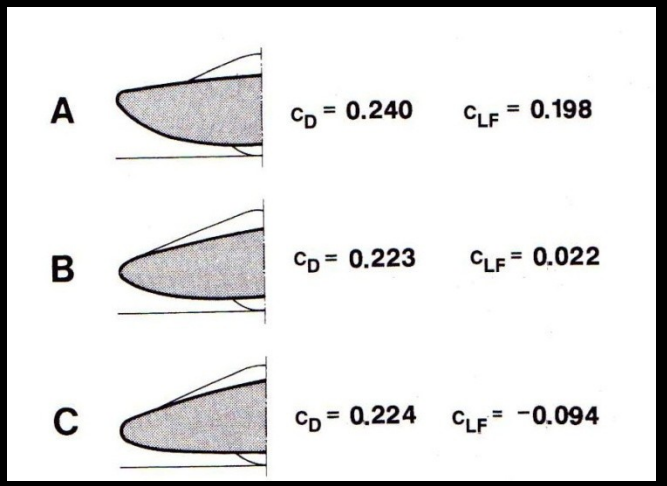
How?

Proper design of the separate parts of the car: nose, rear section, wings, underbody, special air inlets, etc.

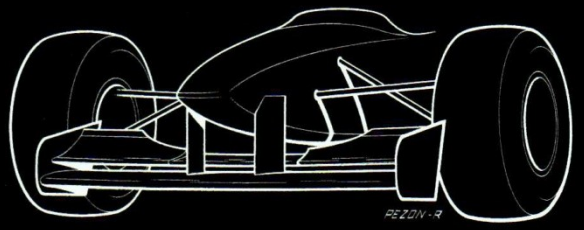
Parts of the car - nose

- Pressure builds up inevitably – streamlined body
- Reducing the lifting force with proper design:





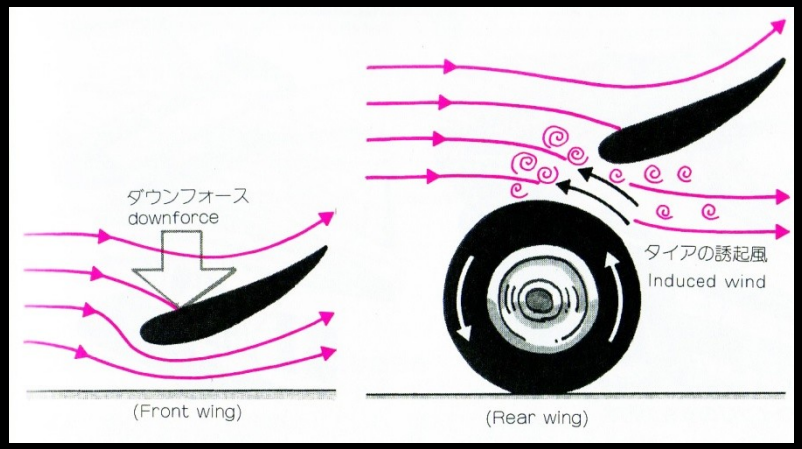
- Tyrrell 019: high-nosed „jet fighter”

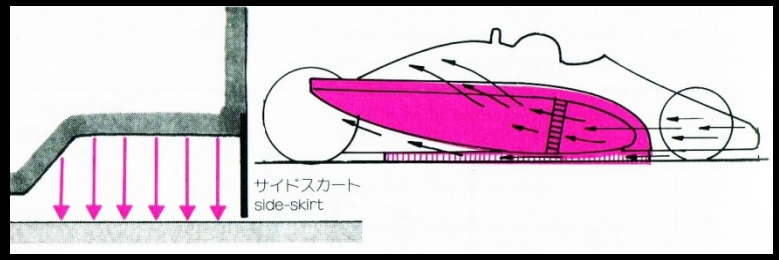


- more air under the car
- undisturbed flow over the wing

Parts of the car - wings

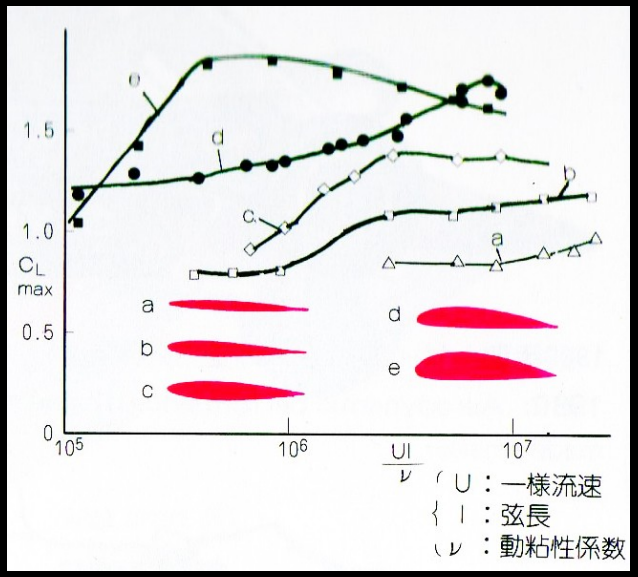
- Use of wings to produce downward acting force: front, rear and the sides (side pod)

