Simulation cost analysis of NEXTfoam BARAM on Rescale HPC Cloud

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Contents

Introduction

- Backgrounds
  - Simulation cost ($) = HPC hardware cost + simulation software license cost + simulation time
    - Limited simulation infrastructure (HW + SW) forces queuing the simulation
    - Simulation software license cost is more expensive than hardware cost
  - HPC Cloud & open-source software becomes the alternative for reducing the simulation cost

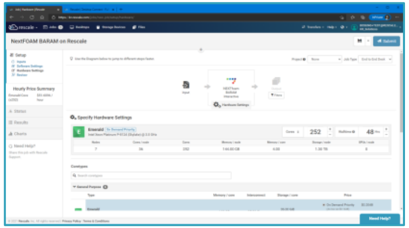
- Objectives
  - Simulation cost analysis using NEXTfoam BARAM, Ansys Fluent and Siemens StarCCM+
    - Simulation accuracy comparison using the DrivAer full car model
    - Cloud hardware cost on Rescale HPC Cloud
    - Simulation software license cost
    - Simulation time
  - Discuss about how to reduce the total cost of simulation

Rescale HPC cloud

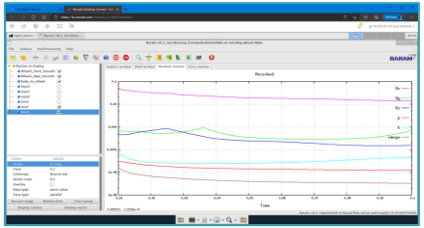
- Fully managed HPC Cloud platform with public cloud hardware and pre-installed simulation software

Model setup

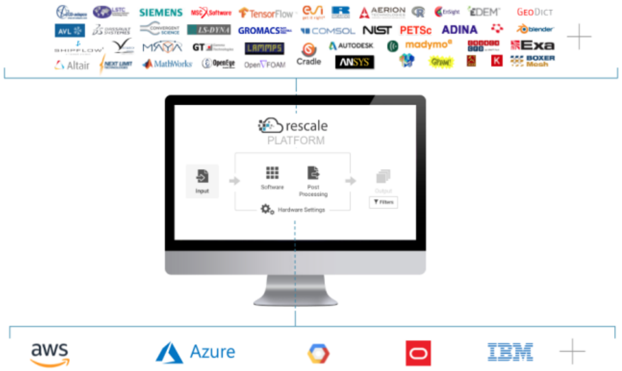
Model upload



Software and hardware setting



Solving

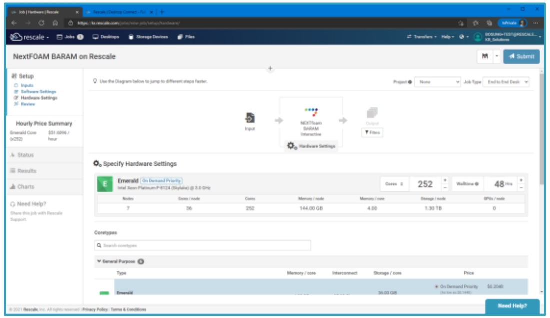
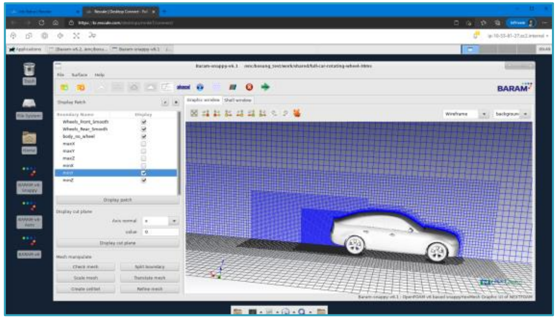
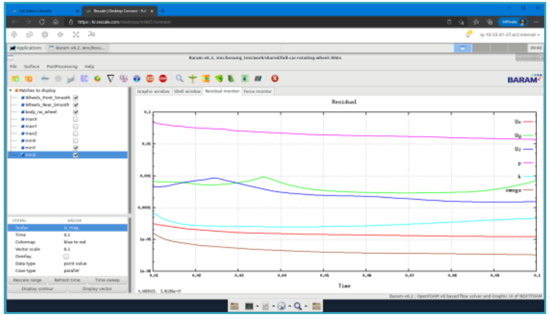
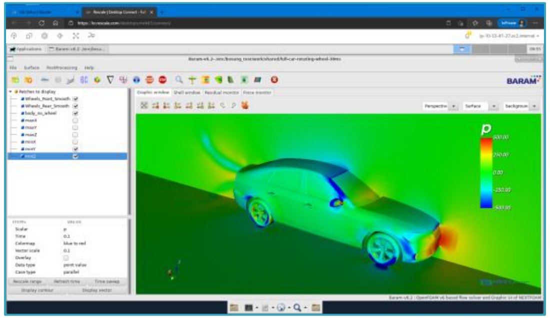
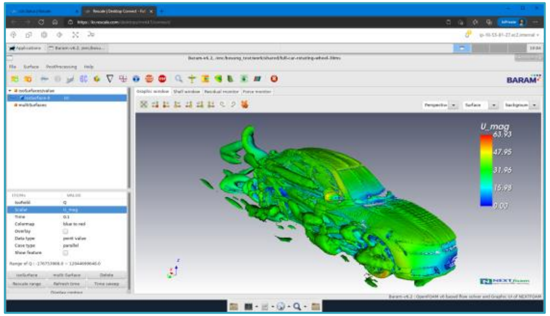
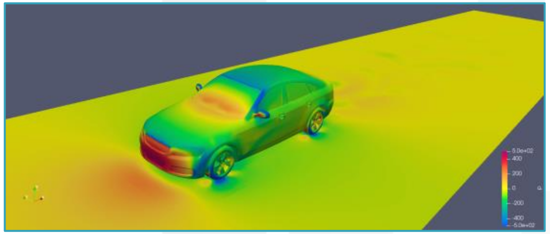


