The LEXIS Platform

Easy access to heterogenous computational workflows execution

HiPEAC 2022 Everest workshop | 22/06/2022

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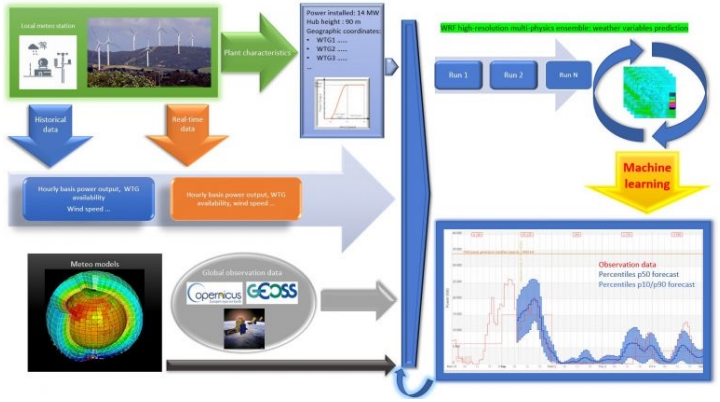
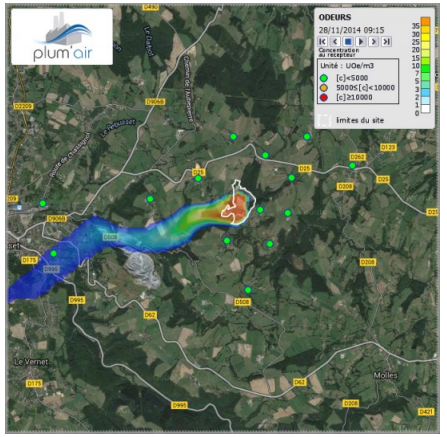
Executing workflows for the EVEREST project applications

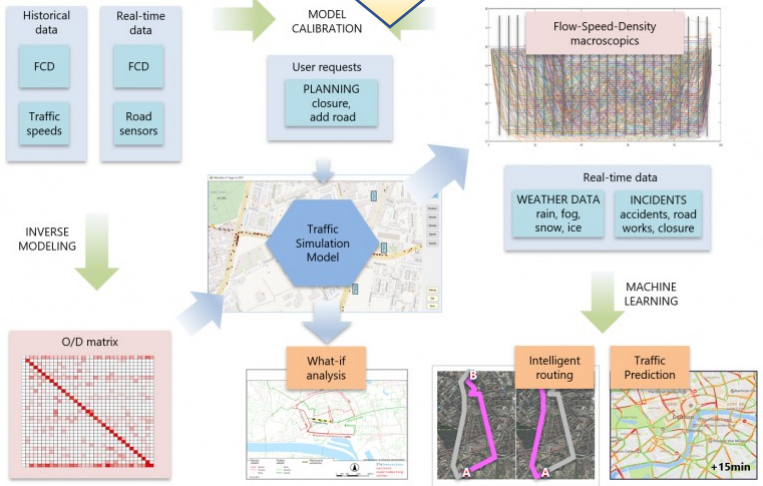
EVEREST



Renewable-energy prediction



Air-quality monitoring

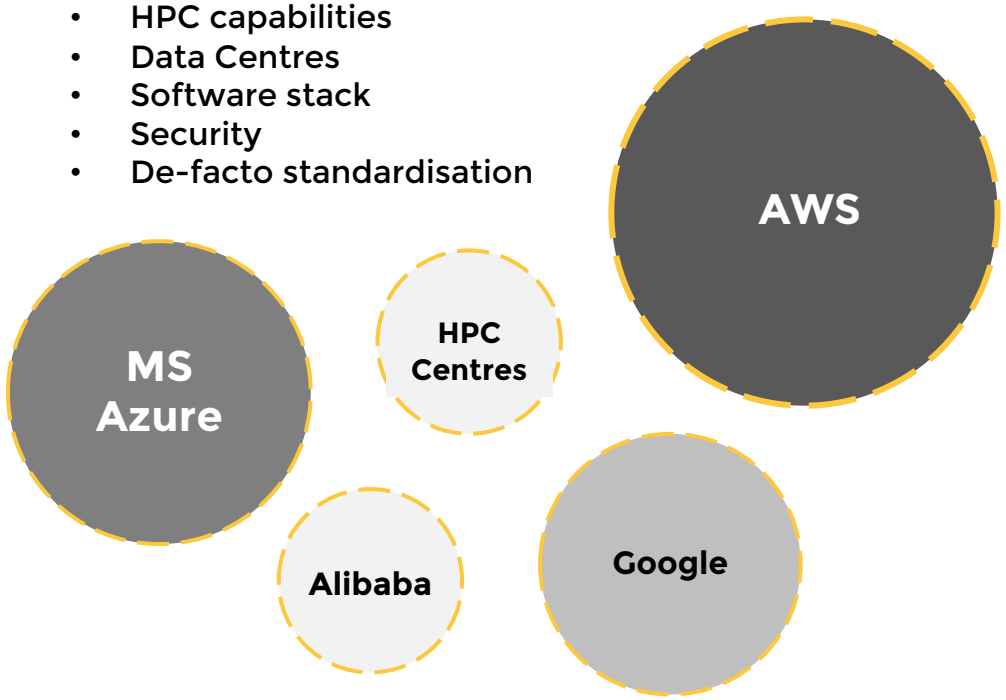


Traffic modeling

TODAY IN EUROPE...

