



WEBINAR

T3S4: Optimizing CFD on Graviton for Sustainable Performance

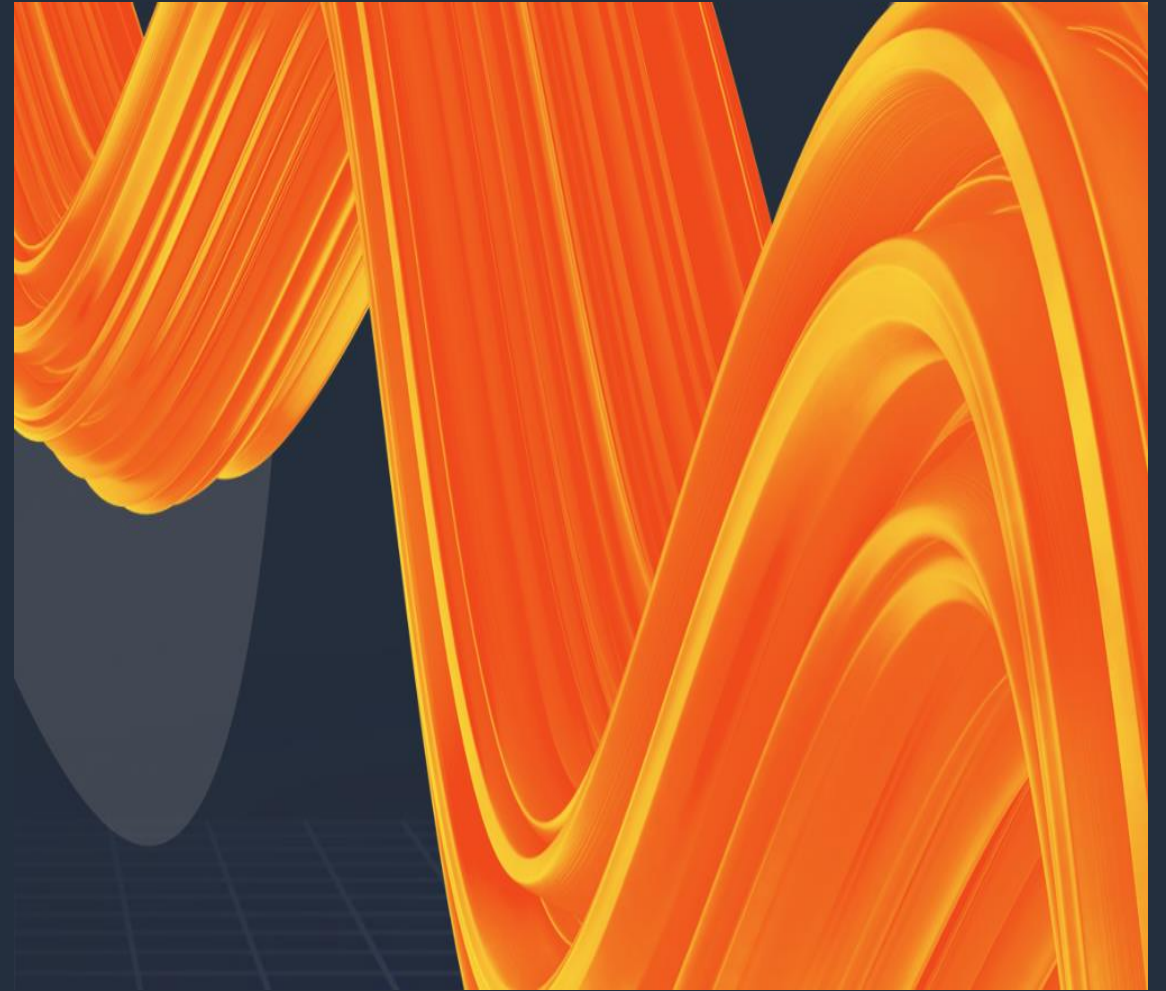
Steve Messenger (he/him)

Senior HPC Solutions Architect
Amazon Web Services



Agenda

- HPC Technology
- AWS Instances
- Graviton and Nitro
- Common CFD Applications
 - Commercial
 - Open Source
- Case Studies
- What next?



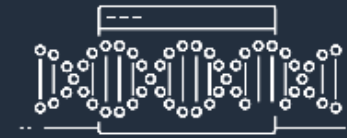
High performance computing (HPC) is all around us



Build designs faster with computational fluid dynamics (CFD) simulations



Fast-track drug discovery and structure-based drug design



Advance genomics insights using predictive, real-time, or retrospective data applications



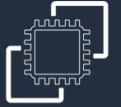
Run geoscientific simulations and seismic processing and iterate models faster



Conduct grid-computing simulations and identify portfolio risks and hedging opportunities



Process complex workloads and analyze massive data pipelines to further research



Broadest choice of processors



Intel® Xeon Scalable processors



AMD EPYC processors



AWS Graviton processors



Apple M1 processors

x86

Arm64

Broadest and deepest compute platform choice

CATEGORIES

General purpose
Burstable
Compute intensive
Memory intensive
Storage (High I/O)
Dense storage
GPU compute
Graphics intensive



CAPABILITIES

Choice of processor
(AWS Graviton, Intel, AMD,
Apple)
Fast processors
(up to 4.5 GHz)
High memory footprint
(up to 24 TiB)
Instance storage
(HDD and SSD)
Accelerated computing
(GPUs, FPGA & ASIC)
Networking
(up to 3200 Gbps)
Bare Metal
Size
(Nano to 96xlarge)



OPTIONS

Elastic Block Store (EBS)
Elastic Fabric Adapter
Elastic Inference
Elastic Graphics
Linux, Unix, Windows,
macOS



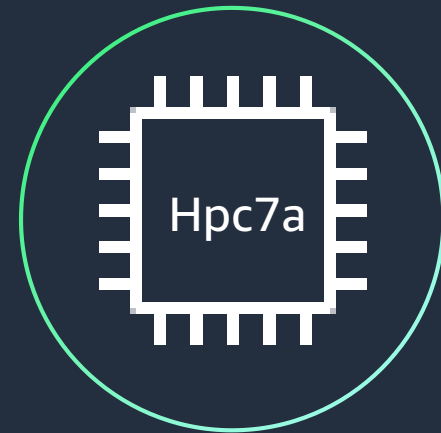
MORE THAN
650+
INSTANCE TYPES
for virtually every
workload and
business need

Amazon EC2 Hpc7a instances

4th Gen AMD EPYC Genoa processors:

- Four sizes: **hpc7a.96xlarge**, **hpc7a.48xlarge**, **hpc7a.24xlarge**, and **hpc7a.12xlarge**
- Up to 192 physical cores (**no hyperthreading**)
- **3.7 GHz** all-core turbo
- 768 GB of RAM (**4 GB/core**)
- **300 Gbps EFA**

Deliver 2.5x better performance compared to Hpc6a instances

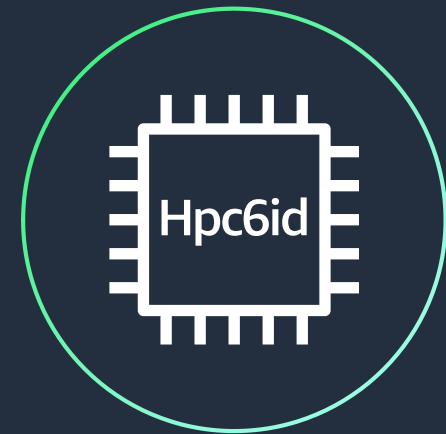


Amazon EC2 Hpc6id instances

3rd Generation Intel Xeon Scalable processors:

- One size: **Hpc6id.32xlarge**
- 64 physical cores (**no hyperthreading**)
- **Up to 3.5 GHz**
- **5 GB/s memory bandwidth per vCPU**
- 1,024 GB memory
- Up to 15.2 TB local storage
- **200 Gbps EFA**

Best price performance for memory and data-intensive HPC workloads on Amazon EC2



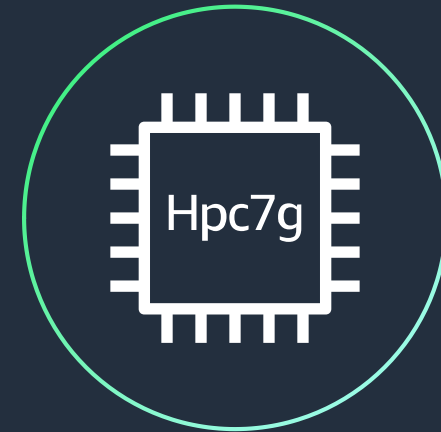
Amazon EC2 Hpc7g instances

Based on custom AWS Graviton3E processors:

- 64 physical cores
- **Up to 2.6 GHz**
- 128 GiB of memory
- **200 Gbps EFA**

70% better performance and almost 3x better price performance compared to previous-generation AWS Graviton-based instances for compute-intensive HPC workloads

Provide up to 35% higher vector instruction performance compared to existing instances based on AWS Graviton3 processors



