IT4Innovations
national supercomputing center

IT4Innovations
Národní superpočítačové centrum

Superpočítání v Ostravě

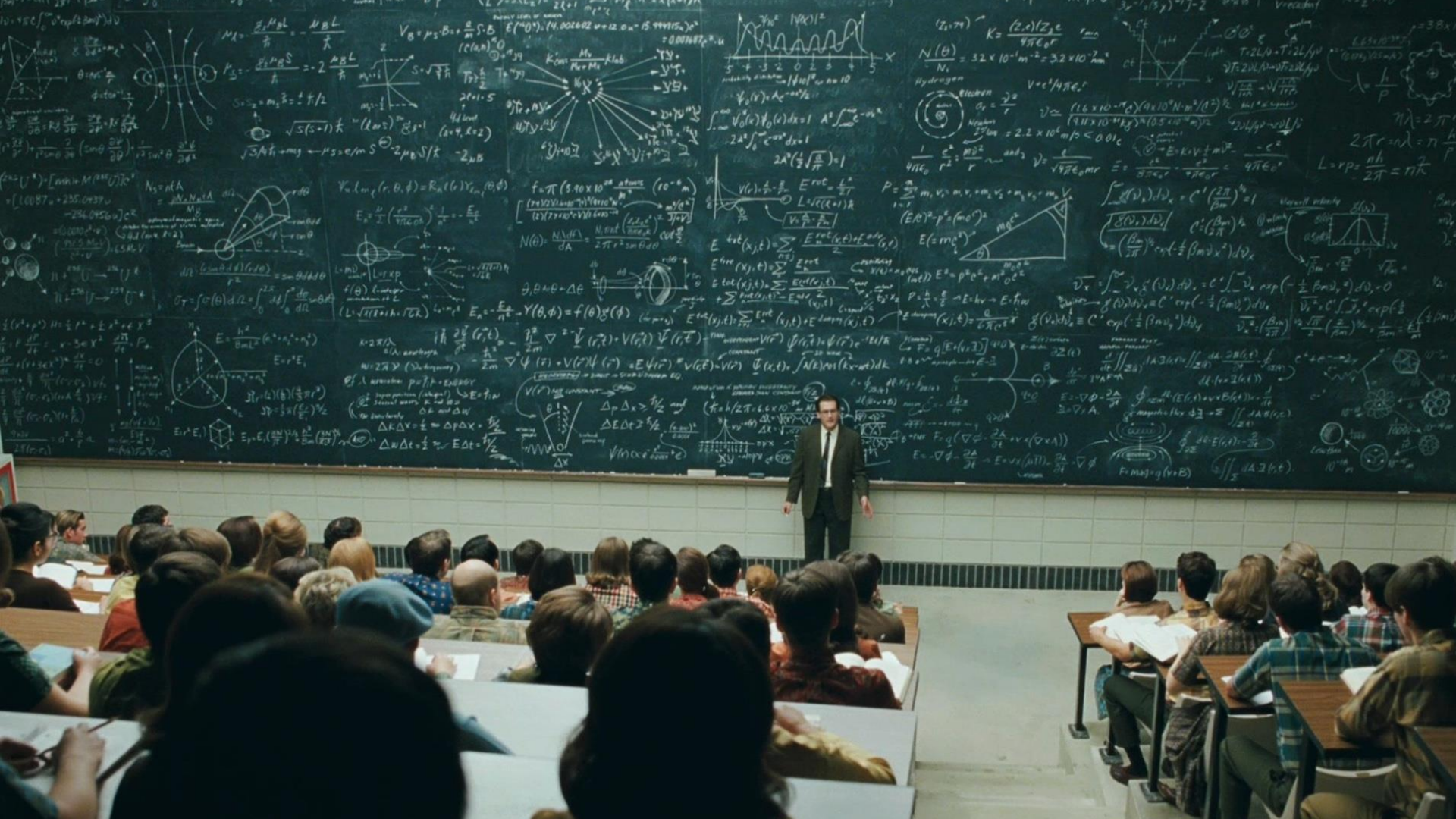
Tomáš Brzobohatý




UNIVERSITAS OSTRAVIENSIS

Institute of Geonics ASCR

FIT



$$\frac{\partial \rho}{\partial t} + u\frac{\partial \rho}{\partial x} + v\frac{\partial \rho}{\partial y} + \rho\frac{\partial u}{\partial x} + \rho\frac{\partial v}{\partial y} = 0$$

$$\rho\left(\frac{\partial u}{\partial t} + u\frac{\partial u}{\partial x} + v\frac{\partial u}{\partial y}\right) = -\frac{\partial p}{\partial x} + \frac{\partial \tau_{xx}}{\partial x} + \frac{\partial \tau_{yx}}{\partial y}$$

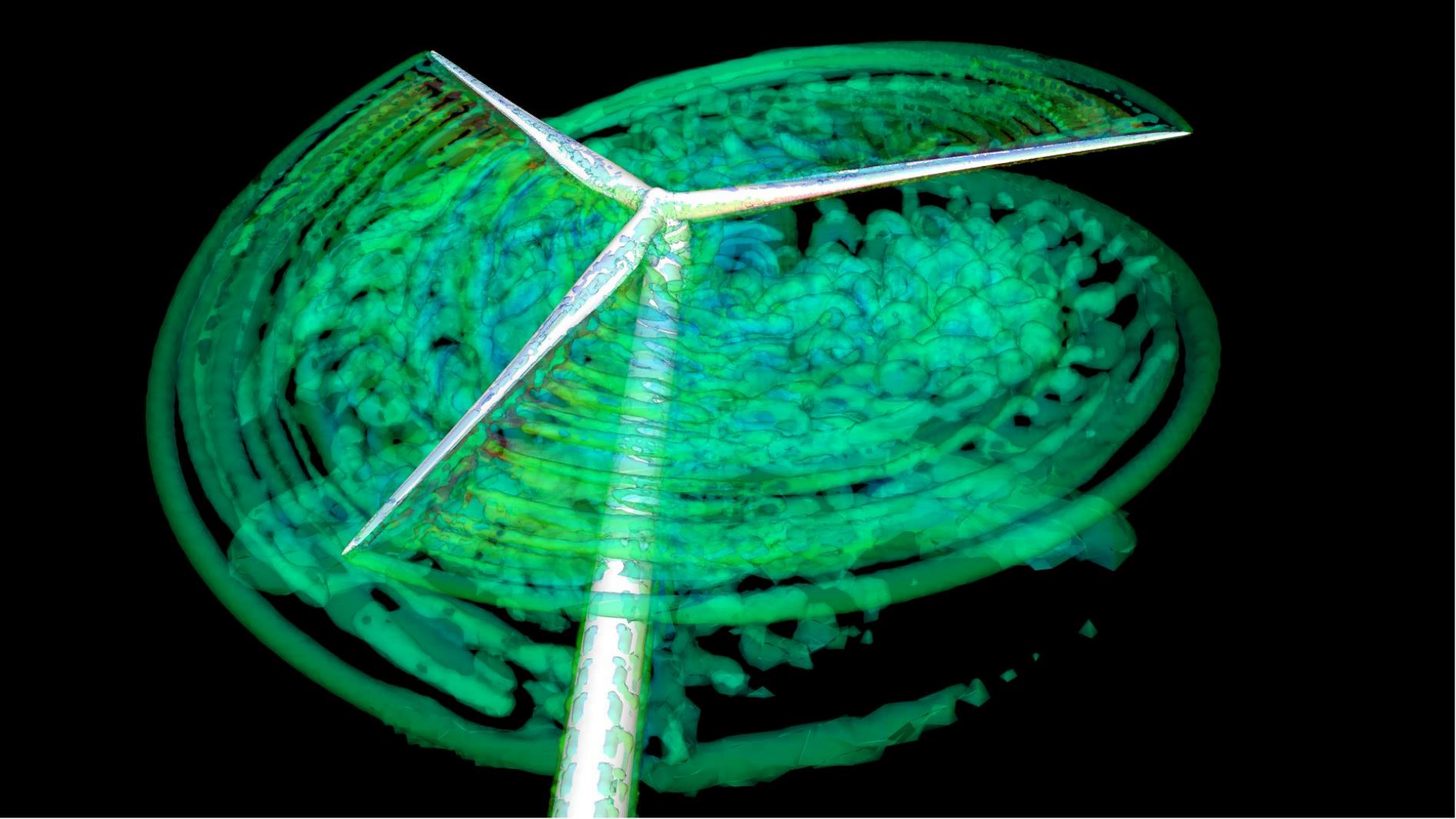
$$\rho\left(\frac{\partial v}{\partial t} + u\frac{\partial v}{\partial x} + v\frac{\partial v}{\partial y}\right) = -\frac{\partial p}{\partial y} + \frac{\partial \tau_{xy}}{\partial x} + \frac{\partial \tau_{yy}}{\partial y}$$

