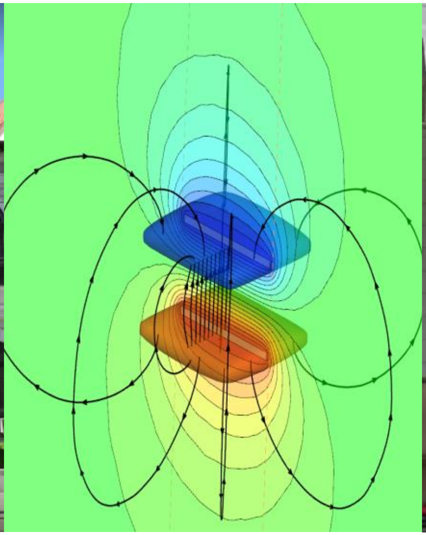
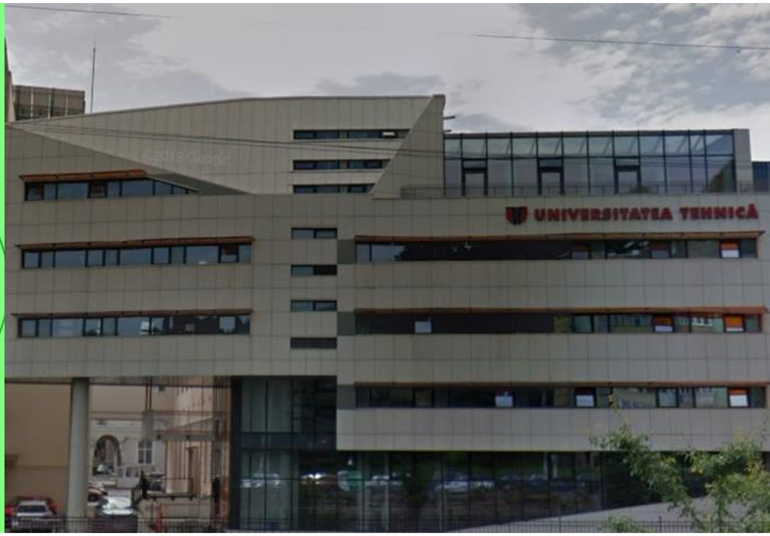
UNIVERSITATEA TEHNICĂ
DIN CLUJ-NAPOCA

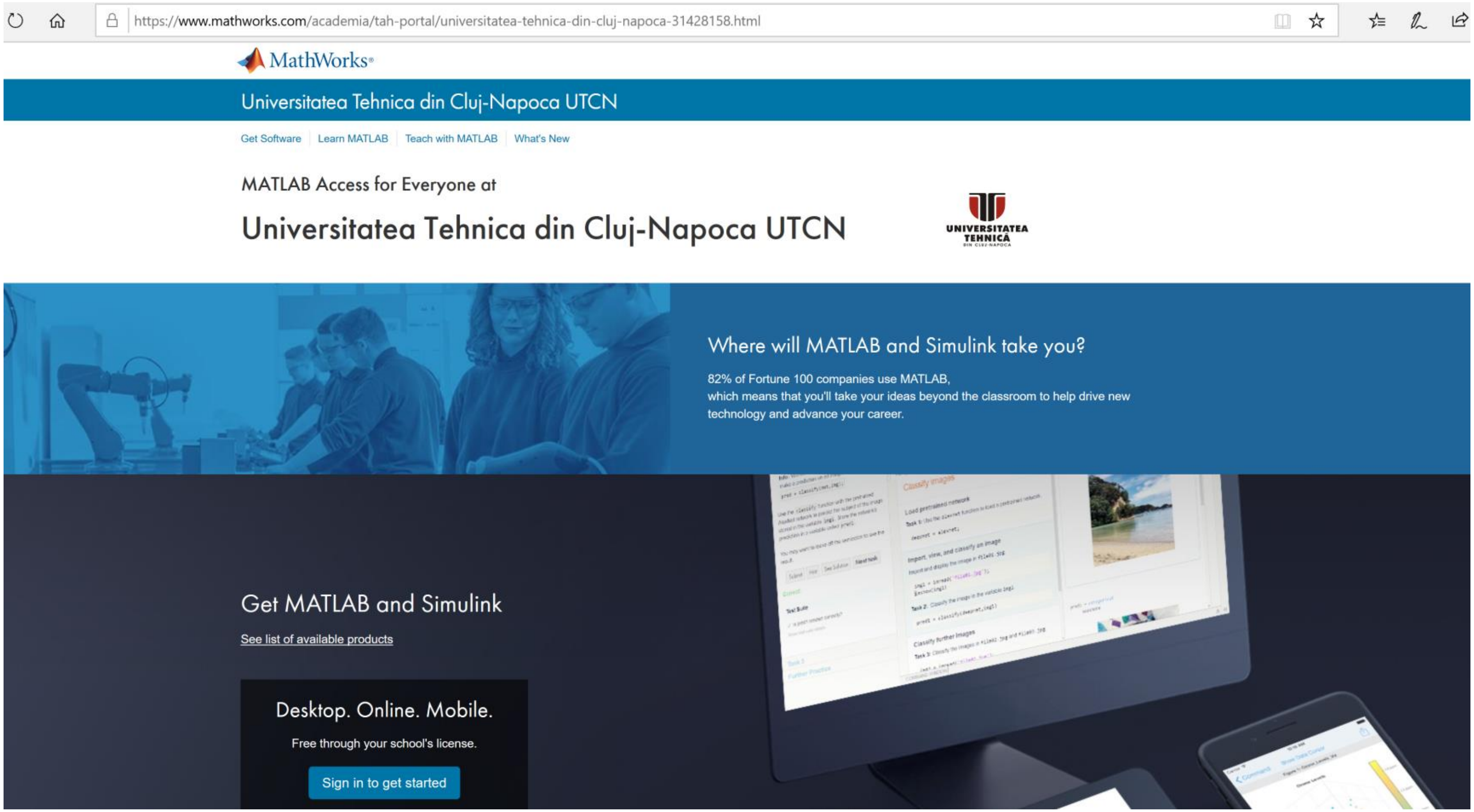
# Technical University of Cluj-Napoca


# Software Tools for Cloud Computation in Engineering Applications

Marius Purcar
Facultatea de Inginerie Electrica
Dep. de Electrotehnica si Masurari

## UTCN is the first university in Romania to purchase a MATLAB Campus Wide License!




**Institutional project "Supporting Excellence in the Research Field of Nanotechnologies and Advanced Materials" - ExNanoMat**