Powered by the next-generation AWS Nitro System

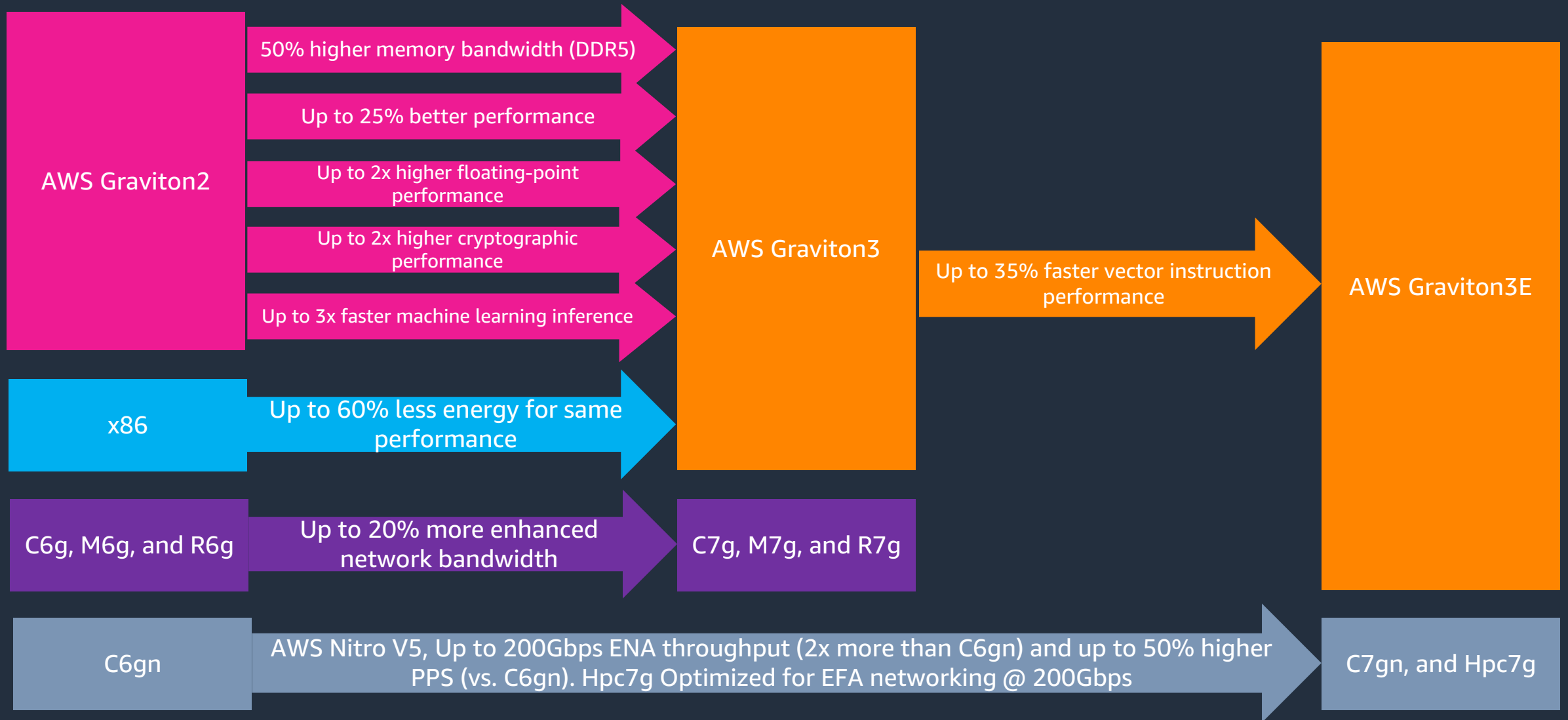


AWS Graviton-based Amazon EC2 instances

	Graviton2	Graviton3	Graviton3E
General Purpose	M6g, M6gd, T4g	M7g, M7gd	
Compute Optimized	C6g, C6gd, C6gn	C7g, C7gd	C7gn, Hpc7g
Memory Optimized	R6g, R6gd, X2gd	R7g, R7gd	
Storage Optimized	Im4gn, Is4gen, I4g		
Accelerated Computing	G5g		

Note: Not all instances available in all regions.

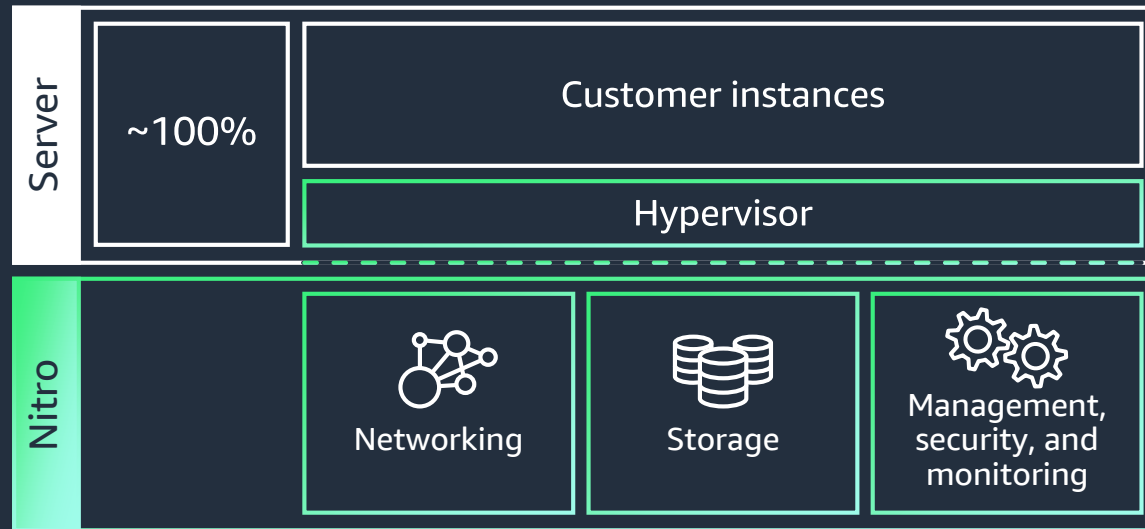
AWS Graviton Processor – generational improvements



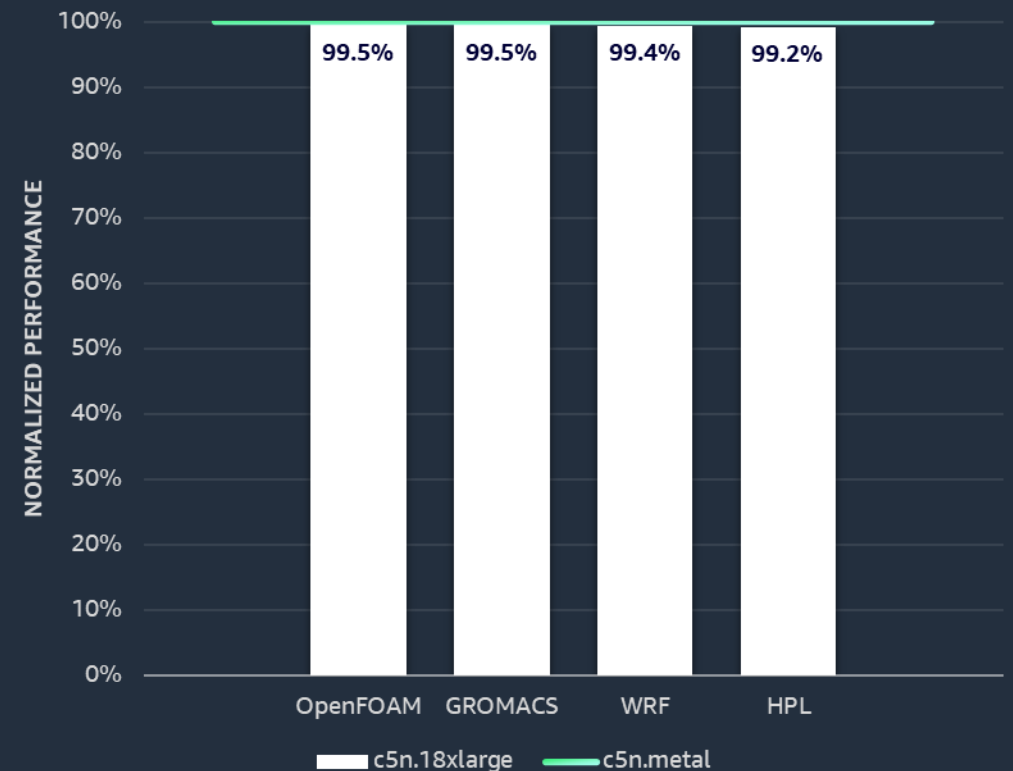
AWS Nitro System

Lightweight hypervisor memory and CPU allocation designed for **performance nearly indistinguishable from bare metal**

Designed using a security chip that monitors, protects, and verifies the instance hardware and firmware



Metal vs. Nitro Hypervisor
(16 instances)



Elastic Fabric Adapter (EFA)