$$\rho\left(\frac{\partial E}{\partial t} + u\frac{\partial E}{\partial x} + v\frac{\partial E}{\partial y}\right) = \frac{\partial}{\partial x}\left(\kappa\frac{\partial T}{\partial x}\right) + \frac{\partial}{\partial y}\left(\kappa\frac{\partial T}{\partial y}\right)$$

$$- \frac{\partial (up)}{\partial x} - \frac{\partial (vp)}{\partial y} + \frac{\partial (u\tau_{xx})}{\partial x}$$

$$+ \frac{\partial (u\tau_{xy})}{\partial y} + \frac{\partial (v\tau_{xy})}{\partial x} + \frac{\partial (v\tau_{yy})}{\partial y}$$

$$
\begin{aligned}
\nabla\tau + f &= 0 \\
\tau &= (\lambda\nabla\cdot\mathbf{u})\,\mathbf{I} + \mu\left(\nabla\mathbf{u} + \nabla\left(\mathbf{u}\right)^{t}\right) \\
\tau\cdot\mathbf{n} &= -F\mathbf{n} \\
\tau\cdot\mathbf{e}_r &= -\varrho g\mathbf{u}\cdot e_r
\end{aligned}
$$



$$A\,x = b$$

Velikost úlohy

- rozsáhlé celky, území

Fyzikální složitost

- nelineární strukturální mechanika
- proudění tekutin (spalování, AMI)
- aeroakustika
- optimalizace
- FSI

Paralelní strategie

- více výpočtů současně
- paralelizace na úrovni algebry
- využití prostorové dekompozice
- využití prostorové a časové dekompozice

WWW.top500.org

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TOP 10 Sites for November 2015

For more information about the sites and systems in the list, click on the links or view the complete list.

RANK	SITE	SYSTEM	CORES	RMAX (TFLOP/S)	RPEAK (TFLOP/S)	POWER (KW)
1	National Super Computer Center in Guangzhou China	**Tianhe-2 (MilkyWay-2)** - TH-IVB-FEP Cluster, Intel Xeon E5-2692 12C 2.200GHz, TH Express-2, Intel Xeon Phi 31S1P NUDT	3,120,000	33,862.7	54,902.4	17,808
2	DOE/SC/Oak Ridge National Laboratory United States	**Titan** - Cray XK7 , Opteron 6274 16C 2.200GHz, Cray Gemini interconnect, NVIDIA K20x Cray Inc.	560,640	17,590.0	27,112.5	8,209
3	DOE/NNSA/LLNL United States	**Sequoia** - BlueGene/Q, Power BQC 16C 1.60 GHz, Custom IBM	1,572,864	17,173.2	20,132.7	7,890
4	RIKEN Advanced Institute for Computational Science (AICS) Japan	K computer, SPARC64 VIIIfx 2.0GHz, Tofu interconnect Fujitsu	705,024	10,510.0	11,280.4	12,660
5	DOE/SC/Argonne National Laboratory United States	**Mira** - BlueGene/Q, Power BQC 16C 1.60GHz, Custom IBM	786,432	8,586.6	10,066.3	3,945

Tianhe-2 156 GWh/rok

Moravskoslezský kraj 1277 GWh/rok

ANSELM Cluster

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Total measured performance (Rmax) 73 Tflop/s

FLOPS

SALOMON Cluster

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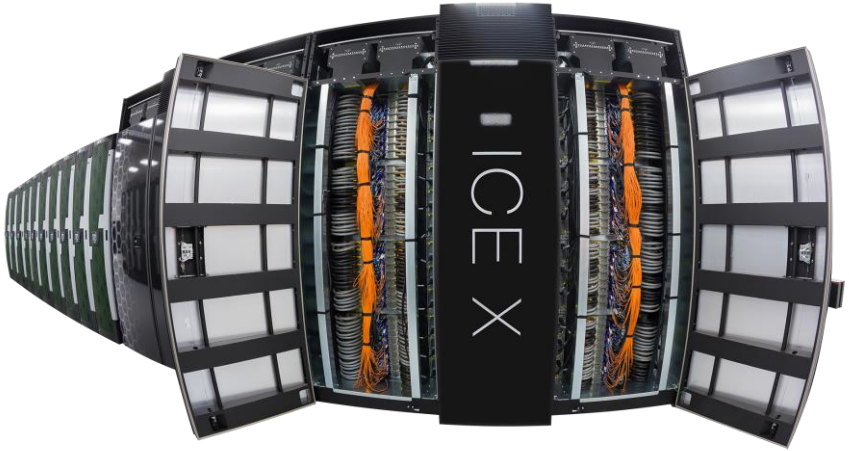

Total measured performance (Rmax) 1457 Tflop/s

SALOMON Cluster

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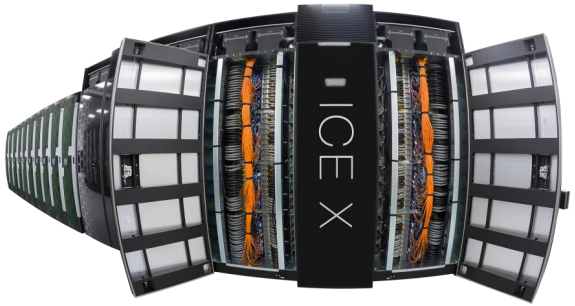
TOP500 LIST 40TH
Q3 - 2015

In total	
Total theoretical peak performance (Rpeak)	2011 Tflop/s
Total measured performance (Rmax)	1457 Tflop/s
Total amount of RAM	129.024 TB

Compute Nodes

Totally	1008
Processor	2x Intel Xeon E5-2680v3, 2.5GHz, 12cores
RAM	128GB, 5.3GB per core, DDR4@2133 MHz
Local disk drive	no
Compute network / Topology	InfiniBand FDR56 / 7D Enhanced hypercube
w/o accelerator	576
MIC accelerated	432

Node	Processor	Memory	Accelerator
w/o accelerator	2x Intel Xeon E5-2680v3, 2.5GHz	128GB	
MIC accelerated	2x Intel Xeon E5-2680v3, 2.5GHz	128GB	2x Intel Xeon Phi 7120P, 61cores, 16GB RAM



Research programmes at IT4Innovations

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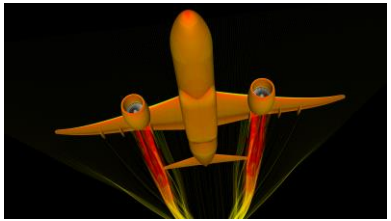
- RP 1 – IT for disaster and traffic management
- RP 2 – Numerical modelling for engineering
- RP 3 – HPC libraries and supercomputing for industry
- RP 4 – Modelling for nanotechnologies
- RP 5 – IT for knowledge management
- RP 6 – Soft computing methods with supercomputer applications
- RP 7 – Multimedia information recognition and presentation
- RP 8 – Secure and safe architectures, networks and protocols