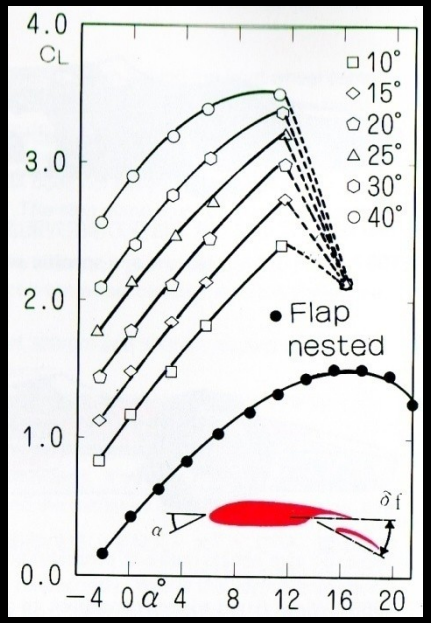


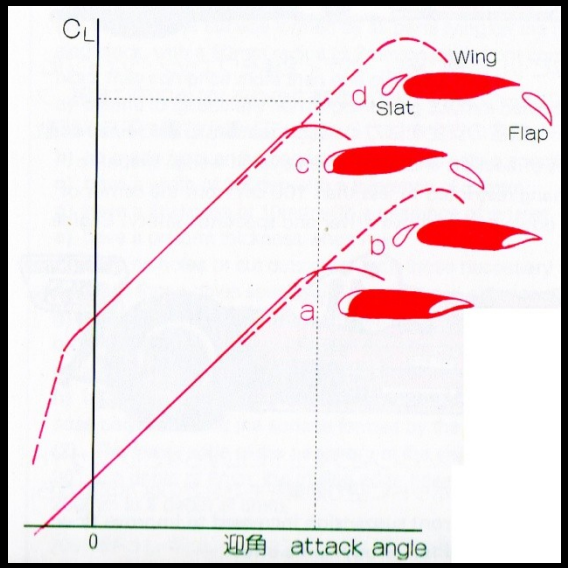


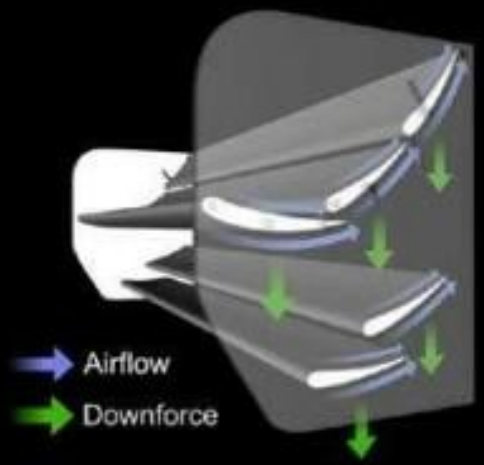
- Important when installing:
  - placement: at front – distance from road; rear – distance from car body and wheels
  - angle: optimal angle to produce large negative lift; no separation
  - wing profile: shape, width, camber are important; slats & flaps
  - end-plates: reduction of wing tip vortices