SRD protocol



Proving myths about latency constraints wrong



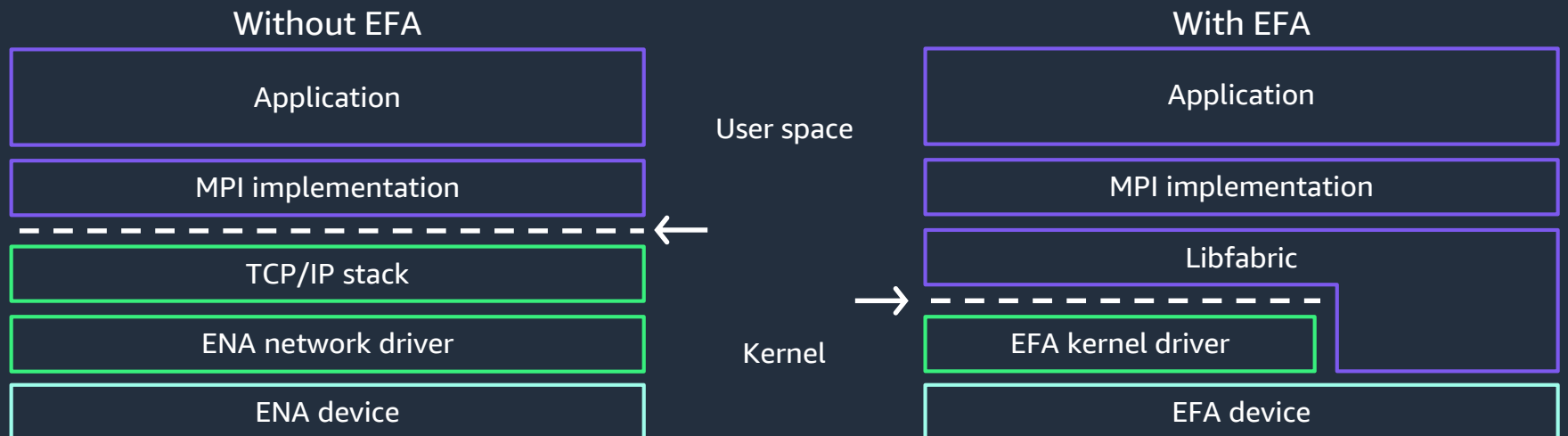
CFD



Seismic



Weather modeling

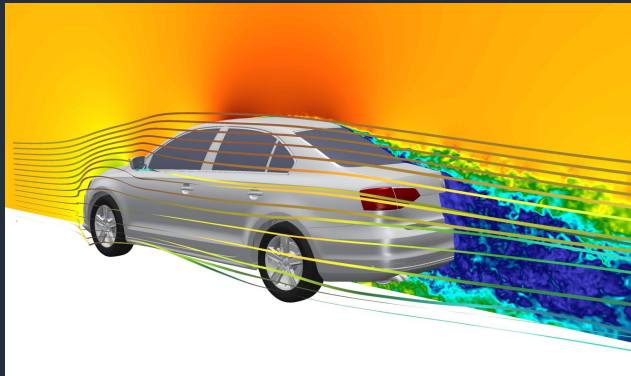


AWS Best HPC Cloud Platform – Readers choice.



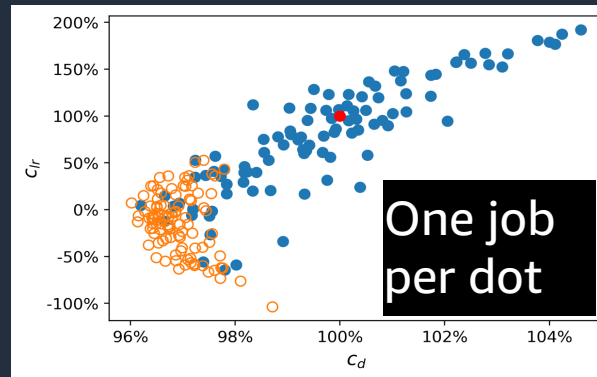
Engineering Simulation workloads are –

Large



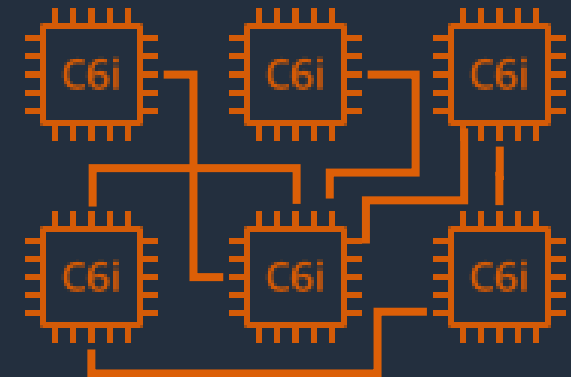
e.g. One engineering simulation job can run on **1000 cores** for **hours**

Numerous



Designing one product needs **100s** of types of simulation
100s of jobs per sim. type

Tightly Coupled



If a single core fails, the entire job fails

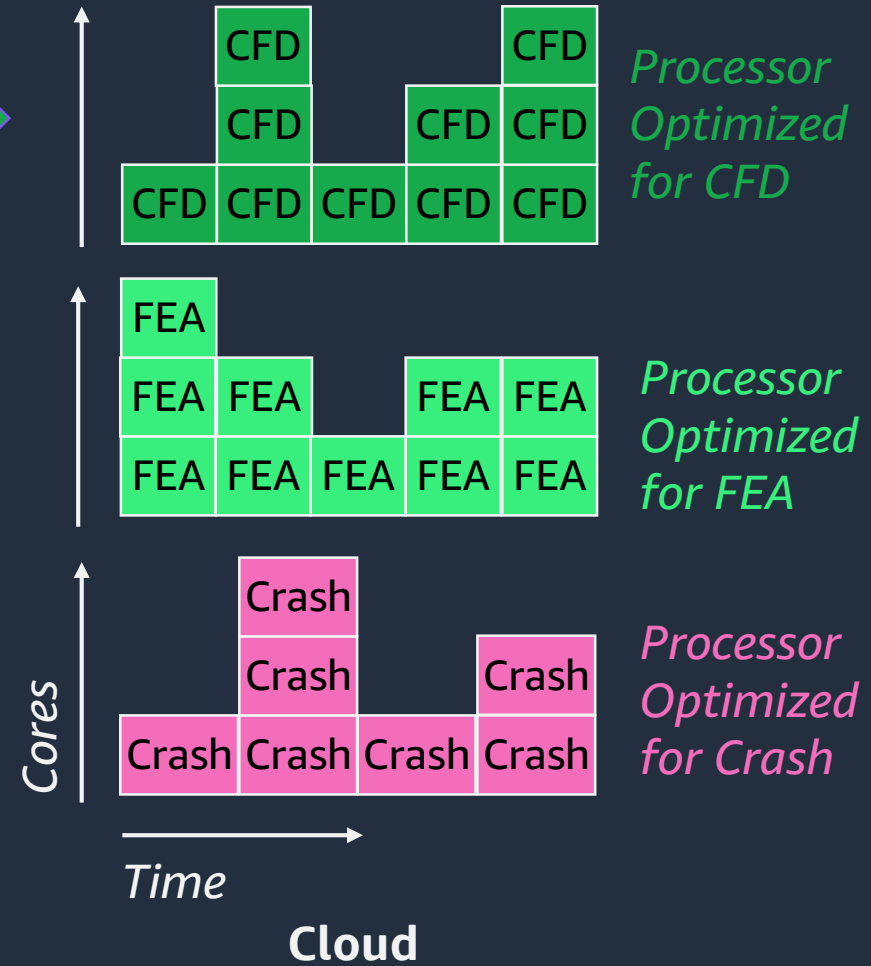
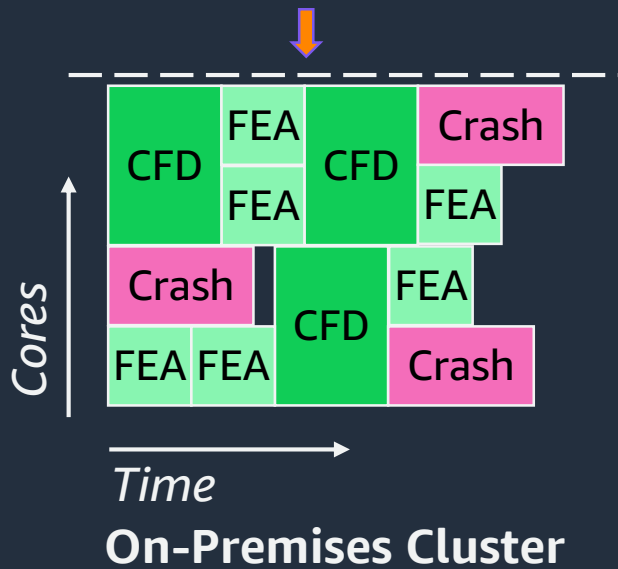
Images from case study: <https://aws.amazon.com/partners/success/volkswagen-ag-altair/>

