AERODYNAMICS AND CFD AT VOLVO CAR CORPORATION

KTH April 2012

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Volvo Car Corporation

AGENDA

- **BACKGROUND** ..... CFD group, Organization, Basic aerodynamics definitions
- **INFLUENCE OF AERODYNAMICS** ..... Why is aerodynamics important? Review, Challenges facing Aerodynamics
- **DEVELOPMENT PROCESS** ..... Process overview
- **DRIVe PROJECT** ..... Aerodynamics development of C30 DRIVe
- **FACILITIES** ..... Test techniques and methods

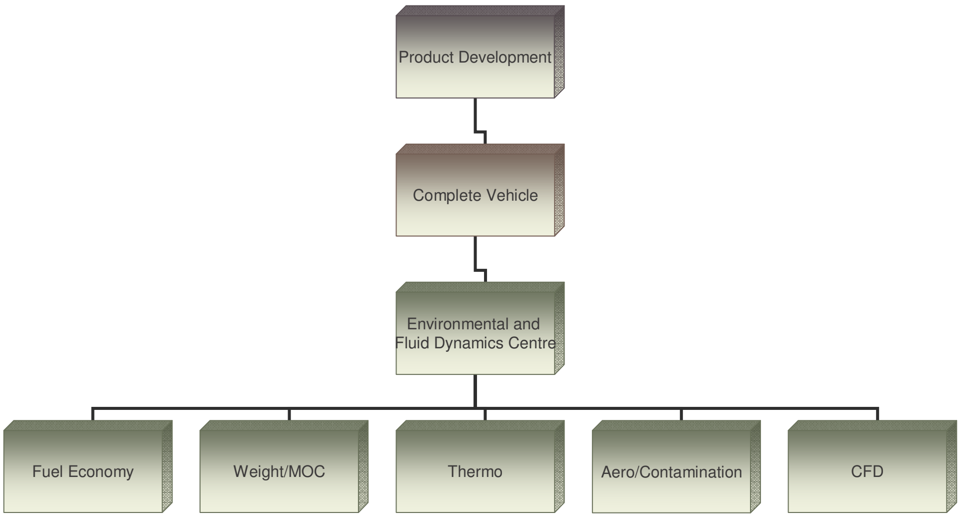
Graduated from KTH 2005

Scania AB 2005-2006

Volvo Cars 2006-

Present at the CFD group: 19 employees

VCC Environmental & Fluid Dynamics Centre



Aerodynamics definitions

$$D = \tfrac{1}{2} \times \rho \times v^2 \times Cd \times A$$

D is the force of drag, which is by defention the force component in the direction of the flow velocity

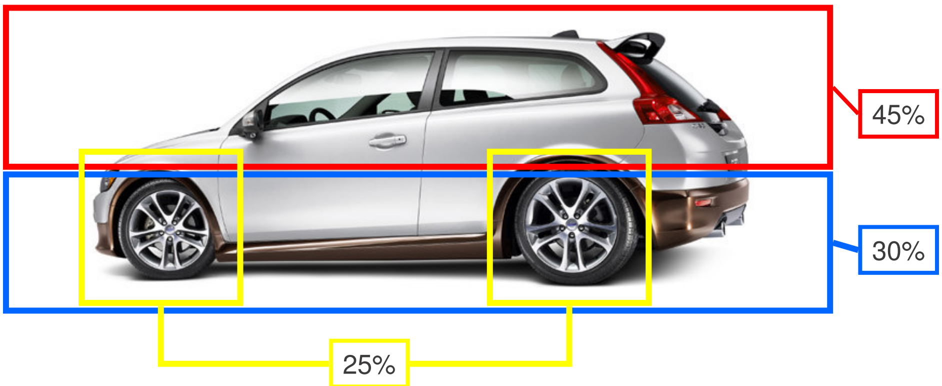
- ρ is the mass density of the fluid
- v is the velocity of the object relative to the fluid
- A is the frontal area
- Cd is the dimensionless drag coefficient, related to the object´s shape

INFLUENCE OF AERODYNAMICS

- Drag (fuel consumption, top speed, acceleration)
- High-speed stability (lift)
- Cross-wind stability (side force and yawing moment)
- Passenger comfort (cabriolets)
- Cooling Performance
- Dirt deposition (visibility)
- Aero acoustics (limiting the strength of sources)
- Body deformation (Door frames etc)

