

# DRAG REDUCTION ON A PRODUCTION VEHICLE

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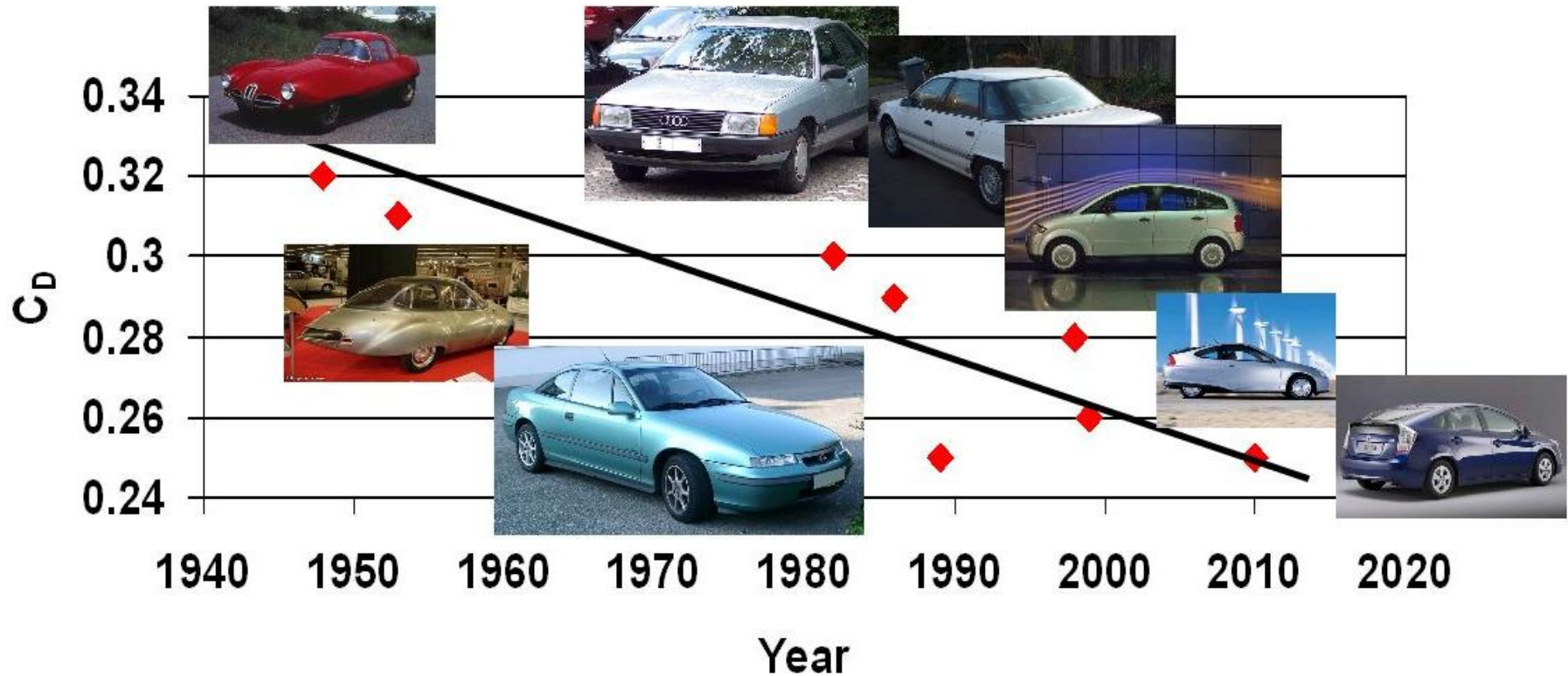
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# CONTENTS

- $C_D$  trends in Automotive industry
- Major contributors to drag
- Inputs to Full Scale Testing
- Audi A2
- How Drag was reduced

# PRODUCTION CAR DRAG LEVELS

## Production car examples



Trendline  
through data

# MAJOR CONTRIBUTORS TO DRAG

Base Pressures – Low pressure region at the rear of the car

Wheels and wheel arches – Up to 30% of cars total  $C_D$

Cooling – Air passing through cooling components

Underfloor – “Rough” exposed car parts in direct contact with airflow



University  
Research

Model Scale  
Tests

Wheel & Wheel  
Arch findings

Full Scale Wind Tunnel  
Tests at Mira

# Audi A2

## Low $C_D$

When measured in the Mira wind tunnel, the Audi A2 showed a Co-efficient of Drag ( $C_D$ ) of 0.288

## Good Basic Aerodynamic shape



The launch vehicle had a  $C_D$  of 0.25



# FULL SCALE TESTING

Full scale tests carried out at Mira in Nuneaton

8m x 4m tunnel

Fixed ground tunnel

Balances in the floor



The next few slides will show how the  $C_D$  of the Audi A2 was reduced from 0.288 to 0.204

# WIND TUNNEL TESTING

## Cooling Drag



## Cooling:

- All vents and intakes closed on front end
- Total Contribution: **9%** of total Drag



# WIND TUNNEL TESTING

## Underfloor Drag



## Underfloor:

- Foamboard and tape
- All components covered
- Total Contribution: **7%** of total Drag

# WIND TUNNEL TESTING

## Door Mirrors



### Mirrors:

- A-Pillar Vortex interaction
- Bluff rear face causes drag
- Total Contribution: **5%** of total Drag