Elasticity of the cloud provides business agility

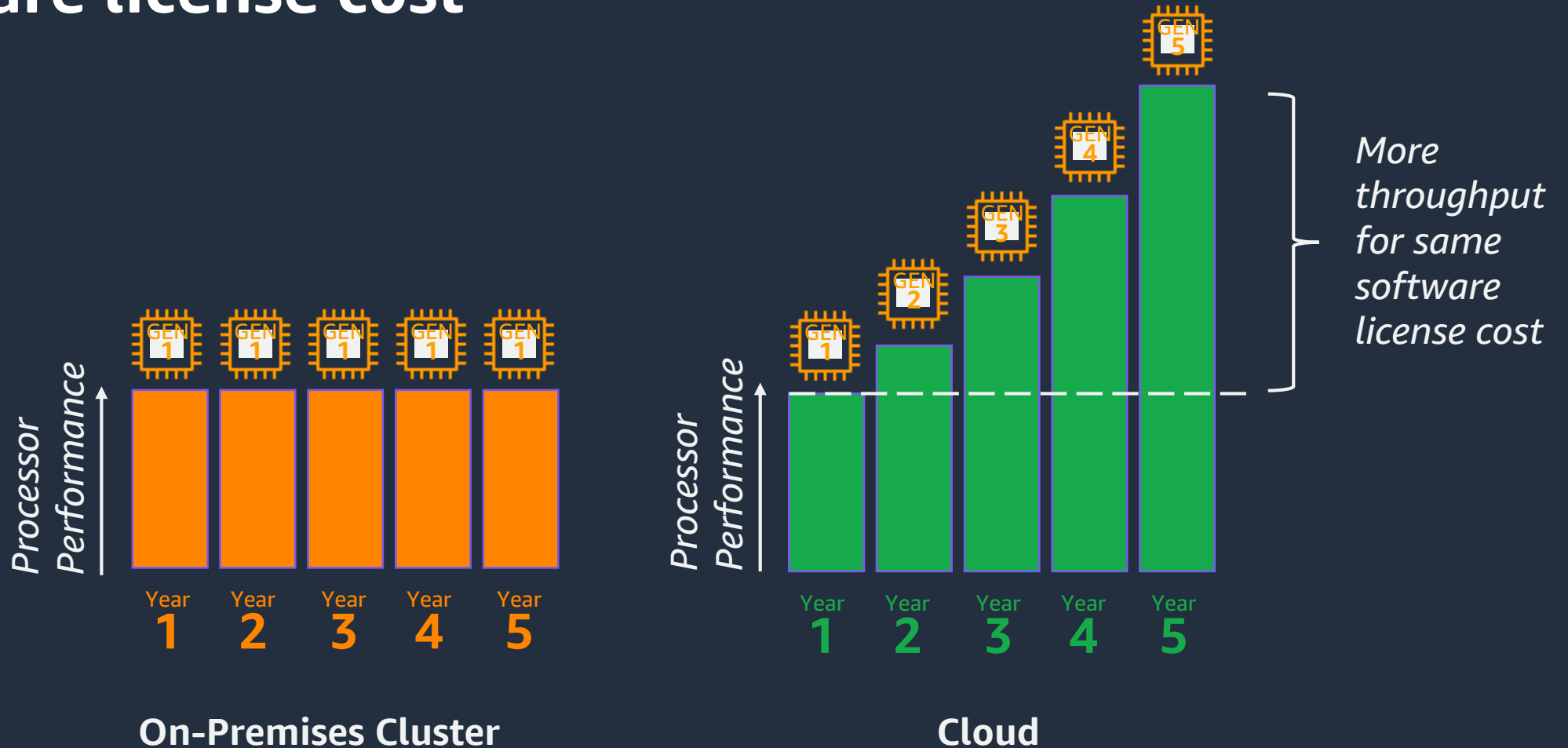
- Flexible capacity
- Optimum processor for each application



- Limited capacity
- Same processor for all applications



Latest processors on the cloud provide best ROI for software license cost

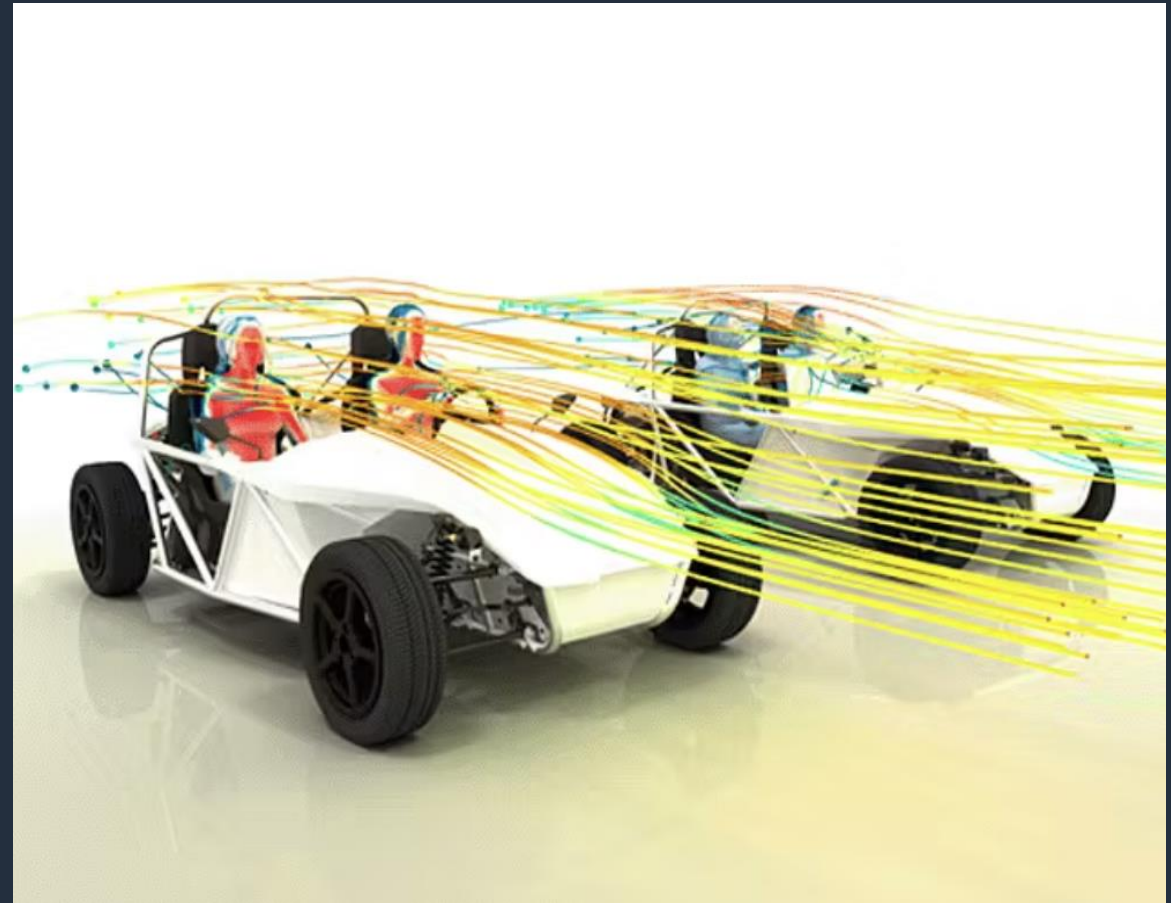


Engineering Simulation is done with partner apps

Example apps	Fluid Simulation	Structural Simulation	Electromagnetics Simulation
Method Name	Computational Fluid Dynamics (CFD)	Finite Element Analysis/Method (FEA/FEM)	Finite Element Analysis/method (FEA/FEM)
Software Provider			
Altair	AcuSolve, uFX	Radioss, Optistruct	Feko
Ansys	Fluent, CFX	Mechanical, LS-Dyna	Maxwell, HFSS
Dassault Systemes	PowerFLOW	Abaqus	CST
ESI	Ace+	PamCrash	Prosivic
OpenSource	OpenFOAM / FDS		
Siemens	Star-CCM+	Simcenter Nastran	Simcenter LF EM

Siemens StarCCM+

- One of the most common CFD Applications run on AWS
- Runs on Intel, AMD, ARM and GPU systems
- ARM support for several releases
- Many choices of technology



<https://blogs.sw.siemens.com/simcenter/an-engineers-guide-to-the-cfd-hardware-galaxy/> <https://plm.sw.siemens.com/en-US/simcenter/fluids-thermal-simulation/star-ccm/>

Ansys Fluent

- Another very popular CFD Application
- Runs on Intel, AMD, ARM and GPU systems
- Vortech
 - Ansys Fluent, CADFEM
 - Cut customer energy usage by upto 41%
- Ansys Gateway – cloud built on AWS.
 - Remove hardware restrictions
 - HPC & VDI