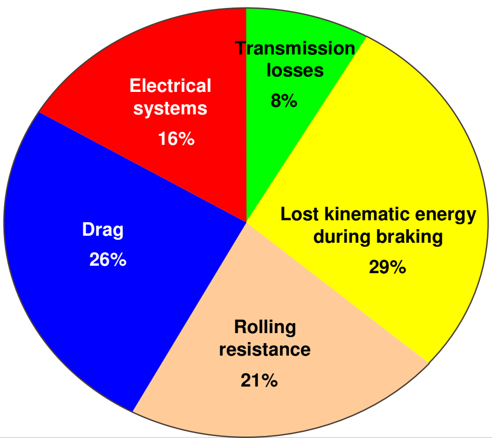
INFLUENCE OF AERODYNAMICS

Sources of drag on a modern car



INFLUENCE OF AERODYNAMICS

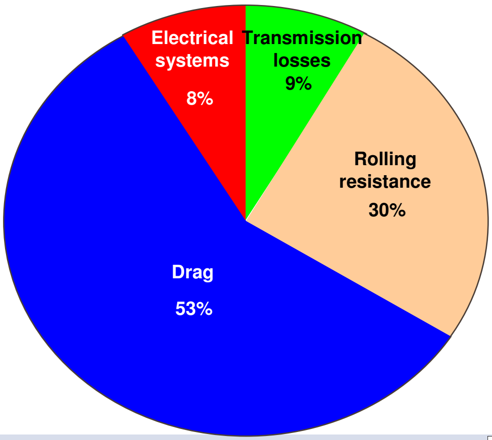
Aerodynamics part of total fuel consumption



”EU Combined cycle” NEDC
(Note! Average speed ≈33km/h)

INFLUENCE OF AERODYNAMICS

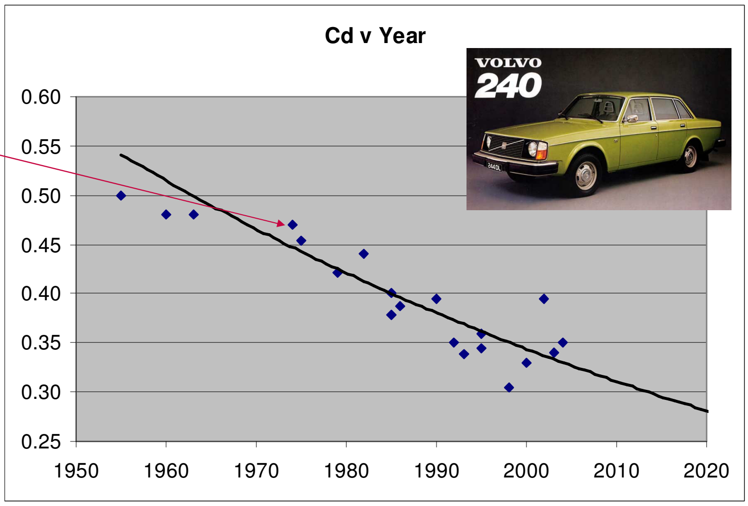
Aerodynamics part of total fuel consumption



Constant speed 90 km/h

INFLUENCE OF AERODYNAMICS

	Year	Cd
PV 544	1955	0,50
Amazon	1960	0,48
P1800	1963	0,48
P1800ES	1968	0,61
240	1974	0,47
245	1975	0,45
343	1979	0,42
760	1982	0,44
765	1985	0,40
960	1990	0,40
854	1992	0,35
855	1993	0,34
S80	1998	0,31
V70	2000	0,33
XC90	2002	0,40
V50	2004	0,35
S40N	2003	0,34
460	1986	0,39
480ES	1985	0,38
S40	1995	0,34
V40	1995	0,36



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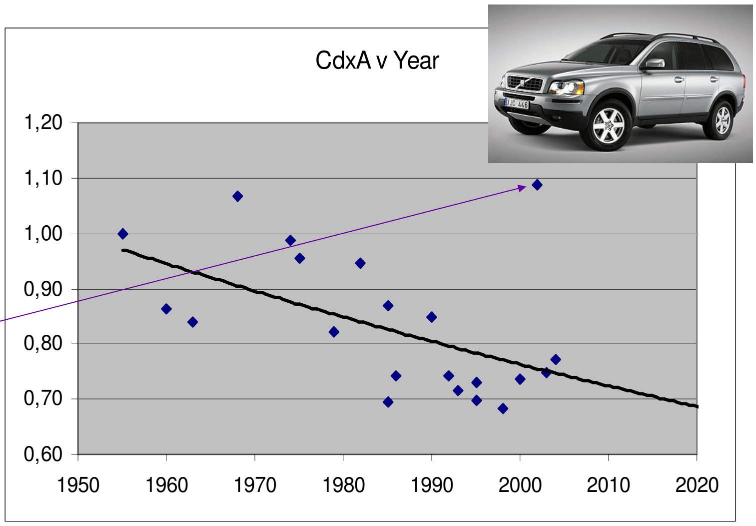