**Over 1.000 universities have a MATLAB Campus License Enabling over 3.5 million students**

# MATLAB & Simulink | Applications & Industries

**Mathematical Modeling**

**Signals and Communications**

**Control Systems**

**Data Analytics**

**Computer Vision and Image Processing**

**Physical Modeling**

**Internet of Things**

**Aerospace and Defense**

**Automotive**

**Communications, Electronics, Semiconductors**

**Industrial Automation and Machinery**

**Energy and Chemical Production**

**Financial Services**

**Biotech and Pharmaceuticals**

# MATLAB campus-wide license full toolboxes

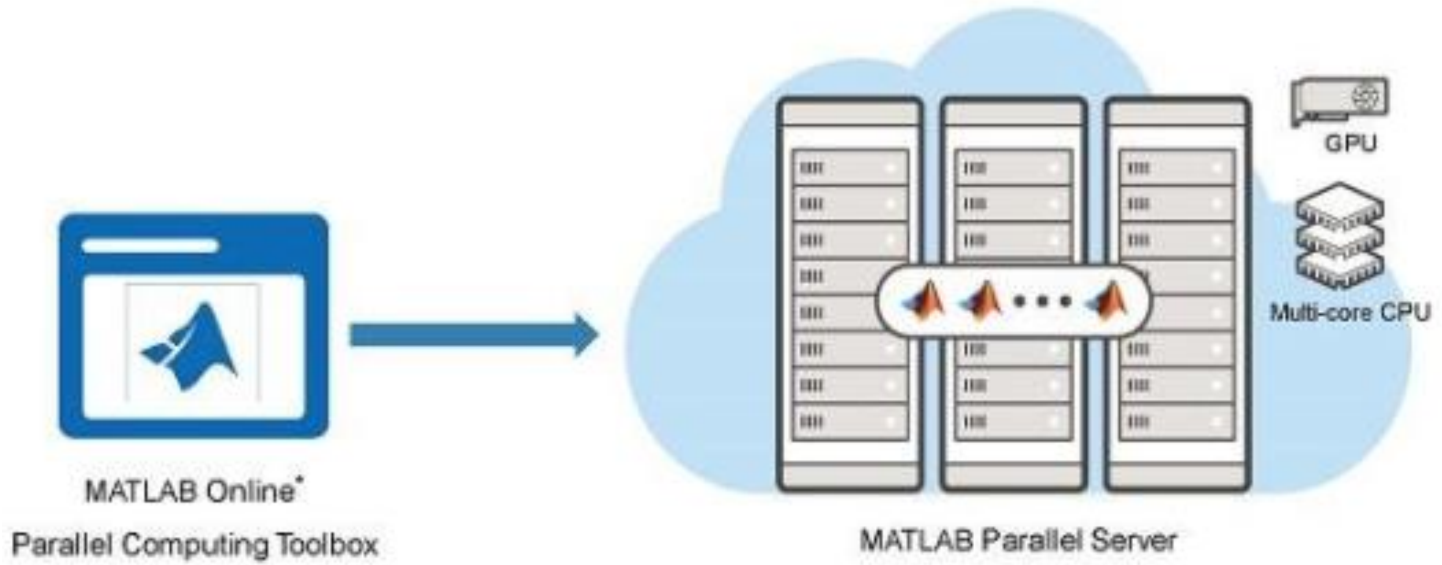
| | | | | | |
|---|---|---|---|---|---|
| 1 | MATLAB | 41 | Model Predictive Control Toolbox | 81 | Simulink Report Generator |
| 2 | Simulink | 42 | Model-Based Calibration Toolbox | 82 | Simulink Requirements |
| 3 | 5G Toolbox | 43 | Motor Control Blockset | 83 | Simulink Test |
| 4 | AUTOSAR Blockset | 44 | Navigation Toolbox | 84 | SoC Blockset |
| 5 | Aerospace Blockset | 45 | OPC Toolbox | 85 | Spreadsheet Link |
| 6 | Aerospace Toolbox | 46 | Optimization Toolbox | 86 | Stateflow |
| 7 | Antenna Toolbox | 47 | Parallel Computing Toolbox | 87 | Statistics and Machine Learning Toolbox |
| 8 | Audio Toolbox | 48 | Partial Differential Equation Toolbox | 88 | Symbolic Math Toolbox |
| 9 | Automated Driving Toolbox | 49 | Phased Array System Toolbox | 89 | System Composer |
| 10 | Bioinformatics Toolbox | 50 | Powertrain Blockset | 90 | System Identification Toolbox |
| 11 | Communications Toolbox | 51 | Predictive Maintenance Toolbox | 91 | Text Analytics Toolbox |
| 12 | Computer Vision Toolbox | 52 | RF Blockset | 92 | Trading Toolbox |
| 13 | Control System Toolbox | 53 | RF Toolbox | 93 | Vehicle Dynamics Blockset |
| 14 | Curve Fitting Toolbox | 54 | ROS Toolbox | 94 | Vehicle Network Toolbox |
| 15 | DSP System Toolbox | 55 | Reinforcement Learning Toolbox | 95 | Vision HDL Toolbox |
| 16 | Data Acquisition Toolbox | 56 | Risk Management Toolbox | 96 | WLAN Toolbox |
| 17 | Database Toolbox | 57 | Robotics System Toolbox | 97 | Wavelet Toolbox |
| 18 | Datafeed Toolbox | 58 | Robust Control Toolbox | 98 | Wireless HDL Toolbox |
| 19 | Deep Learning Toolbox | 59 | Sensor Fusion and Tracking Toolbox | | |
| 20 | Econometrics Toolbox | 60 | SerDes Toolbox | | |
| 21 | Embedded Coder | 61 | Signal Processing Toolbox | | |
| 22 | Filter Design HDL Coder | 62 | SimBiology | | |
| 23 | Financial Instruments Toolbox | 63 | SimEvents | | |
| 24 | Financial Toolbox | 64 | Simscape Driveline | | |
| 25 | Fixed-Point Designer | 65 | Simscape Electrical | | |
| 26 | Fuzzy Logic Toolbox | 66 | Simscape Fluids | | |
| 27 | GPU Coder | 67 | Simscape Multibody | | |
| 28 | Global Optimization Toolbox | 68 | Simscape | | |
| 29 | HDL Coder | 69 | Simulink 3D Animation | | |
| 30 | HDL Verifier | 70 | Simulink Check | | |
| 31 | Image Acquisition Toolbox | 71 | Simulink Code Inspector | | |
| 32 | Image Processing Toolbox | 72 | Simulink Coder | | |
| 33 | Instrument Control Toolbox | 73 | Simulink Compiler | | |
| 34 | LTE Toolbox | 74 | Simulink Control Design | | |
| 35 | MATLAB Coder | 75 | Simulink Coverage | | |
| 36 | MATLAB Compiler SDK | 76 | Simulink Design Optimization | | |
| 37 | MATLAB Compiler | 77 | Simulink Design Verifier | | |
| 38 | MATLAB Report Generator | 78 | Simulink Desktop Real-Time | | |
| 39 | Mapping Toolbox | 79 | Simulink PLC Coder | | |
| 40 | Mixed-Signal Blockset | 80 | Simulink Real-Time | | |

**3786 activations from 20.06.2019 until now**

- 3502 students
- 284 cadre didactice si cercetători
- 7 laboratoare

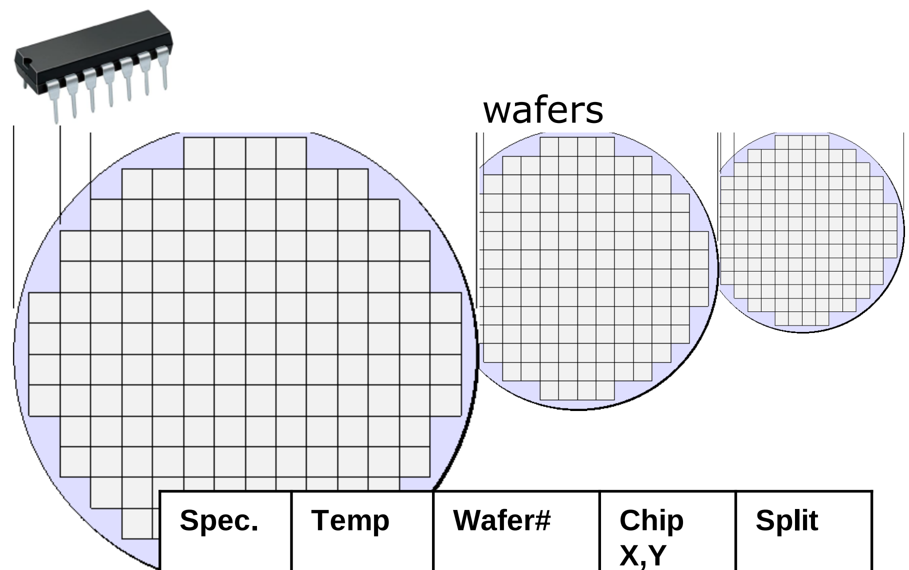
# Matlab for Cloud

- MATLAB Parallel Server™ lets you scale MATLAB® programs and Simulink® simulations to clusters and clouds.
- You can prototype your programs and simulations on the desktop and then run them on clusters and clouds without recoding. MATLAB Parallel Server supports batch jobs, interactive parallel computations, and distributed computations with large matrices.