Rescale ScaleX Platform

- Enterprise big compute
- Innovation acceleration
- User-first SaaS platform
- Security and admin controls

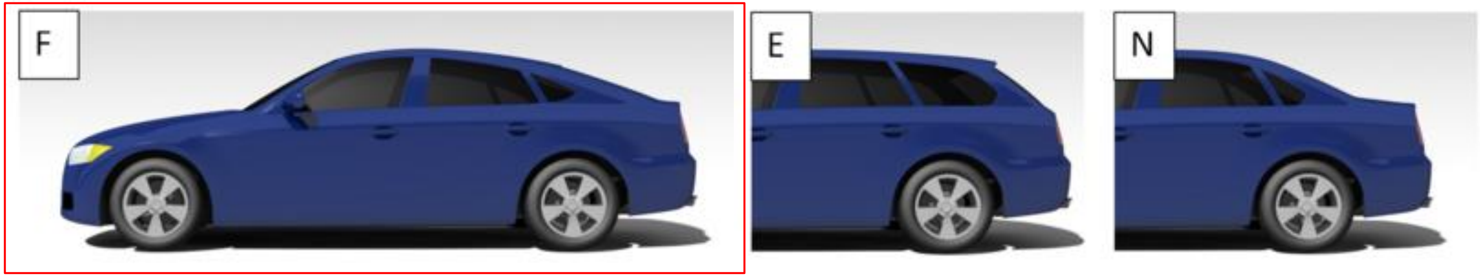
NEXTfoam BARAM on Rescale HPC cloud

- GUI capable OpenFOAM®-based CFD solver released by NEXTfoam under the GNU GPL license
- GUI support using web-browser without installation on the local workstation / on-prem HPC