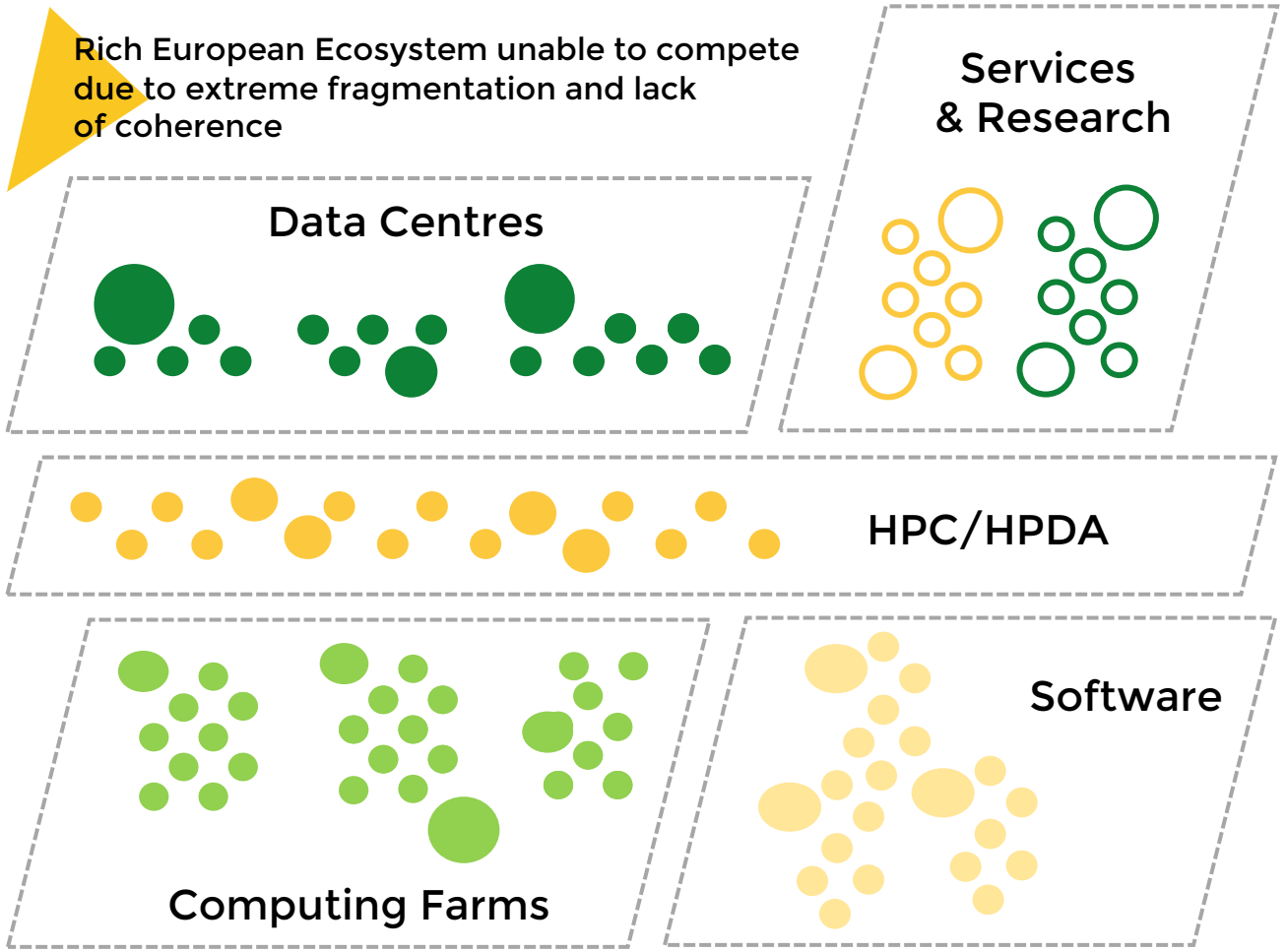
Private Operators integrating with high level of coherence:

- Computing Infrastructures
- HPC capabilities
- Data Centres
- Software stack
- Security
- De-facto standardisation



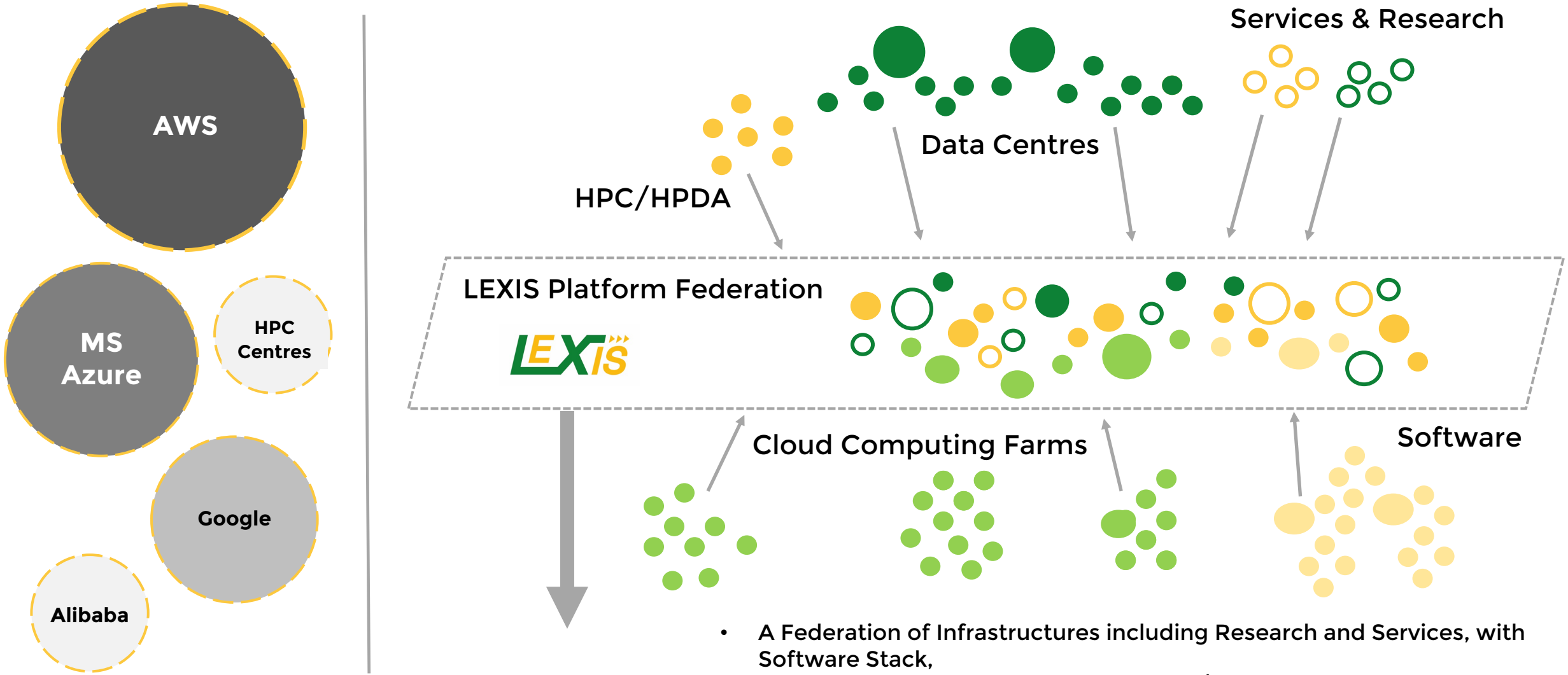
>80% of European Market in US and Chinese hands

Rich European Ecosystem unable to compete due to extreme fragmentation and lack of coherence



- No operator has a critical size / Silo culture
- Mix of private and publicly funded operators
- Very difficult to address the Digital Continuum
- No Sovereignty possible for Europe

THE LEXIS PLATFORM CONCEPT



- A Federation of Infrastructures including Research and Services, with Software Stack,
- Building Coherence, Solving the Private/Public difficulties,
- Performance, Openness, Orchestration, Coherence, Security for the full Digital Continuum
- Ready for compliance with EU Digital Sovereignty policies (GAIA-X or