## 1. Big data processing for yield estimation

- At different verification phases of an integrated circuit (IC), a high volume of measurements is usually done and saved in large, tabular formats (e.g. csv files);
- These measurements are repeated on every chip, on every wafer (one wafer contains thousands/tens of thousands of chips) and every lot (one lot contains several wafers) for each combination of operating conditions;
- The resulted files for a single (IC) can reach orders of GB of data;
- For the statistical analysis performed by our group (e.g. yield assessment, correlation analysis, etc), these large data files need to be processed and transformed into a unified and MATLAB-compatible format;
- Using the could service, we could benefit of a much lower processing time for the data files.

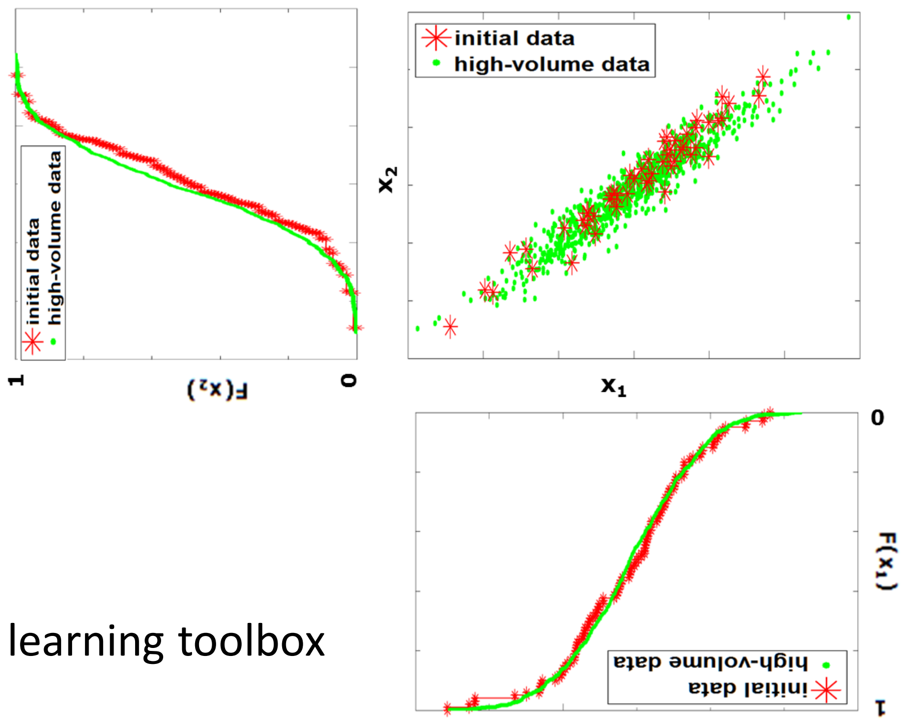



| Spec. | Temp | Wafer# | Chip X,Y | Split |
|---|---|---|---|---|
| Test x | … | … | … | … |
| … | … | … | … | … |

Statistics and machine learning toolbox

## 2. High-volume data generation for yield estimation

- The method of accurate yield estimation, includes a step of high-volume data generation based on the statistical correlation information of input data for estimation accuracy improvement
- Thus, the initial data set of *v*-dimensions and *n*-samples (*n* usually in the range of hundreds, marked in red), is transformed into a data set with the same dimensions but <u>millions</u> of samples (marked in green)
- Using the could service, we could benefit of a lower generation time of the high-volume data and also store this data for subsequent statistical analysis




