Adrian Gaylard
JLR

Integrating simulation and test in automotive aerodynamics

Introduction: Gary Page

INTEGRATING SIMULATION AND TEST IN AUTOMOTIVE AERODYNAMICS

ADRIAN GAYLARD, 02 April 2025

Title: Integrating simulation and test in automotive aerodynamics
Record Owner: agaylar1
Classification: Public

Record Type: TRANSIENT
Date Last Modified: 11 March 2025
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OVERVIEW

Characteristics Of Full-scale Automotive Wind Tunnels

Integrating Test & Simulation

Development Example: Land Rover Defender

Looking Forwards

CHARACTERISTICS OF FULL-SCALE AUTOMOTIVE WIND TUNNELS

CHARACTERISTICS OF A FULL-SCALE AUTOMOTIVE WIND TUNNEL

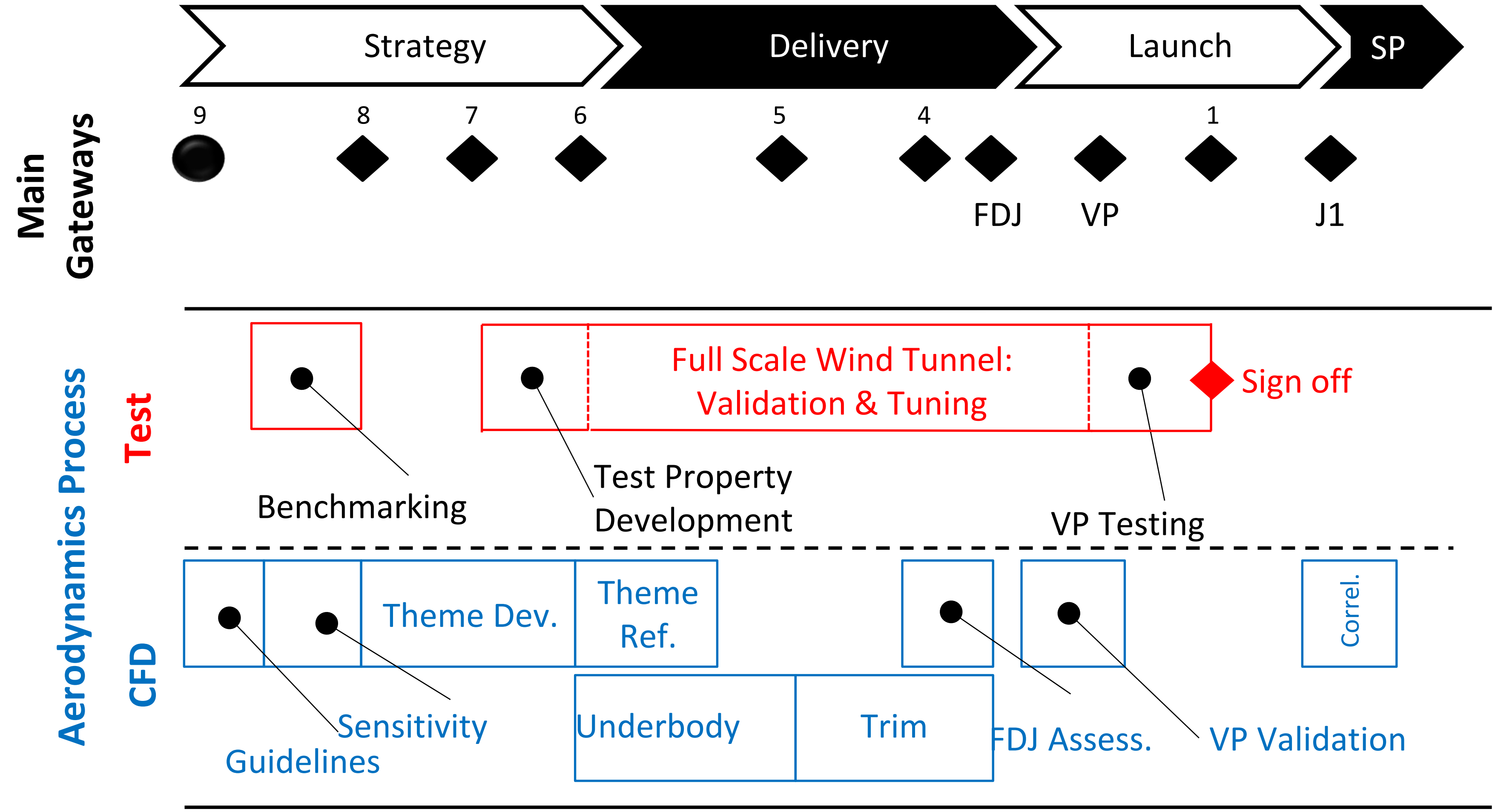
CHARACTERISTICS OF A FULL-SCALE AUTOMOTIVE WIND TUNNEL

.