Analysis model

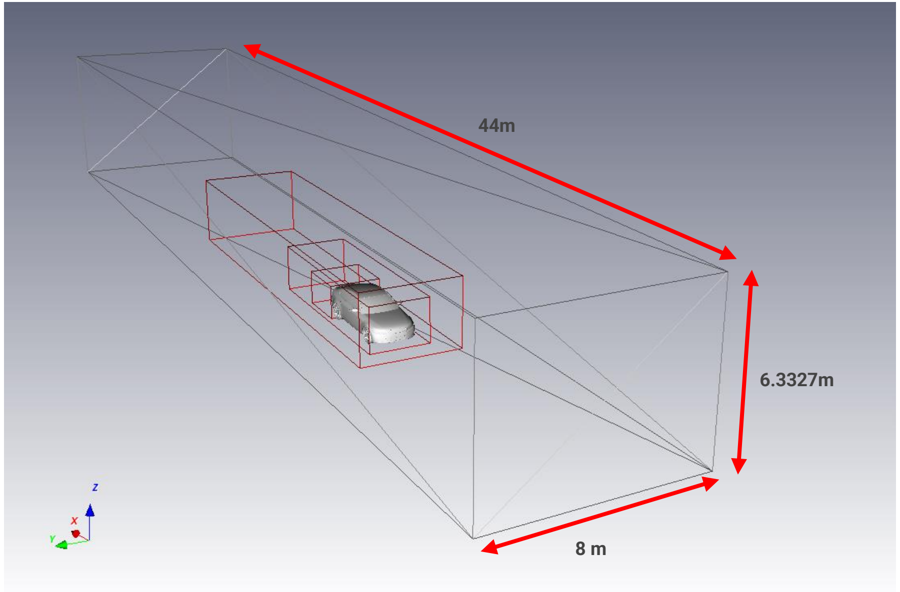
- Fastback DrivAer Model
  - The new generic full car model for external flow to close the gap between the strongly simplified models and the highly complex production cars

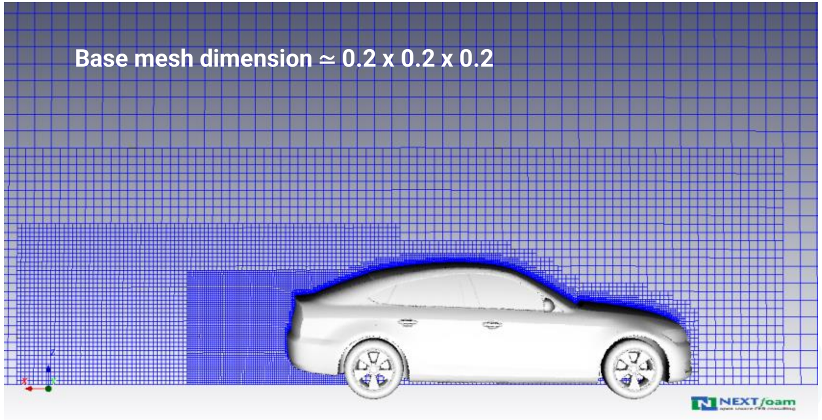


- Simulation conditions
  - Fastback / smooth underbody / with mirror / rotating wheel / moving ground
  - Full 3D (not half) unsteady flow with *k-ω SST* turbulence model
  - Free-stream velocity : 30 m/s
  - Compared with the experimental results

Domain dimensions and mesh generation

- Base mesh was generated using BARAM-Snappy (BARAM version of SnappyHexMesh)
  - OpenFOAM base mesh was converted to Fluent mesh (.msh) using '**foamMeshToFluent**'
  - Fluent mesh was imported to StarCCM+