Statistics and machine learning toolbox



iDev40

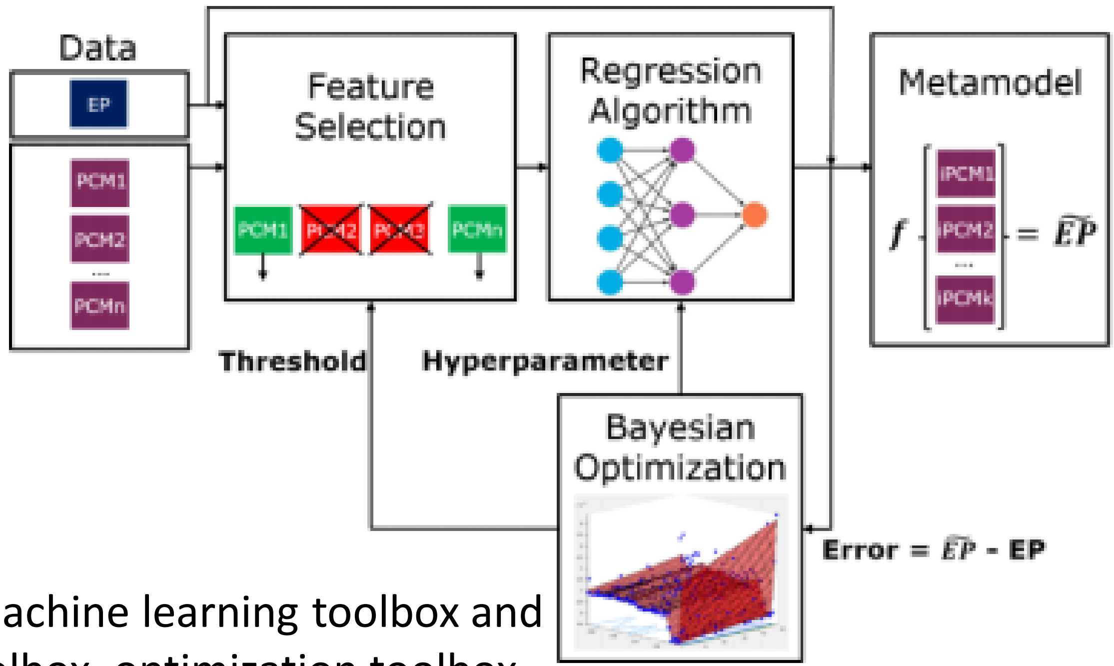
Infineon

TECHNICAL UNIVERSITY OF CLUJ-NAPOCA ROMANIA

# Matlab for Cloud Applications

## 3. Fitting of neural networks

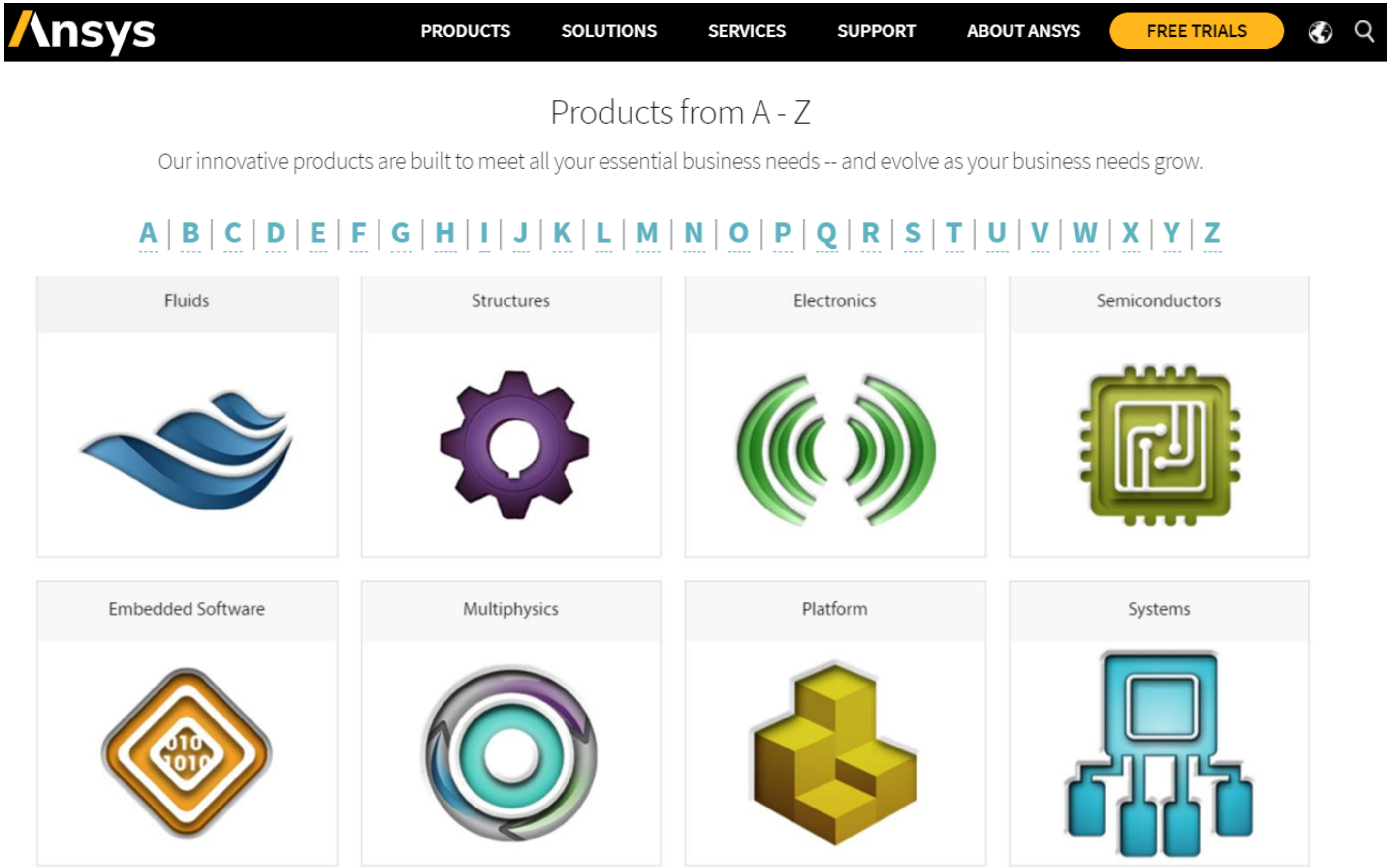
- For the purpose of accurate yield estimation towards yield prediction, machine learning-based regression models are used for modeling the dependence of performance and technology parameters;
- The fitting of such dependencies is a time-consuming process (hours/days). We use neural networks in our methods, but others, such as SVMs (support vector machines) come with the same disadvantage;
- Moreover, these regression models usually come with a set of hyperparameters to be tuned, which adds to the global computational cost and time;
- Using the could service, we could benefit of a lower fitting and modeling time, enabling a faster yield prediction.




Statistics and machine learning toolbox and curve fitting toolbox, optimization toolbox

## Ansys Multiphysics Academic Research 2020R2 - 100 licenses

- Fluent, CFX, ICEM, Electronics Desktop, SIWAVE, Emit, Savant, RedHawketc etc.
- HPC 128 processors




**Research project "Integrated Development 4.0" – iDev40, H2020-ECSEL-2017-1-IA-two-stage**

# Ansys Multiphysics

### 3D DESIGN

Rapidly explore ideas, iterate and innovate with Ansys Discovery 3D design software. With the easy-to-use tools, you can build and optimize lighter and smarter products.

LEARN MORE

### ELECTRONICS

Ansys software can uniquely simulate electromagnetic performance across component, circuit and system design, and can evaluate temperature, vibration and other critical mechanical effects.

LEARN MORE

### EMBEDDED SOFTWARE

Ansys provides a model-based embedded software development and simulation environment with a built-in automatic code generator to accelerate embedded software development projects.

LEARN MORE

### FLUIDS

Ansys CFD goes beyond qualitative results to deliver accurate quantitative predictions of fluid interactions and trade-offs.

LEARN MORE

### MATERIALS

Ansys software ensures accurate, consistent, traceable materials information every time and provides the tools you need to support design, research and teaching.

LEARN MORE

### OPTICAL

Ansys optical simulation software uniquely simulates a system's optical performance and evaluates the final illumination effect.

LEARN MORE

### PHOTONICS

Products, solvers and interoperability features that work together seamlessly to allow designers to model the most challenging problems in photonics that include interacting optical, electrical and thermal effects.

LEARN MORE

### PLATFORM

The Ansys simulation platform delivers the broadest suite of best-in-class simulation technology and unifies it with your custom applications, CAD software and enterprise business process tools such as PLM.

LEARN MORE

# Ansys Multiphysics

## SEMICONDUCTORS

Ansys empowers customers with multiphysics simulations to simultaneously solve power, thermal, variability, timing, electromagnetics and reliability challenges across the spectrum of chip, package and system to promote first-time silicon and system success.

LEARN MORE

## STRUCTURES

With the finite element analysis (FEA) solvers available in the suite, you can customize and automate solutions for your structural mechanics problems and parameterize them to analyze multiple design scenarios.

LEARN MORE

## SYSTEMS

As product complexity grows, so does the challenge of integrating individual components within a system to ensure they work together as expected.