INTEGRATING TEST & SIMULATION

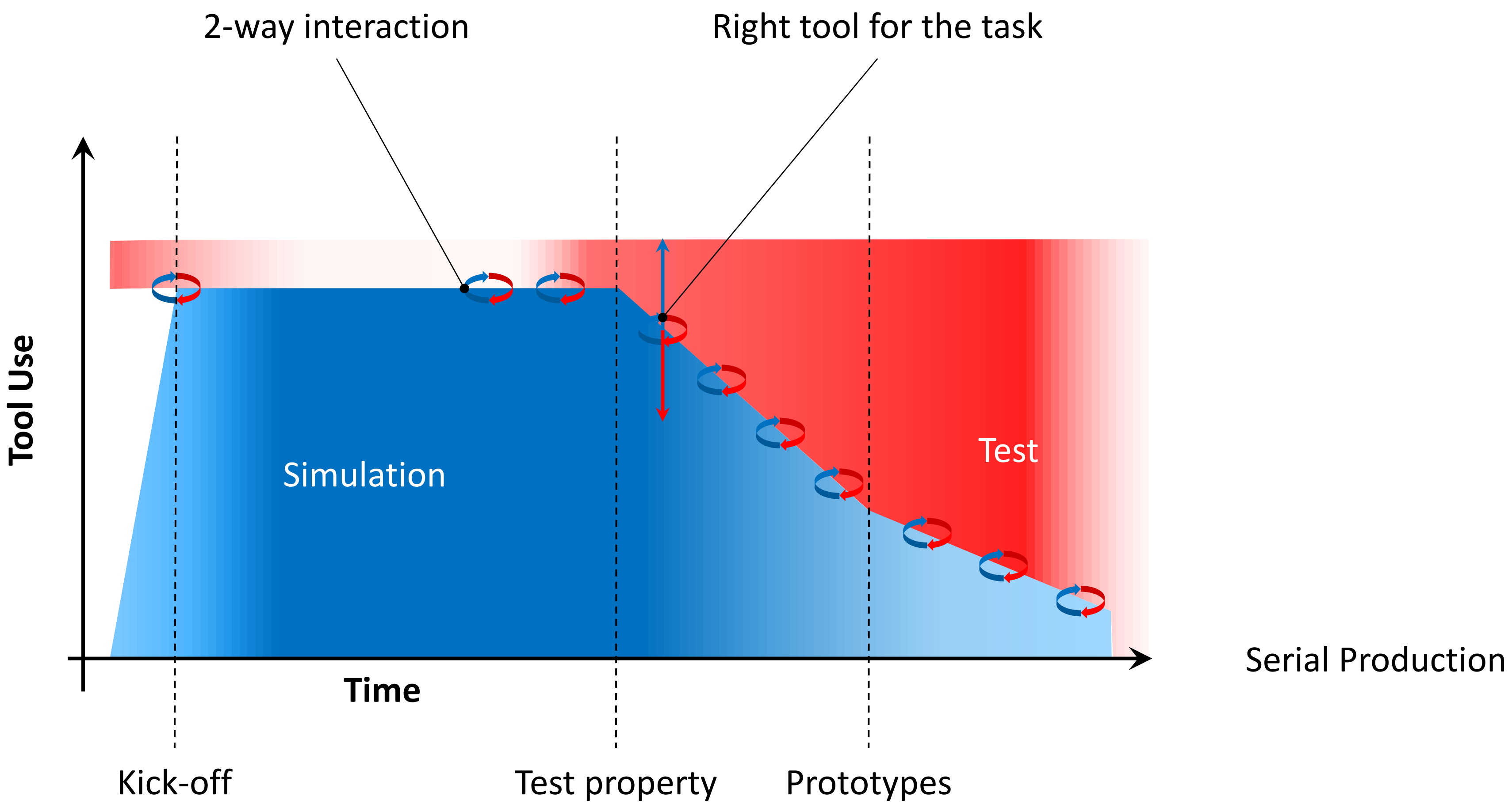
JLR

Parallel "Swim Lane" Model



Gaylard (2019), Eng.D. Thesis, http://wrap.warwick.ac.uk/143065/

Integrated Model



Eliyas, J., & Gaylard, A., "Integrating Simulation and Test to Develop the Aerodynamics of the New Land Rover Defender," SAE Technical Paper 2024-01-2537, 2024, https://doi.org/10.4271/2024-01-2537.

DEVELOPMENT EXAMPLE: LAND ROVER DEFENDER

THE DEVELOPMENT CHALENGES

Redefining the iconic Land Rover Defender while maintaining a strong design identity

Delivering dramatically improved aerodynamic efficiency

Challenging as the original car had drag in the range $0.62 \leq C_D \leq 0.69$

Integrating simulation and test

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TOOLSET: WIND TUNNEL TESTING

Clay demonstrator

Design Engagement

“Aerobuck”

Vehicle Development

Prototype

Final confirmation

Horiba-MIRA Full Scale Wind Tunnel

FKFS Vehicle Aeroacoustics Wind Tunnel

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TOOLSET: FKFS VEHICLE AEROACOUSTICS WIND TUNNEL

Test Section
- ¾ Open Jet
- Moving ground

Nozzle
- 5.8 m (W) x 3.87 m (H)
- Exit area: 22.45 m2

Performance
- Maximum flow velocity 72 m/s

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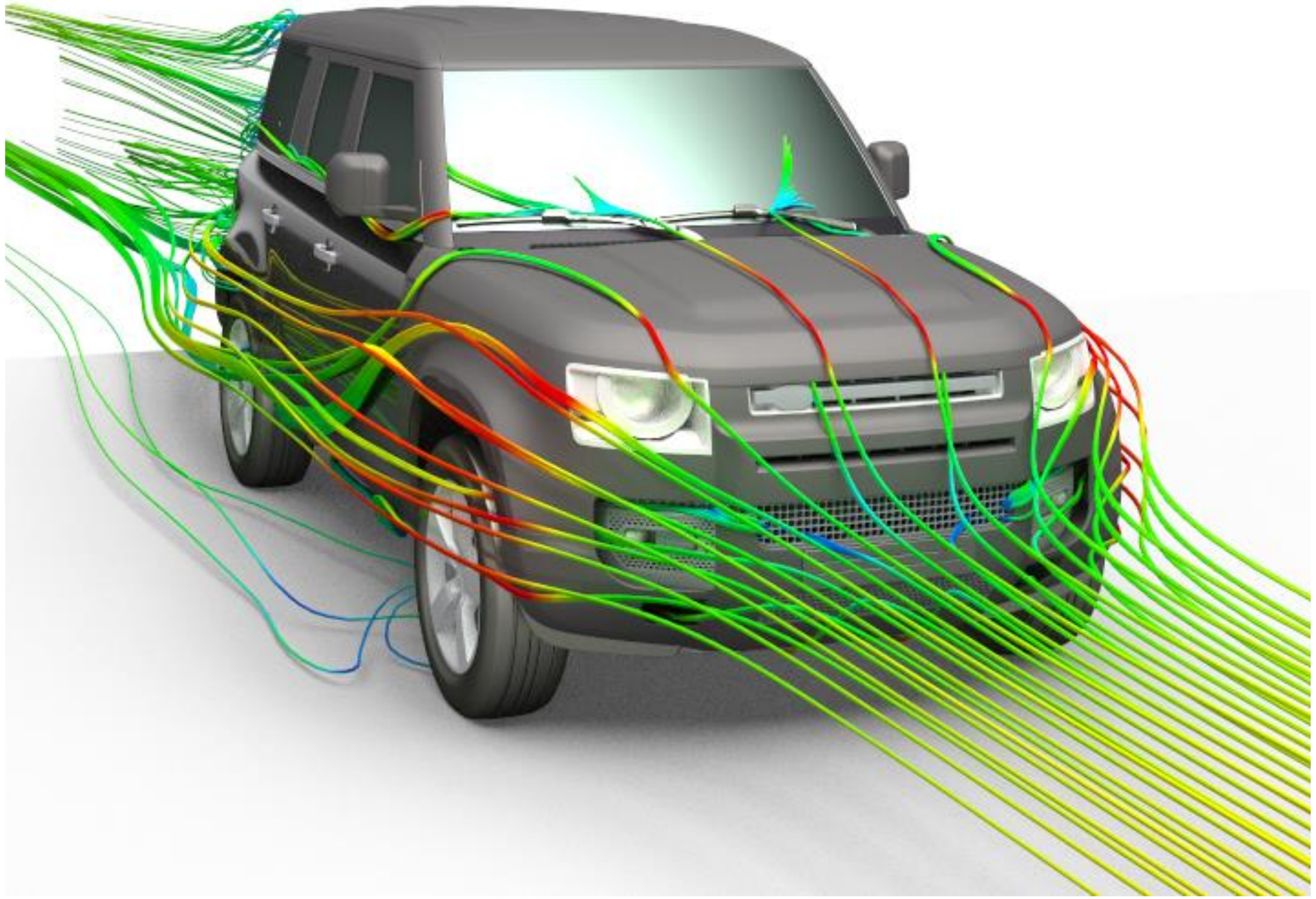
TOOLSET: NUMERICAL SIMULATION