THE LEXIS PLATFORM: Timeline

2018 – LEXIS Platform concept

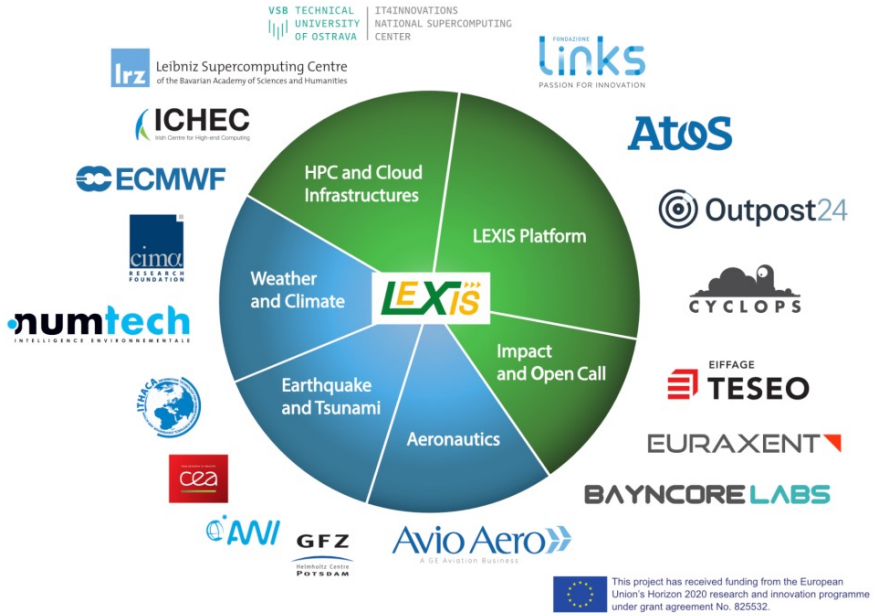
- Technical Concept
- Creation of a Consortium – 17 members, from Germany, Czech Republic, France, Ireland, UK, Italy, Switzerland
- Submission of the LEXIS Project to the EU Commission – Programme H2020
- Approval by the EU Commission - total budget circa 14 millions € - Grant agreement 825532
- Coordinator: IT4Innovations – National Supercomputing Centre of Czech Republic (Dr. Jan Martinovic)

2019 – Start of the project – 3 years timeline

- Project ending December 2021
- Completion validated by the EU Commission June 2022
- Exploitation post-end of project: starting now

2022 – Onward

- Technical tuning & development
- Enrolling new partners (Infrastructures, Data, Services)
- Structuration of legal entity
- Funding



THE LEXIS PLATFORM: an Ecosystem for an Ecosystem for the Digital Continuum

From inception LEXIS has been built by an ecosystem made of representants of:

- Industries, (4)
- Research Organisations (6)
- Super computing centres (4)
- Service companies (4)
- SMEs and Start-ups (5)

The LEXIS Platform will further develop by capitalising on:

- Existing partners,
- Developing the number of infrastructures as members of the federation,
- Strongly reinforcing services by welcoming new Service partners,
- Increase technical ways for integration, interconnections and cooperation with the addition of new components to the federation via development of APIs,
- Digital Sovereignty European framework (GAIA-X or else).

