

Experimental Methods in Vehicle Aerodynamics



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Outline

- Introduction
- Vehicle aerodynamics for trucks
- Wind tunnels for automotive testing
- Ground simulation
- Testing & analysis



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Historical evolution



$C_d \approx 1.2$ (driver dependant)?



$C_d \approx 0.25$



$C_d \approx 0.6$



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Scania products



Long-haulage, Construction & Distribution



Ind. & marine engines



City buses



Bus chassis, intercity and tourist



Vehicle aerodynamics for trucks

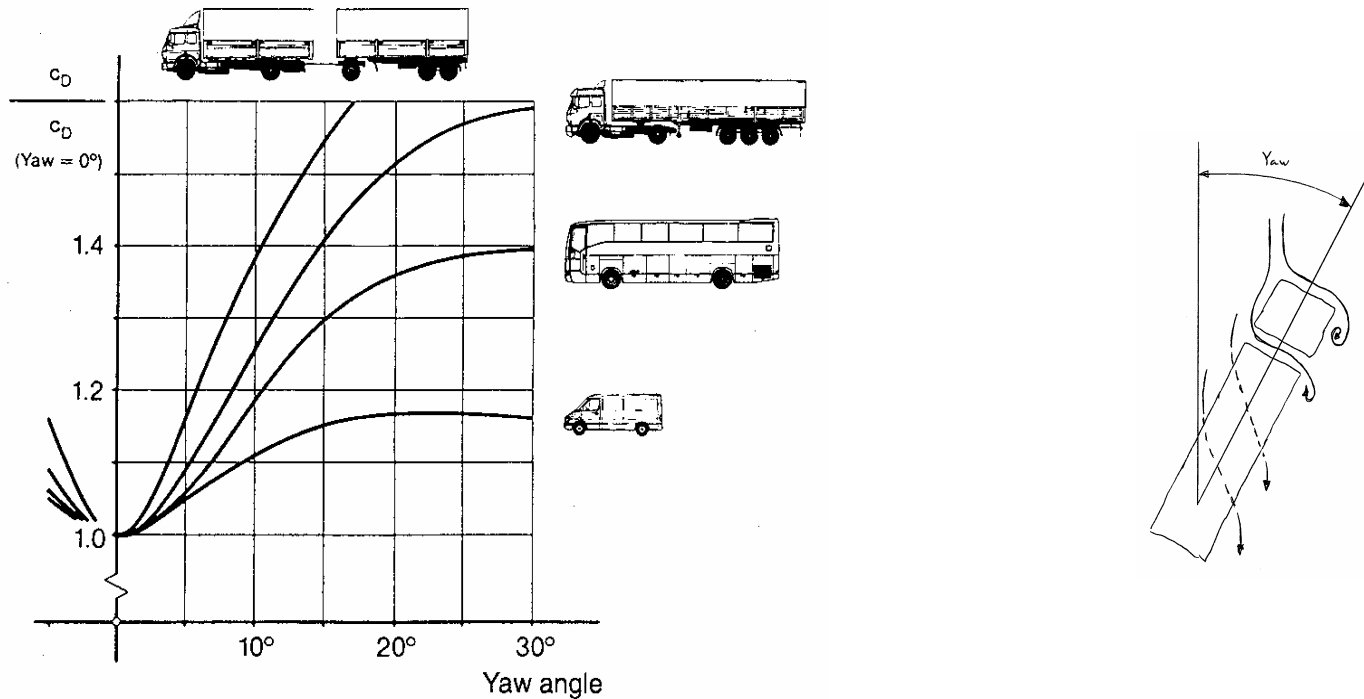
- **Aerodynamic drag**
- Aerodynamic lift is not of great weight
 - $\Delta C_L=0.05$ at 80 kph $\Leftrightarrow \Delta L=150$ N



- Crosswind stability is of low importance for trucks (in general)
- Vehicle soiling is an important field

