High Performance Computing Infrastructure in Technical University Research

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Challenges in academic research

- Diversity of research topics and computing solutions
- Interdisciplinary research domains, groups and projects
- Research project migration into cloud
- Application and services development over the cloud
- Computing resource management
- Standardization, Interoperability, Resource sharing
- Computing resource integration and scalability
- Administration in implementation and sustainability phases

Solutions for HPC

- HPC → Cluster, Grid and Cloud architectures
- Cluster architecture

  High interconnected similar nodes, single task
- Grid infrastructure

  Internet interconnected heterogeneous nodes, distributed tasks, scalability
- Cloud infrastructure

  Virtualization, virtual machine, container, services, flexible configuration, scalability

Cloud computing in universities

- (+) Research projects, doctoral research, teaching activity or administrative services
- (-) Budget costs, licenses, management, administration of computing resources, permanent technological evolution, continuous financial investments in new software and hardware resources
- Client-server systems → Cloud infrastructure

CLOUDUT Project

- **Title:** Cloud Cercetare UTCN – CLOUDUT (http://cloudut.utcluj.ro/en/)
- **MySMIS ID:** 124493
- **Contract no.:** 235/ 21.04.2020
- **Project type:** Operational Program "Competitivitate 2014-2020" (POC)
- **Priority axis 1**: Research, technological development and innovation in support of economic competitiveness and business development
- **Action:** 1.1.2 Development R&D Centers networks, coordinated at national level and connected to European and international networks, ensuring researchers' access to European and international scientific publications and databases
- **Financing:** European Fund of Regional Development, total project value: 4.955.000 RON out of which 4.950.000 RON from European funding.