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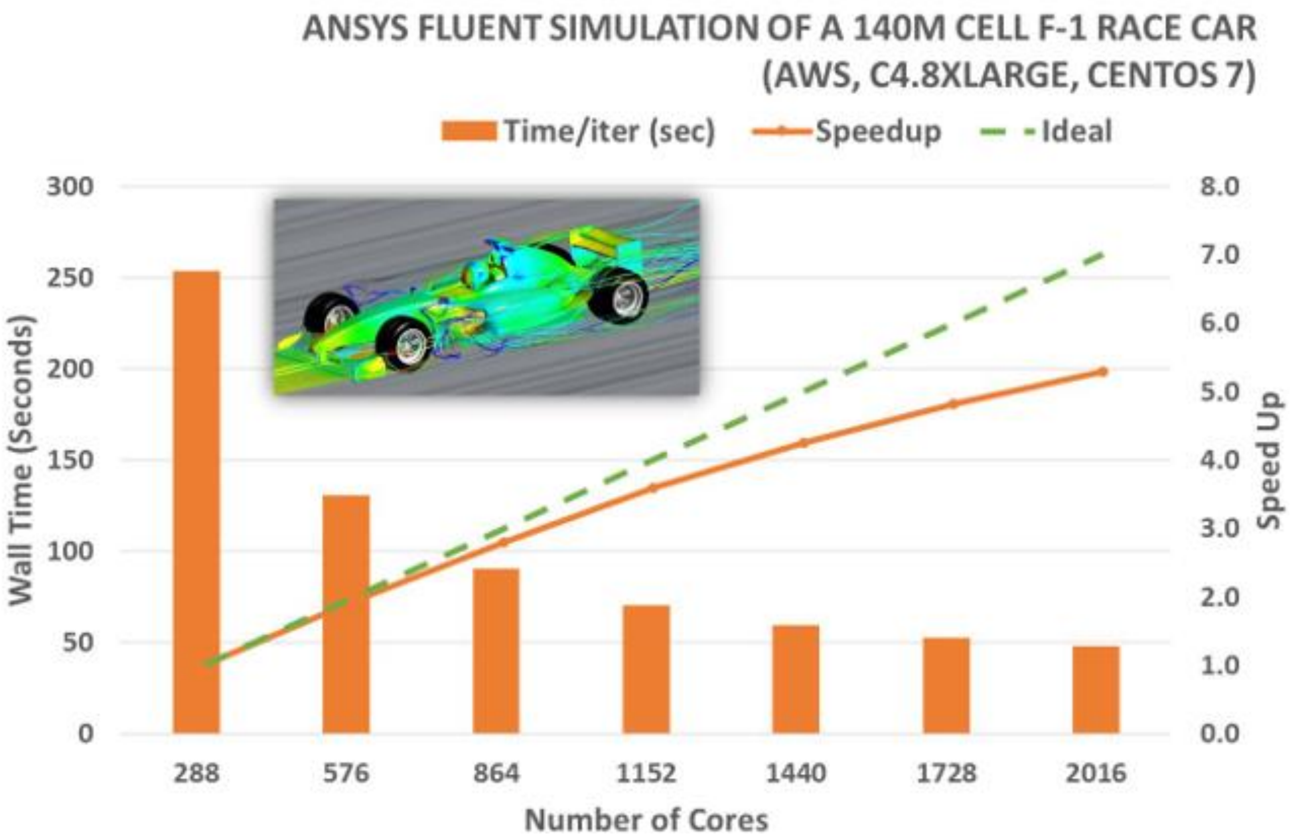
# Ansys Multiphysics for Cloud Applications




- Any relatively detailed structural mechanics model – e.g., mesh size in excess of ~500K DOF – is going to take a very long time to solve on a single CPU core.
- Ansys HPC reduces the time to solution significantly.
- For larger models (in excess of ~10 MDOF) parallel processing with Ansys HPC is needed to make the simulation feasible; a single CPU core typically cannot access enough computer memory to handle these models.

# Ansys Multiphysics for Cloud Applications

ANSYS

## GPU Accelerator Capabilities *

**Release 19.1**

* Used in support of the CPU to process certain calculations and key solver computations for faster performance during a solution.
- Acceleration can be used for both shared-memory parellel processing (shared-memory ANSYS) and distributed-memory parallel processing (Distributed ANSYS).
- Acceleration is available for both Windows and Linux.

### Support by Application

**ANSYS Mechanical APDL** supports NVIDIA's CUDA-enabled Tesla and Quadro series workstation and server cards. When using the sparse solver or eigensolvers based on the sparse solver with NVIDIA cards additional considerations apply (please consult the ANSYS installation guide for details).

**ANSYS Fluent** supports NVIDIA's CUDA-enabled Tesla and Quadro series workstation and server cards.

**ANSYS Polyflow** supports NVIDIA's CUDA-enabled Tesla and Quadro series workstation and server cards.

**ANSYS EMIT** supports NVIDIA Tesla and Quadro V series, P series, M series and K series cards, GeForce GTX Series and GeForce GT Series.

**ANSYS HFSS** supports NVIDIA Tesla V and P series, C20-series, Tesla K series, Quadro V, P and K series (K5000 and above).

**ANSYS ICEPAK** supports NVIDIA's CUDA-enabled Tesla and Quadro series workstation and server cards.

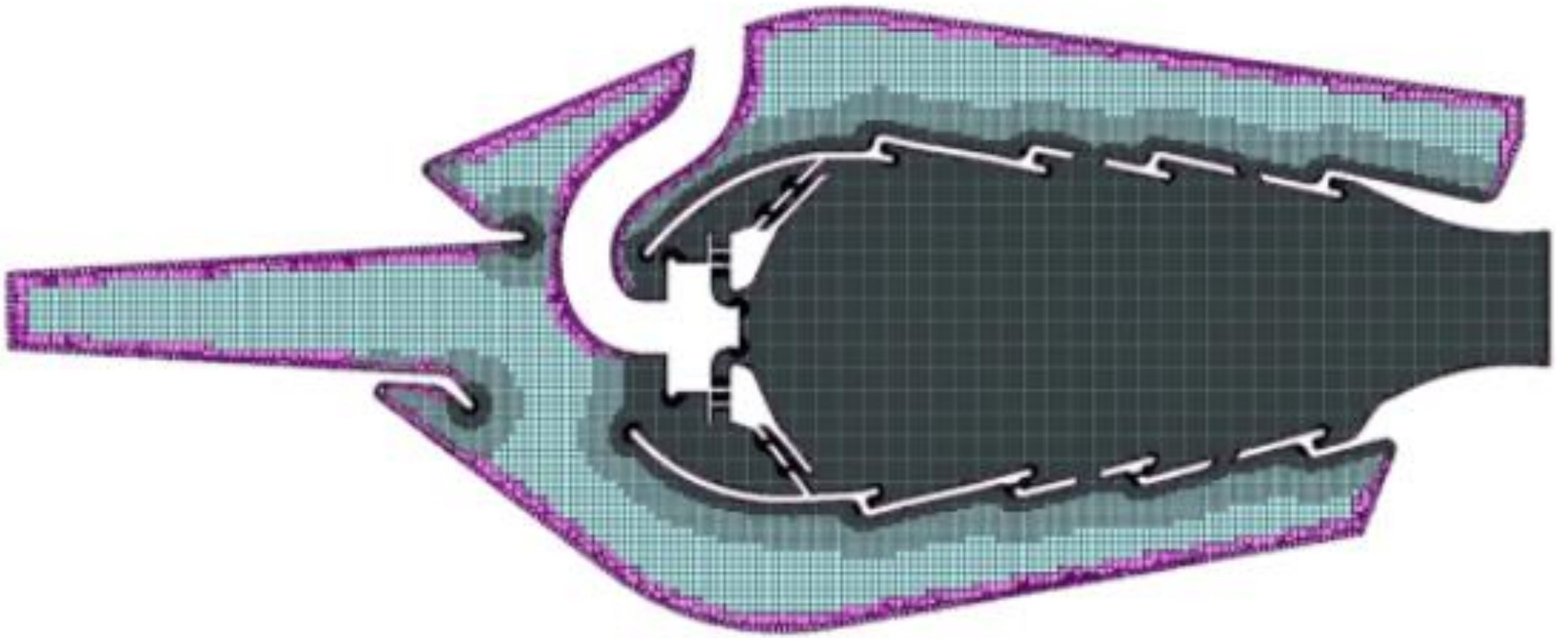
**ANSYS Maxwell** supports NVIDIA Tesla V and P series, C20-series, Tesla K series, Quadro V, P and K series (K5000 and above).