http://www.it4i.cz

CFD and Structural Mechanics

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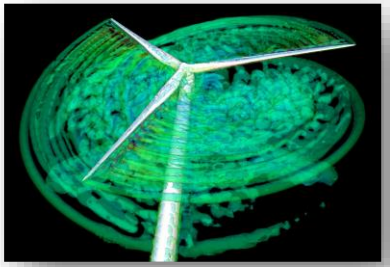
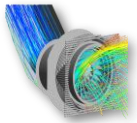
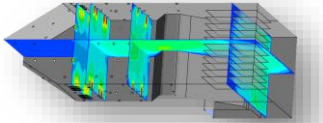
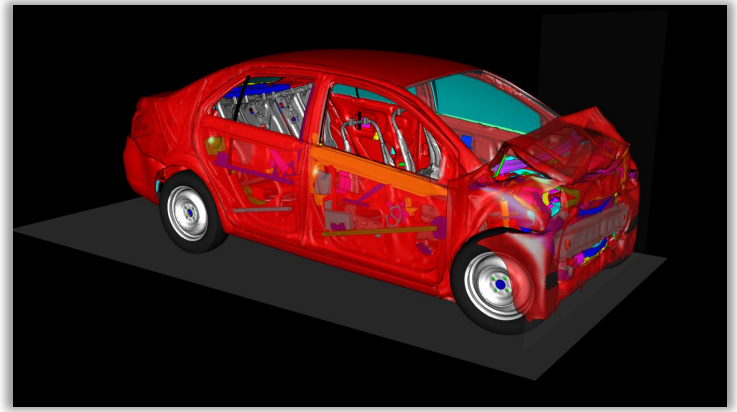
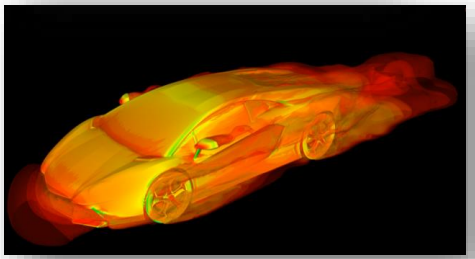
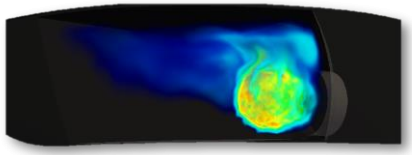


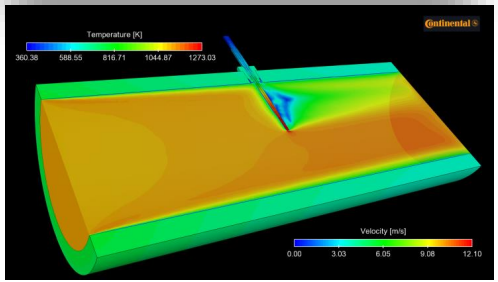


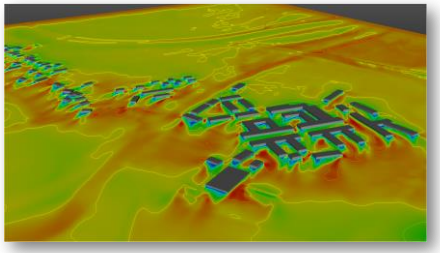


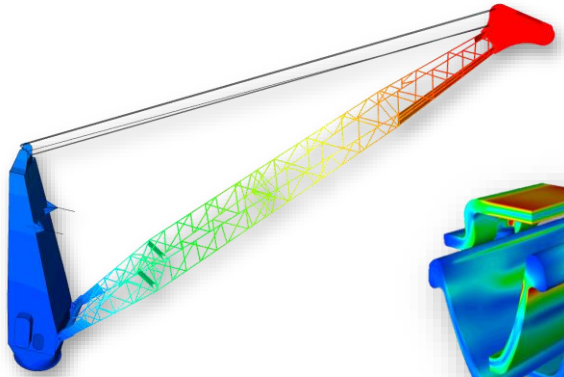


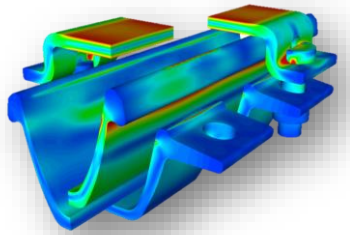






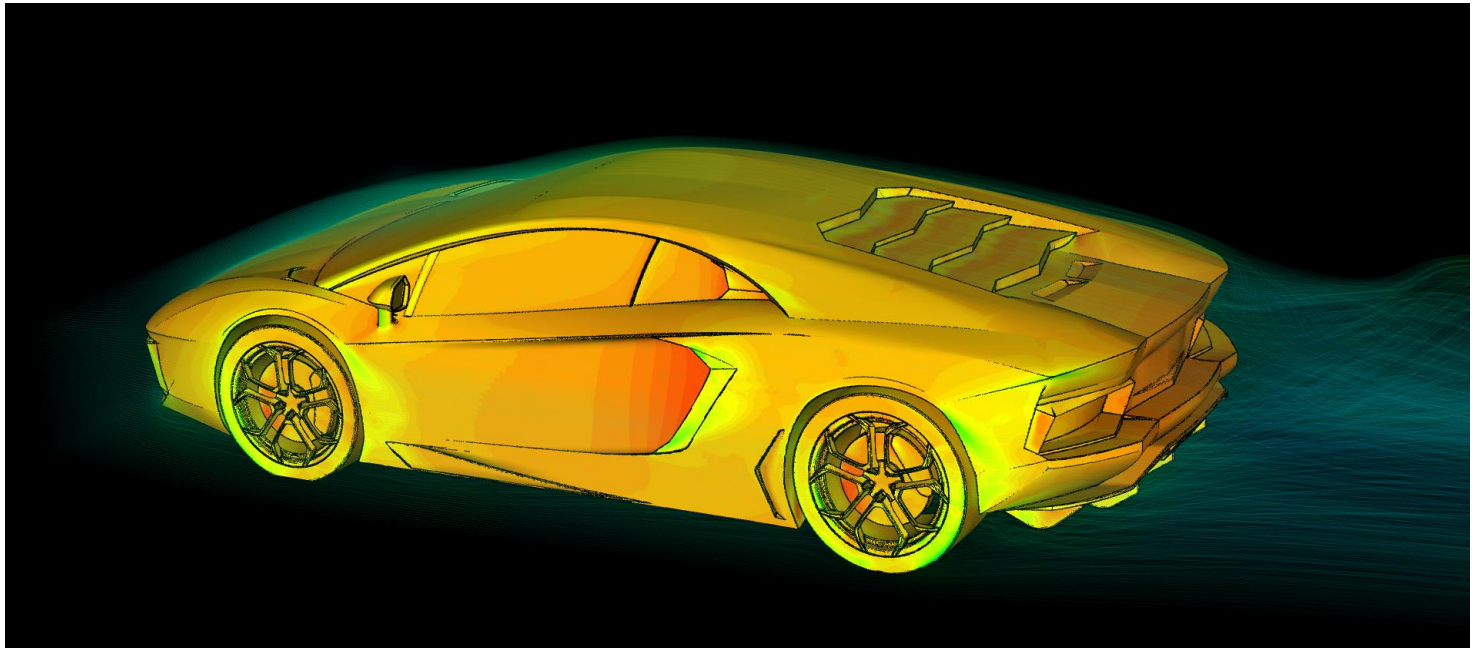






Steady-state problem

225.3 M Cells - 1351.8 M Unknowns



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Parallel Scalability

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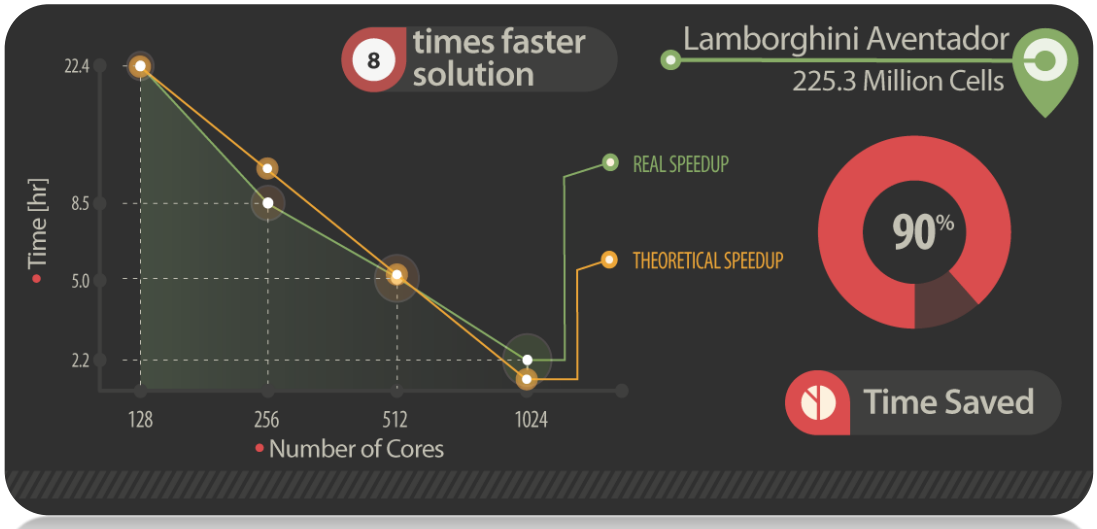