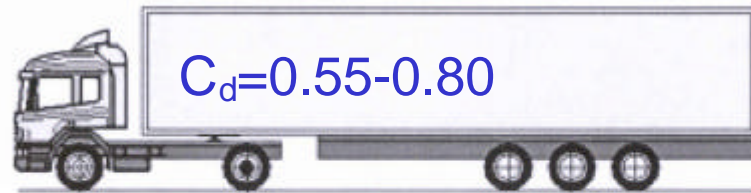
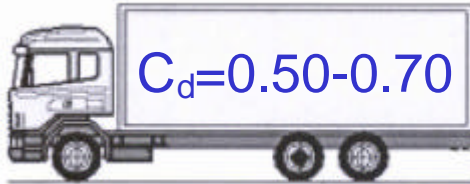


Wind-averaged drag



- Necessary to take account of crosswind influence on drag
- Yaw dependance relates to gap between truck & trailer

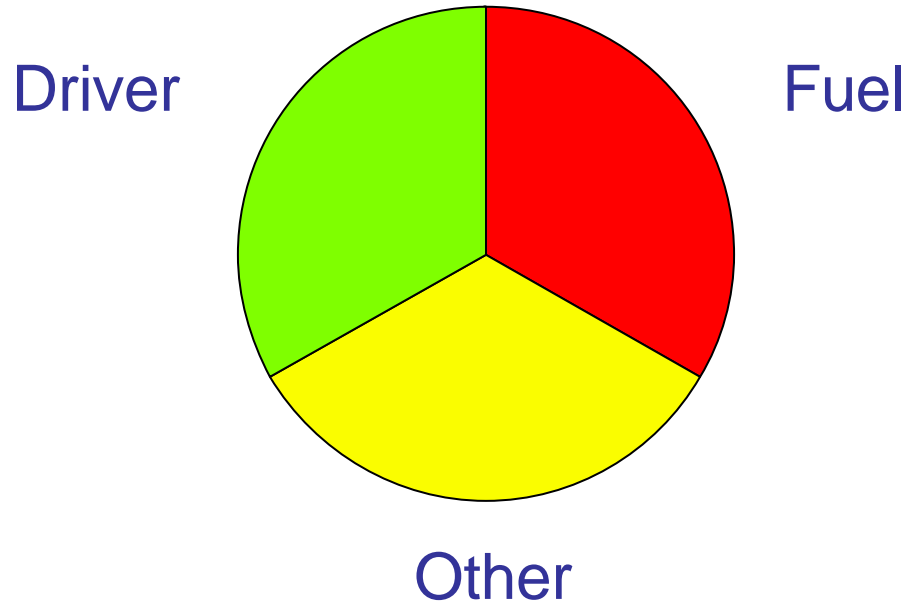
Truck aerodynamics - characteristics



Frontal area: 8 -11.5 m²

Motivation for improved aerodynamics

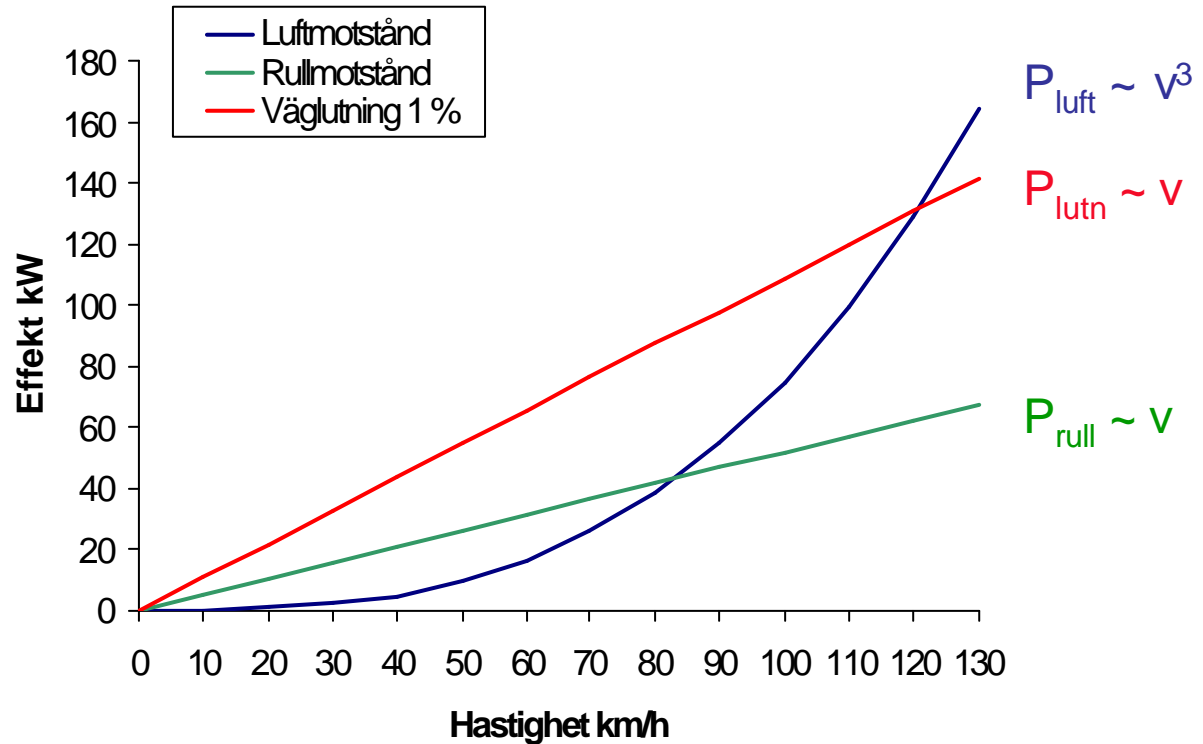
Costs for a truck in long-haulage operation