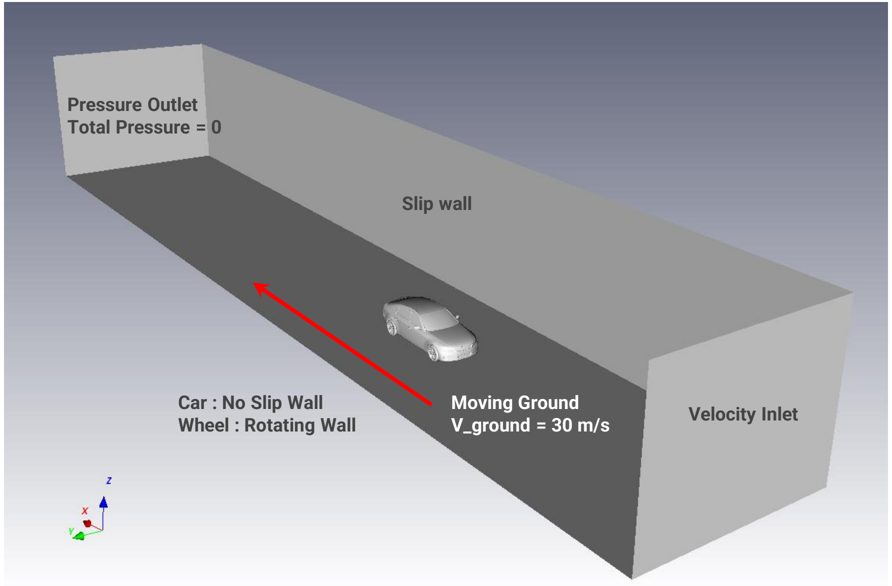


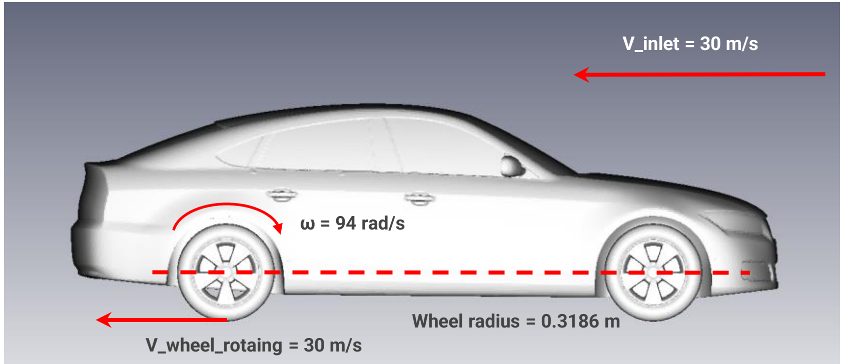


Car Surface / Feature Refinement = 4 / 5
Wheel Surface / Feature Refinement = : 5 / 1
Inflation layer = 3
First cell size = 0.001 / number of cells in the layer = 5
Total number of cells : 3,249,413

Boundary conditions

- Same boundary conditions are applied to BARAM / Fluent / StarCCM+





ρ (density) : 1.205
ט (viscosity) : 1.58e-5
Prt : 0.85
Turbulent intensity : 1%
Viscosity Ratio : 10

Simulation conditions

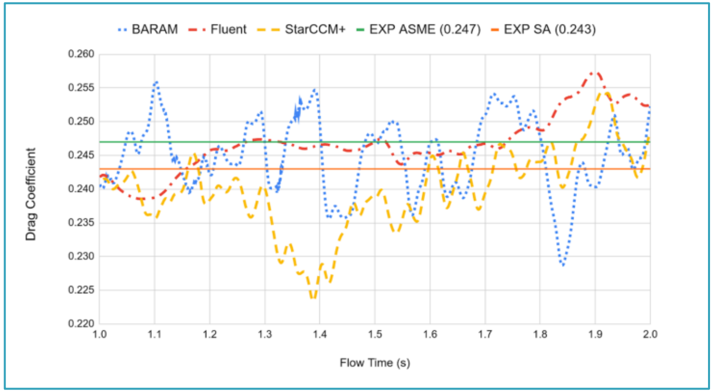
- Simulation conditions

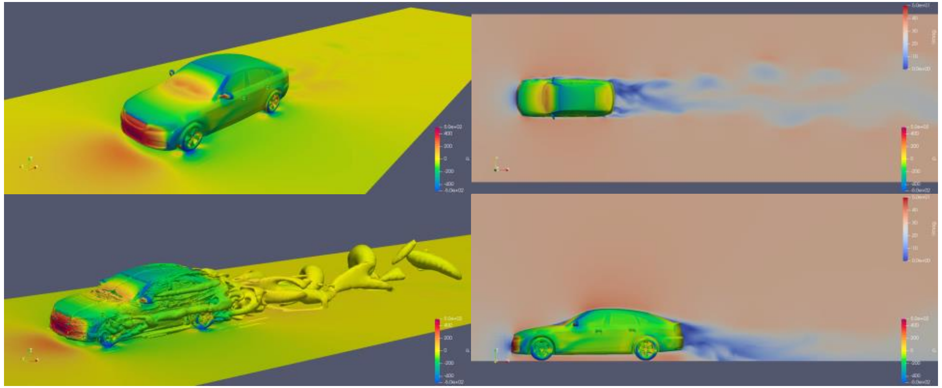
	Version	Solution scheme	Spatial Discretization	Relaxation Factors	Flow Time
BARAM	6.2	simpleNFoam Transient	Momentum : 2nd Turbulent : 1st	Pressure : 0.3 Momentum : 0.3 Turbulence : 0.7	t = 2.0 Δt = 0.001 sub iter = 10
Fluent	2020R1	SIMPLE Unsteady	Momentum : 2nd Turbulent : 1st	Pressure : 0.3 Momentum : 0.3 Turbulence : 0.7	t = 2.0 Δt = 0.001 sub iter = 10
StarCCM+	15.06.008 Double	Segregated Flow Implicit Unsteady	Momentum : 2nd Turbulent : 1st	Pressure : 0.3 Momentum : 0.3 Turbulence : 0.7	t = 2.0 Δt = 0.001 sub iter = 10