IT4I
Supercomputing Centre

Atos
Industry

LINKS
Research Organisation

TESEO
Industry

CEA
Research Organisation

LRZ
Supercomputing Centre

ECMWF
Supercomputing Centre

ITHACA
Research Organisation

CIMA
Research Organisation

AVIO Aero
Industry

GFZ
Research Organisation

AWI
Research Organisation

Outpost24
SME

Cyclops Labs
SME

BAYNCORE
SME

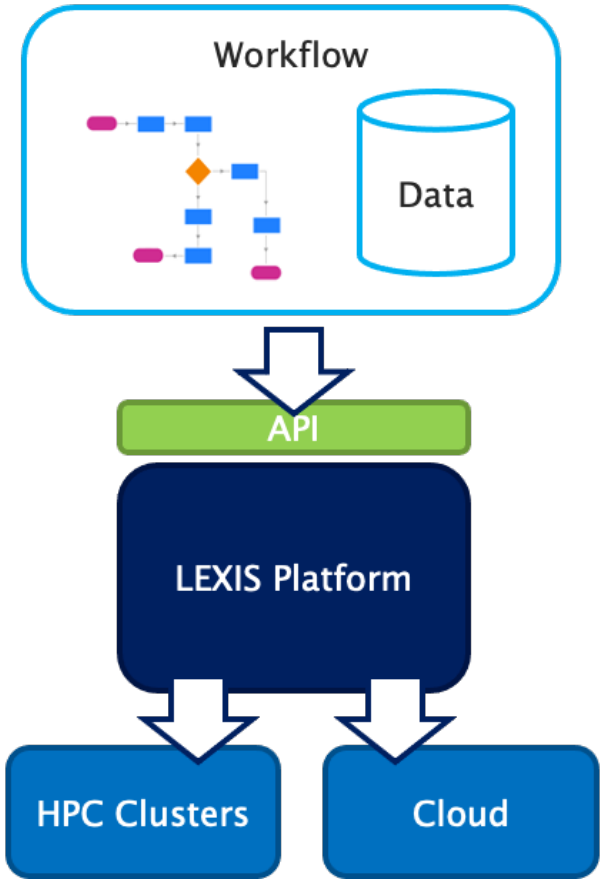
NUMTECH
SME

ICHEC
Supercomputing Centre

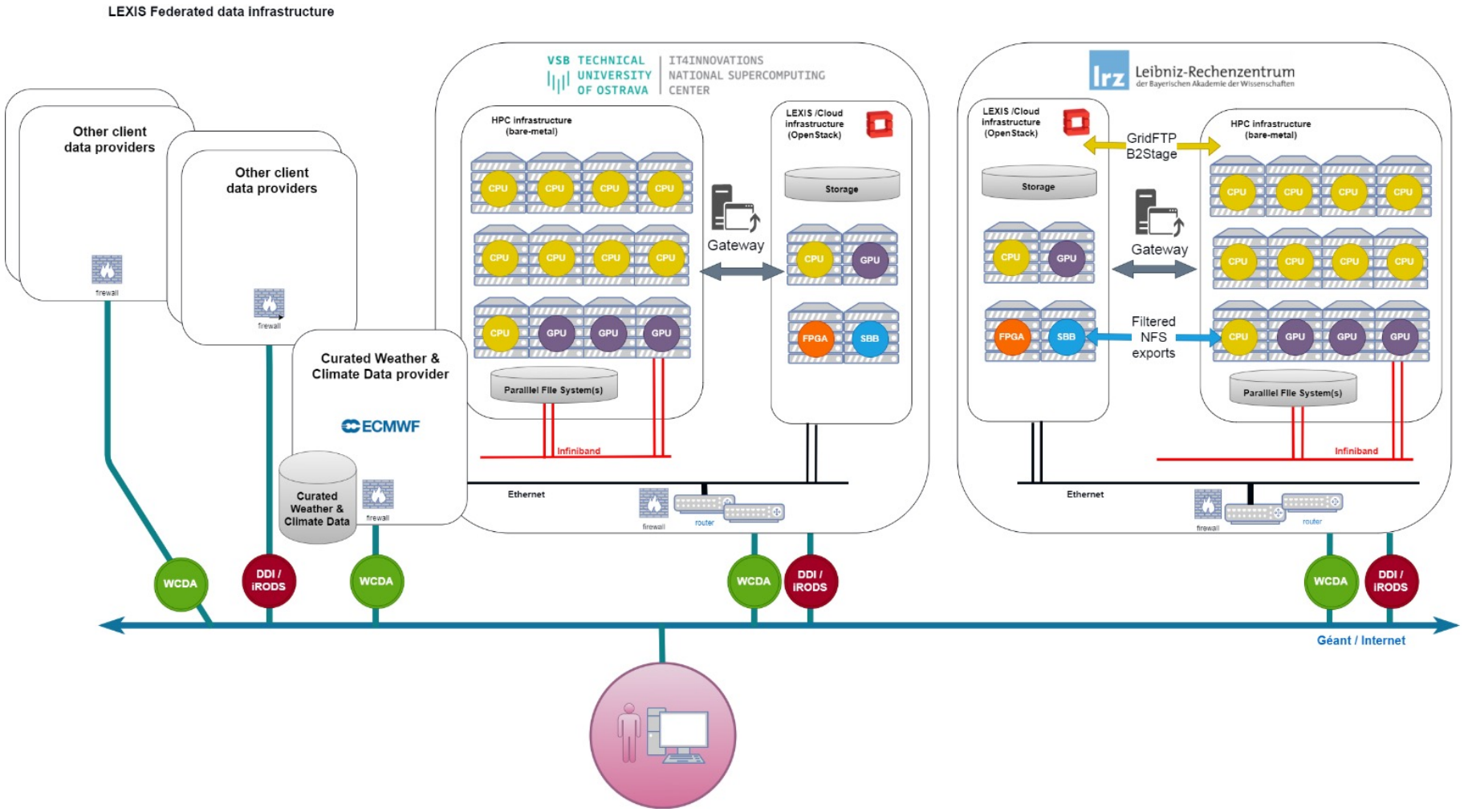
EURAXENT
SME

Key Points of LEXIS Platform

- **Dynamic, complex Cloud- & High-Performance-Computing / Big Data workflows**
  - Orchestration in geographical federation with *YORC, HEAppE*
  - Real-time deadline-aware workflows, etc.
- **Cross-site (meta-)data federation**
  - Distributed data management and data discovery with *EUDAT/iRODS*
  - Data transfers accelerated by Burst Buffer nodes; FPGAs/GPUs for on-line processing
- **Web portal and interfaces for workflow set-up / execution**
  - Unified access to all services via *Keycloak*-based LEXIS AAI
- **Easy HPC/Cloud access for SMEs/Industry – Big Data for everyone**
  - HPC-as-a-Service approach
  - Control over resource usage
  - Fine-grained accounting and billing for multiple HPC centres with *CYCLOPS*



Platform architecture overview

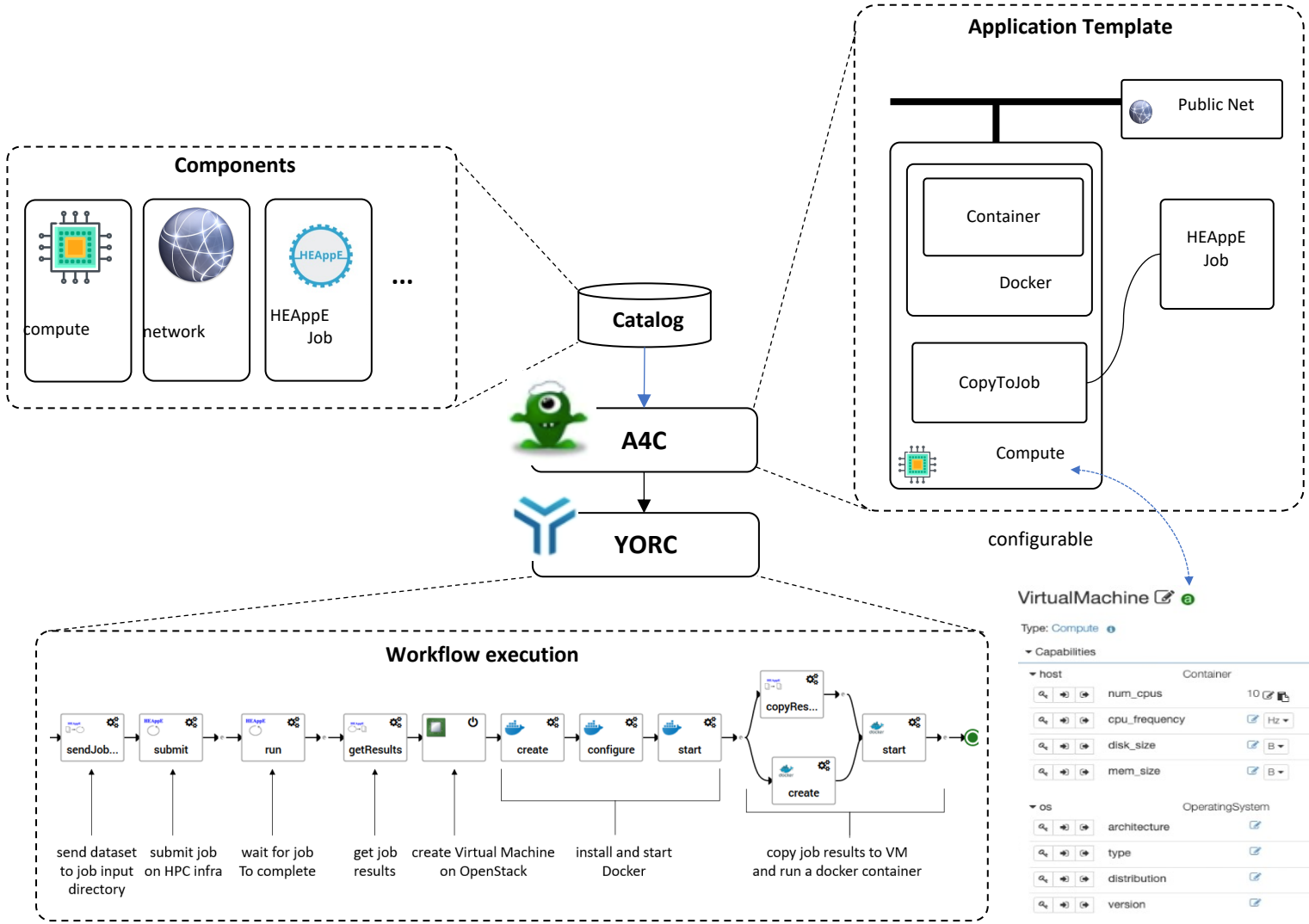


- Federation of European computing centres
- HPC & Cloud service providers, Data providers
- Unified & distributed data management
- Orchestration
- Federated Authentication & Authorization Infrastructure (AAI)
- Masking of technical and operational differences across organizations