The fuel cost is approx. 1/3 of the operational cost

Motivation for improved aerodynamics

Driving resistance:



Truck and semitrailer (40t, 80kph) on a flat road:

- $\Delta C_d = -0,020 \Leftrightarrow 1\%$ Fuel Economy improvement



Fluid Mechanics

- New group (founded January 2003)
- Staff (2004):
 - Manager
 - Aerodynamicist (mainly EFD)
 - 2 CFD Engineers dedicated to aerodynamics
 - 2 CFD Engineers (climate comfort, underhood simulations & general flow analysis)
 - 2 Industrial PhD students (1 CFD and 1 EFD)
- Plan to expand further (aero-acoustic simulations, vehicle soiling)



Experimental aerodynamics at Scania

FROM:

- Full scale development and verification tests at stationary ground conditions
- Development tests with 1:2 scale



TO:

- Full scale development and verification tests at stationary ground conditions
- Development testing of 1:6 scale models with moving ground and rotating wheels
- 1:2 models for limited test purposes



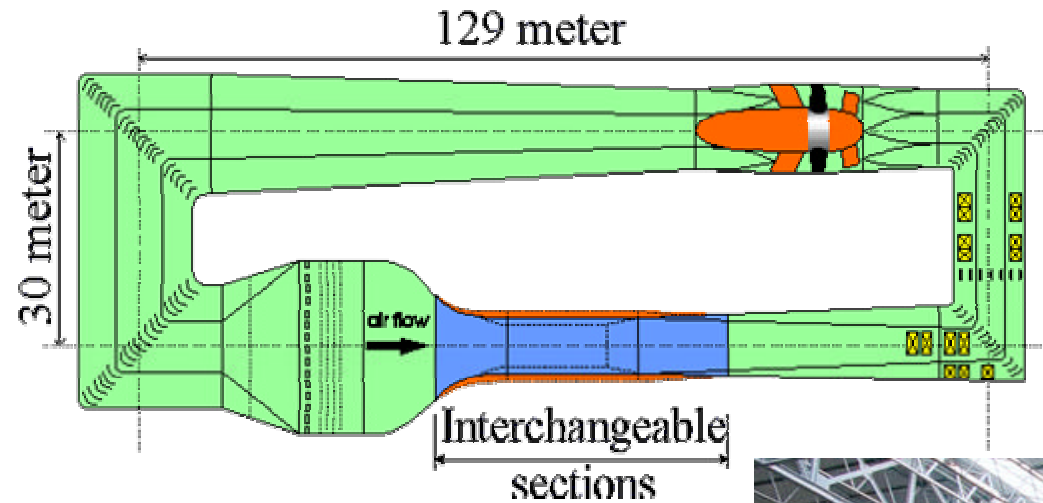
Full scale testing

- Balance measurements (drag, side force & yawing moment)
- Pressure measurements
- Flow visualizations
- Aero-acoustic measurements
- Truck or tractor & semitrailer (non-articulated)