- Lattice Boltzman based VLES solver
- 205×10^6 voxels
- 56×10^6 surfels

- Smallest edge length:1.25 mm

- Timestep: 6.95×10^{-6} s
- Sample: 3.14 s



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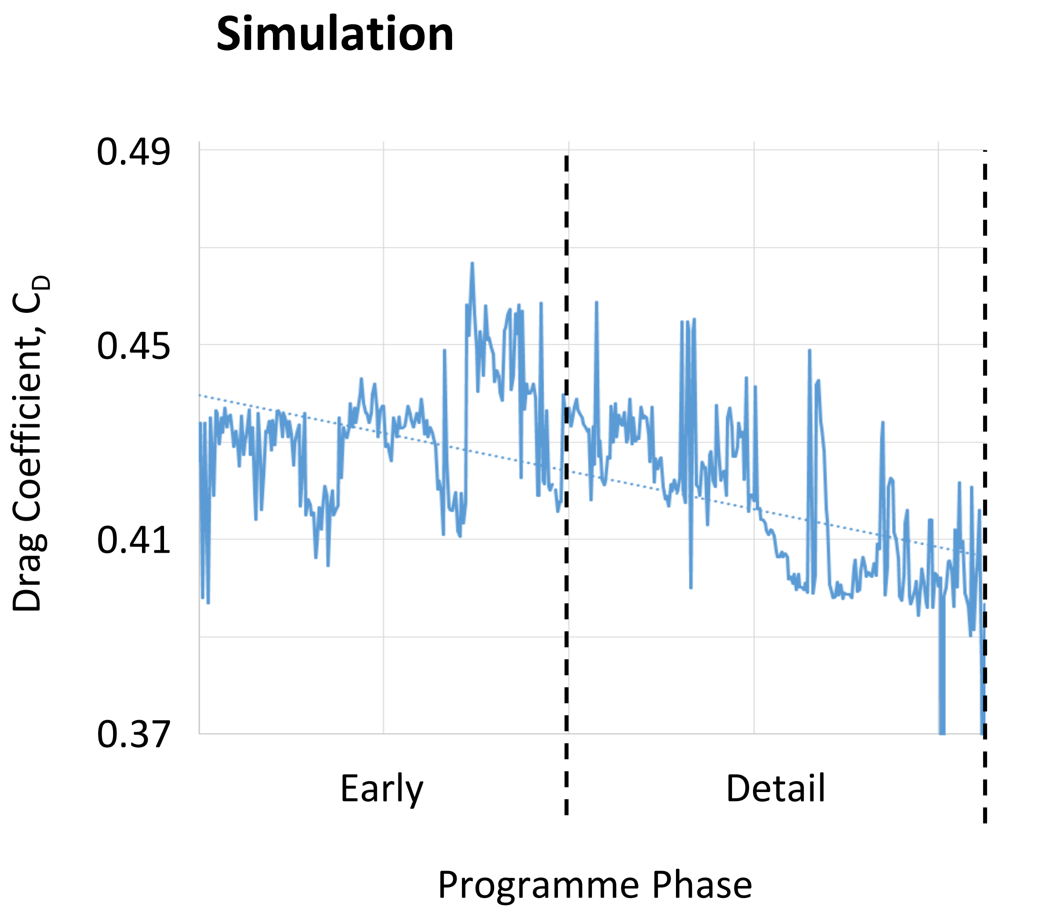
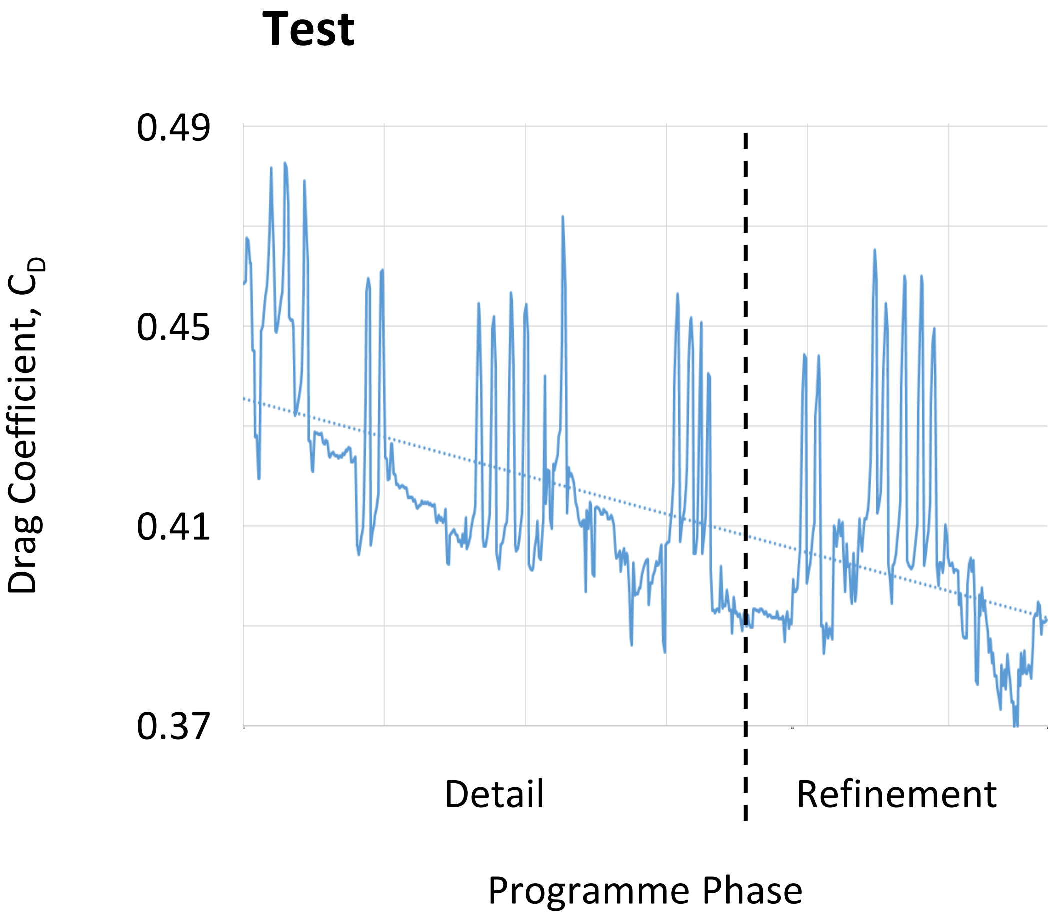
PROGRAMME PROGRESS IN TERMS OF DRAG COEFFICIENT BY TOOLSET