Parts of the car - wings

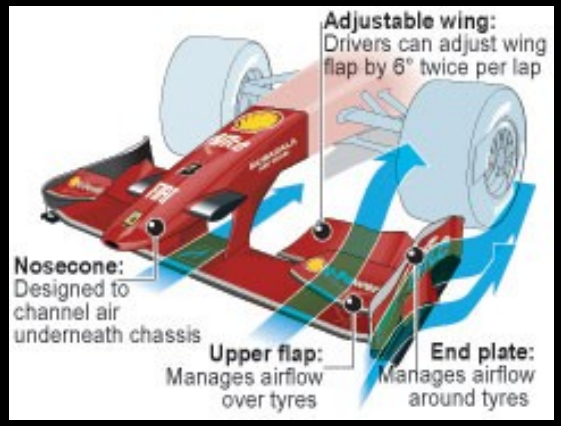


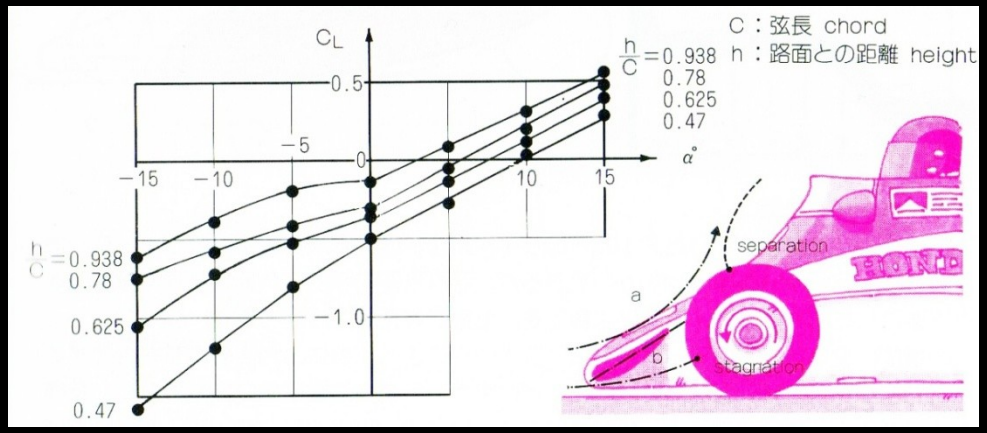


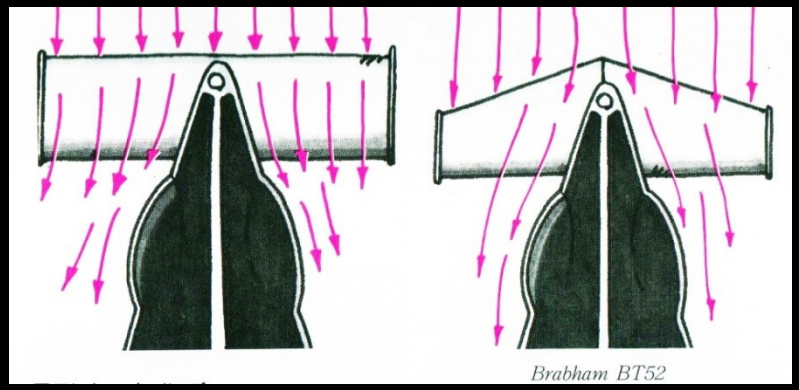


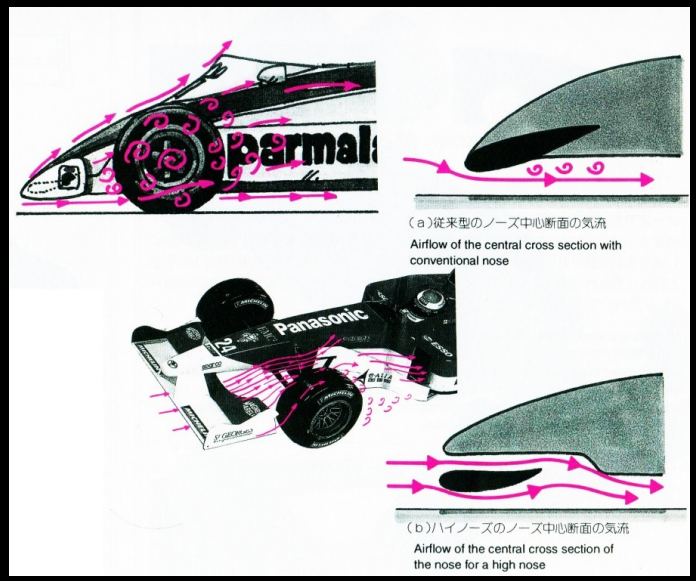


Parts of the car – front wing

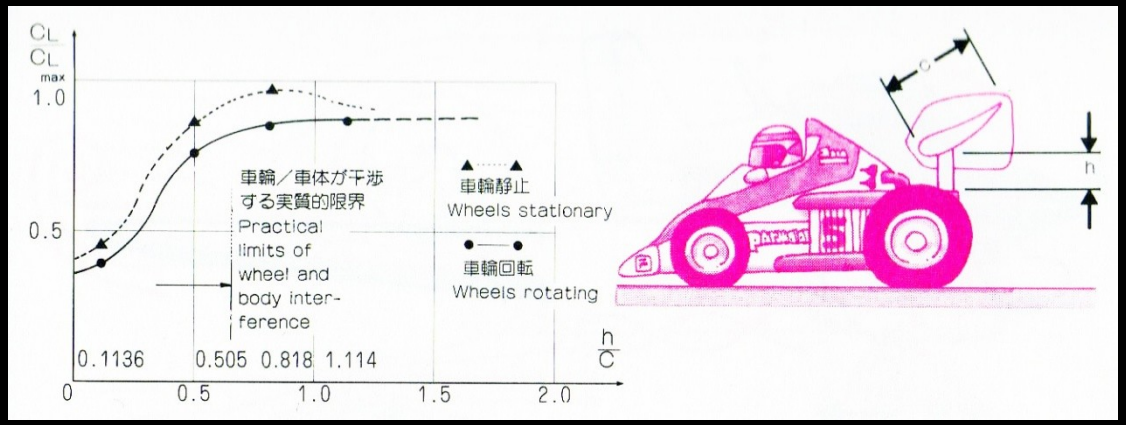