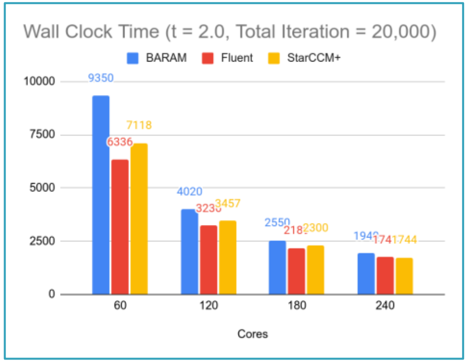
- Hardware specifications

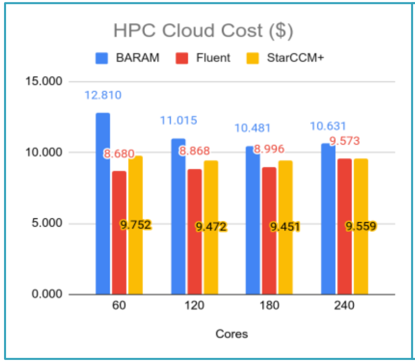
Rescale Coretype	Processor	#of Cores / node	Memory	Interconnect	Hourly price / node
Jasper	AMD EPYC 7742 (Rome) @ 2.4 Ghz	60	8 GB /core 488 GB / node	200 Gbps Infiniband	$4.932

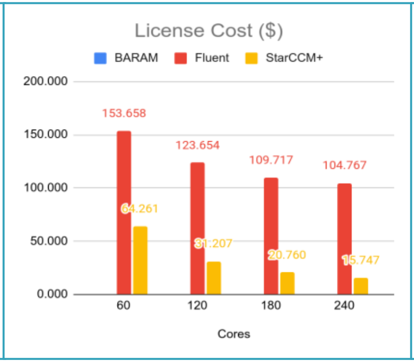
Results

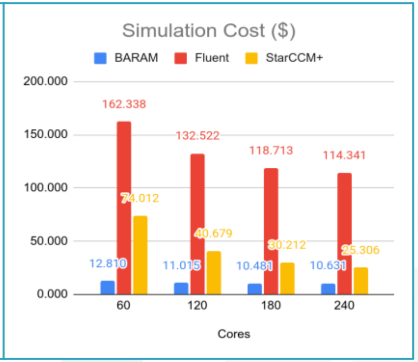












StarCCM+ PoD license cost = $32.5 / hour (estimated)
Fluent required AEC = {20 + INT(5 x nCores$^{0.57}$)}, Fluent AEC cost = $1.4 / AEC (estimated)

Concluding remarks

- NEXTfoam BARAM, Fluent and StarCCM+ show similar drag coefficients compared to experiments
- Elapsed time in NEXTfoam BARAM is slightly longer than Fluent and StarCCM+
    - Rescale cloud cost depends on the elapsed time
- Simulation license cost is very expensive than cloud hardware cost
    - StarCCM+ Power-session & Power-on-Demand license have no limit in the number of cores
    - Fluent AEC license cost requires the complex cost calculation depends on the problem
- Total simulation cost decreases as the number of cores increases
    - Reduced time using more number of cores can reduce the license cost
- Open source simulation software requires only hardware cost

NEXTfoam BARAM on Rescale HPC cloud shows the best price / performance

Reference

[1] DrivAer Model : https://www.epc.ed.tum.de/en/aer/research-groups/automotive/drivaer/, 2021.11

[2] Drivaer validation case, Wolf Dynamics: http://www.wolfdynamics.com/validations/drivAer/tut_drivaer.pdf, 2021.11

[3] R. Yazdani. Steady and Unsteady Numerical Analysis of the DrivAer Model. Chalmers University of Technology, Master Thesis, 2015

[4] Experimental Comparison of the Aerodynamic Behavior of Fastback and Notchback DrivAer Models. SAE 2014-01-0613.