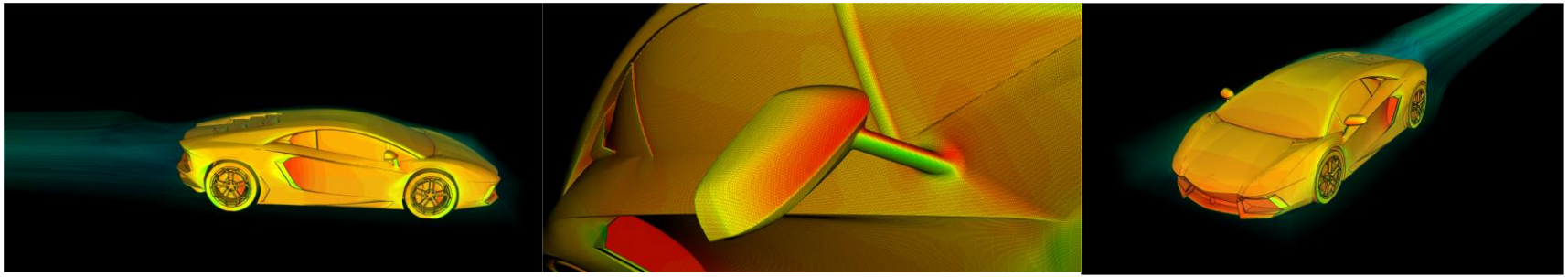

Thermal sensor

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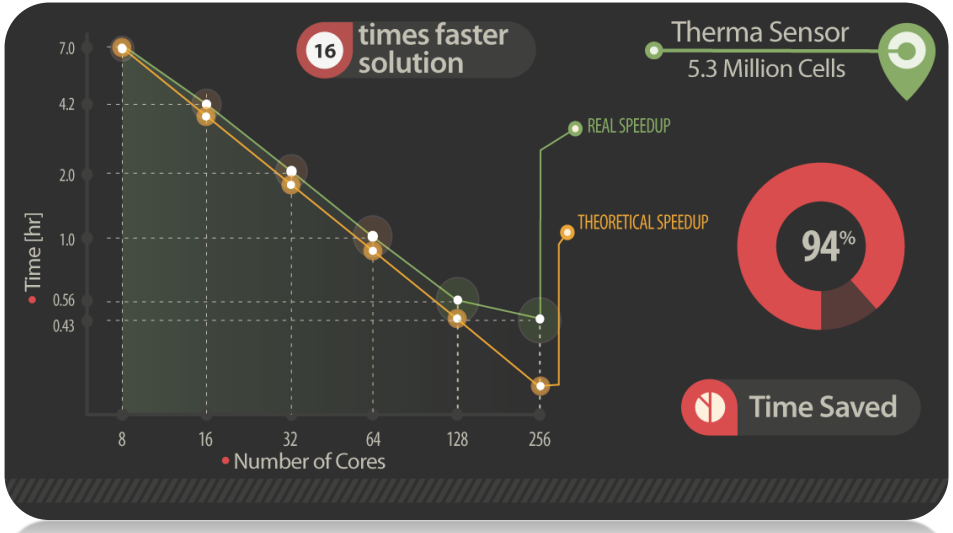

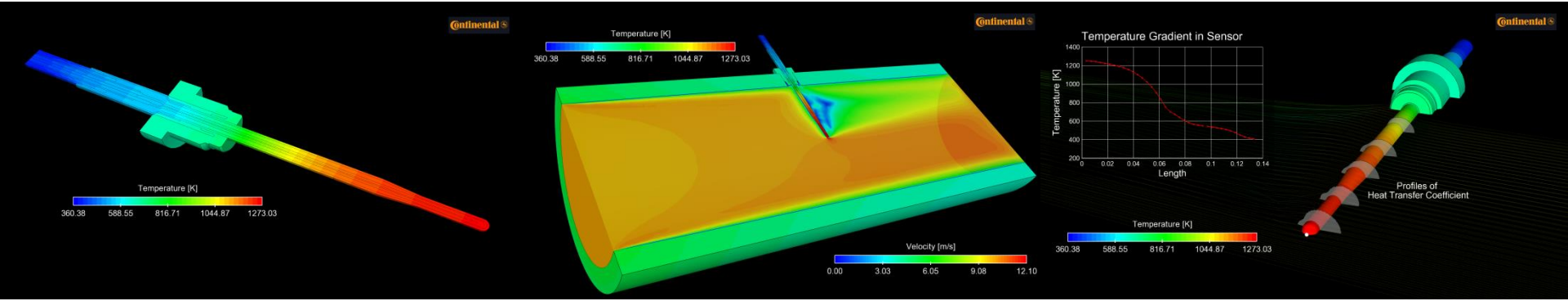

Formula 1's aero restrictions

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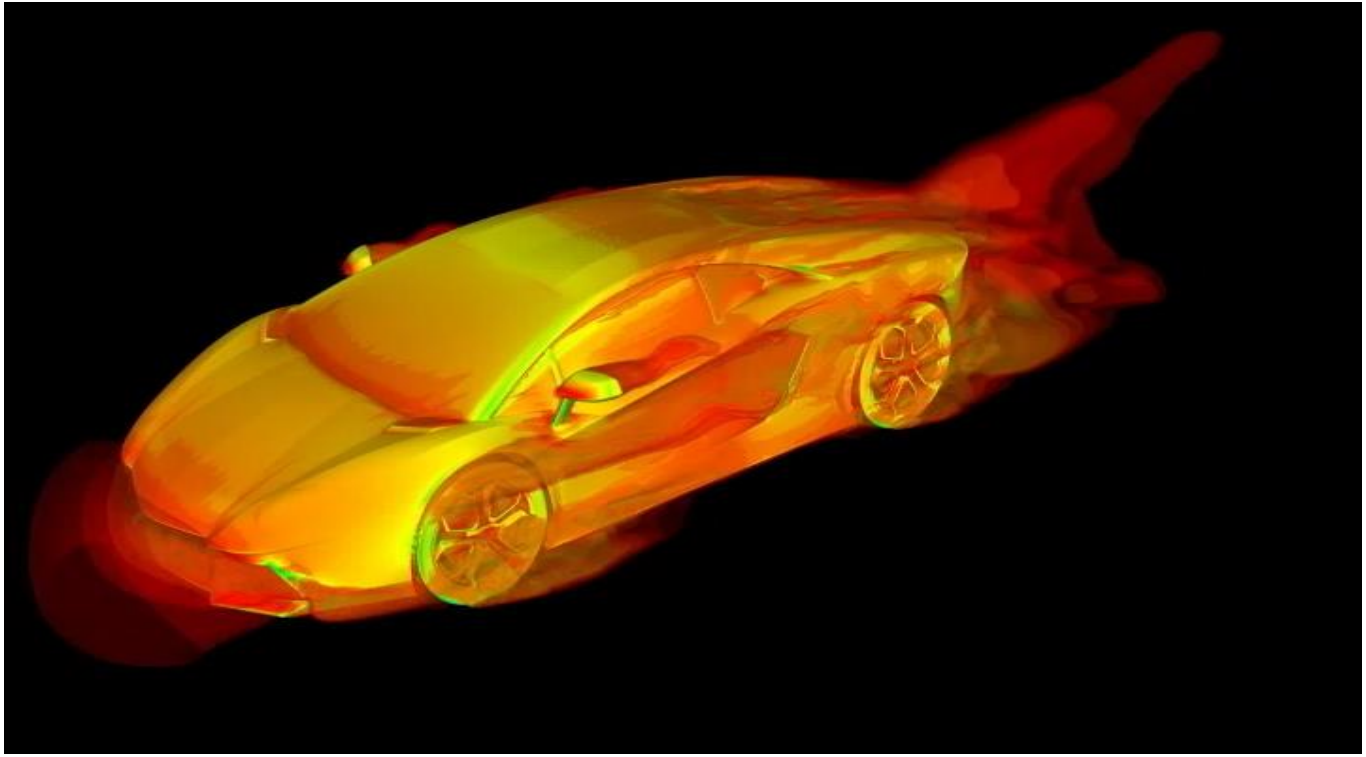
Team could use up to 30 hours per week of wind-on time and no CFD processing, or 30 teraflop of CFD and no wind tunnel or a combination of both