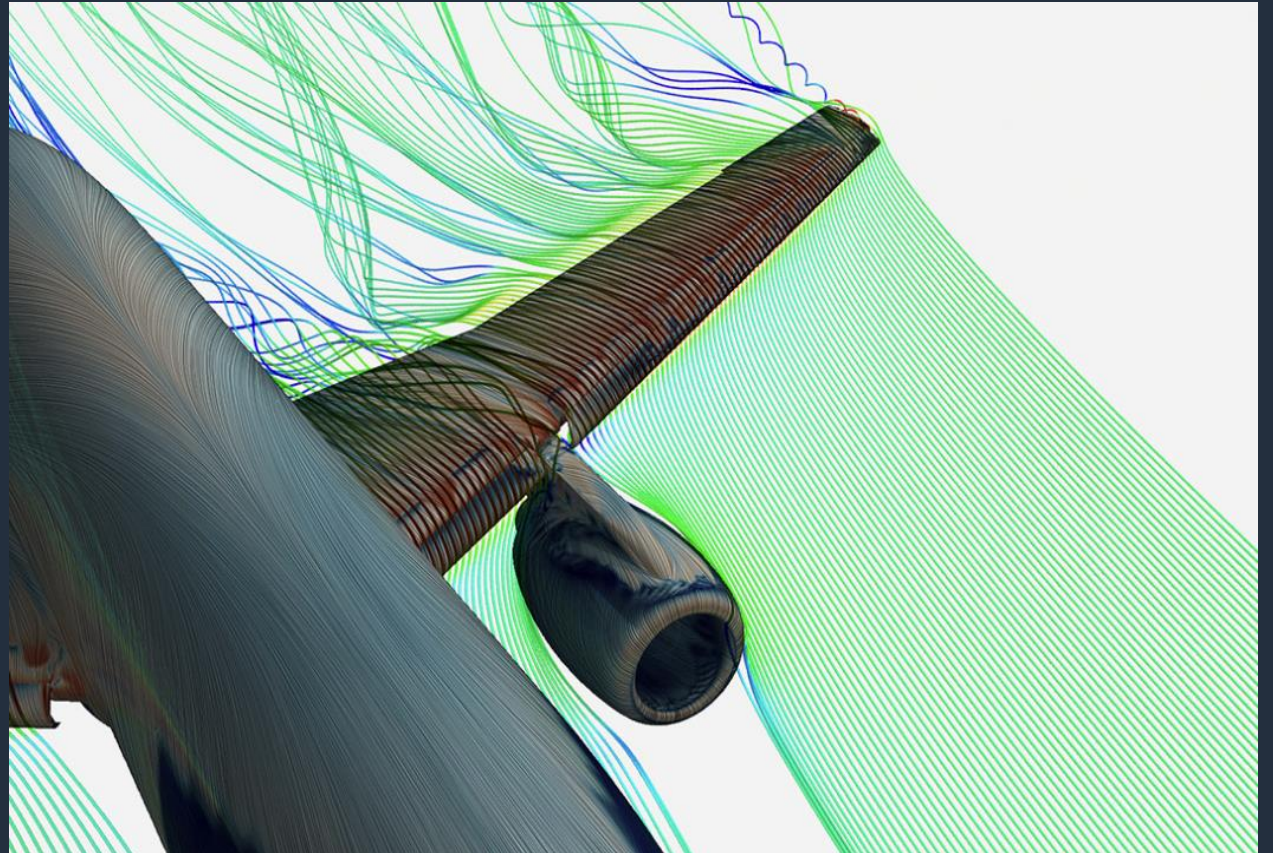


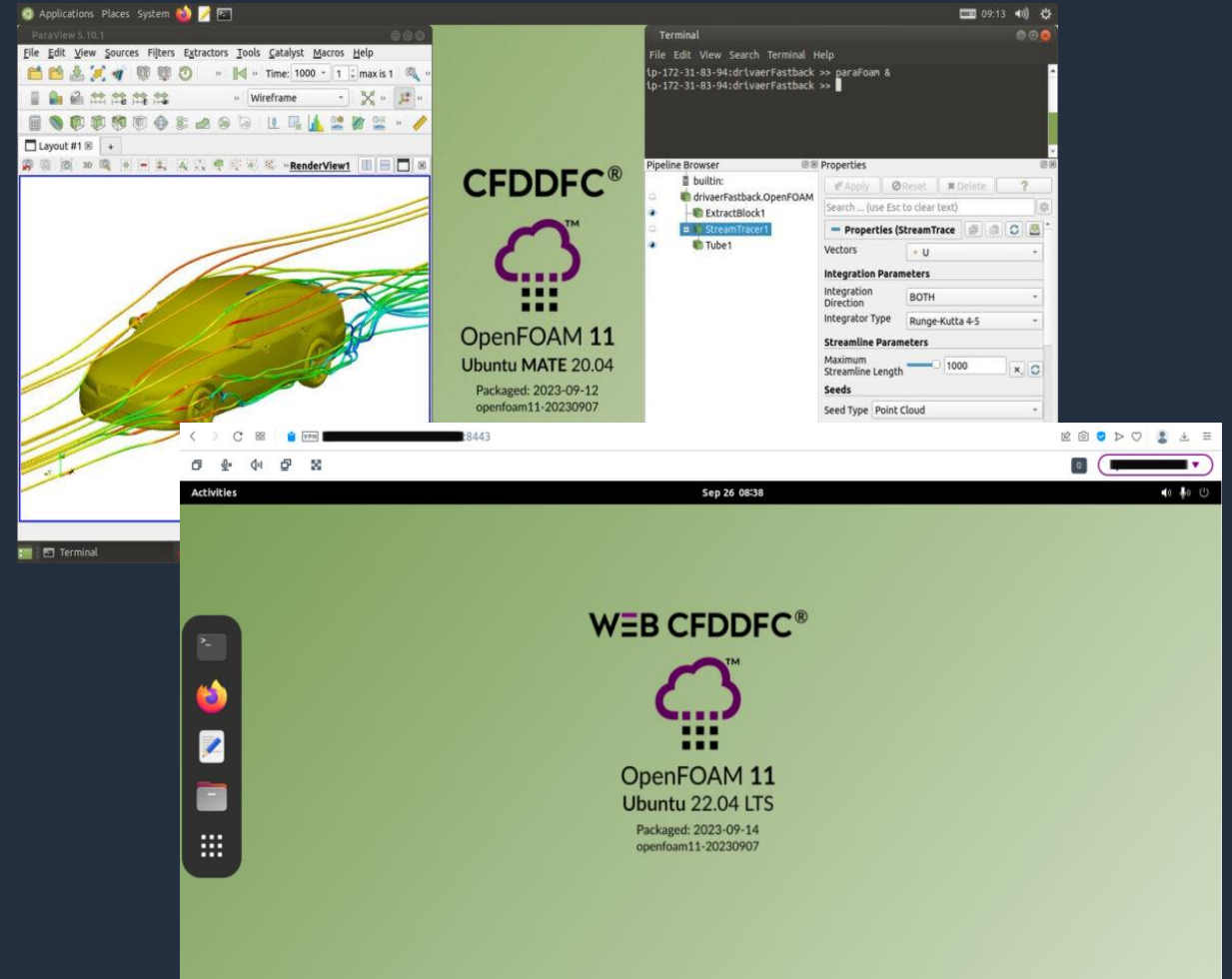
Image from <https://www.ansys.com/products/fluids/ansys-fluent>



CFDDirect - OpenFOAM

- OpenFOAM – widely used opensource CFD
- Partner for many years
- Training
- Support
- Development

- AWS Marketplace
- Container Images



ESI-OpenCFD - OpenFOAM

- ESI-OpenCFD
- Same company that supplies
 - VPS
 - Pam Stamp
- Another provider of OpenFOAM
- Support
- Training
- Development
- Engineering services.