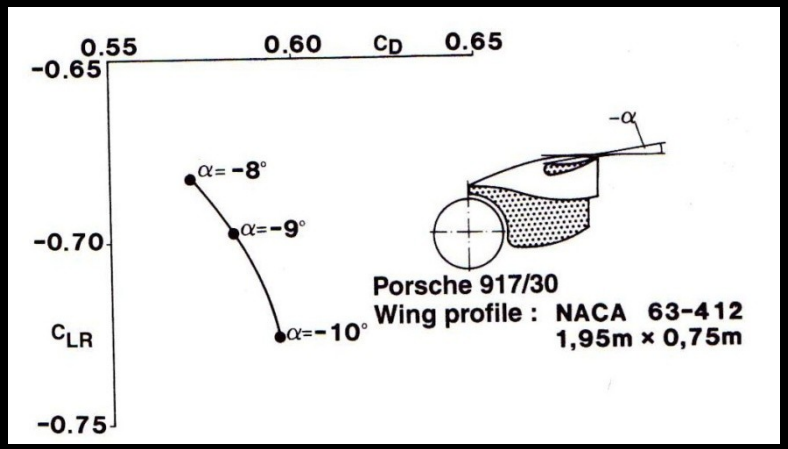


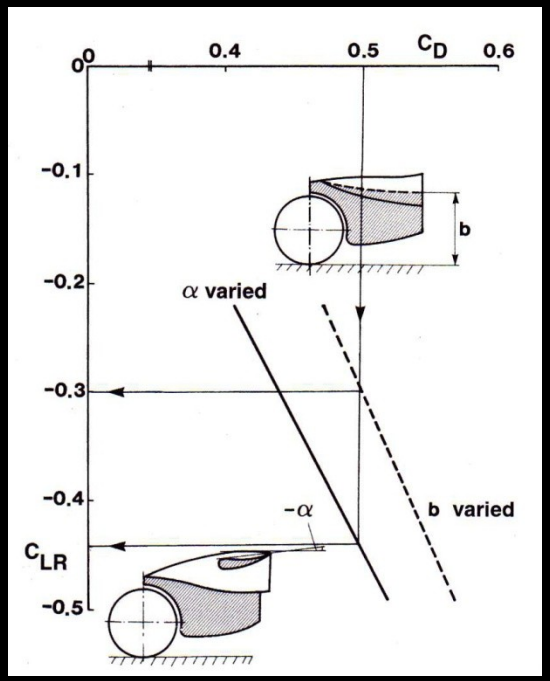




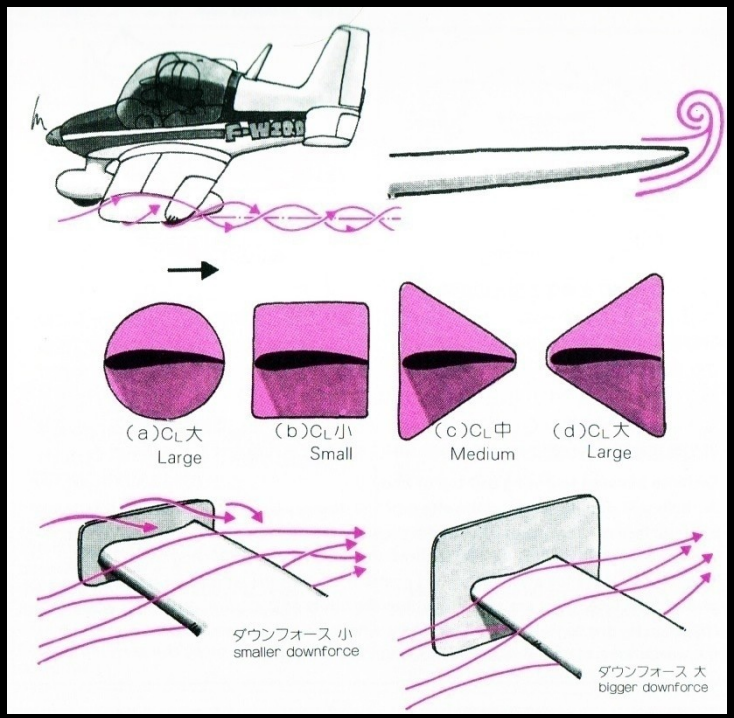
Parts of the car – rear wing

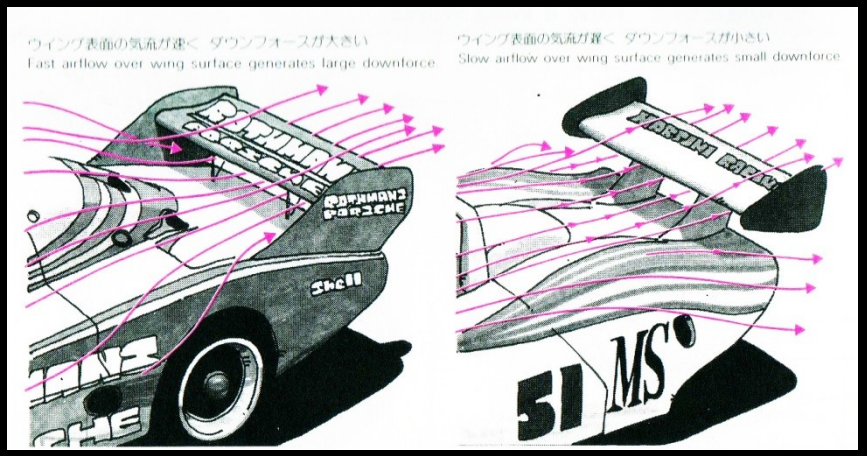


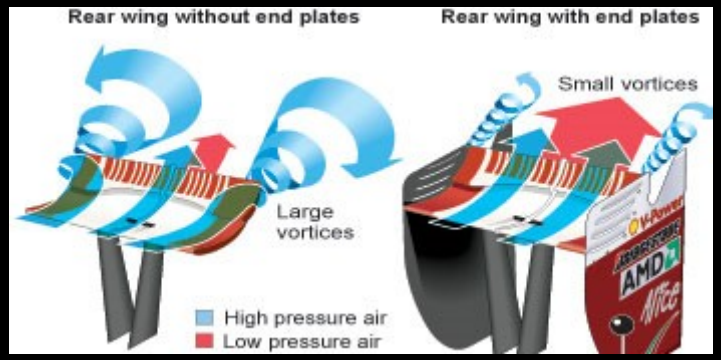




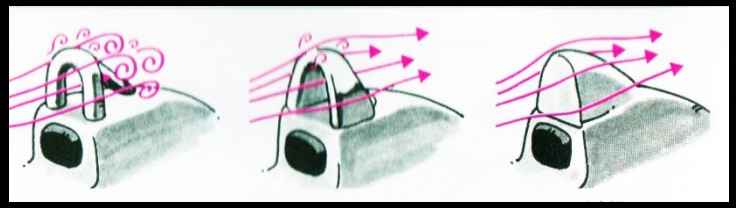
Parts of the car – rear wing