FKFS

Transient problem



Aeroacoustic problems

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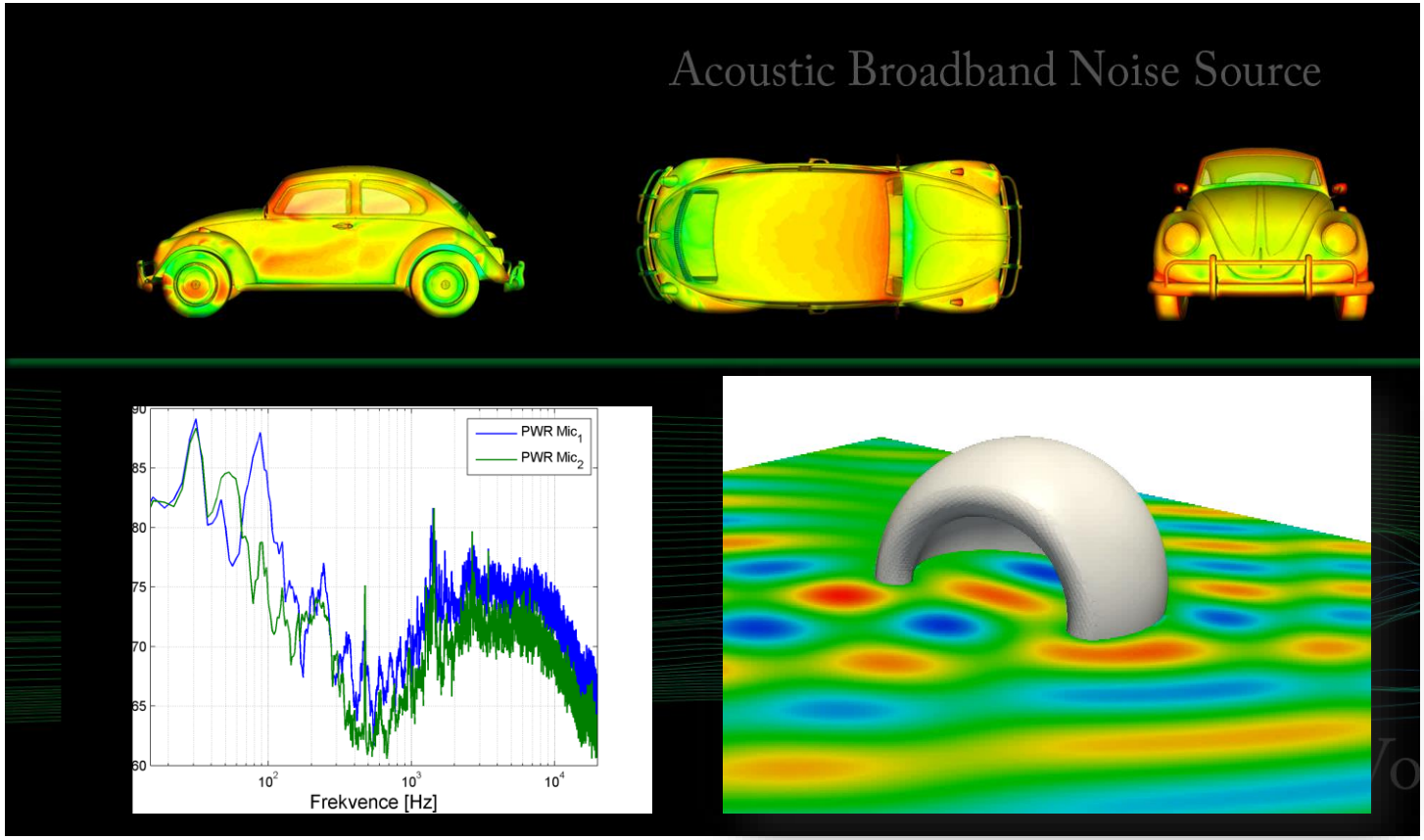

Sound scattering using BEM4I

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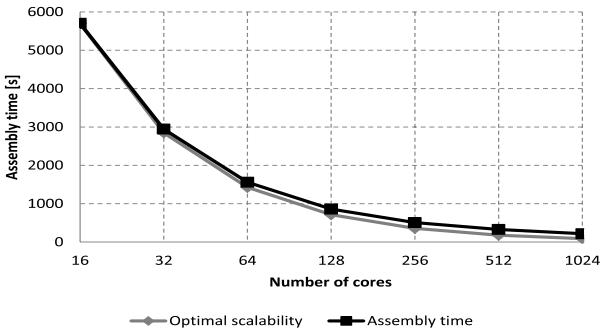
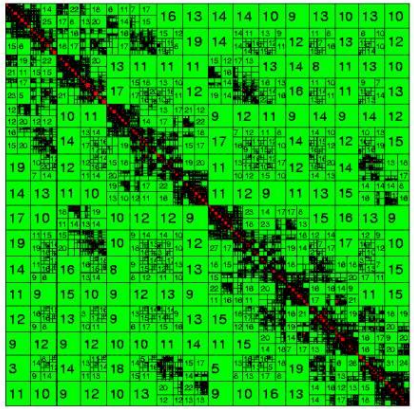
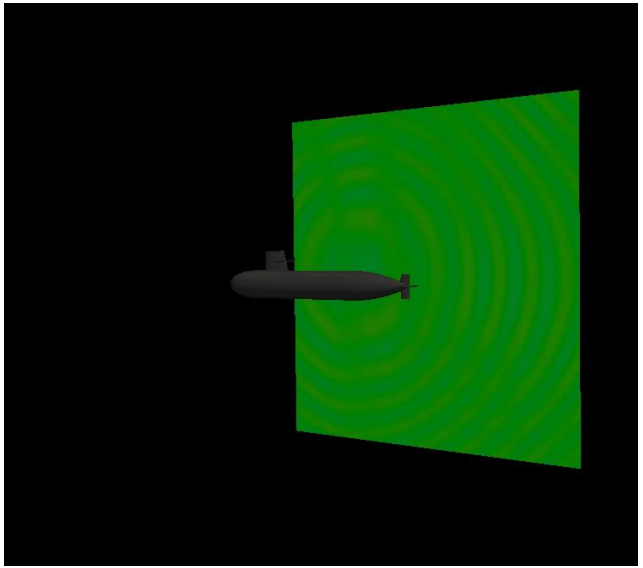
A library of parallel boundary element solvers for the Laplace, Helmholtz, Lamé, and wave equations

Applications in sound scattering, shape optimization, or homogenization.







- Evaluated in 33,685,632 points
- 128 Anselm nodes (2048 cores)
  - Matrix assembly + solve: 140 s
  - Representation formula evaluation: 204 s

Crash Tests

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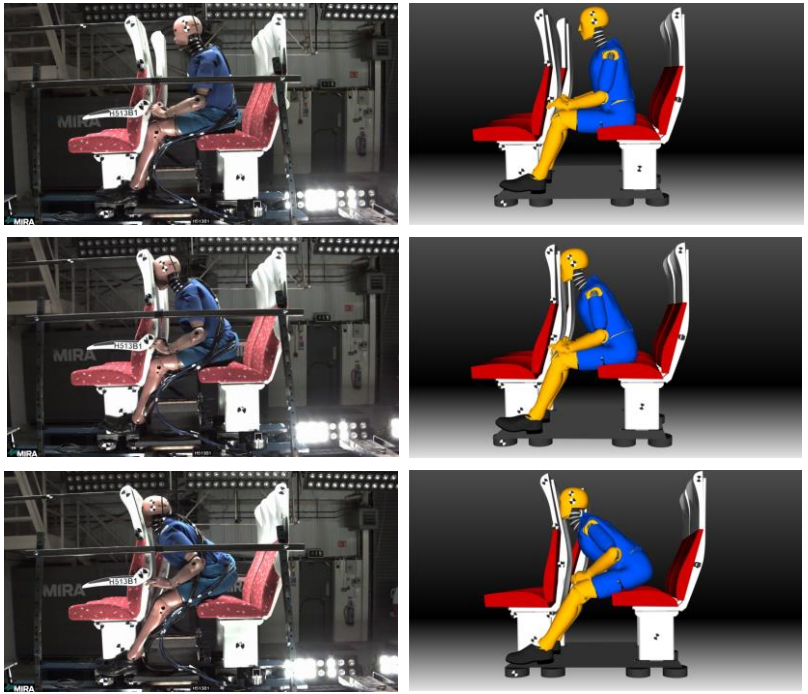
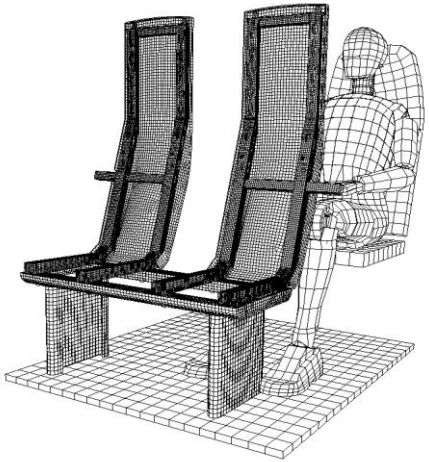
BORCAD