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VEHICLE DEVELOPMENT STRATEGY

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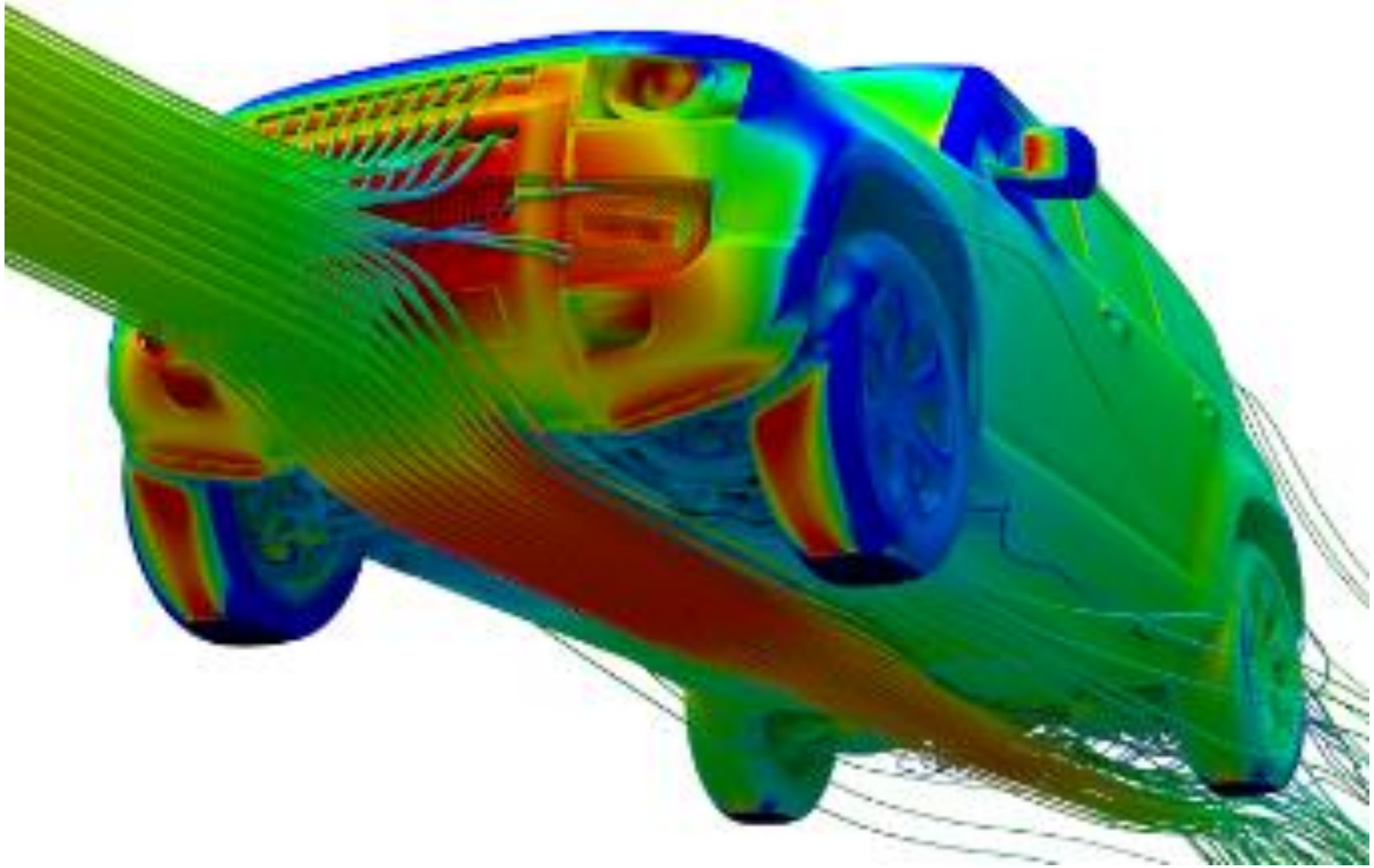
SIMULATION LED DEVELOPMENT: FRONT CHIN