Orchestration service & workflow management

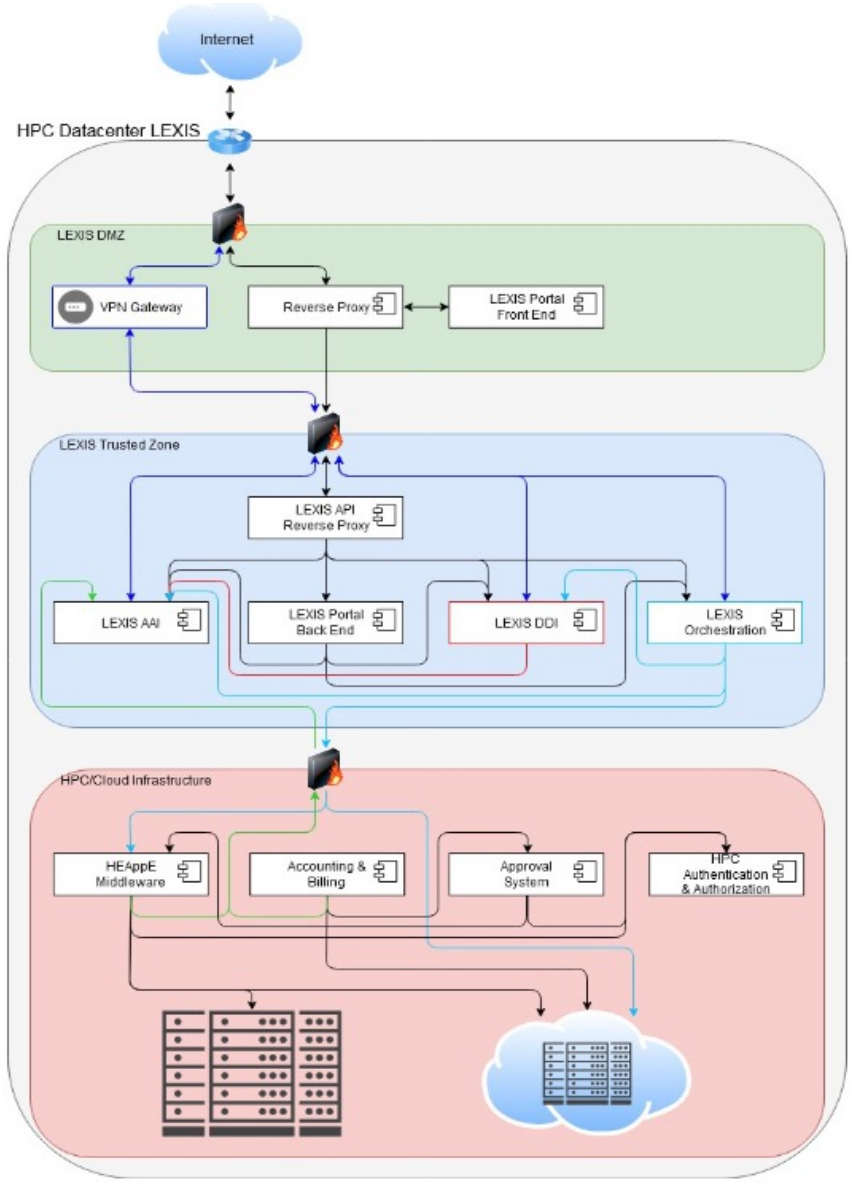
- Execution on geographically distributed HPC and Cloud resources
  - **Cloud**: via OpenStack built-in interface
  - **HPC**: job execution is mediated by HEAppE middleware
- Data management and orchestration policies
  - Leverage the LEXIS DDI service for an effective **data transfer** between systems
  - Placement of **workflow tasks** on the most suitable resource

https://github.com/alien4cloud/alien4cloud
https://github.com/ystia
http://heappe.eu

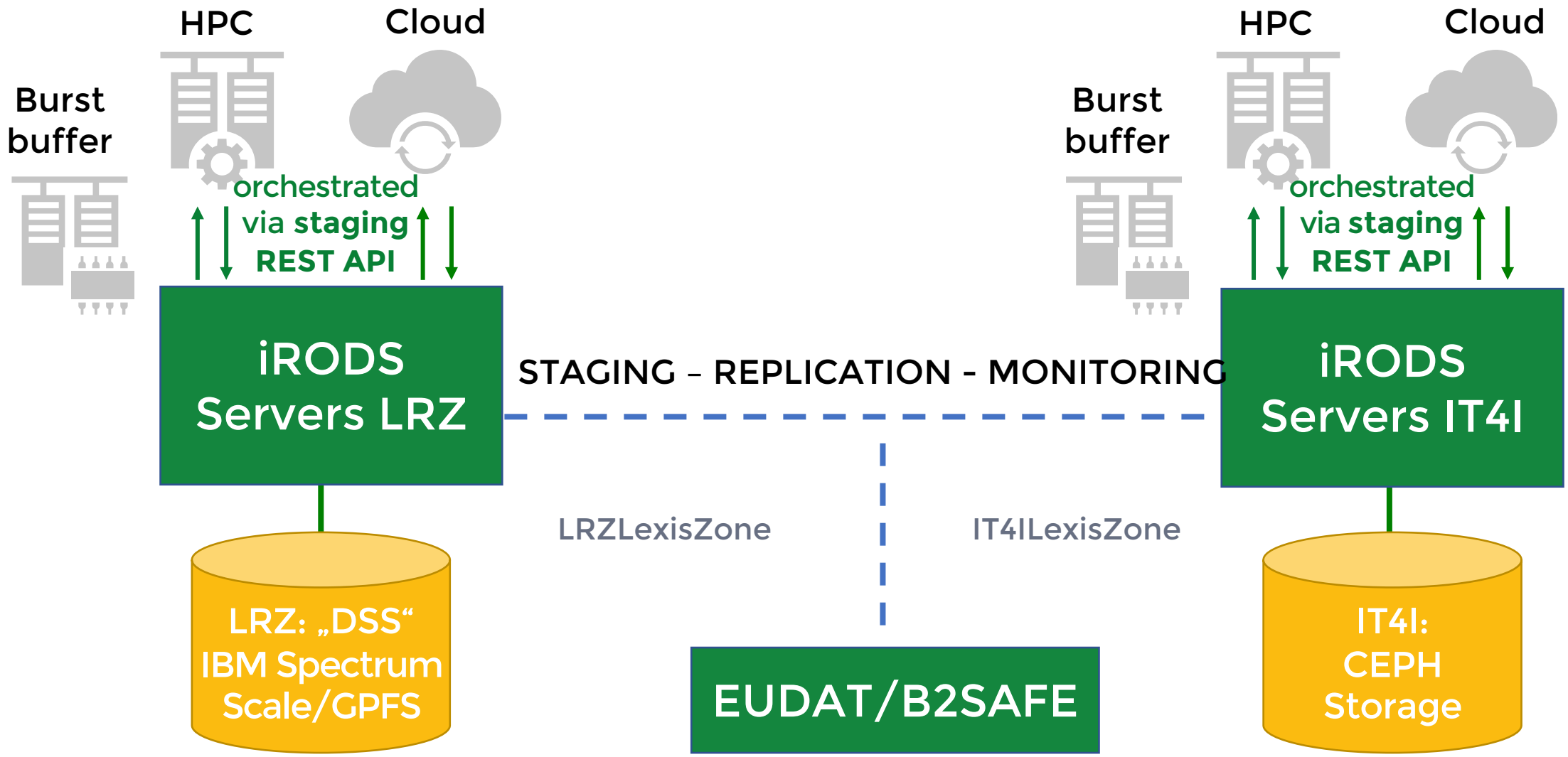


LEXIS Security requirements

- **Custom AAI solution with trusted access to HPC with PI approval**
- Security-by-design
  - **Zero trust, minimal attack surface, separation of concerns**
- Modern frameworks
- HPC infrastructures are protected
  - **Isolated by the HEAppE middleware (developed in IT4I)**
  - **Deployed in both IT4I and LRZ**
- Flexible
  - **Blurs differences between HPC centres**
  - **Provides SSO across the LEXIS federation**