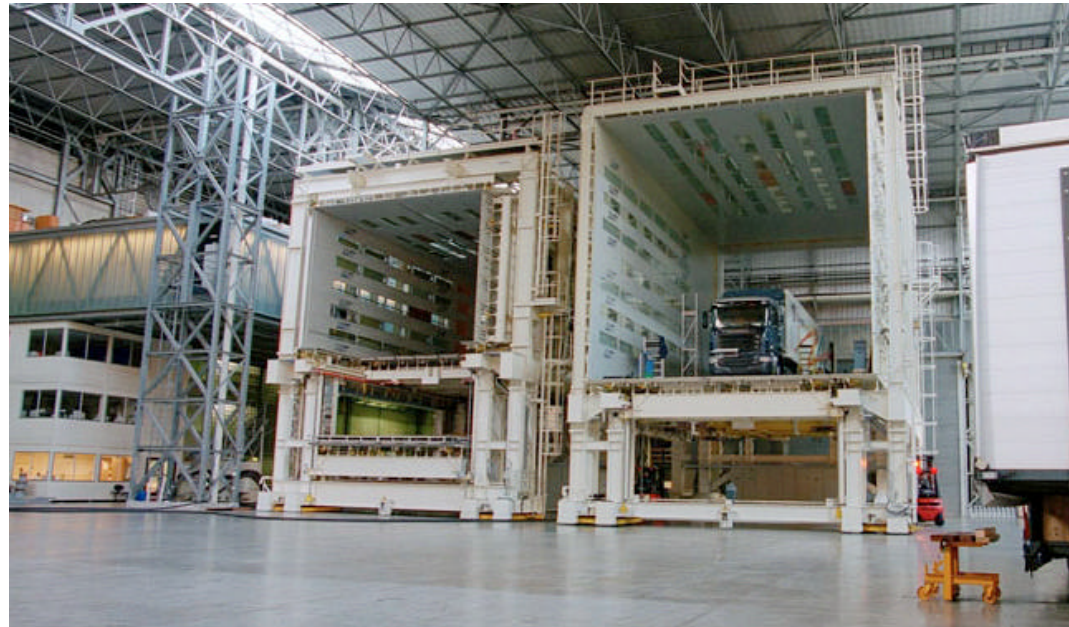


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DNW Wind tunnel

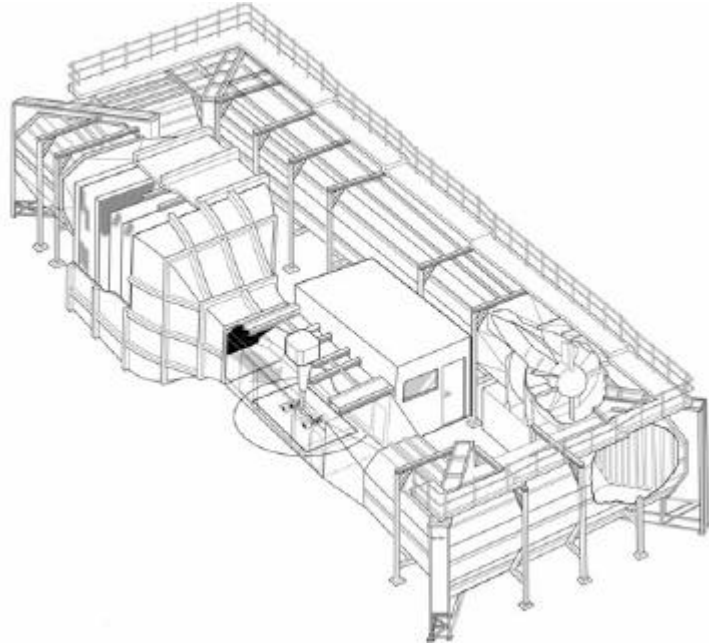


Test vehicle installed in the
9.5 x 9.5 m² test section



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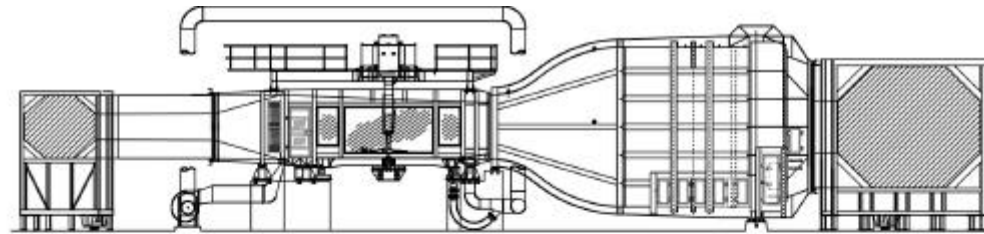
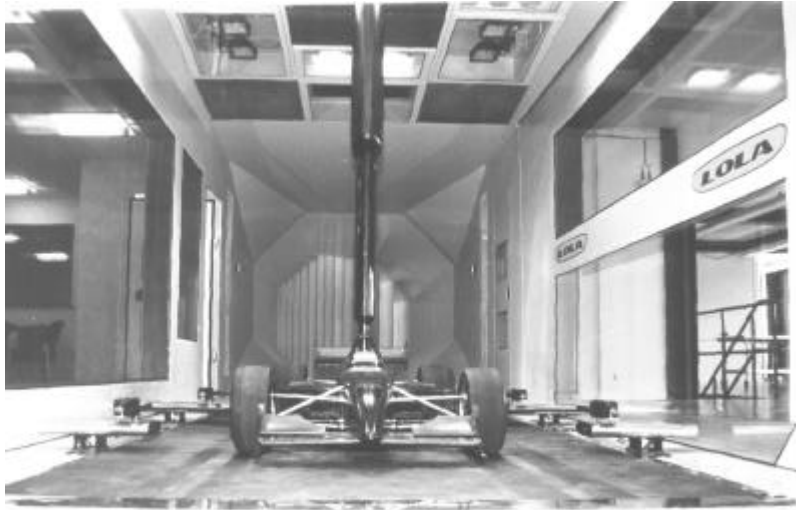