Crash Tests

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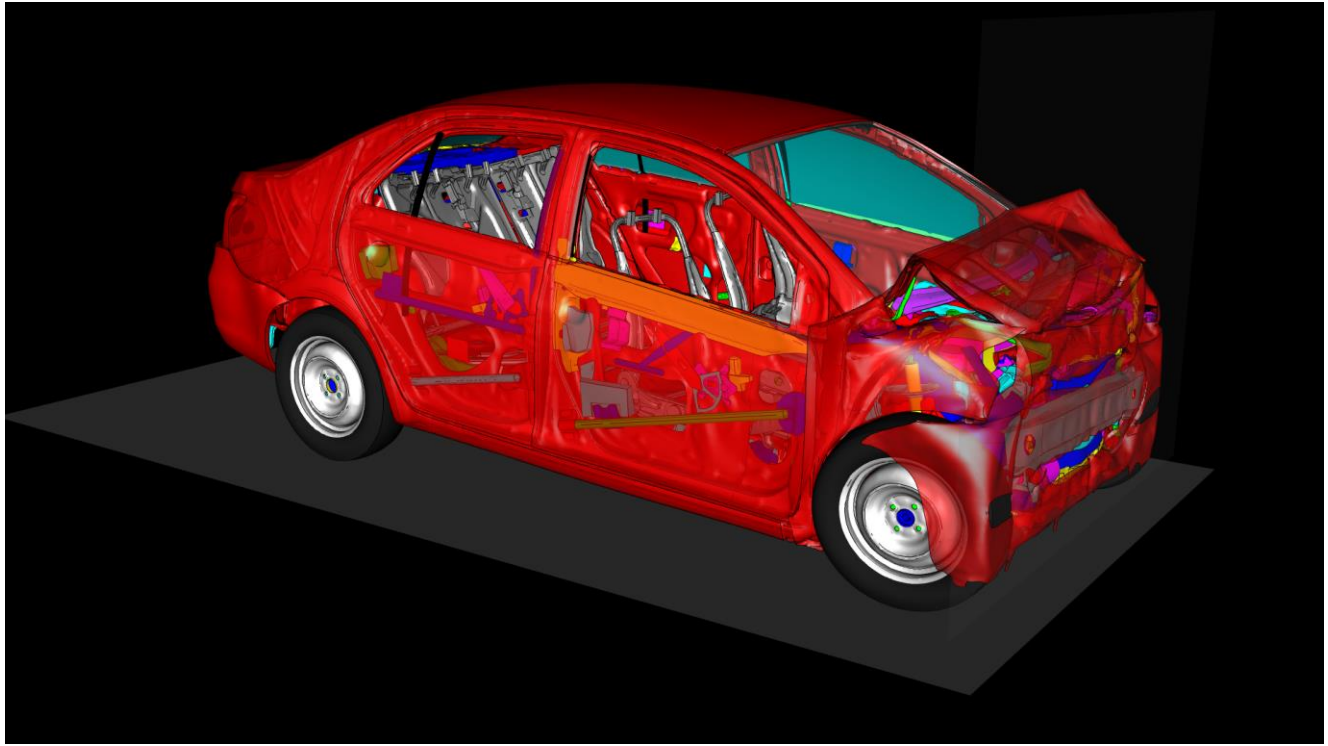

RODOS – viaRODOS.eu

RODOS
ROZVOJ DOPRAVNÍCH SYSTÉMŮ

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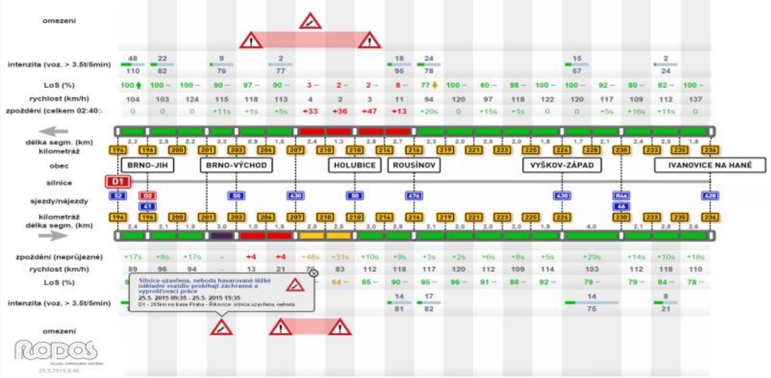
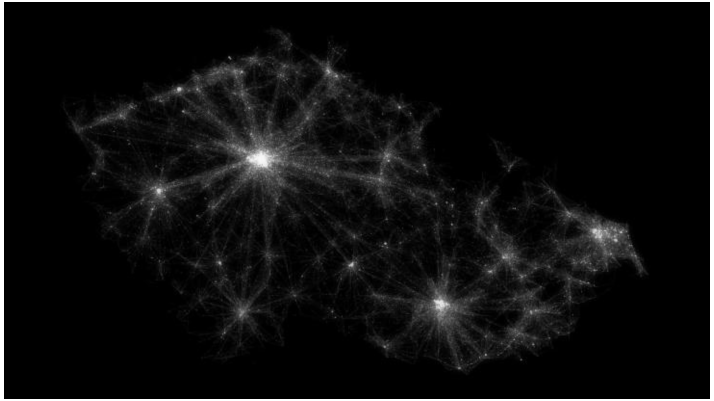


CE-Traffic
kapsch
KVADOS SOFTWARE SOLUTIONS
camea image & signal processing
CENTRUM DOPRAVNÍHO VÝZKUMU
CEDA advanced mapping
ELTODO
FIT



Floreon+ - disaster management support

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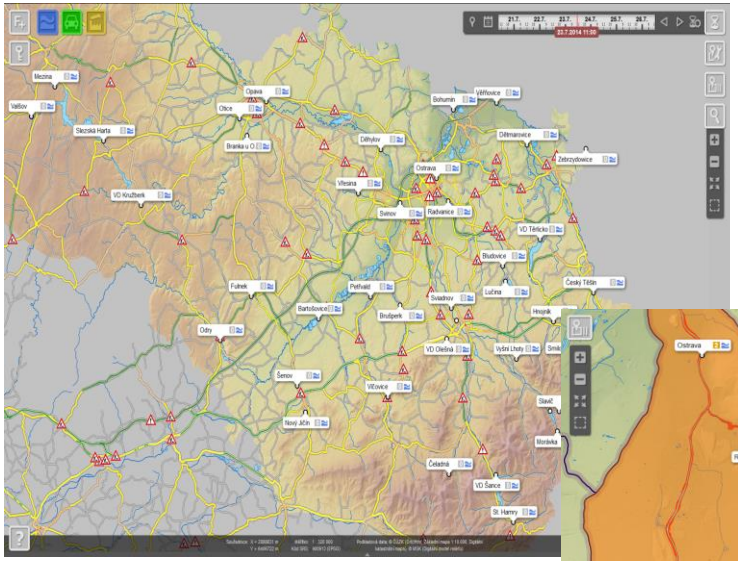
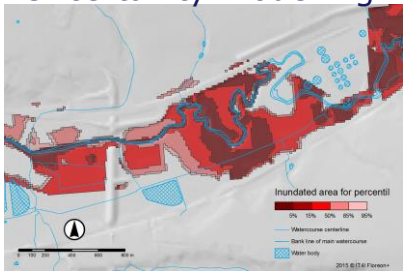
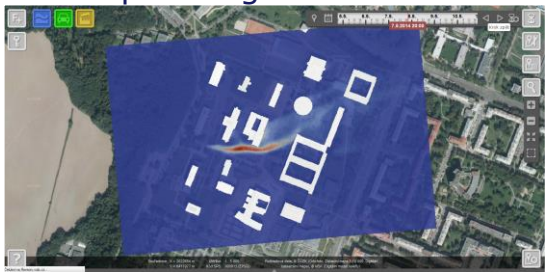
- HPC as a Service extends capabilities of Floreon+ system