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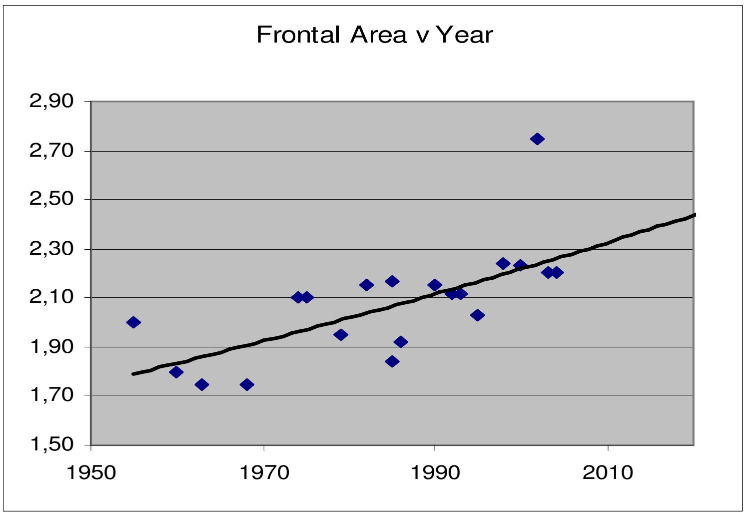


INFLUENCE OF AERODYNAMICS

Challenges facing Aerodynamicists

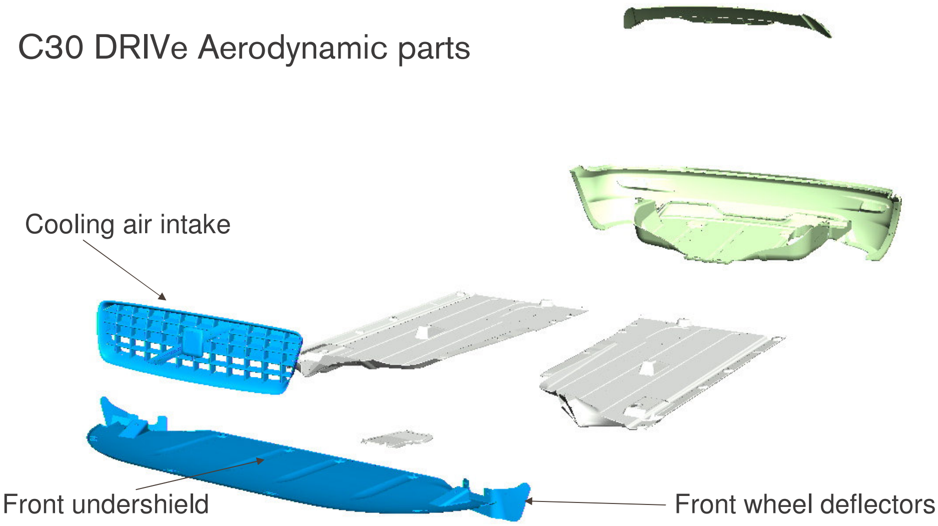
- Styling
- Manufacturing
  - Parts
  - Assembly
- Packaging
- Visbility
- Other attributes (Thermo, dirt, handling, etc)
- ”Carry-over” content
- Cost