**ANSYS Savant** supports NVIDIA Tesla and Quadro V series, P series, M series and K series cards, GeForce GTX Series and GeForce GT Series.

| Application | Manufacturer | Product Series | Card / GPU | Tested Platform | Tested Operating System Version |
|---|---|---|---|---|---|
| **ANSYS Mechanical APDL** | NVIDIA | Tesla | K80 | Linux x64 | Red Hat 6.8 |
| | | | M2075 | Linux x64 | Red Hat 7.3 |
| | | | P100 | Linux x64 | CentOS 7.4 |
| | | | V100 | Windows x64 | Windows Server 2016 |
| **ANSYS Fluent** | NVIDIA | Quadro | GP100 | Linux x64 | Red Hat 7.2 |
| | | | K5000 | Windows x64 | Windows 7 |
| | | Tesla | C2075 | Windows x64 | Windows 7 |
| | | | K40m | Windows x64 | Windows 10 |
| | | | K80 | Linux x64 | Red Hat 7.2 |
| | | | | Linux x64 | SLES 12 SP1 |
| | | | M2075 | Windows x64 | Windows 7 |
| | | | P100 | Linux x64 | SLES 11 SP3 |
| | | | V100 | Linux x64 | SLES 11 SP3 |

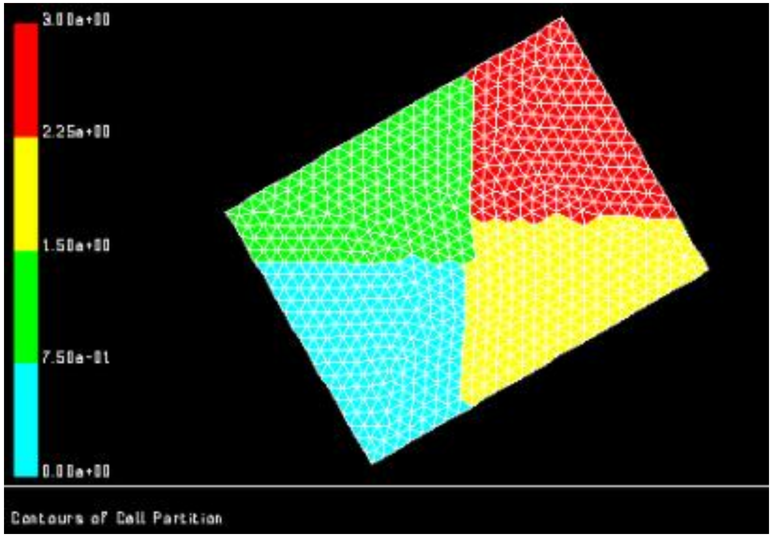
https://www.ansys.com/

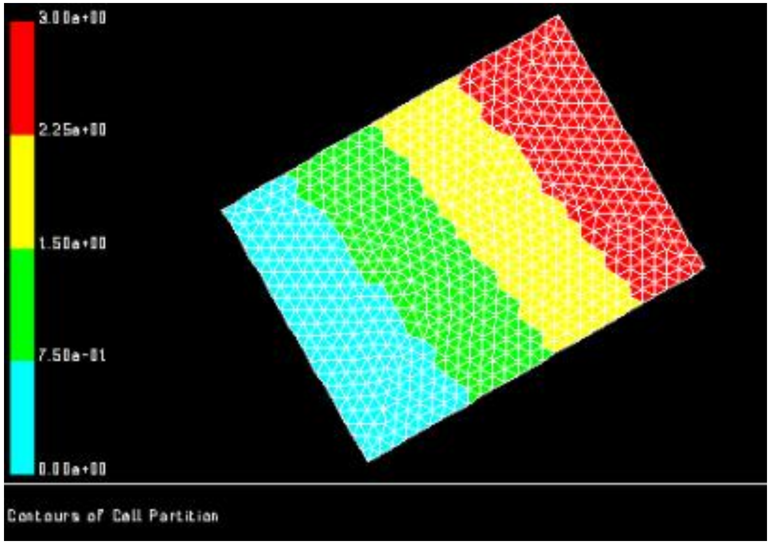
## How does Fluent work?



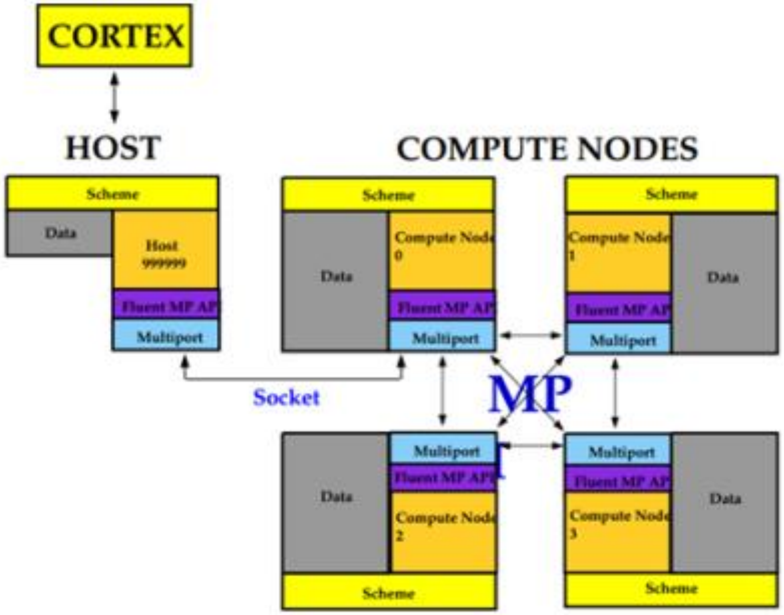
- The mesh is generated using parallel processing — each color depicts the parts of the mesh created by one process.
- All the Fluent processes work together to fill the live fluid/solid space.

## How does Fluent work?



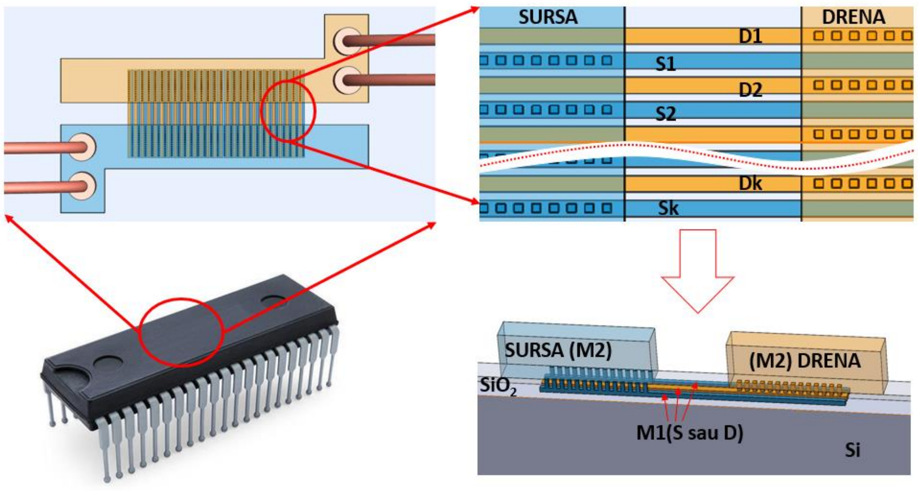



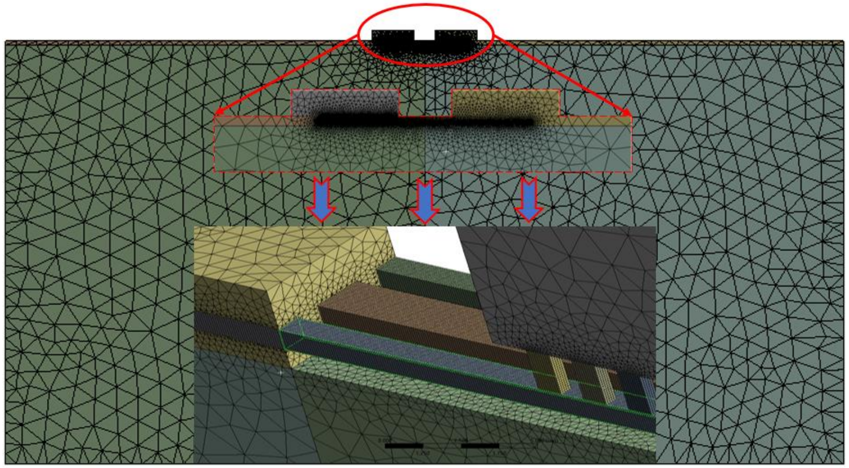

- The mesh is partitioned using a bisection or METIS algorithm
- Each partition is further clustered by the solver