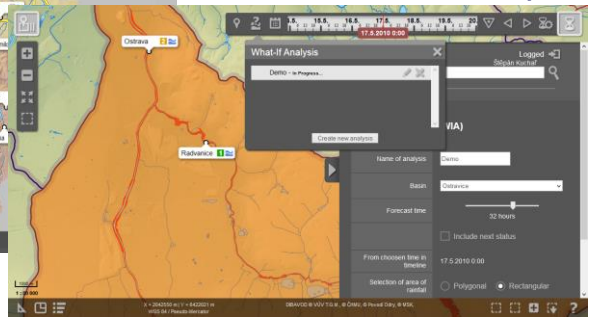
Uncertainty modelling

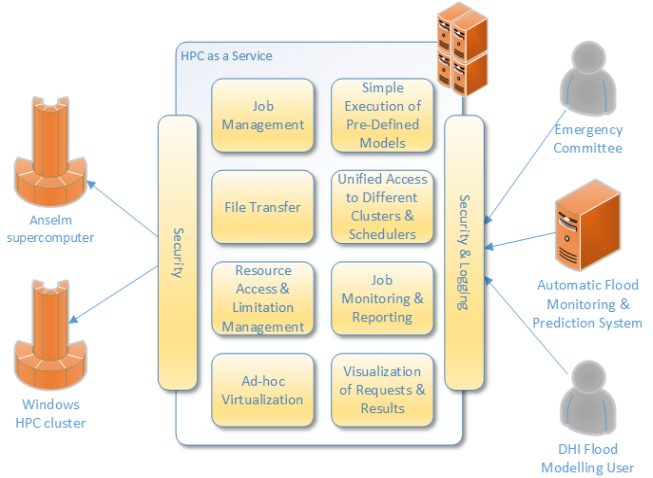


Complex large scale models



What –if analysis





CFD simulation based on open source

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Automatic meshing process over terrain LIDAR data

CFD simulation based on open source

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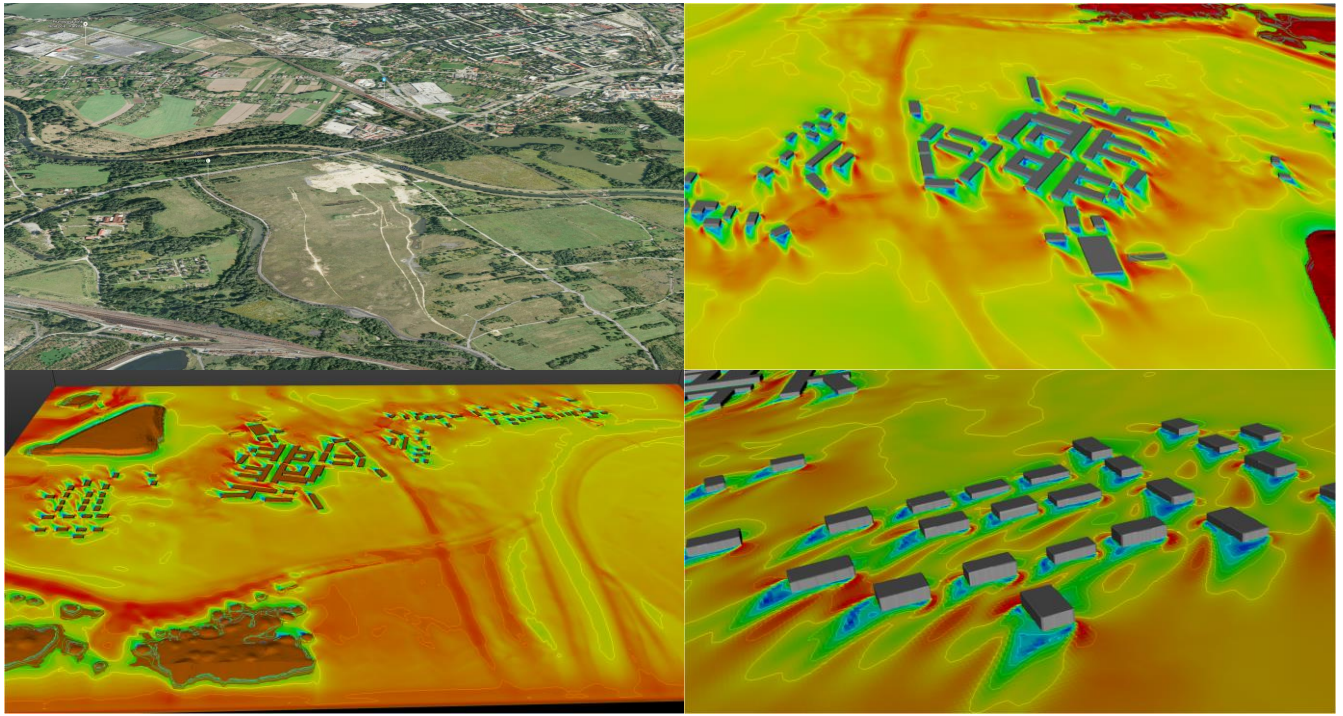
Atmospheric boundary layer

Spread of pollution



Effect of ice-shell thickness variations on the tidal response of Saturn’s moon Enceladus

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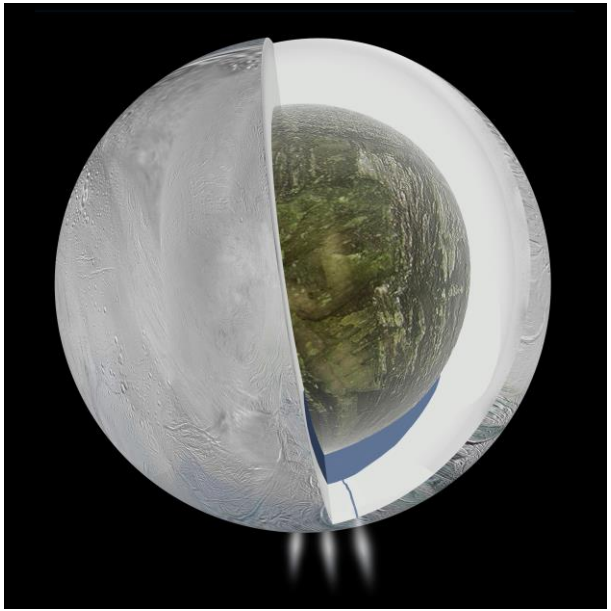

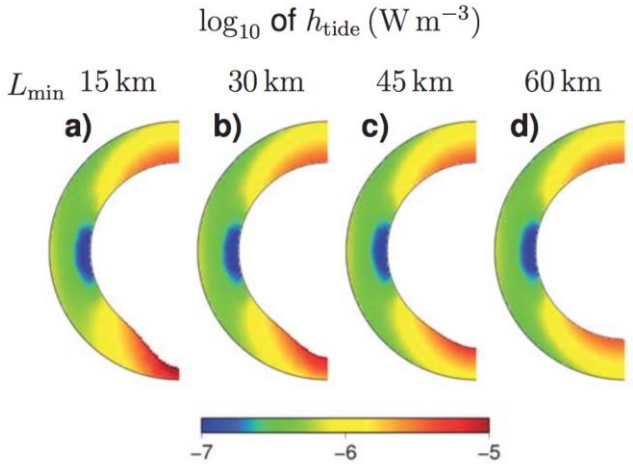

Cooperation with Charles University in Prague, Faculty of Mathematics and Physics, Department of Geophysics