1:6 scale model testing



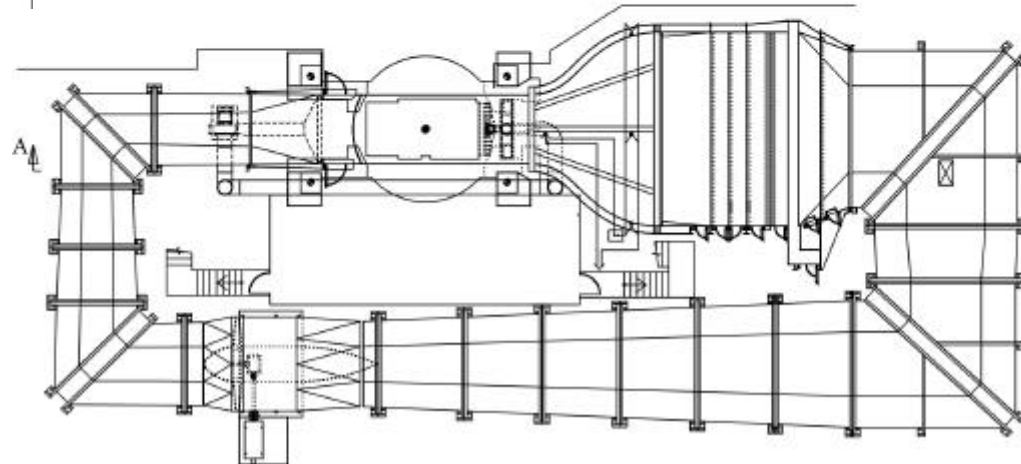
- Moving belt and rotating wheels
- Testing at Lola Cars, UK
- Tractor & semitrailer model with high level of detailing
 - Cooling air-flow and underhood simulation
 - Almost complete representation of chassis parts
 - Model made from aluminium/steel spine, foam blocks, STL and carbon fibre parts