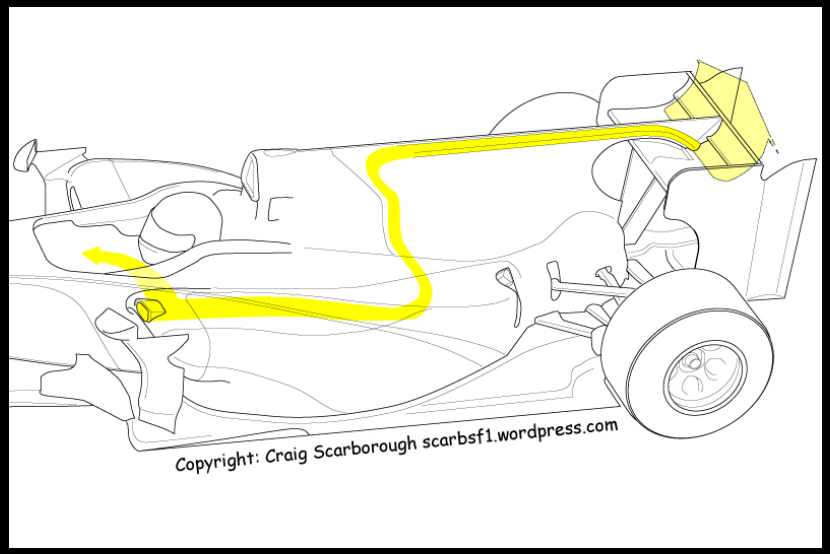


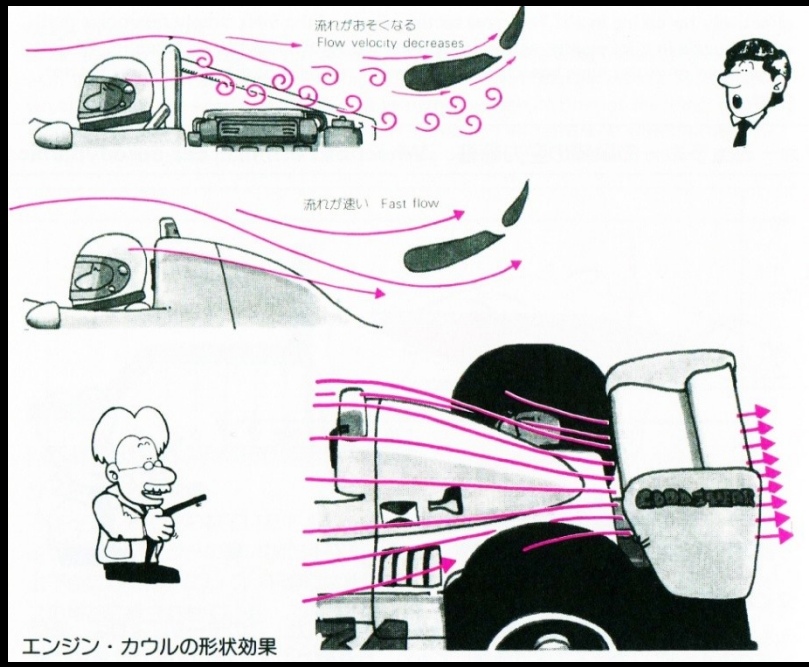




Parts of the car – rear wing



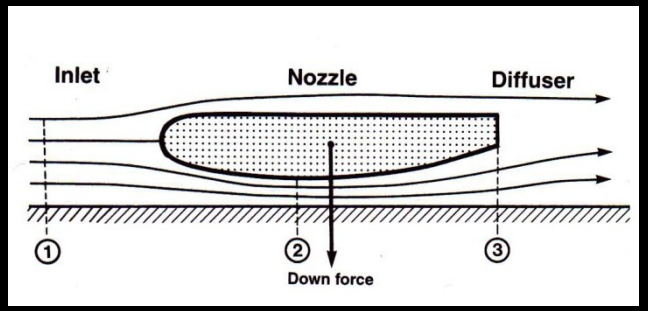


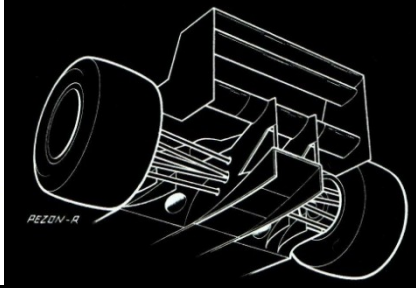


http://www.youtube.com/watch?v=3OjK1FlcsLQ

Parts of the car – underbody (chassis)