# WIND TUNNEL TESTING

## Wheels and Wheel arches

- Wheel Spoilers
- Wheel Blanking
- Wheel Arch Blanking





# WIND TUNNEL TESTING

## Wheels and Wheel arches

- Underfloor Wheel Arch Blanking



# WIND TUNNEL TESTING

## Base Pressure Recovery

Raising the Base pressure can reduce the Drag



• Box Cavity Version 1



• Box Cavity Version 2

Prior to Box Cavity test, diffuser angle was 7°. Afterwards, optimum was 2°

# WIND TUNNEL TESTING

## Base Pressure Recovery

Raising the Base pressure can reduce the Drag



• Box Cavity Version 3



• Box Cavity Version 4

Prior to Box Cavity test, diffuser angle was 7°. Afterwards, optimum was 2°



# WIND TUNNEL TESTING

## Base Pressure Recovery

Raising the Base pressure can reduce the Drag



• Box Cavity Version 5



• Box Cavity Version 6

Prior to Box Cavity test, diffuser angle was 7°. Afterwards, optimum was 2°

# WIND TUNNEL TESTING

## Base Pressure Recovery

Raising the Base pressure can reduce the Drag



- Box Cavity Final design

Prior to Box Cavity test, diffuser angle was 7°. Afterwards, optimum was 2°

# WIND TUNNEL TESTING

Aerodynamic system created

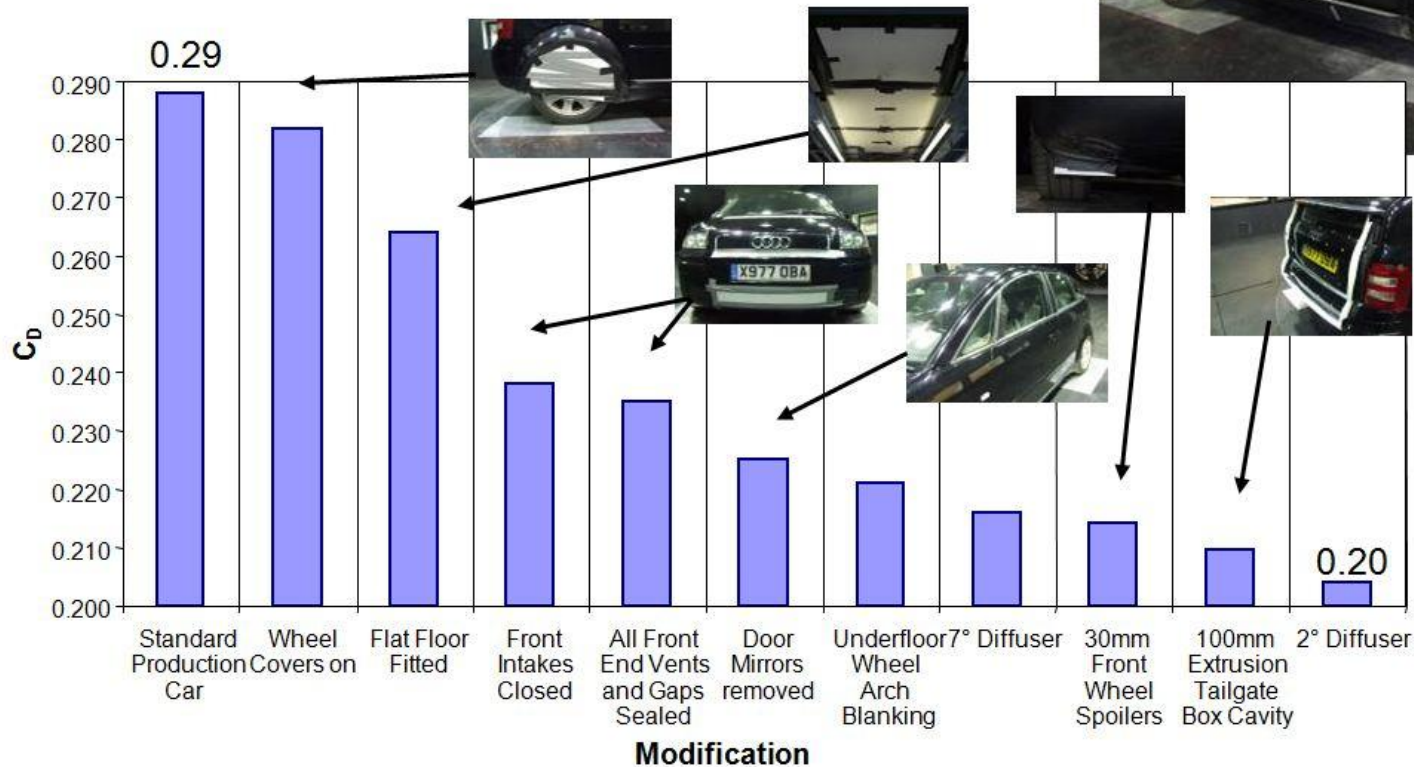
- Diffuser needs a flat floor for maximum efficiency
- 2° Diffuser cant be obtained without the presence of a box Cavity
- Box Cavity needs a diffuser to be present for best results

Interdependencies makes further refinements and drag reductions possible

Other interdependent relationships around the car

# PROGRESS CHART

- Wind tunnel development
- Audi A2 represents low drag tall 1-box shape
- CD reduced from 0.288 to 0.204 (WIP)



# CONCLUSION

## Summary

- Biggest contributors: Base Pressures, Cooling, Wheels & Wheel arches
- 30% reduction in  $C_D$  achieved
- Inputs key to successful Wind Tunnel development

# THANK YOU