Lola Cars Wind tunnel



Section A-A



1:2 scale model testing

- Both stationary ground & moving belt
- Testing at different facilities



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Main development areas

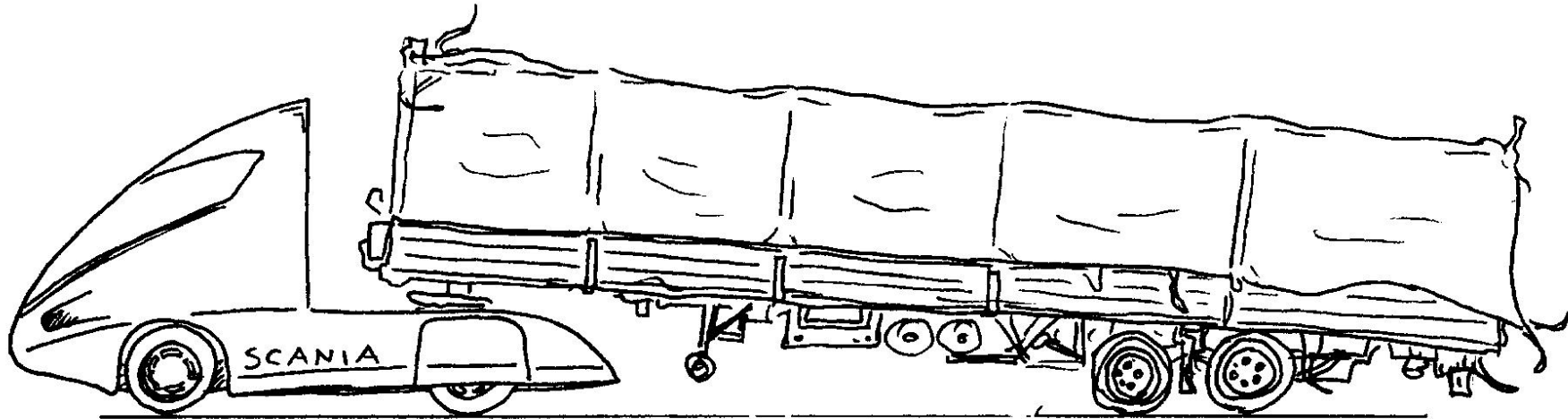
- Cab shape
- Cab details
 - Air deflectors
 - Sun visor, Rear view mirrors
- Chassi details
 - Side skirts
 - Wheel deflectors, floorpanels



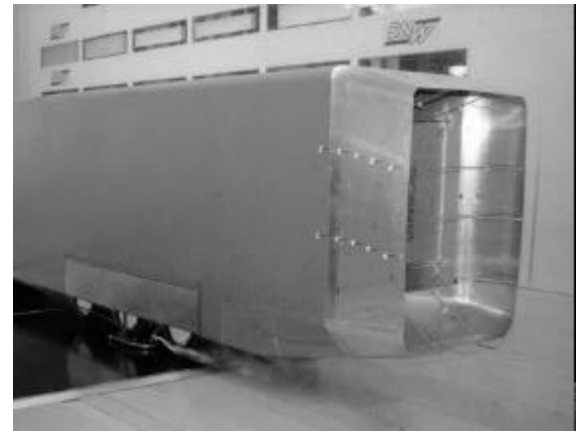
Scania's unique modular product system makes the design work a true challenge!



The whole vehicle must be considered



- Trailer modifications have large potential ($\Delta C_d \approx 0.25$)
 - Side skirts, chassis covers
 - Boat-tail, rear end diffuser