Image Analysis and Processing

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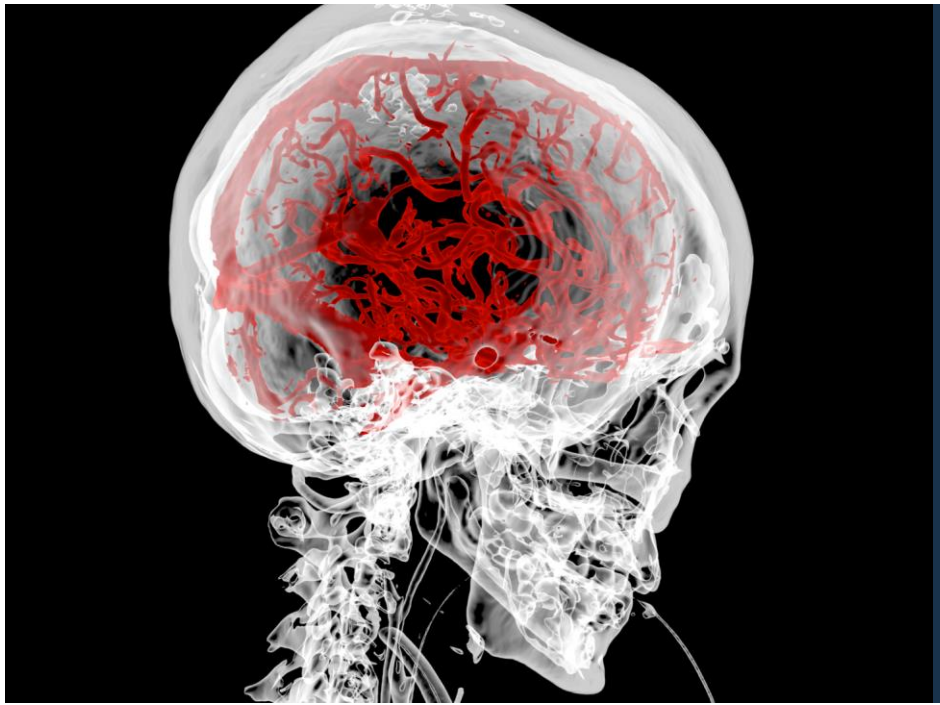
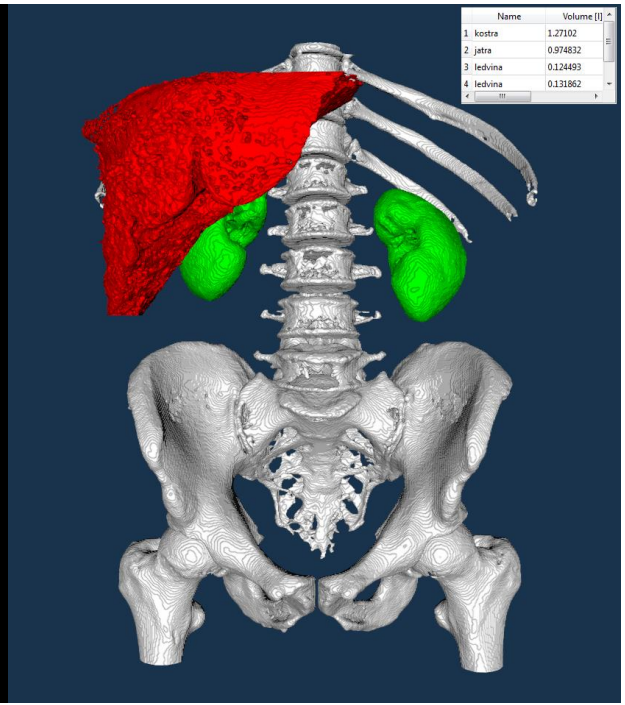
- Rendering
- Creating 3D models from CT and MR scans
- Bio CFD and CSM simulations
- Virtual Reality Lab





Future computing

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US Department of Energy CORAL Supercomputers				
	Aurora	**Theta**	**Summit**	**Sierra**
CPU Architecture	Intel Xeon	Intel Xeon	IBM POWER9	IBM POWER9
Accelerator Architecture	Intel Xeon Phi	Intel Xeon Phi	NVIDIA Volta	NVIDIA Volta
Performance	180 PFLOPS	8.5 PFLOPS	130-300 PFLOPS	100+ PFLOPS
Nodes	50,000	N/A	3,400	N/A
Laboratory	Argonne	Argonne	Oak Ridge	Lawrence Livermore

ExaScale PaRallel FETI SOlver (ESPRESO)

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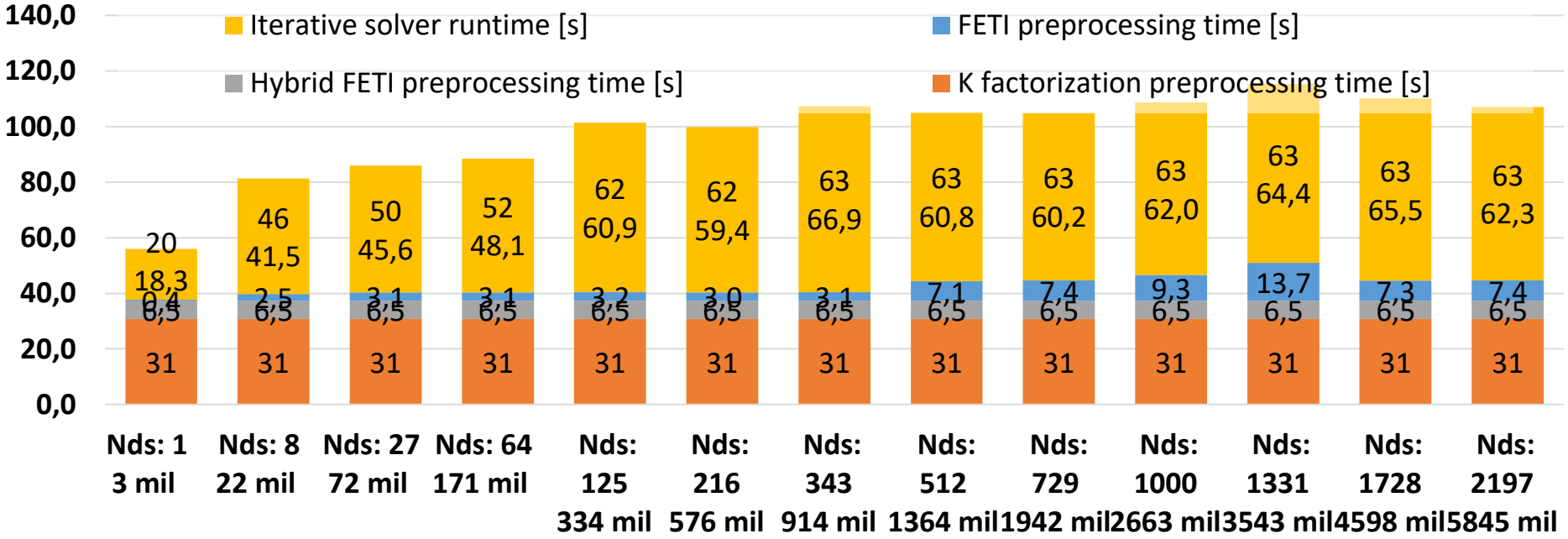
Sparse linear solver designed to solve large problems using Hybrid FETI method

5.8 billions unknowns using CSCS Pitz Daint on 2197 nodes

46,875 DOFs domain size
64 domains per node
140,608 domains total



Výpočetní vědy

Magisterské a doktorské studium

IT4Innovations#
národní01#$%@&0
superpočítačové
centrum$@00&1@&

HPC

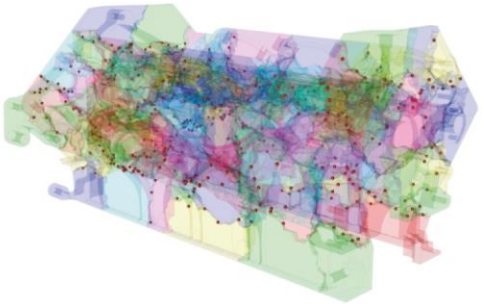
Partneři studia

ŠKODA

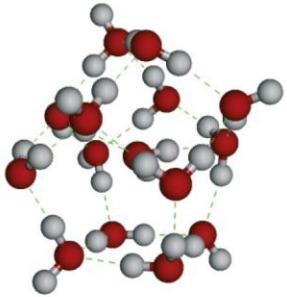
CONTINENTAL SINCE 1871

VÝPOČETNÍ INFORMATIKA

VÝPOČETNÍ MATEMATIKA



VÝPOČETNÍ FYZIKA A CHEMIE



VÝPOČETNÍ MECHANIKA

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