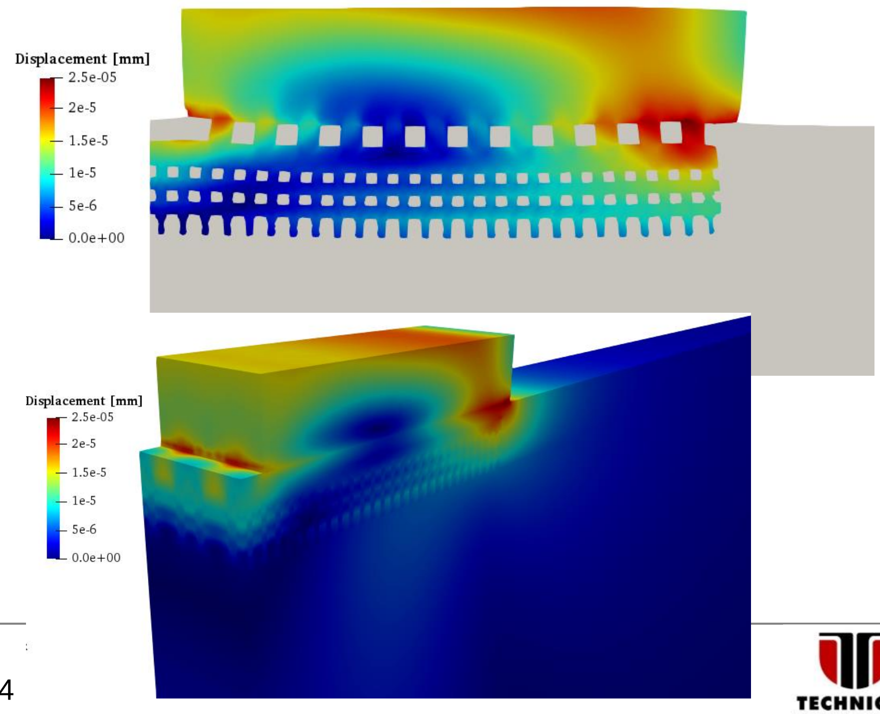


# Ansys Multiphysics for Cloud Applications

- Computational model, transient thermomechanical on Ansys Cloud

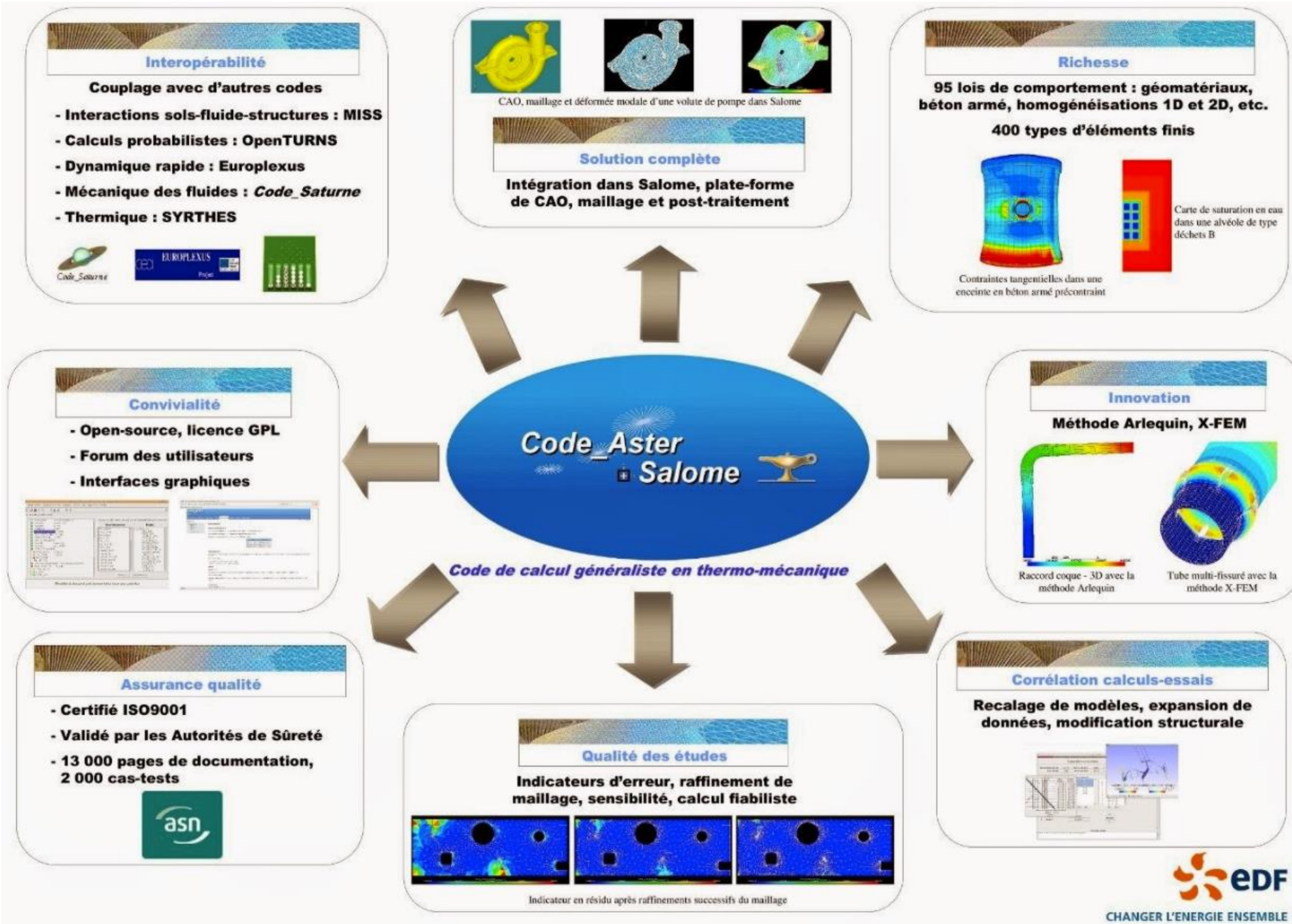





- Mesh: elements: 3.52e+6, nodes: 1.78e+6
- Distributed simulation Ansys Cloud, 12 processors, unlimited memory– between 9 to 10h (10 thermal cycles)
- One processor workstation with 64Gb RAM: between 80 and 90h.