DRIVe PROJECT

Aerodynamics on the C30 DRIVe

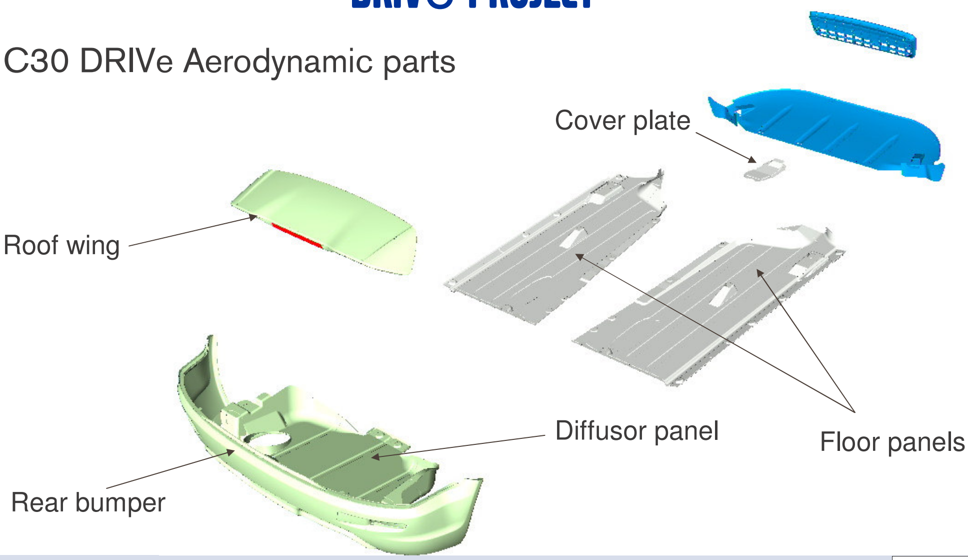
DRIVe PROJECT

C30 DRIVe Aerodynamic parts



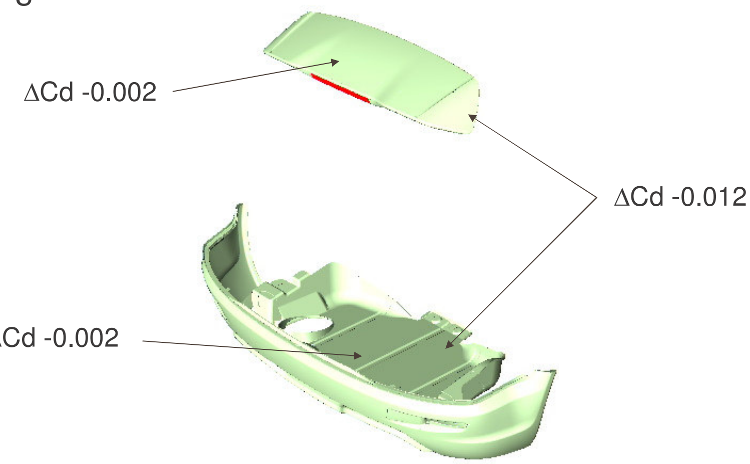
DRIVe PROJECT

C30 DRIVe Aerodynamic parts



DRIVe PROJECT

C30 DRIVe Drag reduction



DRIVe PROJECT

C30 DRIVe Aerodynamic parts

- Special wheels - Libra
  ΔCd -0.005 (compared to steel rims)
- Lowered chassis
  ΔCd -0.005

Aerodynamic drag reduced more than 10% compared to standard car

Fuel consumption reduced by:

- 0,12 l/100km or 3g CO_2/km (EU Combined)
  - (this corresponds to an equivalent weight reduction of approx. 80kg)
- 0,3 l/100km @ constant 90km/h

FACILITIES

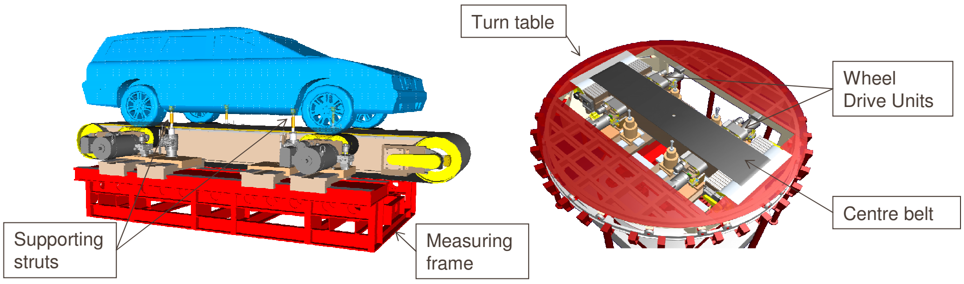
In-house testing in three wind tunnels, Gothenburg

PVT	MWT	Climatic
Test section 27m^2 (6.6mx4.1m , length 15.8m) Max speed 250 kph Temp. +20 to 60° C Chassi dyn. load 150 kW Sun sim. max 1200 W/m^2	1:5 scale of PVT Test section 1.1m^2 Max. speed 200 kph	Test section/nozzle 11.2m^2 Max. speed 200 kph Temp range -40 to +50° C Chassi dyn. load 280 kW Sun sim. max 1200 W/m^2

FACILITIES

Balance measurements

- Effect of configuration changes on aero coefficients
- Sensitivity to flow angle, vehicle attitude and wind speed



FACILITIES

Why Moving Ground is Neccessary

- Provides correct relative movement between the car body and tunnel floor
- Provides correct relative movement between the car body and wheels