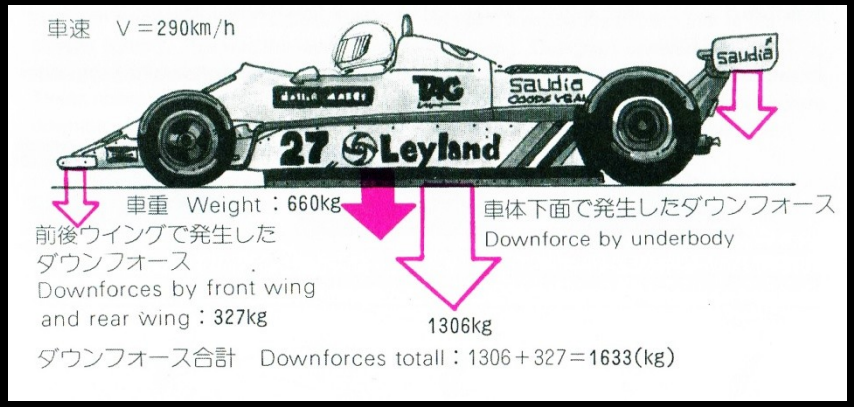
- Special shape of the underbody: ground effect by diffuser (Venturi duct)
  - area ratio
  - angle (BL separation)
  - flowrate

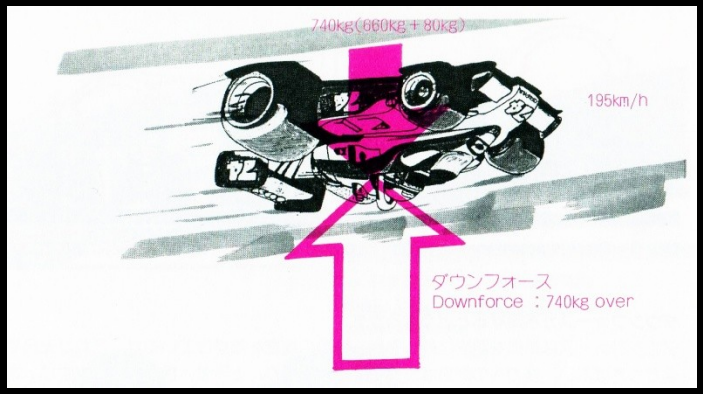




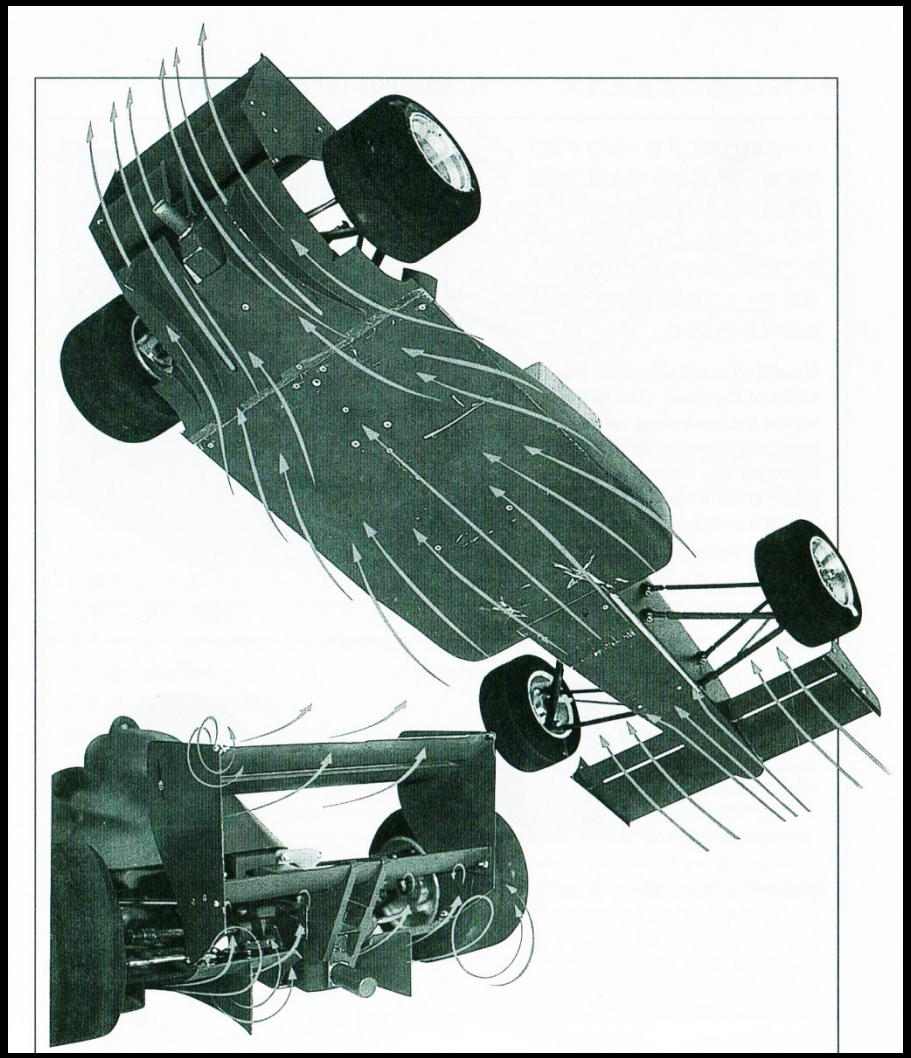
- Ground effect up to 80% of total downforce