Flow Field

0.00 1.00

Relative Velocity Magnitude, V/V_∞

Vehicle Surface

-0.75 0.75

Static Pressure, C_P

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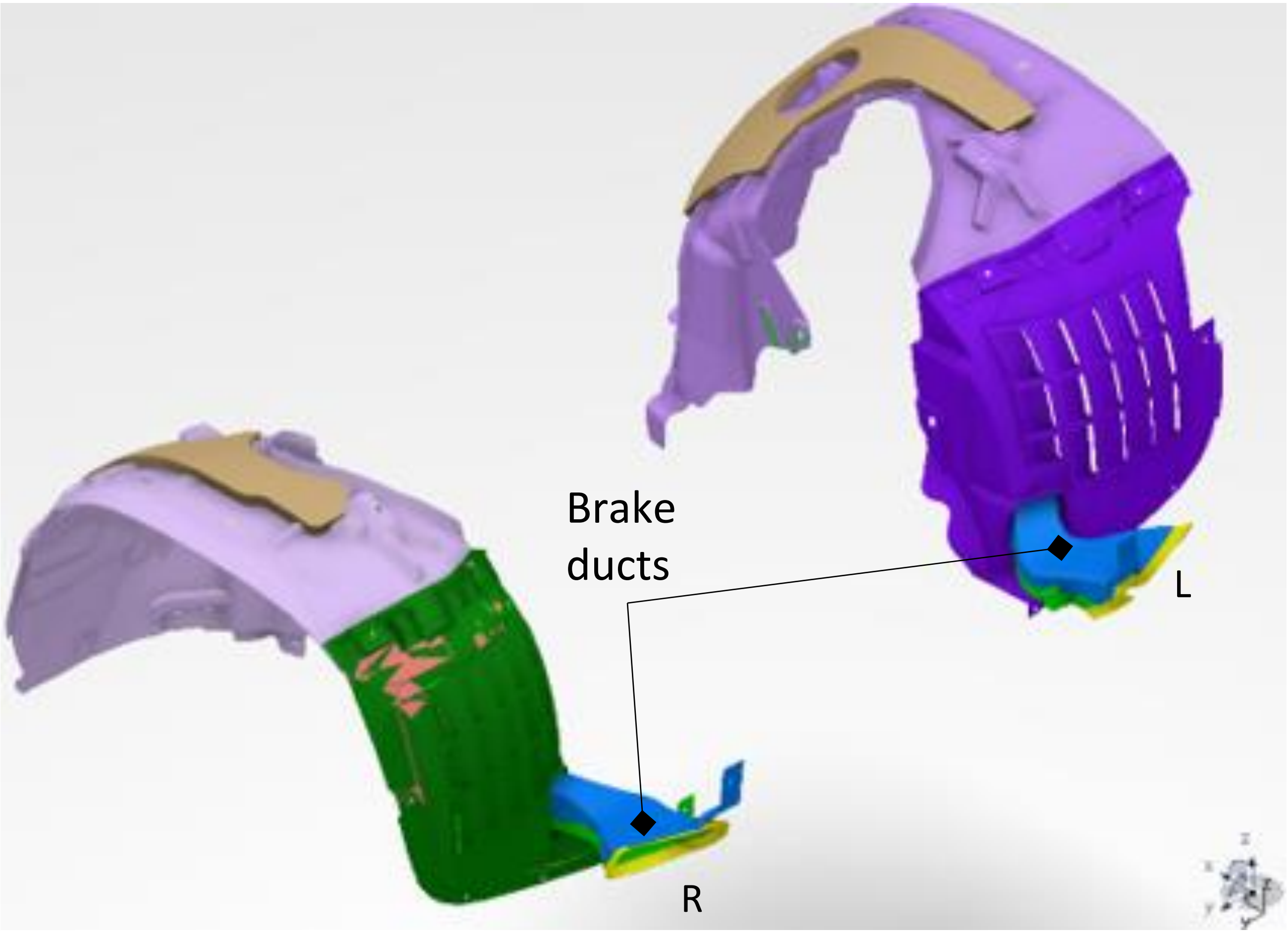
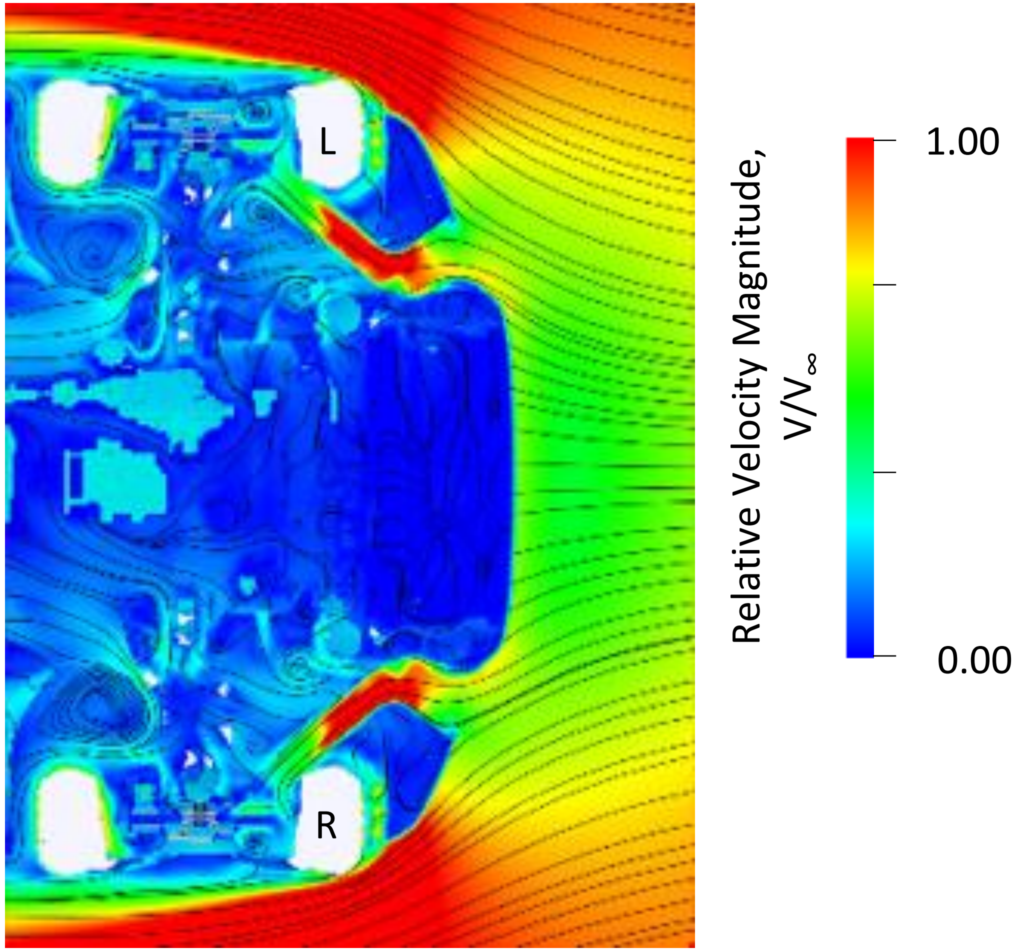
SIMULATION LED DEVELOPMENT: BRAKE COOLING