Distributed data infrastructure



Pilot use-cases

Computation Fluid Dynamics (CFD),
Rotating parts (gearboxes),
3D Visualization

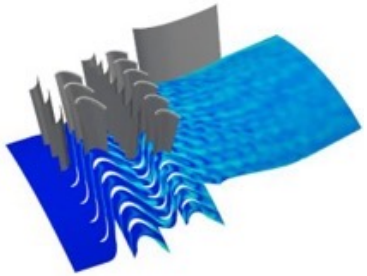
Earthquakes & Tsunami prediction models, geographic and urban databases, emergency organization, urgent computing

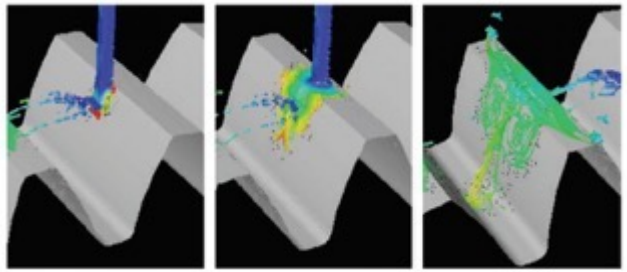
Weather & Climate models (WRF) and various post-processors for flood, wildfire & agriculture applications

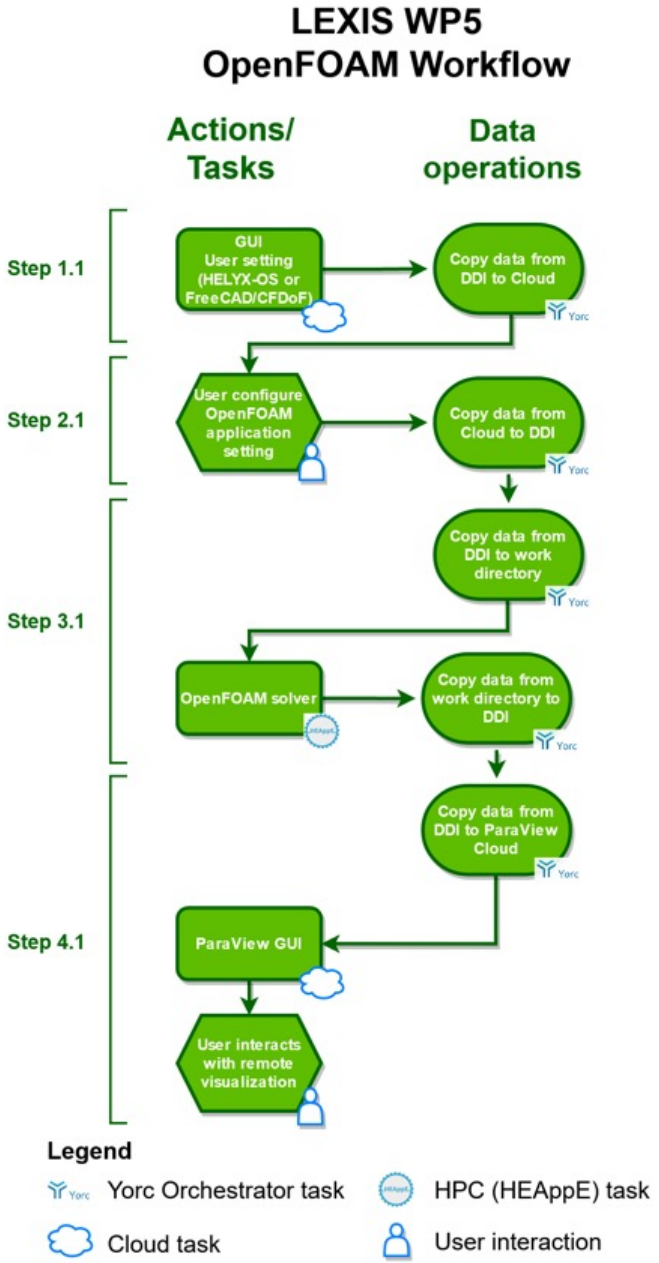
Aeronautics Large-scale Pilot

- Resilient long-term computational jobs across several HPC centres
- Easy use by unified access layer
- Easy access to accelerated visualization of simulation results which is a part of this pilot workflow

- **Investigation of the industrial applicability of the newly designed HPC/Cloud/BD platform**
- **Porting of an adopted software code from an only CPU-based version to a GPU-accelerated one**
- Implementation of a newly developed CFD methodology to predict and simulate with increasing accuracy a flow field operating inside aviation gearboxes