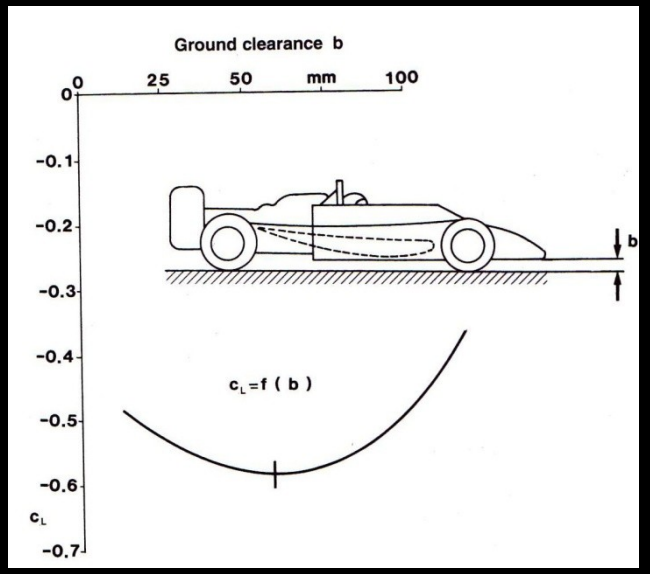
- Cl = -2.6; 16kN downforce, while weight of the car is only 6.5kN – can drive on the ceiling

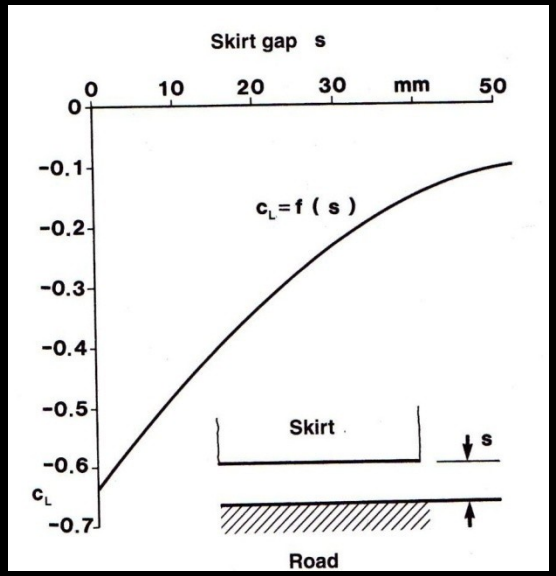




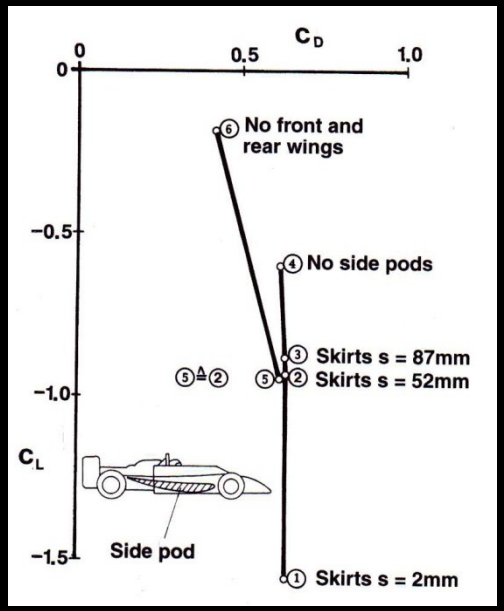
Parts of the car – underbody (chassis)