Influences flow under and around the car

FACILITIES

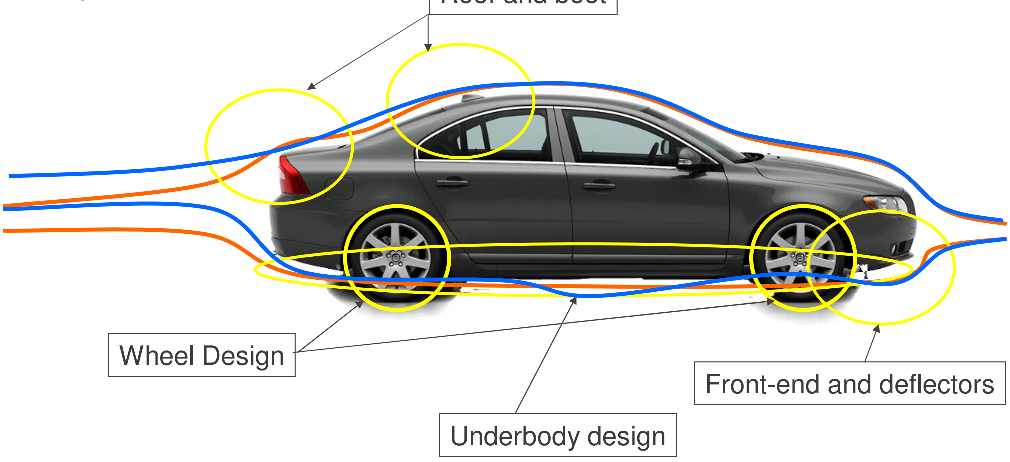
Stationary Floor and Wheels

FACILITIES

Moving ground and rotating wheels

FACILITIES

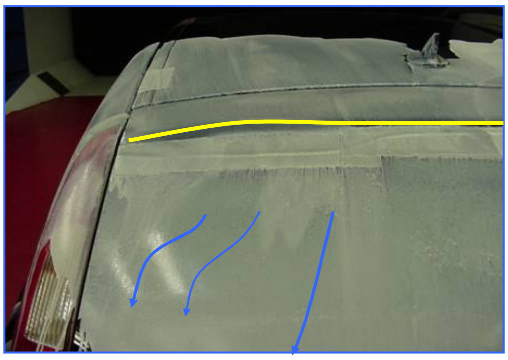
Optimasation affected

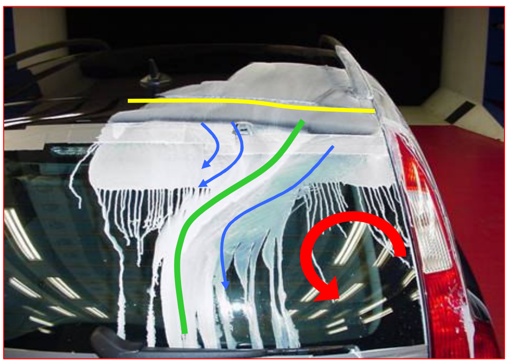


FACILITIES

Increase the knowledge gained from aerodynamic testing

- Flow visualization (smoke, surface paint, tufts)

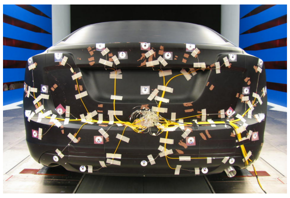


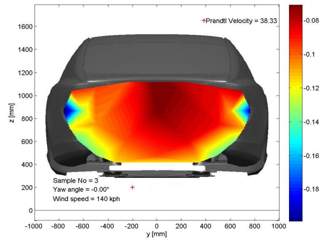


FACILITIES

Increase the knowledge gained from aerodynamic testing

- Preasure measurements





FACILITIES

Increase the knowledge gained from aerodynamic testing

- Wake measurements

$$D = \iint (P_1 + \rho U_1^2 - P_2 - \rho U_2^2) dydz$$

Seven-hole probe rake

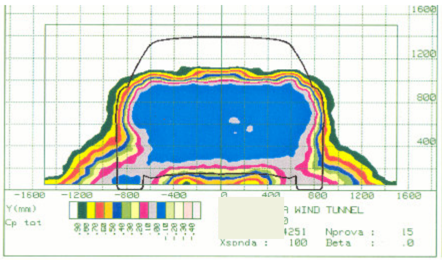
Floor traverse

FACILITIES

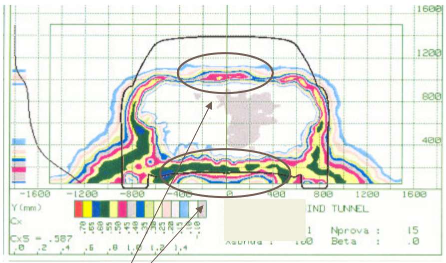
Increase the knowledge gained from aerodynamic testing

- Wake measurements 100 mm downstream base

Total pressure



Microdrag



Identify regions that can be improved

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