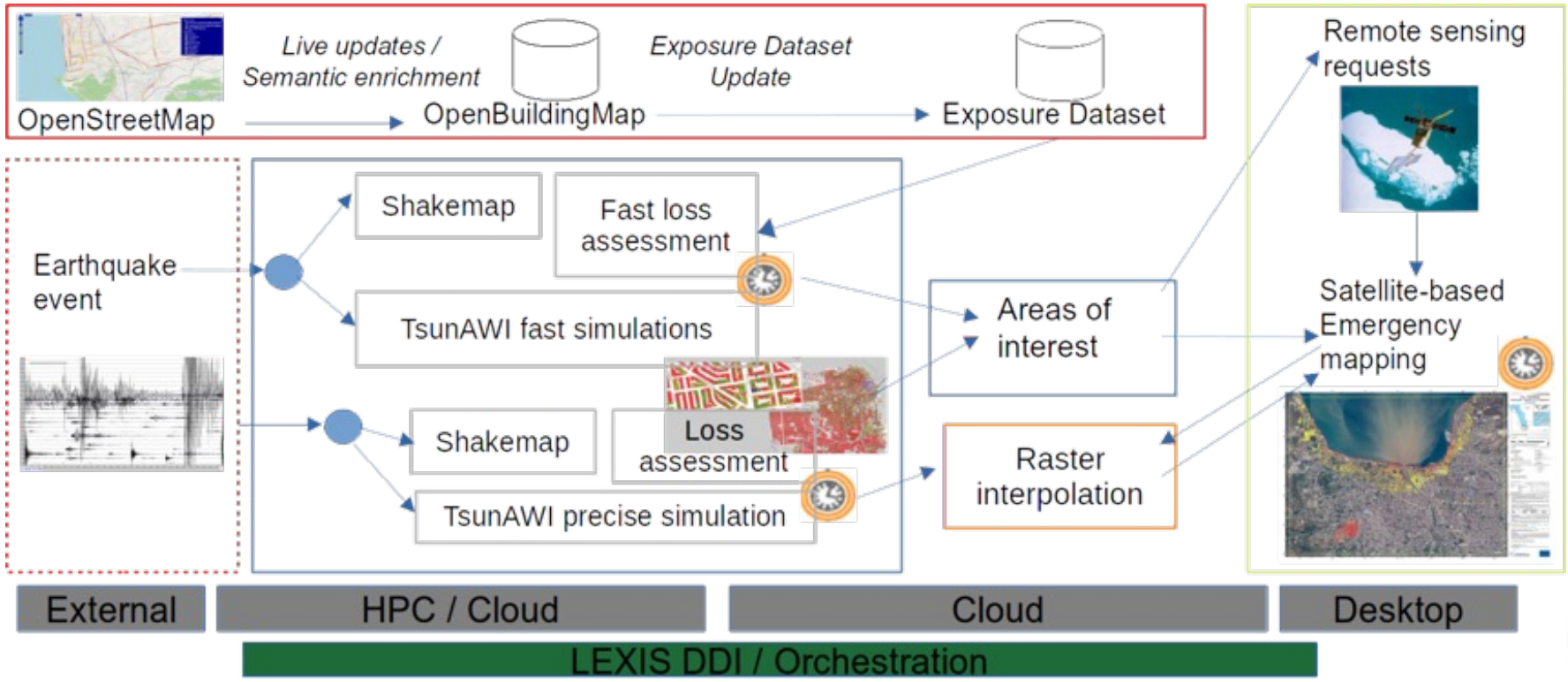


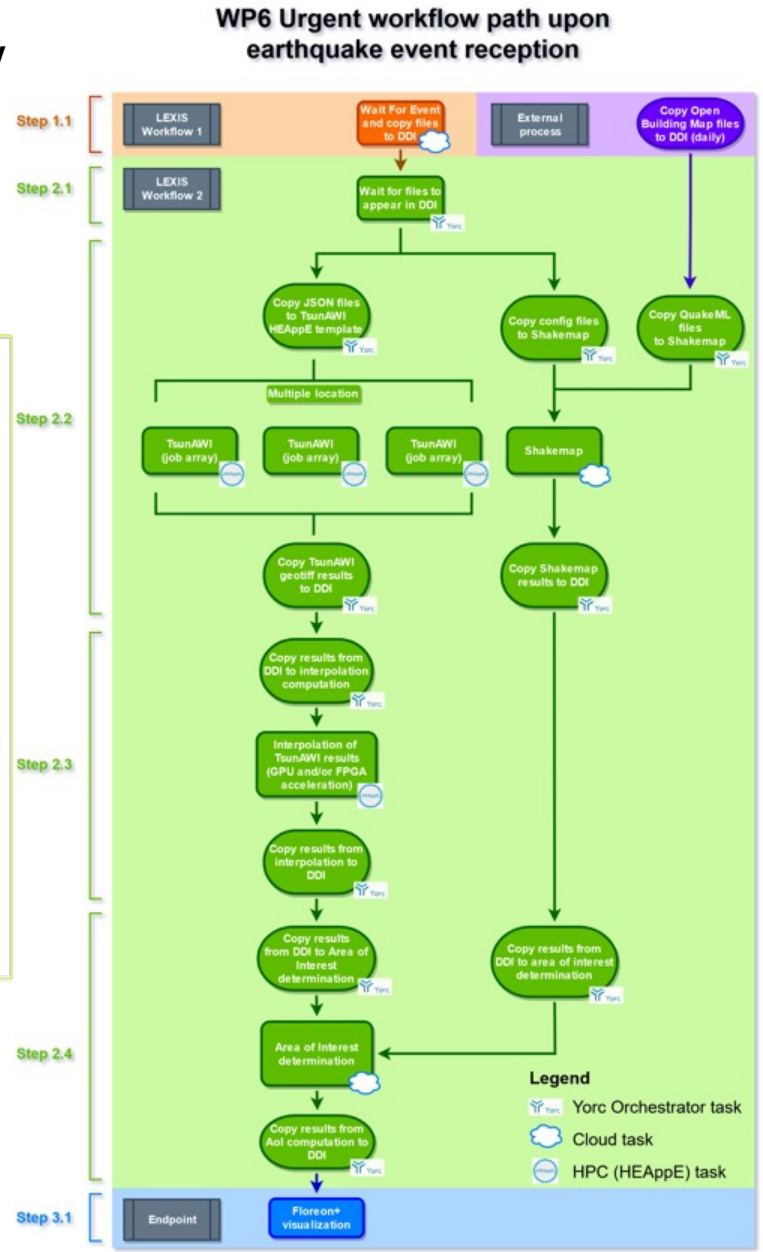




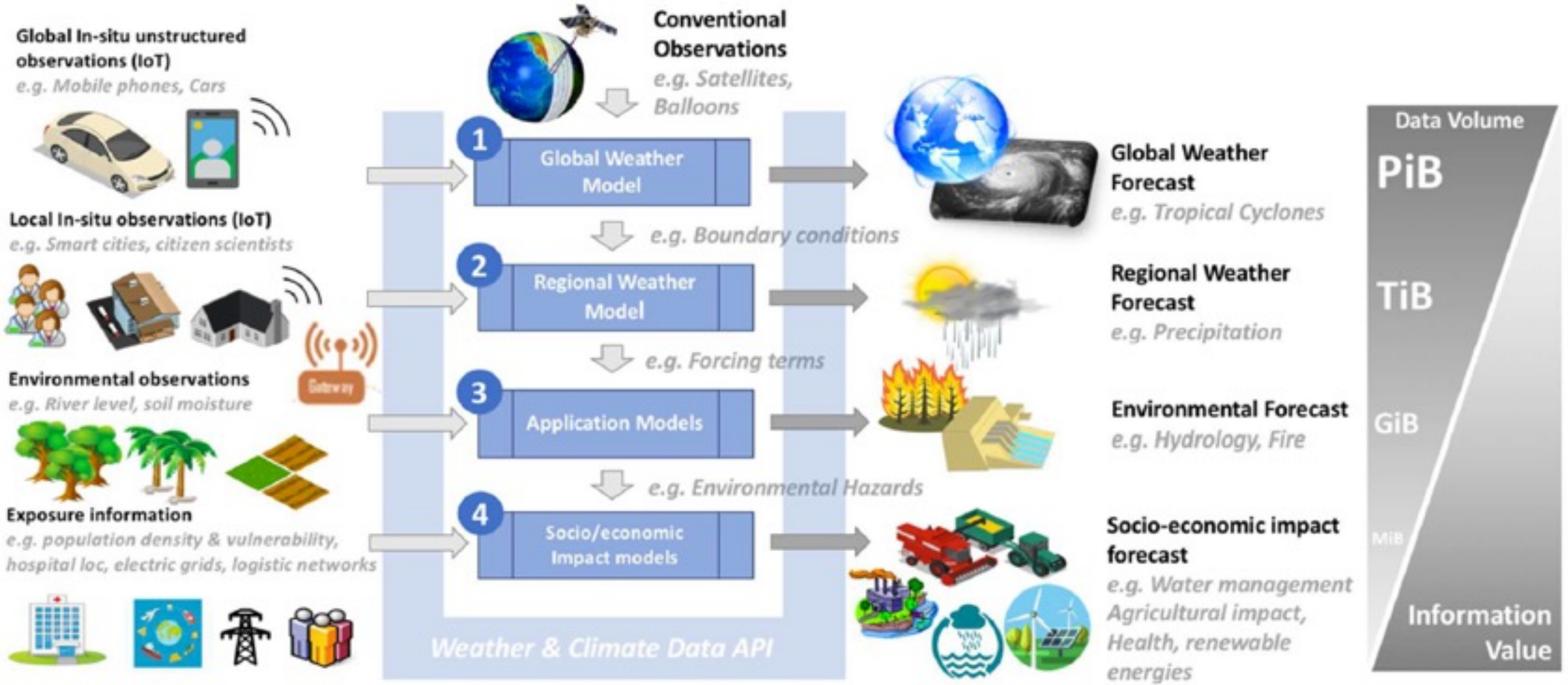
Earthquake and Tsunami large-scale pilot