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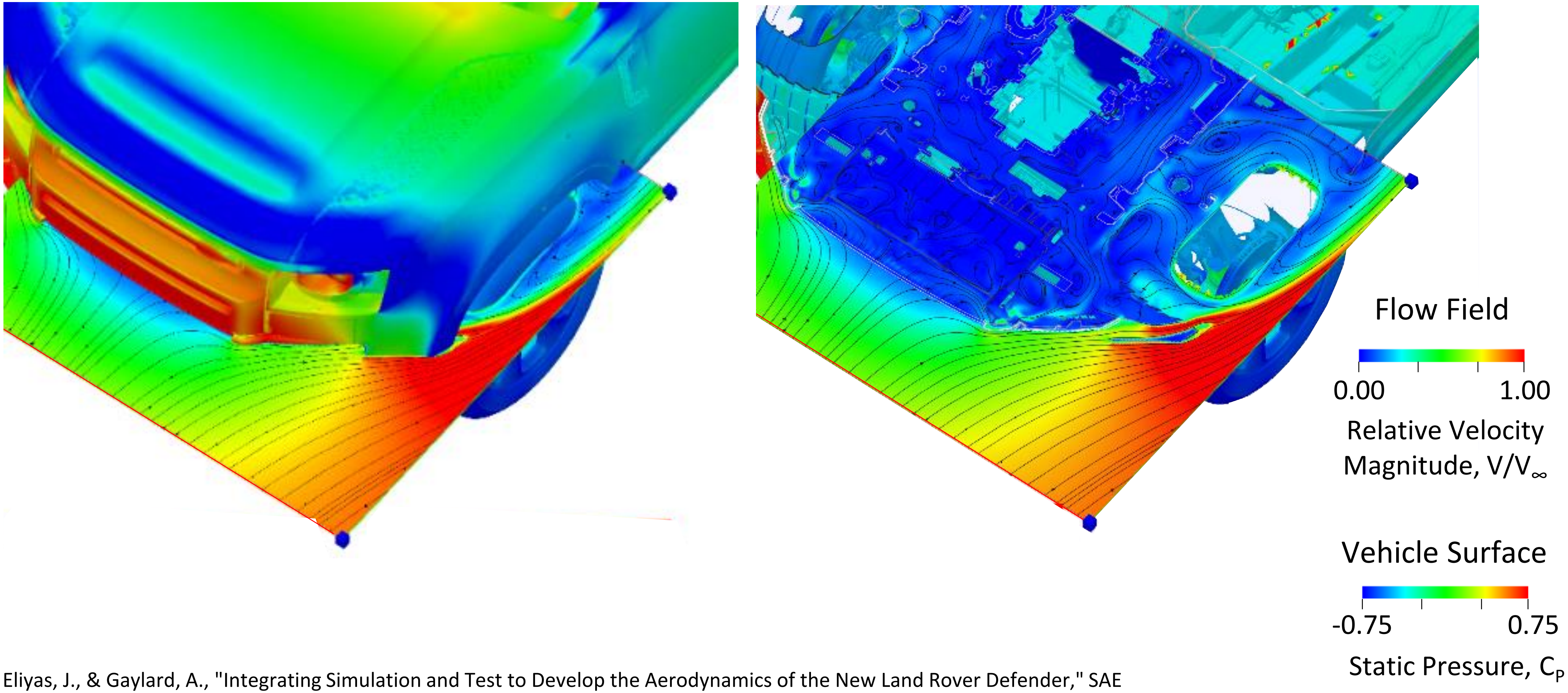
INTEGRATED DEVELOPMENT: "AIR CURTAIN"



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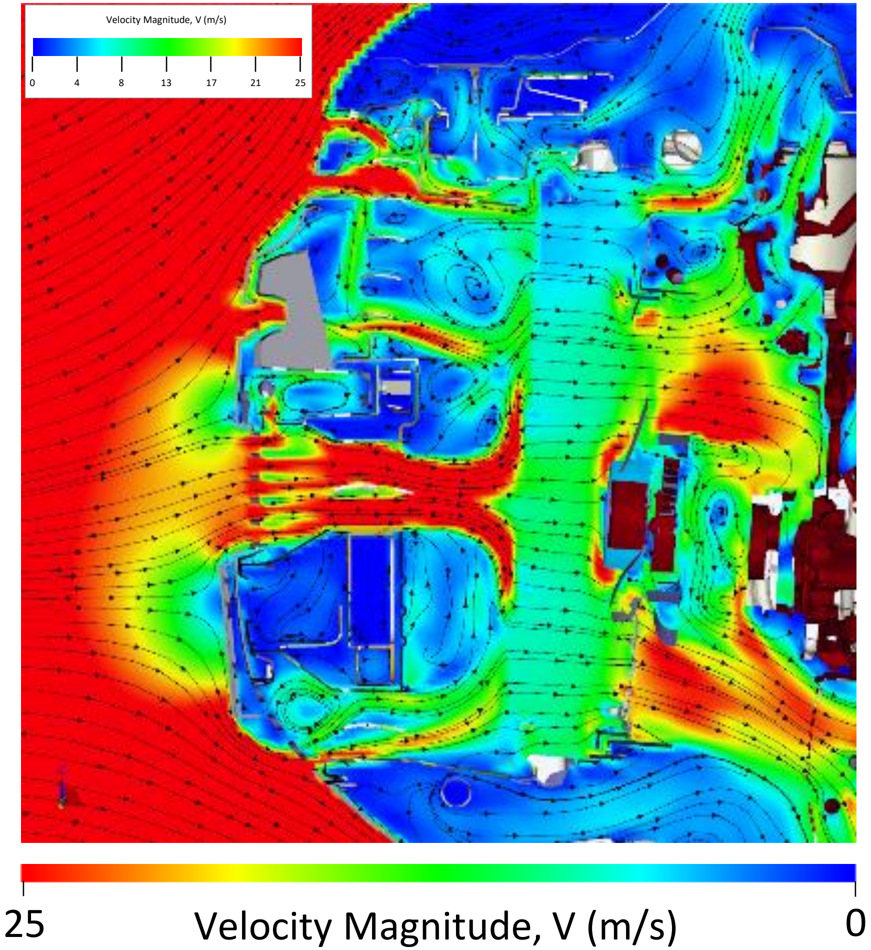
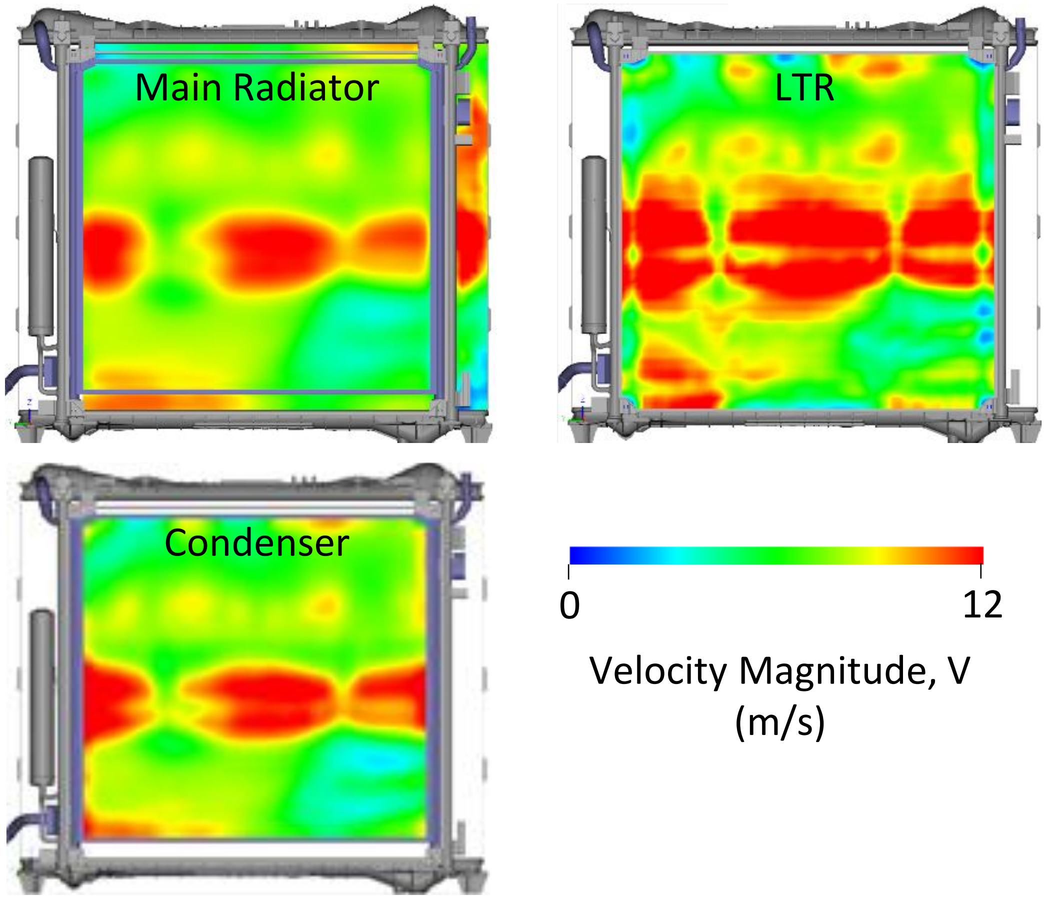
INTEGRATED DEVELOPMENT: GRILLE SHUTTERS