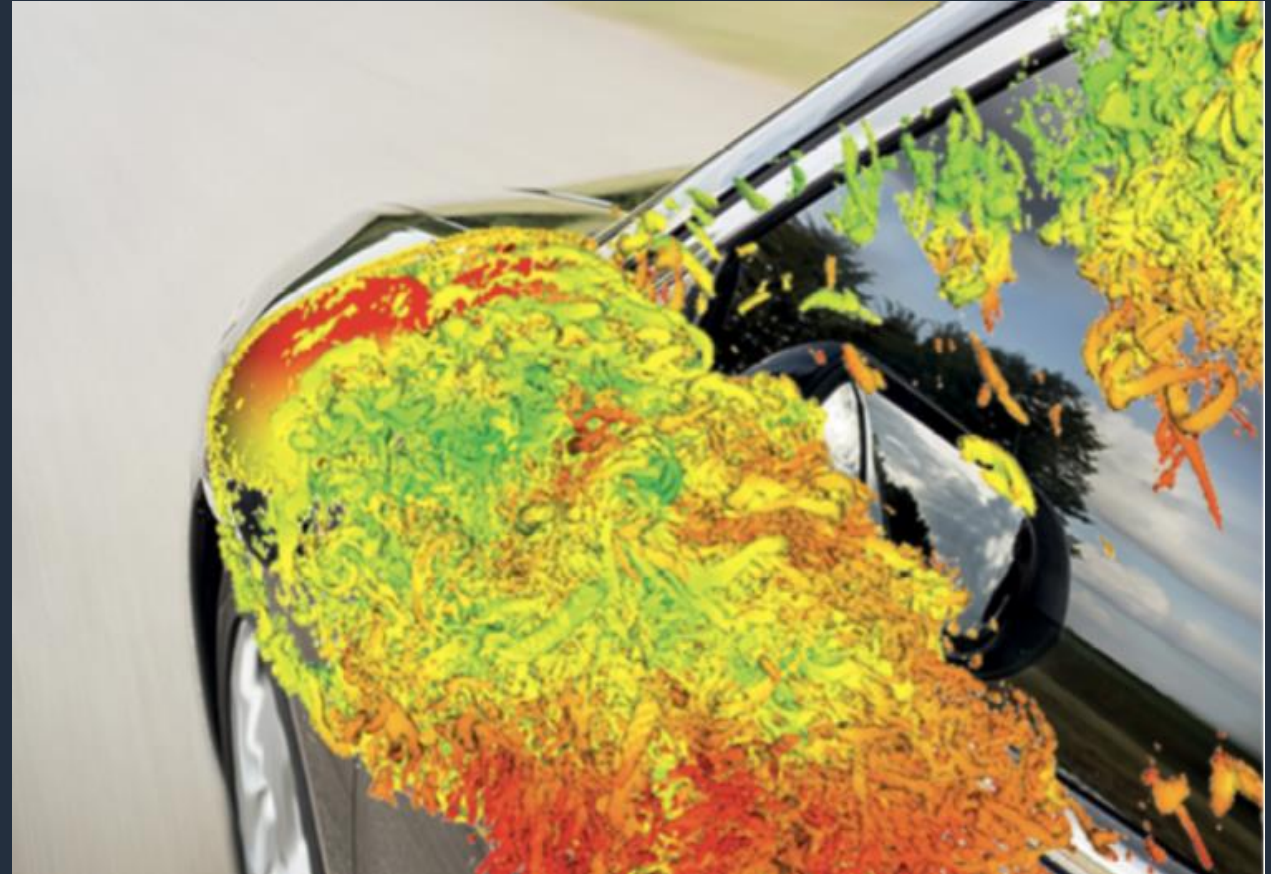


Image from <https://www.openfoam.com/industries/automotive-and-land-transportation>

CERFACS - AVBP

- Very common in research
- Large team of researchers and engineers
- Lots of different software
- Often used in combustion.
- Used at COEC

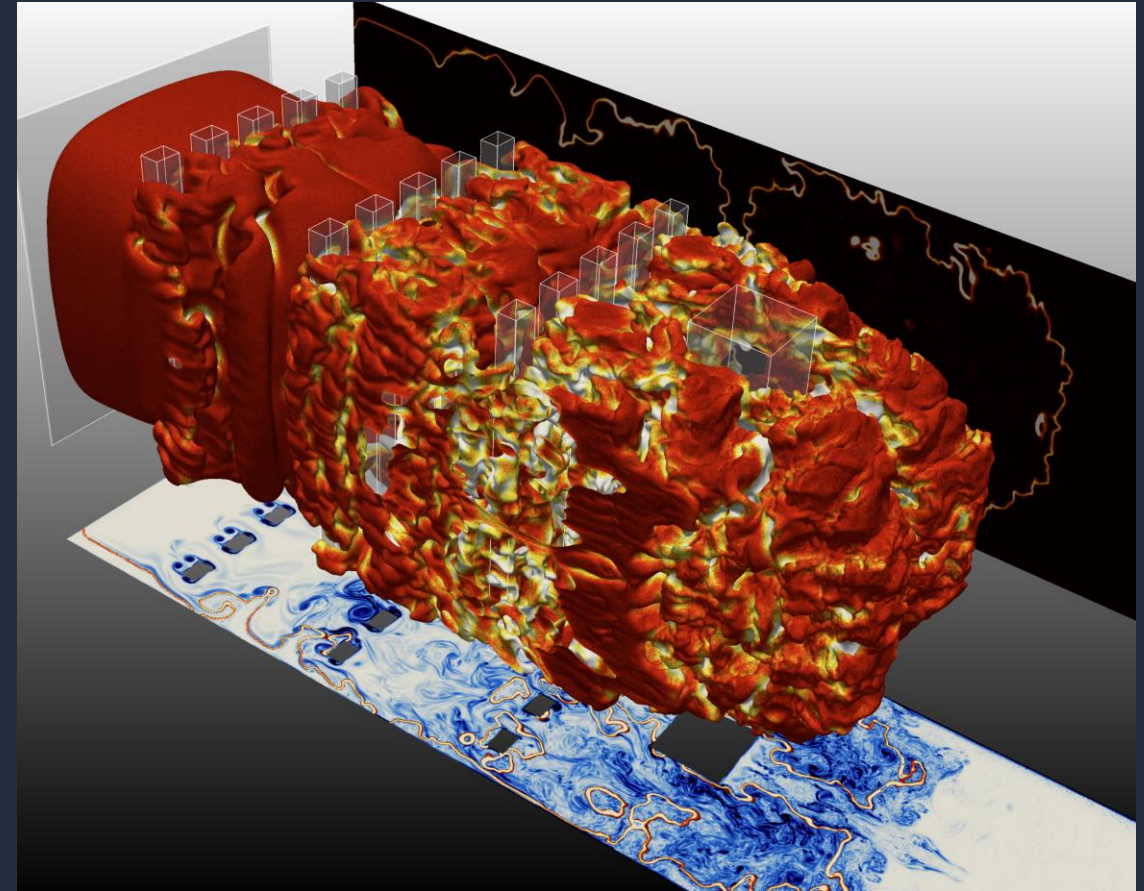


Image from <https://www.cerfacs.fr/avbp7x/>

FDS - Fire Dynamics Simulator

- Simulation of Fire
- Specialized code to simulate fire and smoke
- Can be linked to other tools to simulate peoples evacuating



Image from <https://pages.nist.gov/fds-smv/>

Nalu Wind / ExaWind / AMRWind

- One of the most common CFD Applications run on AWS
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- Many choices of technology

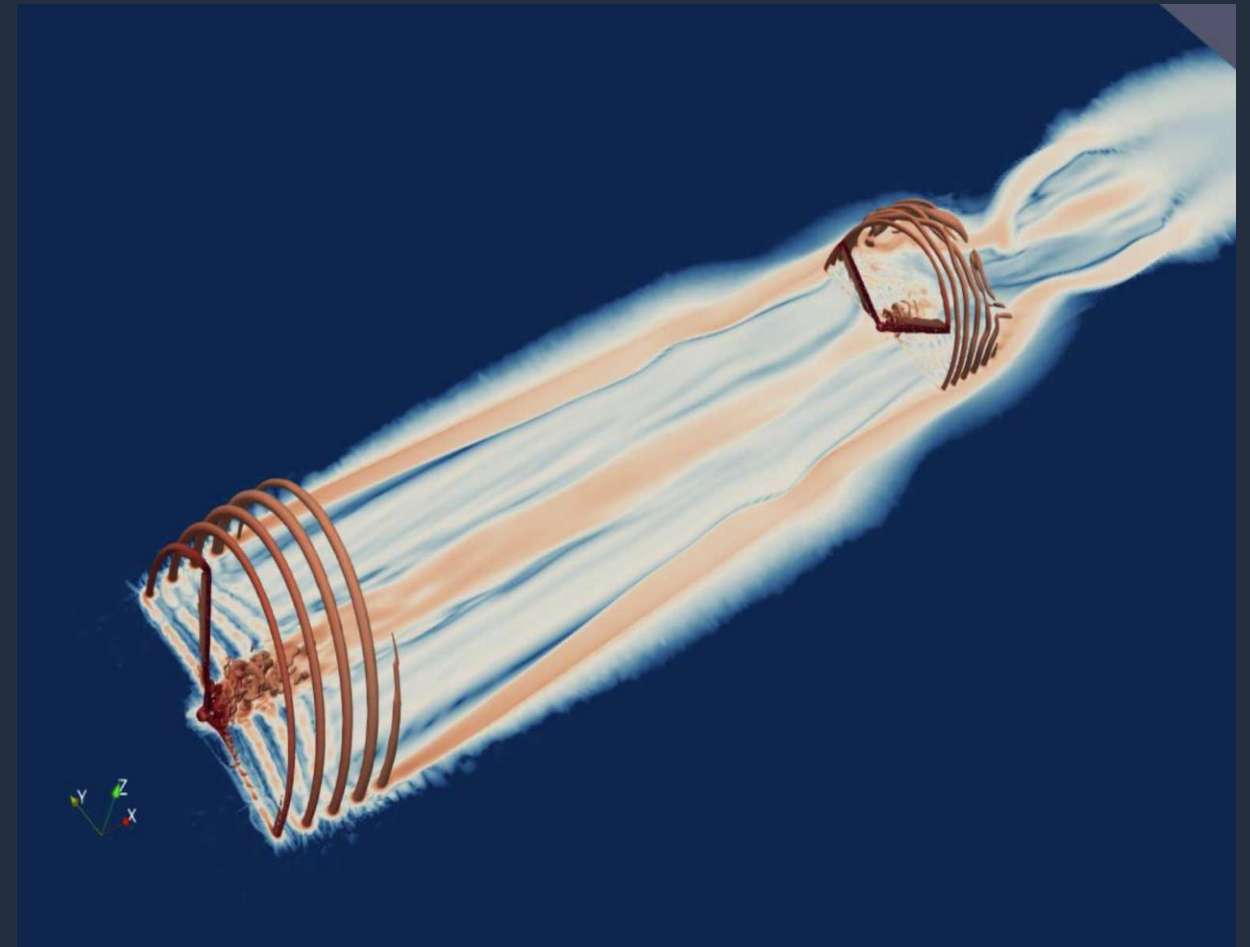
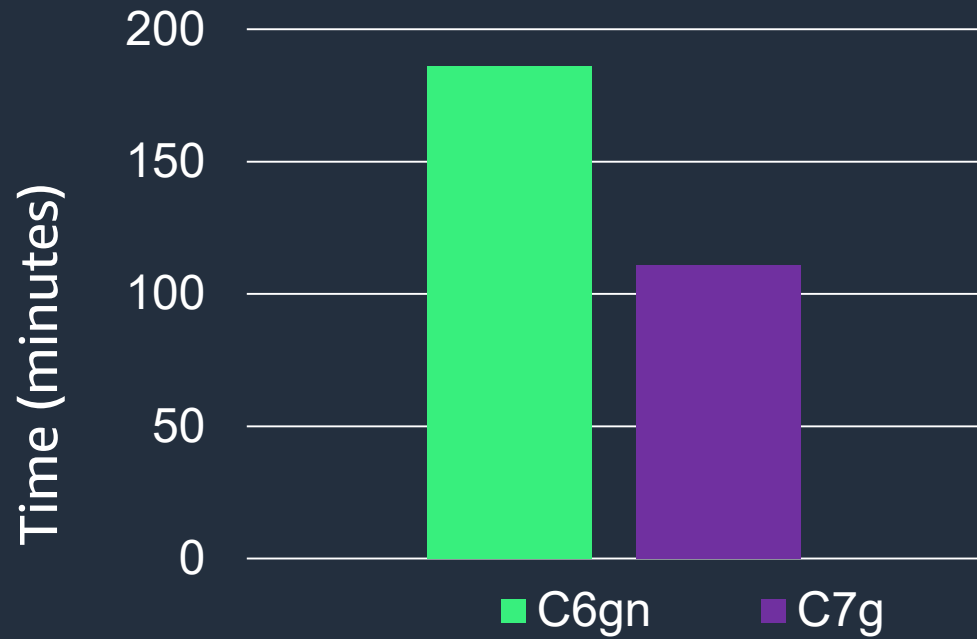