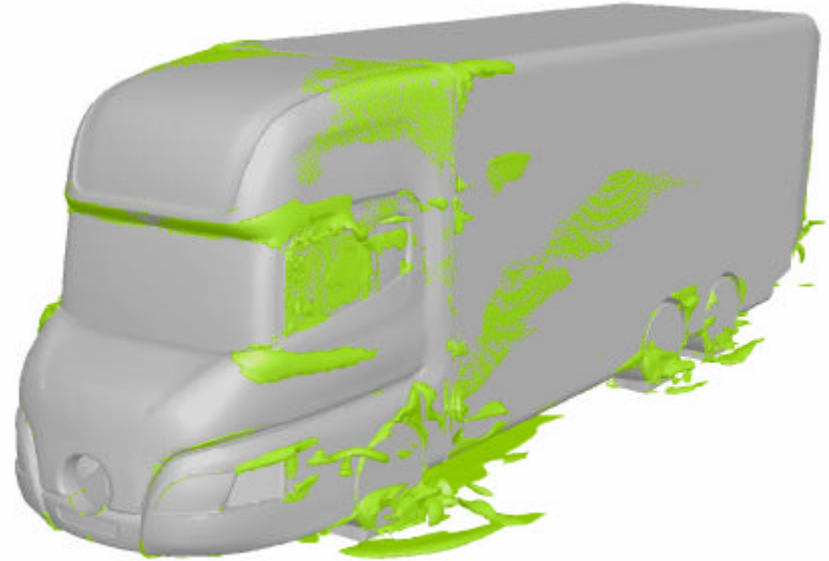


Example – Concept truck

Testing at DNW



CFD



- Wind tunnel testing during development
- Recent CFD simulations
 - Gain knowledge of external CFD
 - Boat-tail studies