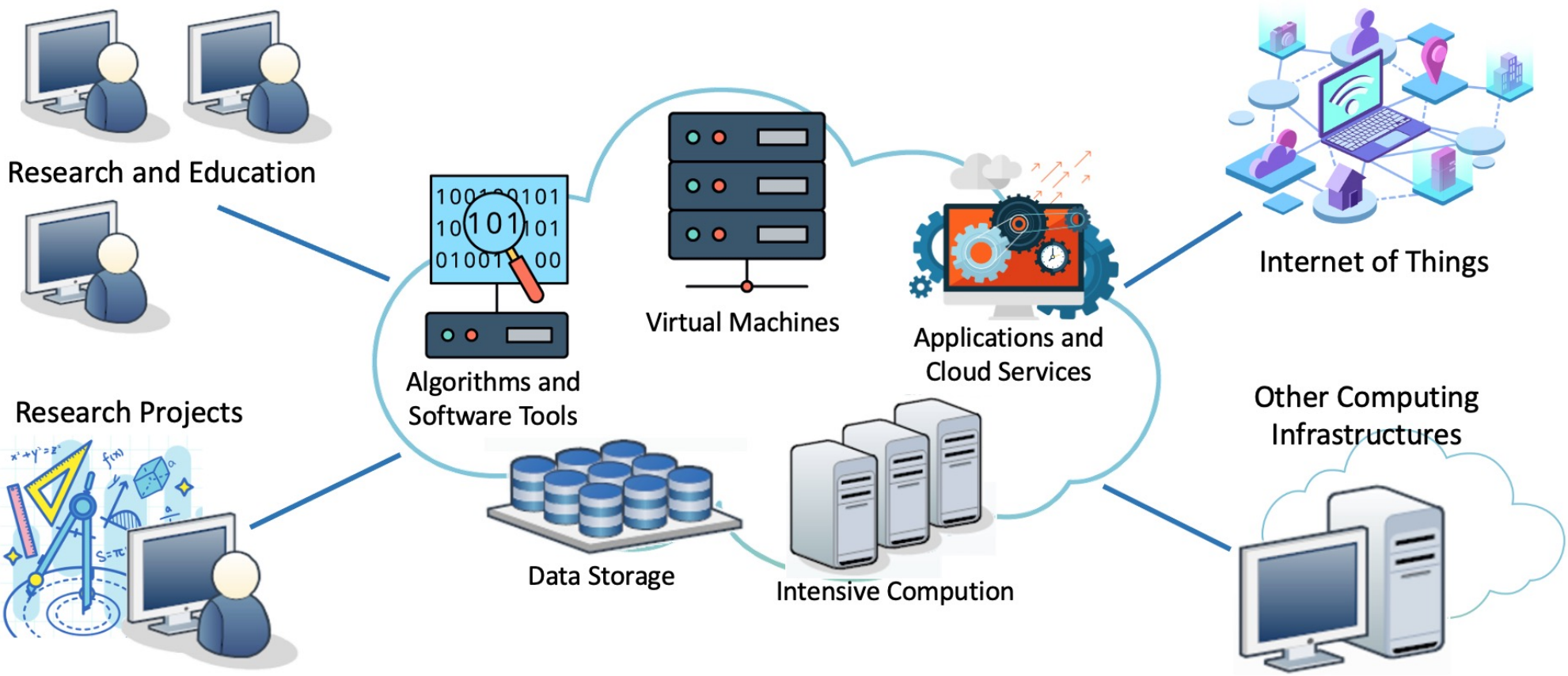
Objectives

- Increasing the *research capacity*
  - Scientific competitiveness at the international level
  - High performance computing infrastructure
  - Integration into national and international cloud structures and massive data infrastructures
- Development of *interdisciplinary scientific research teams*
  - National and international research consortiums
  - Interdisciplinary domains of big data, artificial intelligence, spatial data and IoT
  - Engineering, economic and administrative applications of the regional and national economic environment

Specific Objectives

- **SO1.** Create a *CLOUDUT infrastructure* that will contribute to the development of high-performance computing resources and storage of massive data, necessary for research and scientific collaboration;
- **SO2.** Development of dedicated *cloud software platforms, services and applications*, and the implementation of massive data infrastructures, that will support the specialisation of CLOUDUT for research engineering fields;
- **SO3.** Development of *interdisciplinary scientific research teams* and the capacity to collaborate in national and international research projects;
- **SO4.** Develop the *capacity to publish*, participate to and organise scientific events.

CloudUT Infrastructure



CloudUT Infrastructure

- 10 nodes, 20 processors, 320 cores, 5120 GB RAM, 2 GPU nodes, 2 nodes for management
- 72 TB HDD, 25 Gbps internal interconnectivity
- Each GPU node has 2 processors with 20 cores, 512 GB, 1 TB SSD, 2 Tesla V100 GPU (640 core tensors, 5120 CUDA cores), 32 GB dedicated memory, + NVIDIA A100 GPU 40 GB
- Support for virtualization

CloudUT Center

- Organizational structure
- Group of experts
- Scientific, technical, and technological consultancy
- Management and administration
- Usage policies
- Ticketing application
- Tutorials