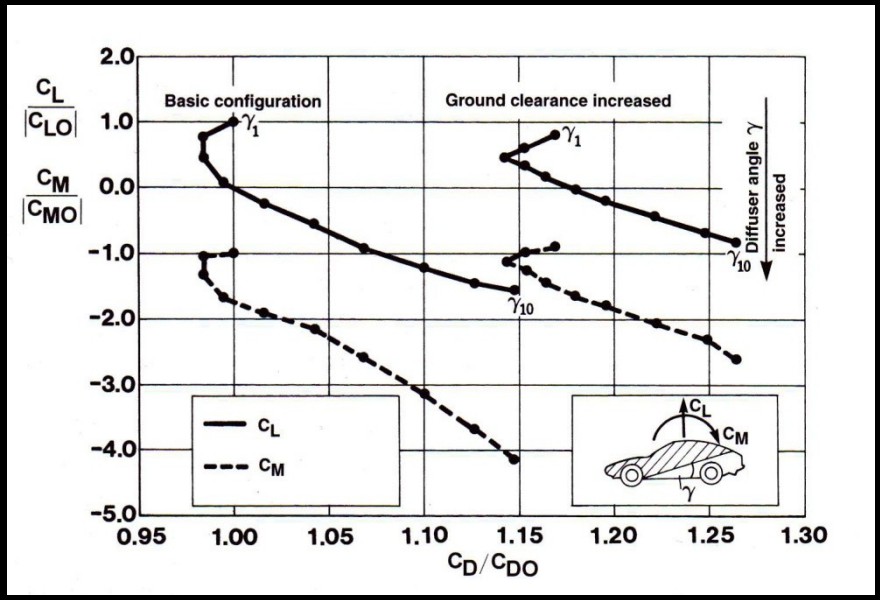


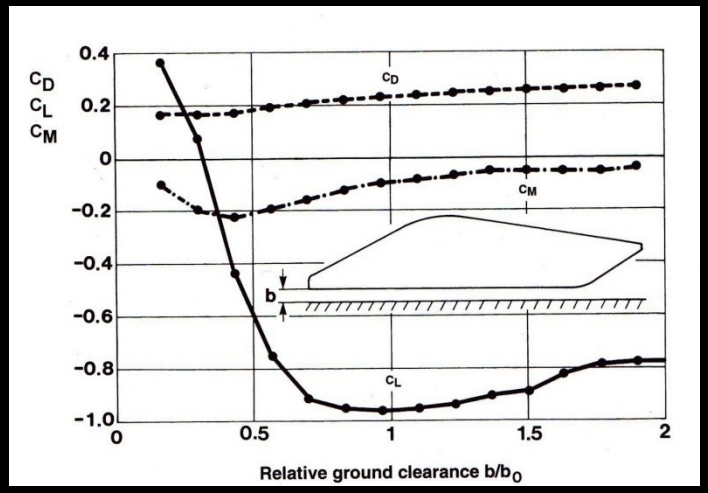


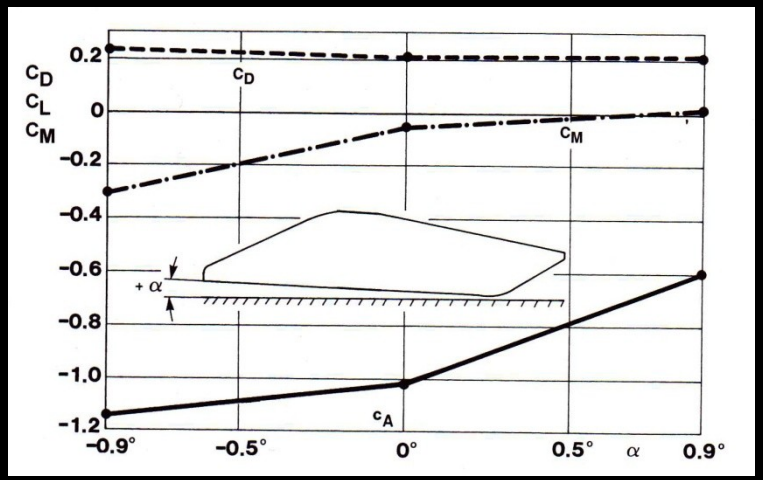


Parts of the car – underbody (chassis)



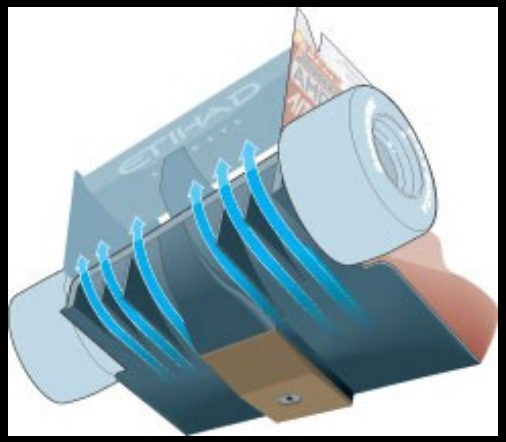


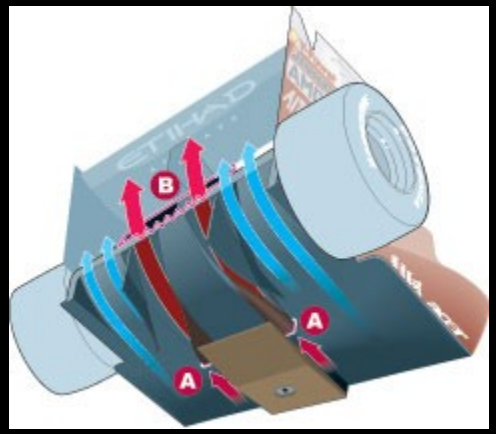




Parts of the car – underbody; double diffuser

- Not straightforward what it is:
  - divided diffuser
  - diffuser with increased flowrate
  - both





http://www.youtube.com/watch?v=xd4remhWoJ8

Small tricks