Image from <https://www.osti.gov/servlets/purl/1762093>

Graviton3 is 40% faster than Graviton2 for F1



“We had already seen that Graviton2-based c6gn instances provided us the best price-performance for some of our CFD workloads. We have now found Graviton3 c7g instances to be 40% faster than the Graviton2 c6gn instances for those same simulations. We’re excited that EFA will be standard on this instance type and given this much improved price/performance we expect Graviton3-based instances to become the optimal choice to run all of our CFD workloads.”

Pat Symonds, CTO, Formula 1 Management

Boom Supersonic

Boom Supersonic leveraged AWS to **accelerate the design and construction** of its supersonic aircraft

Boom can run thousands of advanced computer simulations concurrently, resulting in an estimated **6x increase in productivity versus an on-premises environment**

Boom utilized more than **53 million compute hours** on AWS to **complete design and testing** of its Overture airliner





Rivian Executes Vision of Agile Engineering on AWS

“In early product development stages, we don’t have many physical vehicles, so we use AWS to bring the design space to life.”

“People who were skeptical about high-performance computing in the cloud are more open minded after seeing our results on AWS”

- Madhavi Isanaka, CIO, Rivian



Boeing

Press release

**Boeing and AWS Join Forces
to Transform Aerospace
Design and Manufacturing**
April 6, 2022

*Boeing will **migrate applications out of on-premises data centers to AWS** and create a technology foundation that will strengthen engineering and manufacturing processes.*



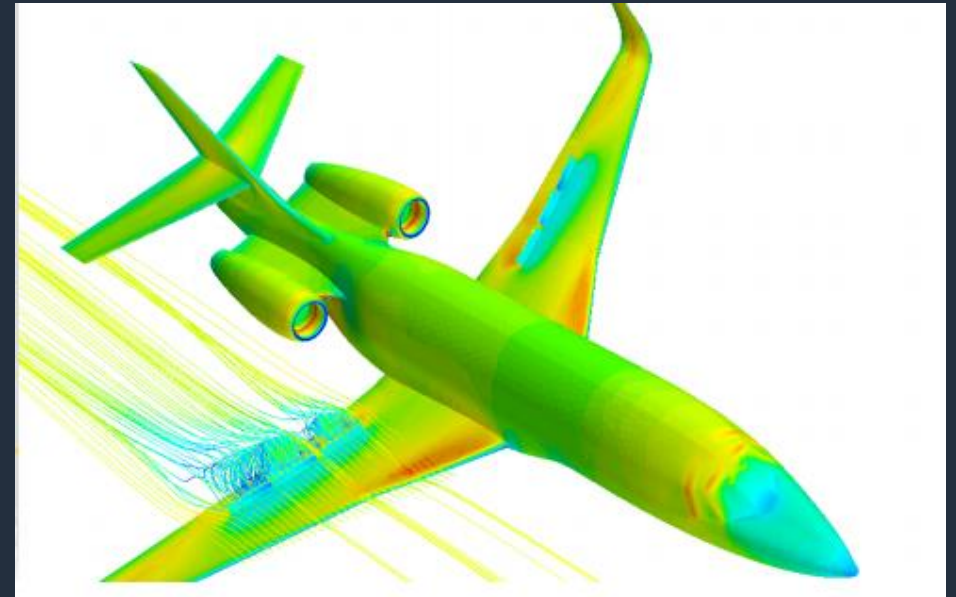
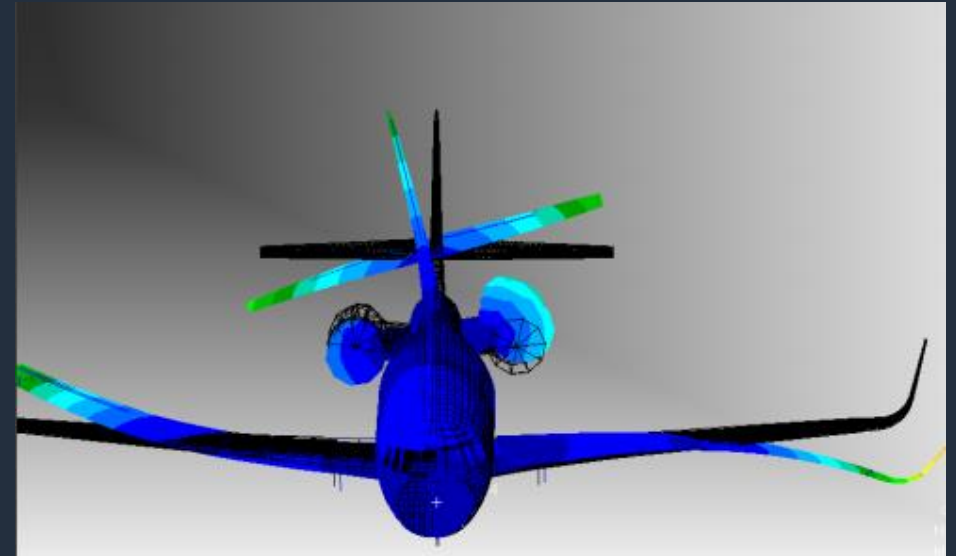


We saw a 75% reduction in the cost per CFD simulation as soon as we started using Amazon EC2 Spot instances. We are able to pass those savings along to our customers—and be more competitive.”