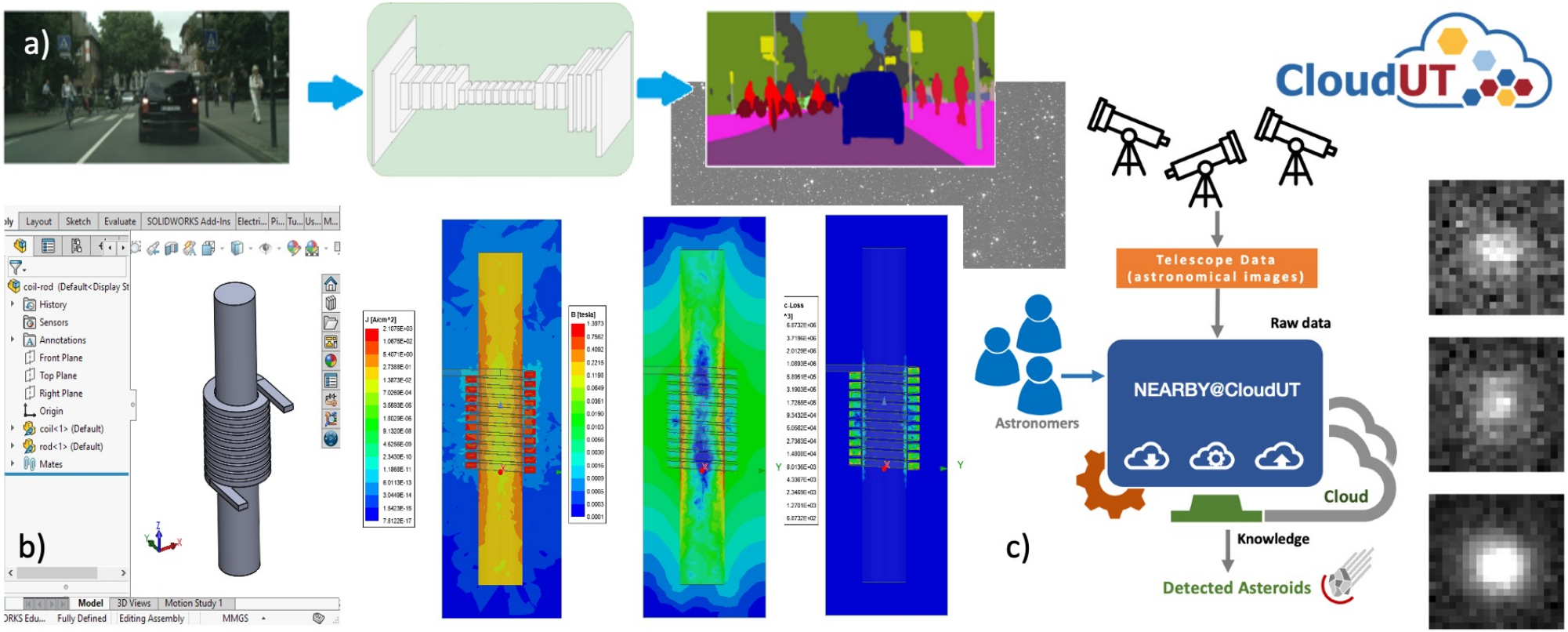
Applications and services

- Scientific topics - big data, deep learning, IOT, complex simulation, computer-aided design
- Technical fields - distributed architectures, parallel computing, massive data, flexible architectures, virtualization, cloud services, open data, or other directions in technical fields such as mechanical, construction, electrical, automatics, computers, architecture, etc.
- Technologies – HPC nodes, orchestration and virtualization nodes, GPU intensive computing and graphics processing nodes, data storage nodes, simulation and assisted design platforms (Matlab, Ansys, PyTorch, Dockers, Kubernetes, etc).