Example – Concept truck



$C_d < 0.25$

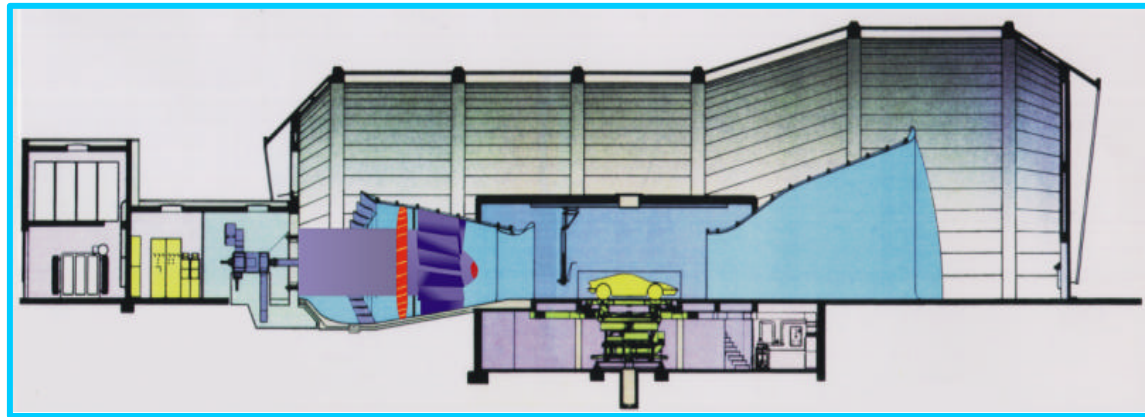


$C_d \sim 0.3$



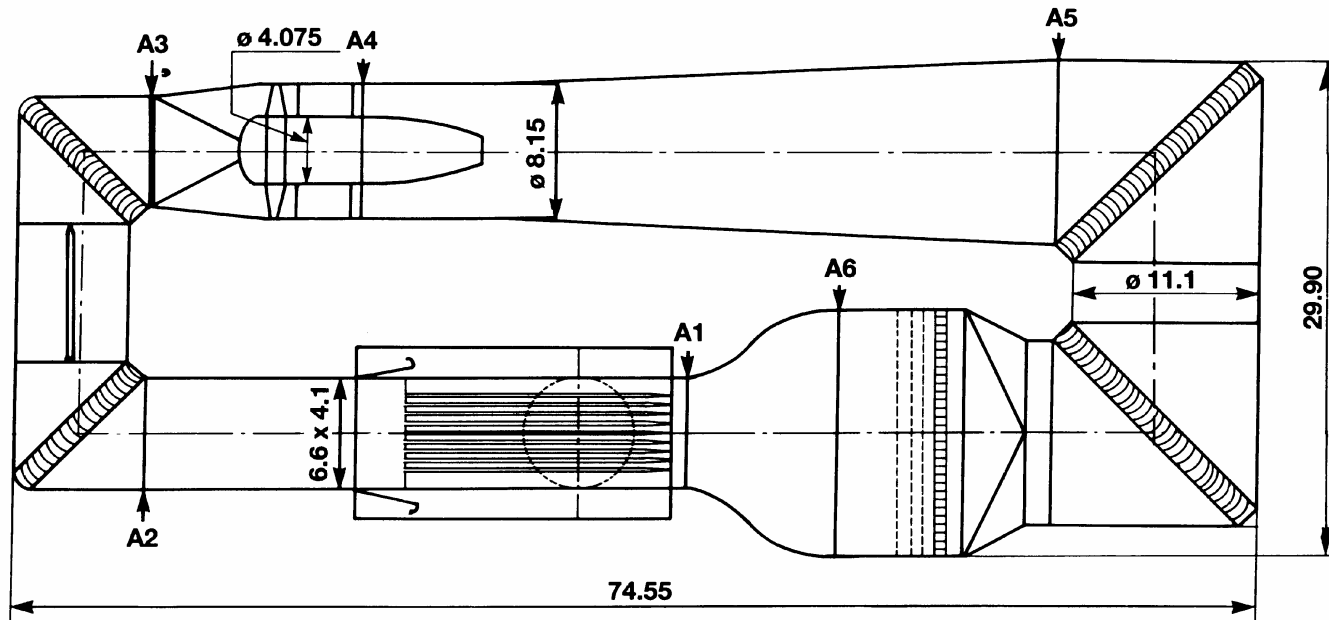
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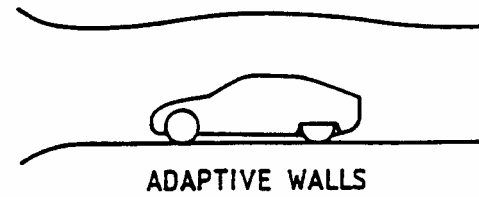
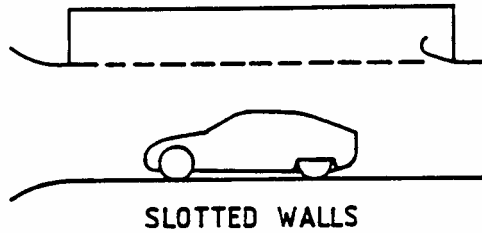
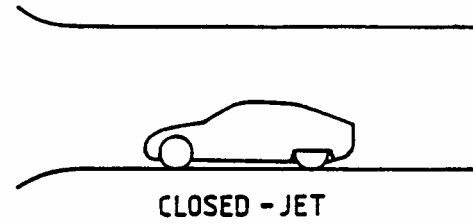
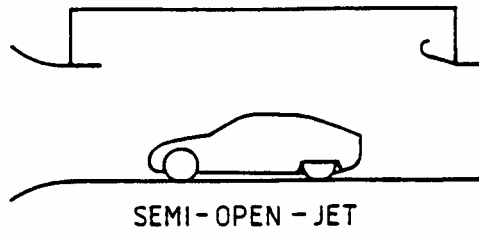
Performance of automotive wind tunnels



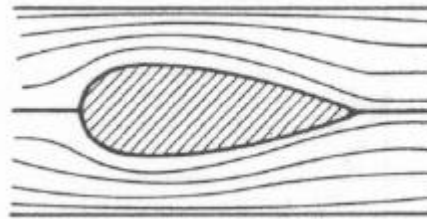
- Maximum wind speed: 140 – 270 km/h
- Test section (area): 10 - 40 m²
- Fan power: 0.6 - 4 MW



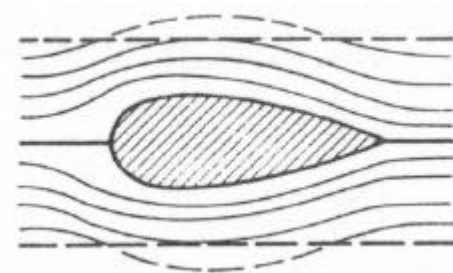
Test section types



Effect of lateral boundaries



Closed TS



Open TS



Multi-purpose wind tunnels



- Provides additional test functionality:
 - Soiling (dirt deposition) tests
 - Climate comfort
 - Thermodynamics & cooling performance tests at accurate flow conditions