Andrew McComas

Engineering Manager, TLG Aerospace

<https://aws.amazon.com/solutions/case-studies/tlg-aerospace/>



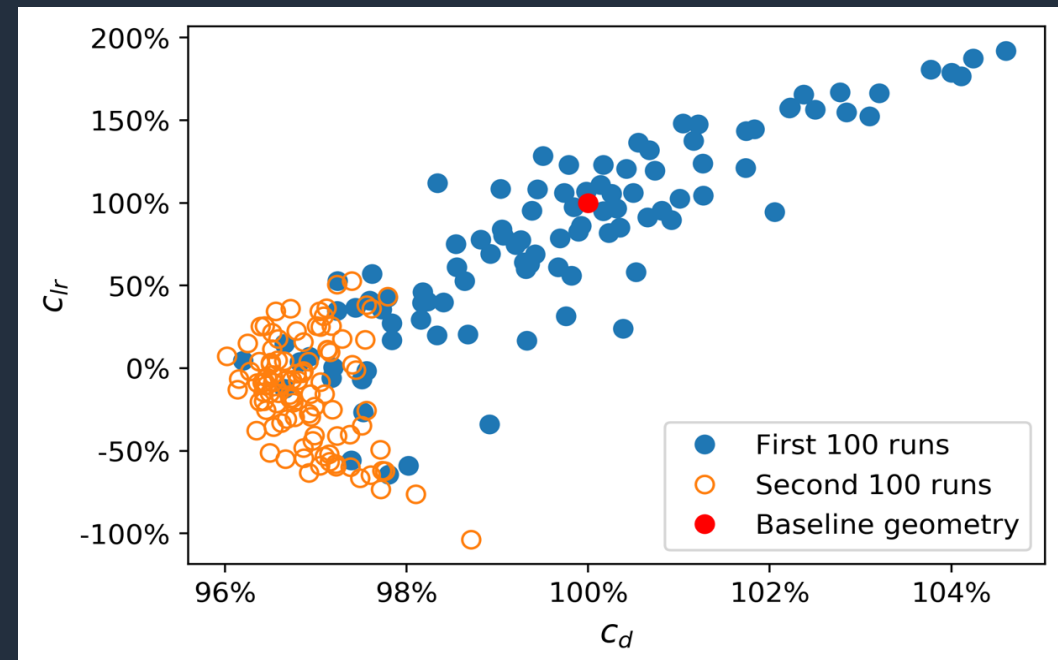
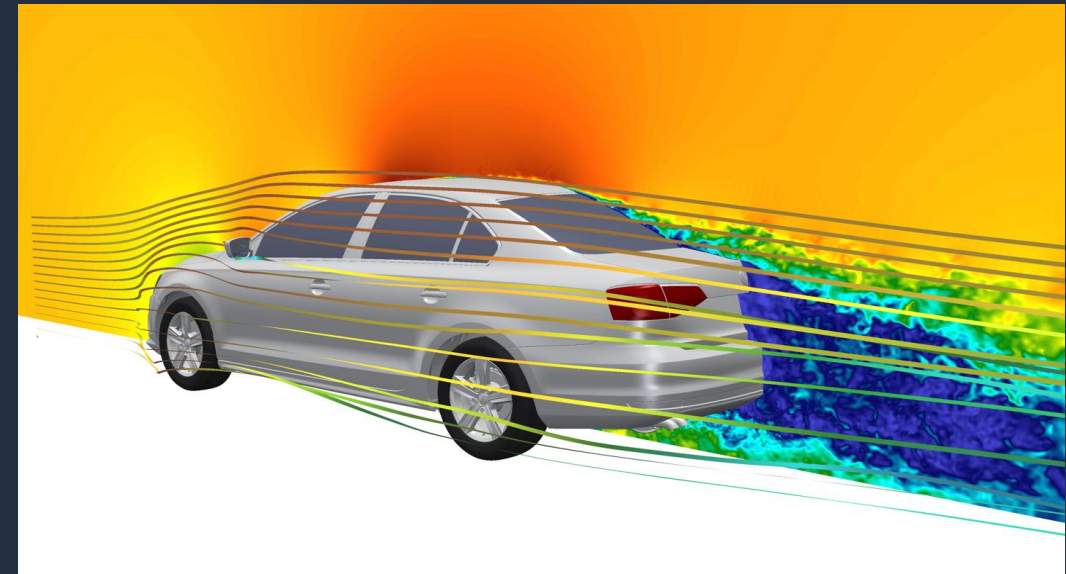
VOLKSWAGEN GROUP

Simulation on NVIDIA GPU's on AWS is a game-changer for aerodynamic development in the automotive industry.

We were able to run 200 car shape variants in a time frame that would normally correspond to only a few runs with our current operational tools

Dr. Henry Bensler, head of CAE Methods at Volkswagen Group Research

<https://aws.amazon.com/partners/success/volkswagen-ag-altair/>



INEOS | TEAM UK

- 36th America's Cup (2021)
- 15,000 designs in less than a month (x20 more than on-prem)

“Working with AWS for the first time this year has given us access to more and faster computational resources, which has proven crucial in developing the fastest race boat possible. It has helped the team push ahead as we continue to design and develop our race boat for the America's Cup.”

- Sir Ben Ainslie (most successful Olympic sailor)



Toyota

Virtual Desktops for Engineering



Reference: <https://www.youtube.com/watch?v=vrA-KiYXTug>



Time to open files

5 min. – near data
on premises

35–55 min. – remote
to data on premises

3 min. – AWS Cloud



User experience

~150 hours of productivity
gained per engineer with
AWS solution

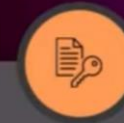
Improved employee
satisfaction anticipated
based on feedback



Engineering performance

On-premises
benchmarking – 10.5 min.

AWS Cloud – 10 min.



Remote work capability

Users tested in the
office and at home

Observed results were
better than current
remote access options
to physical workstations

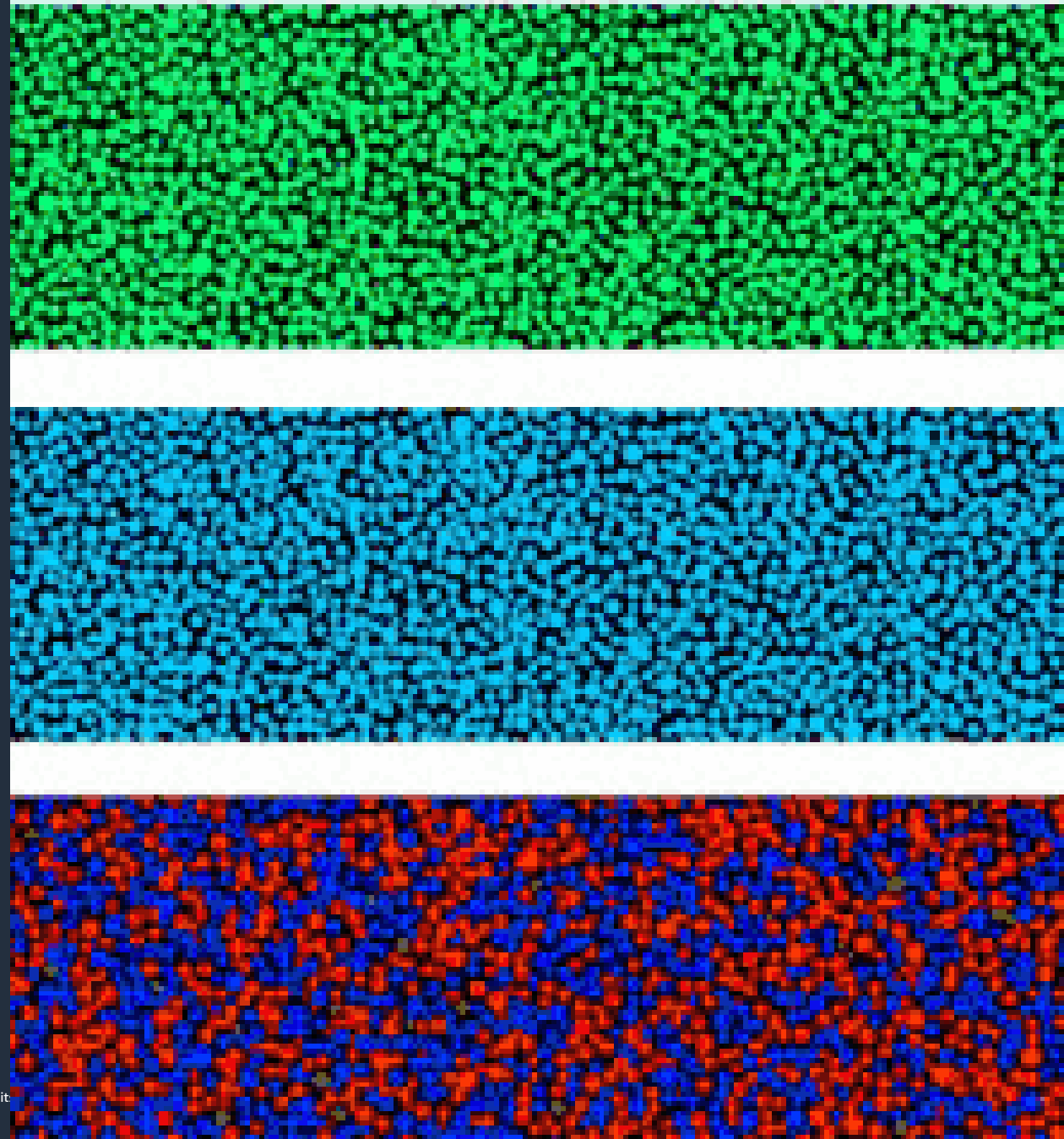
Western Digital

Over 2.3 million simulation jobs on a single HPC cluster of 1 million vCPUs—built using Amazon EC2 Spot Instances.

Time to results: 20 Days → 8 hours

"Using AWS to easily shrink simulation time from 20 days to 8 hours allows Western Digital R&D teams to explore new designs and innovations at a pace un-imaginable just a short time ago."

– Steve Phillpott, CIO, Western Digital



The cloud offers carbon footprint reduction opportunity

AWS can lower the carbon footprint of average on-premises data center workloads by nearly 80% today and up to 96% once AWS is powered with 100% renewable energy



Find all the reports on aws.amazon.com/sustainability/resources/



How can I try it?

1. Talk to AWS.
2. Talk to the software vendor.
3. Interested in the technology?

Steve Messenger
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