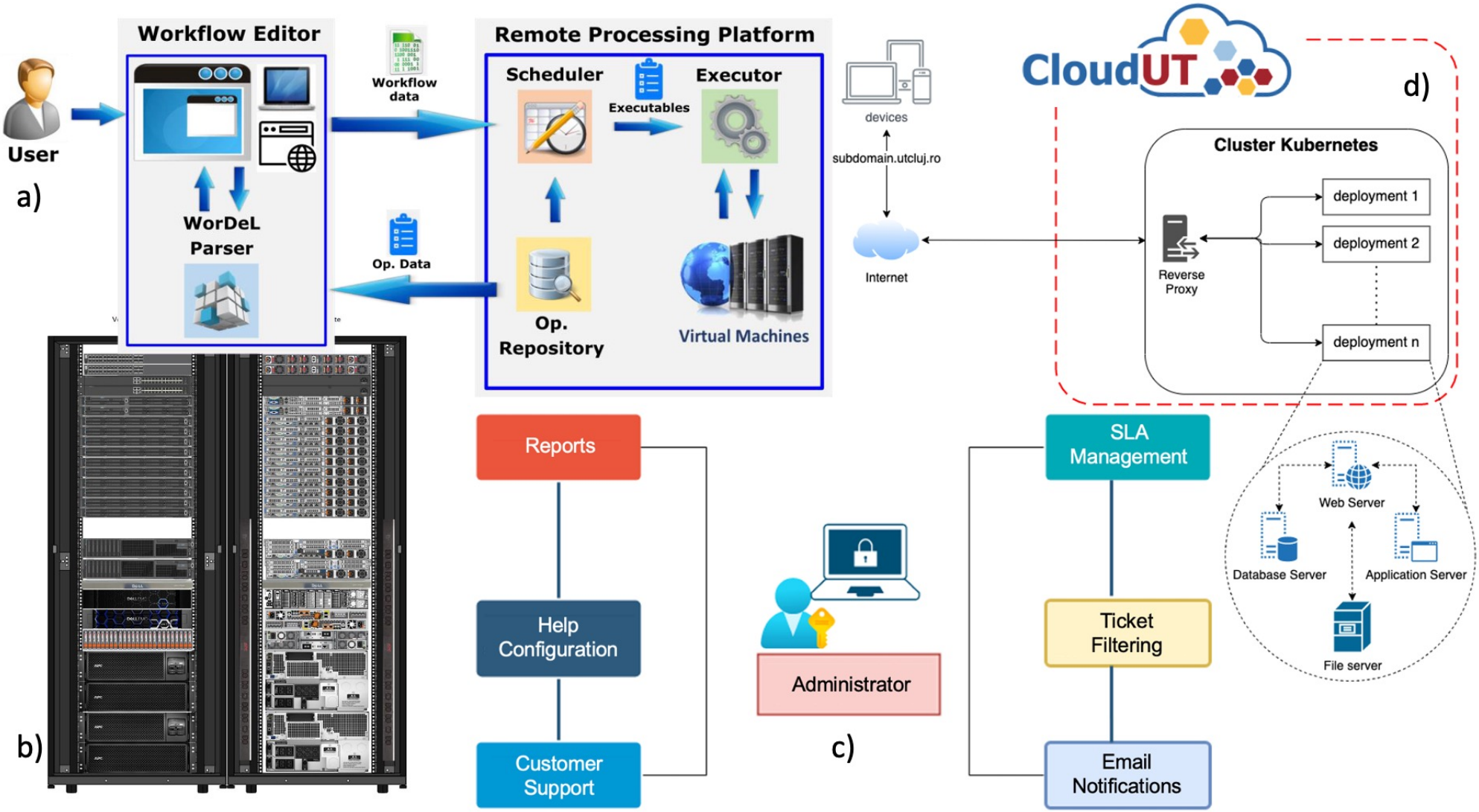
Applications and services

- Spatial data processing service using visual analysis techniques
- Deep learning for artificial vision using PyTorch and Matlab
- Solutions for GPU virtualization in CloudUT architecture
- IoT data collection and analysis service
- Web Hosting as a Service
- System for the management and distribution of data processing in virtual machine networks
- Advanced simulation platform using Ansys
- Private container repository for CloudUT infrastructure
- Applications and services for efficient management, monitoring, ticketing and administration