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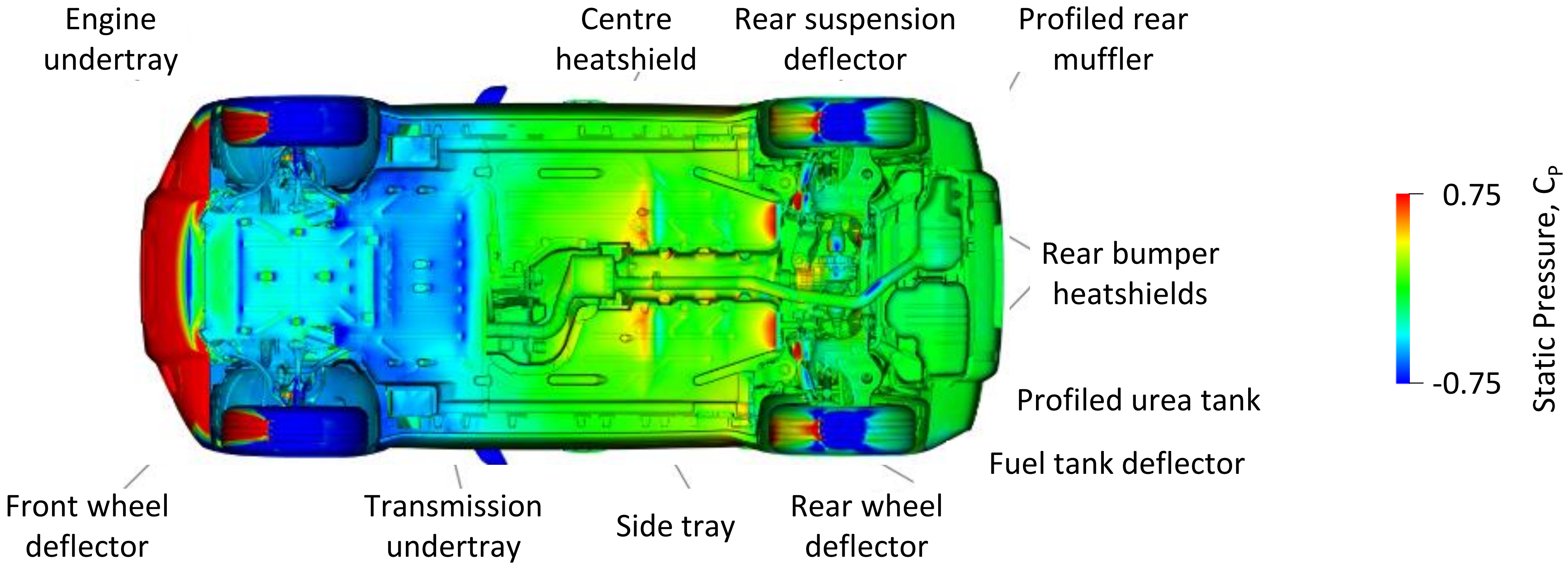
INTEGRATED DEVELOPMENT: UNDERBODY