# Code_Aster Open Source



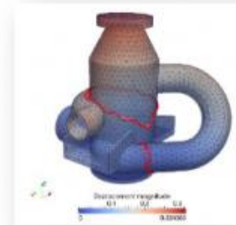

https://www.code-aster.org/

# Code_Aster Open Source

- **Elasto-plastic computation (static and non-linear)**

| Dof | Procs | Solving time (s) |
|---|---|---|
| 5 547 411 | 1 080 | 56 |
| 41 051 928 | 1 080 | 257 |

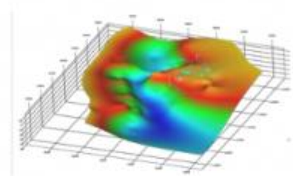
code_aster: **3 h 30 min**
code_aster HPC: **4 min**

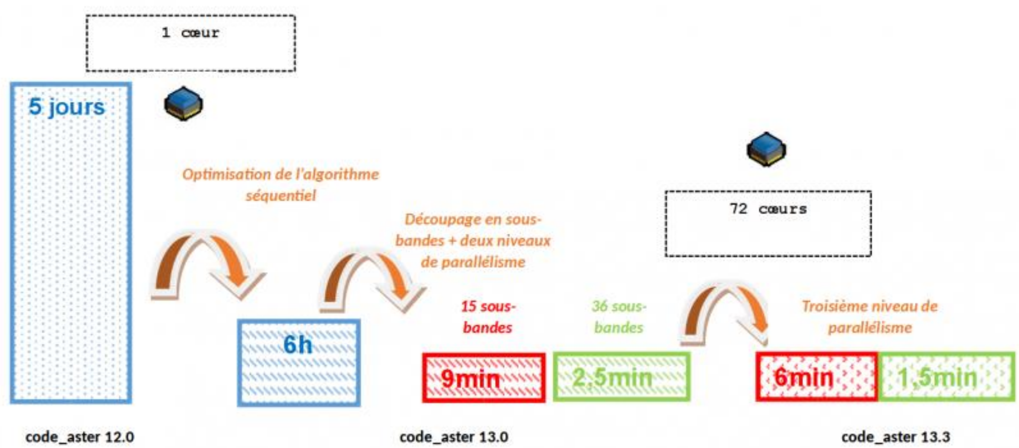


- **Sedimentary basin calculation (linear dynamic)**

| Dof | Procs | Solving time (s) |
|---|---|---|
| 25 842 015 | 270 | 1.5 |
| 185 911 227 | 1 080 | 4.8 |

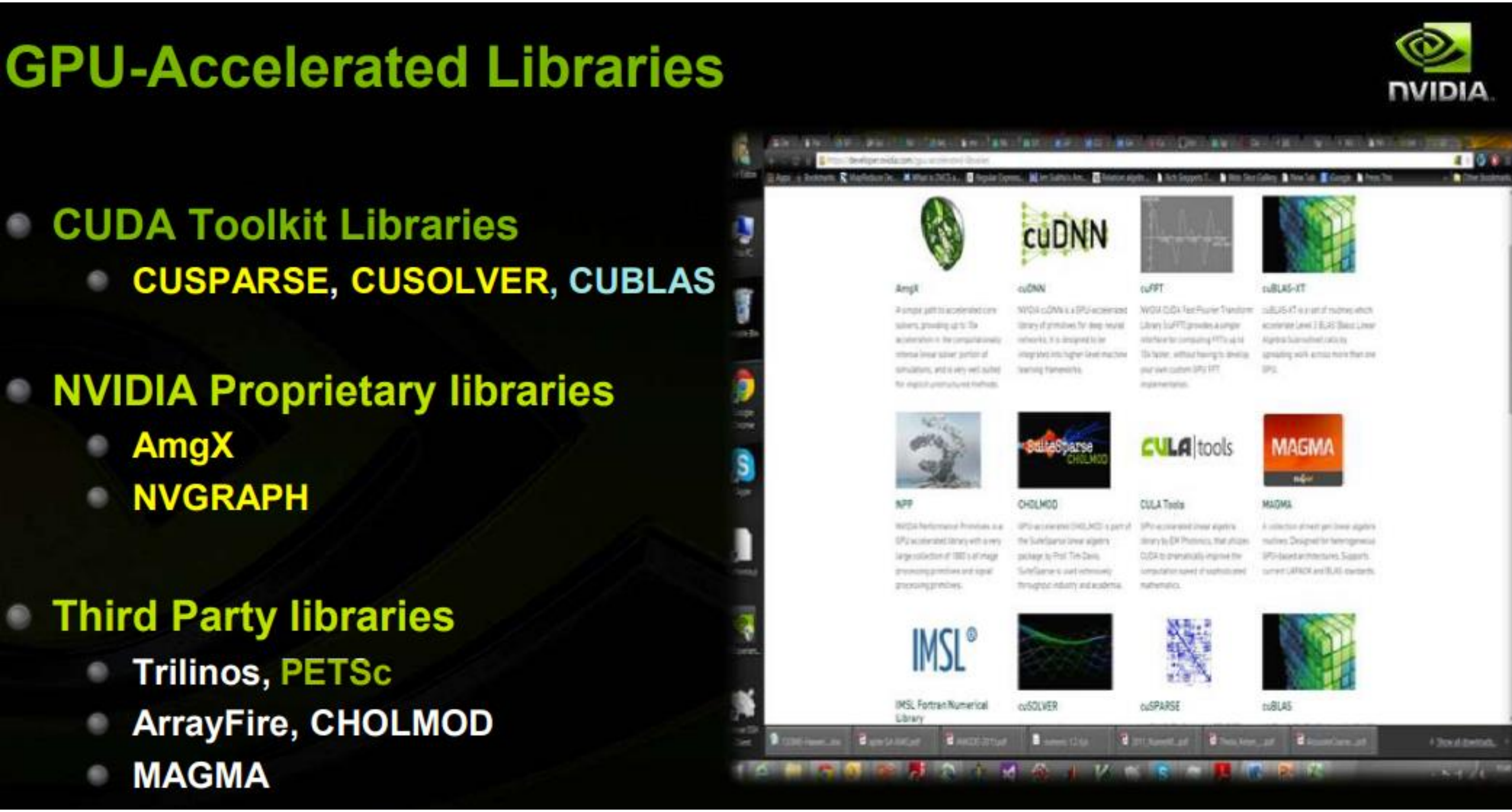
Extrapolation for 2000 time steps: **3 h**





# Software Tools

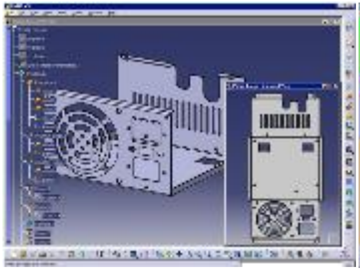
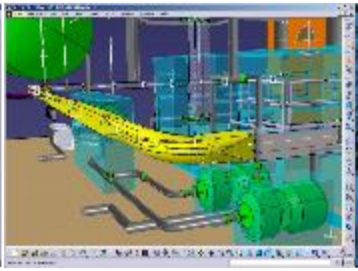
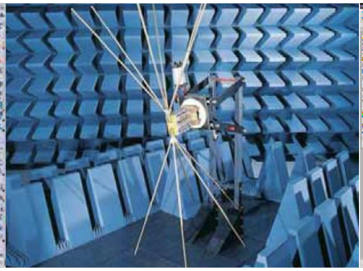
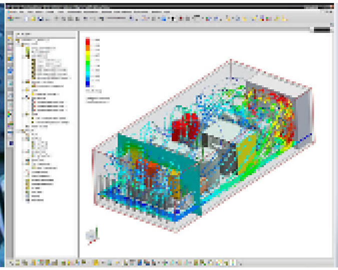
## Code_Aster Open Source




http://mumps.enseeiht.fr/doc/ud_2017/Courteille_Talk.pdf

# Software Tools

## **Thank you**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