CloudUT pplications and services

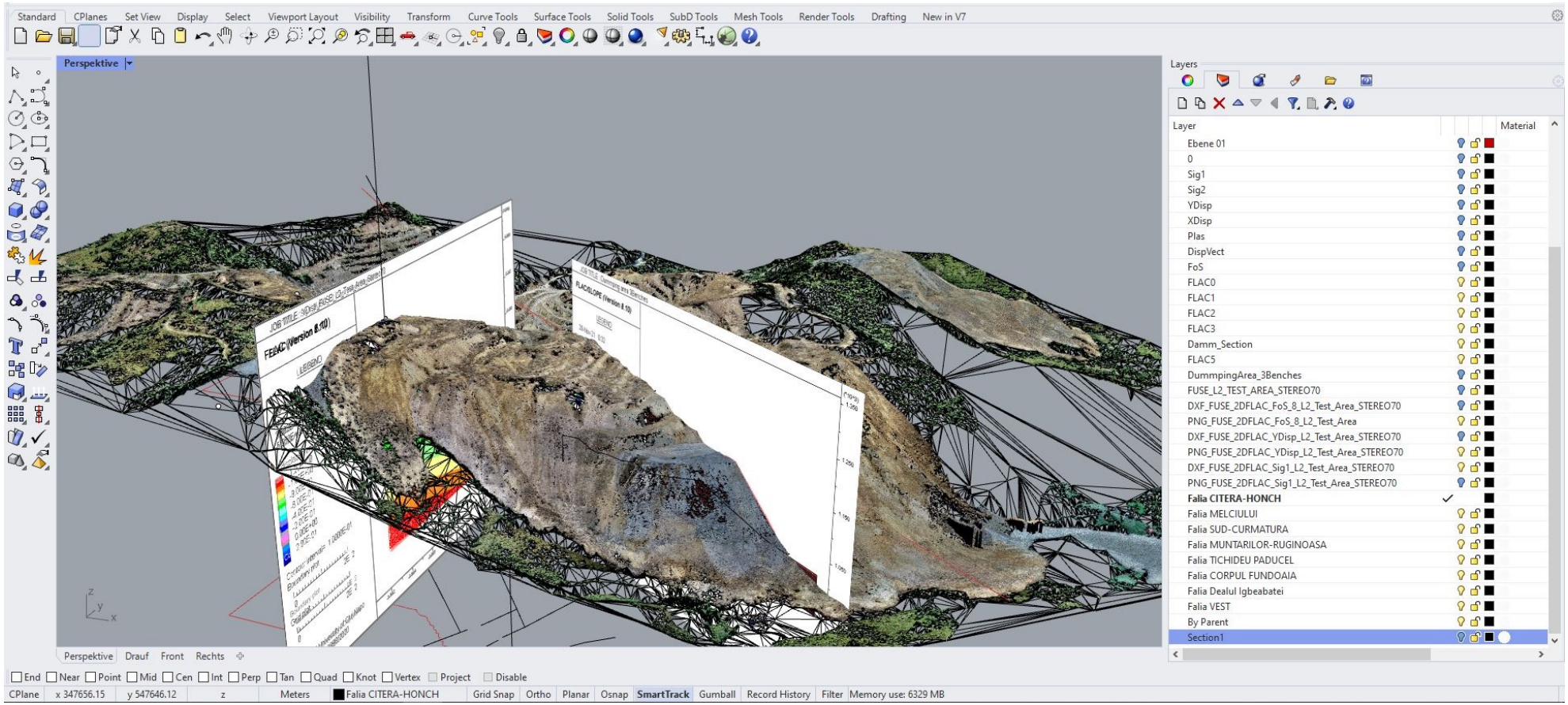


(a) Use Matlab and PyTorch in artificial vision applications;
(b) The use of Ansys in complex simulation;
(c) Astronomic data processing by the NEARBY@CloudUT service.



(a) Parallel and distributed processing of massive spatial data;
(b) Rack-mounted CloudUT infrastructure equipment;
(c) Ticketing application; (d) Web Hosting in CloudUT.

GoldenEye Project



GoldenEye Project (Innovative Actions H2020). The processing of the 3D model of the tailings deposit resulted from the extraction of the copper from the Roșia Poieni mining perimeter.

Conclusions

- *Virtualization and flexible configuration* of processing elements (i.e., CPU, GPU, virtual machines) and massive data storage elements is one of the main requirements.
- It is imperative that software packages (e.g., Matlab, Ansys, Solid Works or CADENCE) to be installed in CloudUT and to be *used simply and efficiently* by a large community of young researchers.
- Important requirements in the acceptance and effective use of the CloudUT infrastructure in interdisciplinary research is the continuous provision of *scientific, technical and technological consultancy* by the CloudUT Center.

Many thanks for your attention!

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