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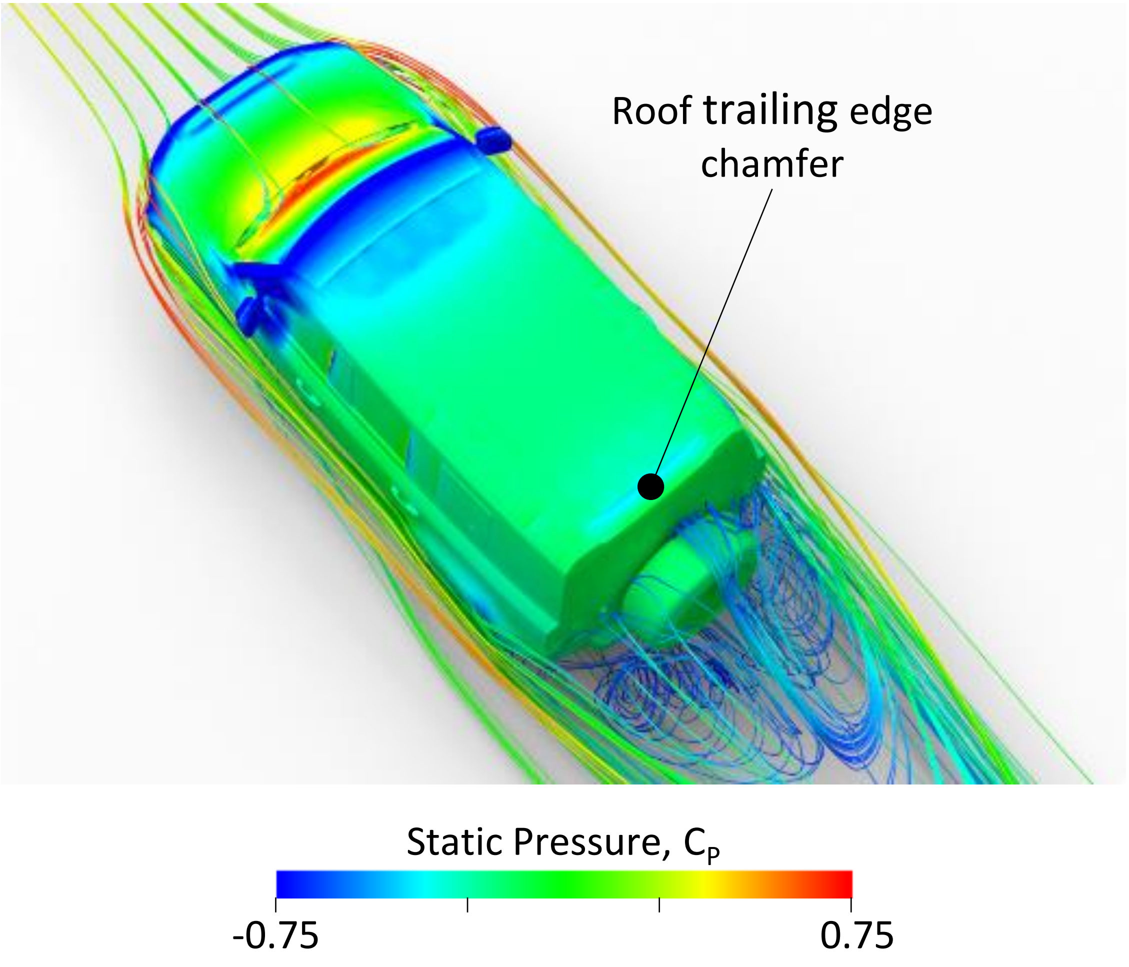
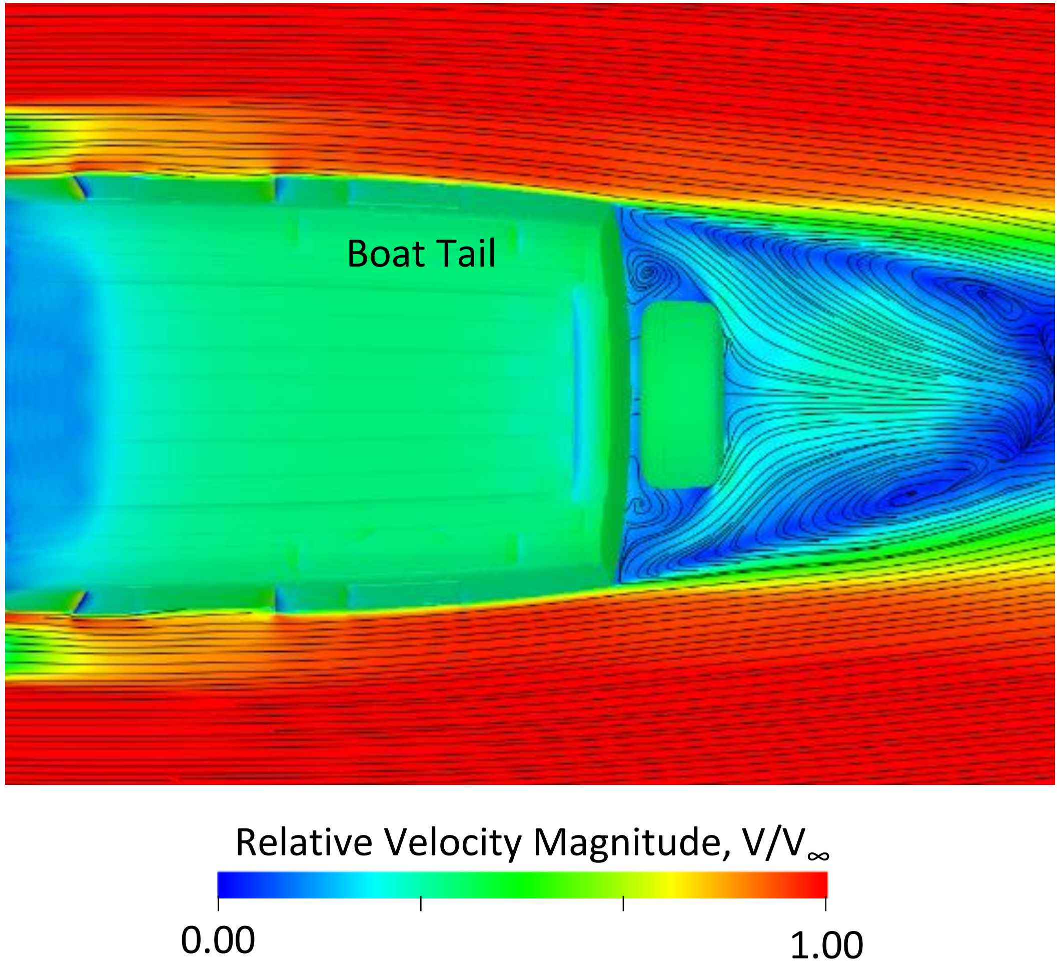
INTEGRATED DEVELOPMENT: WAKE CONTROL STRATEGY





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CONCLUSIONS

Careful integration of numerical simulation and physical test enabled the delivery of a challenging programme that met its aerodynamic targets.

Compared to its predecessor, a drag reduction of 48% or 0.240 C_D was delivered, resulting in a best of 0.38 C_D.

Drag area (C_DA) is also significantly less than its predecessor, even with a larger frontal area (A).

LOOKING FORWARDS

THE FUTURE: SOME QUESTIONS

To better serve customers (and society) how much of the on-road environment should we bring into our wind tunnels and CFD models?

How should we integrate AI/ML into the vehicle aerodynamics development process?

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