- Event-driven automatized execution of urgent computing complex workflow infrastructure
- Event-triggered, deadline-dependent simulations for short-term forecasts
- Near-real time analysis



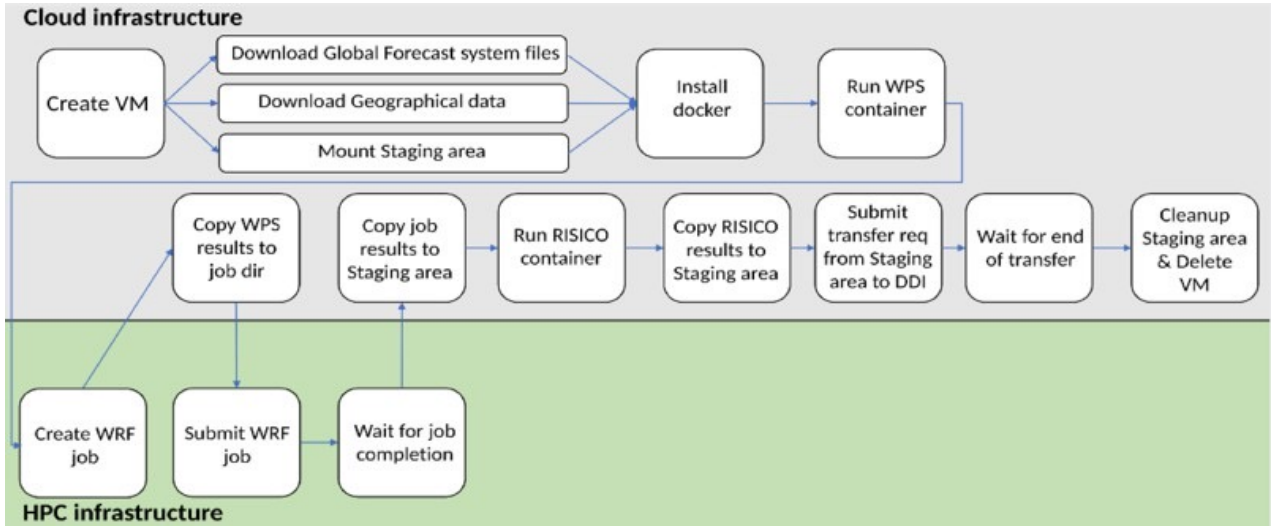


Weather and Climate Large-scale Pilot



Weather and Climate Large-scale Pilot

- **Naturally "hybrid" (Cloud-HPC) workflows**
  - Preprocessing of initial/boundary data
  - High-Resolution HPC regional weather model (WRF)
  - Application simulations using WRF data
    - forest fire risk, hydrological risk / flash-flood prediction

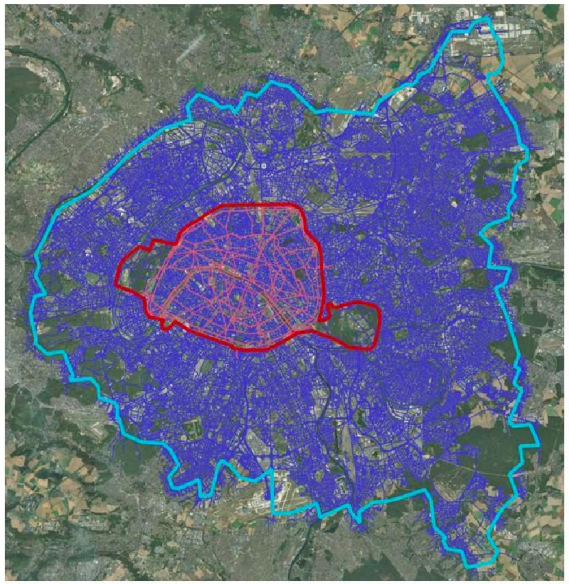


- **Enhanced, data-aware weather & climate workflow orchestration**
  - Urgent simulations when one computing centre is unavailable
  - Large-scale data assimilation (e.g. from sensor networks) for better prediction
  - Distributed data management solution
    - Specialised - Weather and Climate Data API
    - General - Distributed Data Infrastructure

BEFORE LEXIS: red

Area: 106 km2
Roads: 3 489
Others sources: 837
Output points: 80 674

Sub-domains to run: 13



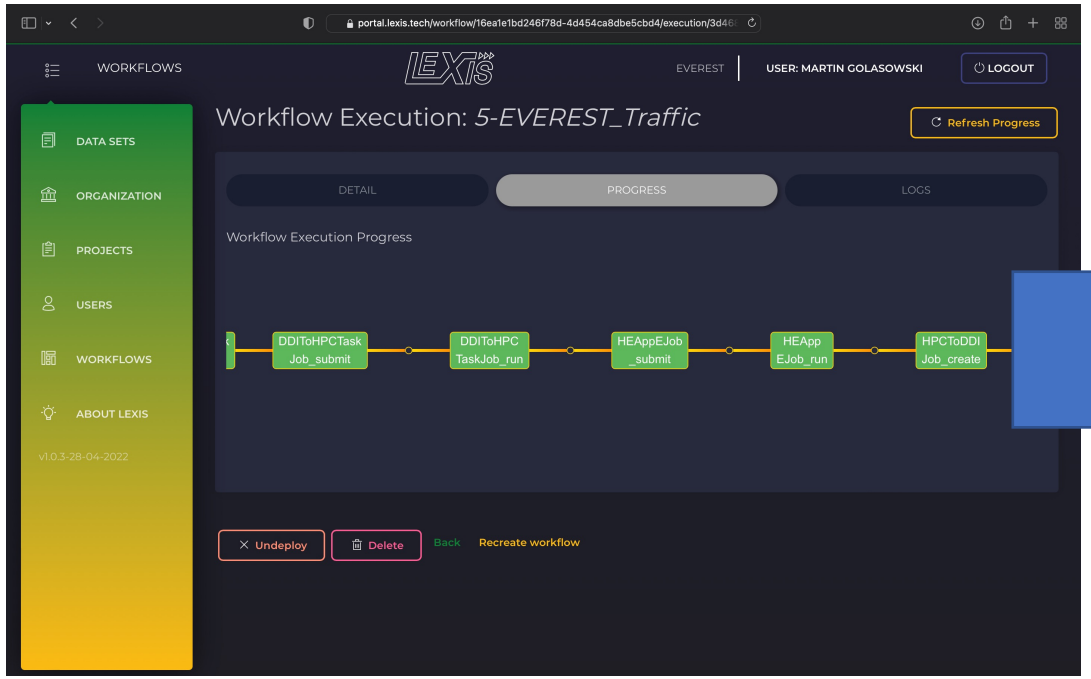
WITH LEXIS: Blue

Area: 772 km2
Roads: 75 883
Others sources: 4 000
Output points: 950 000

Sub-domains to run: 160

LEXIS Platform APIs & Web portal

Web based UI

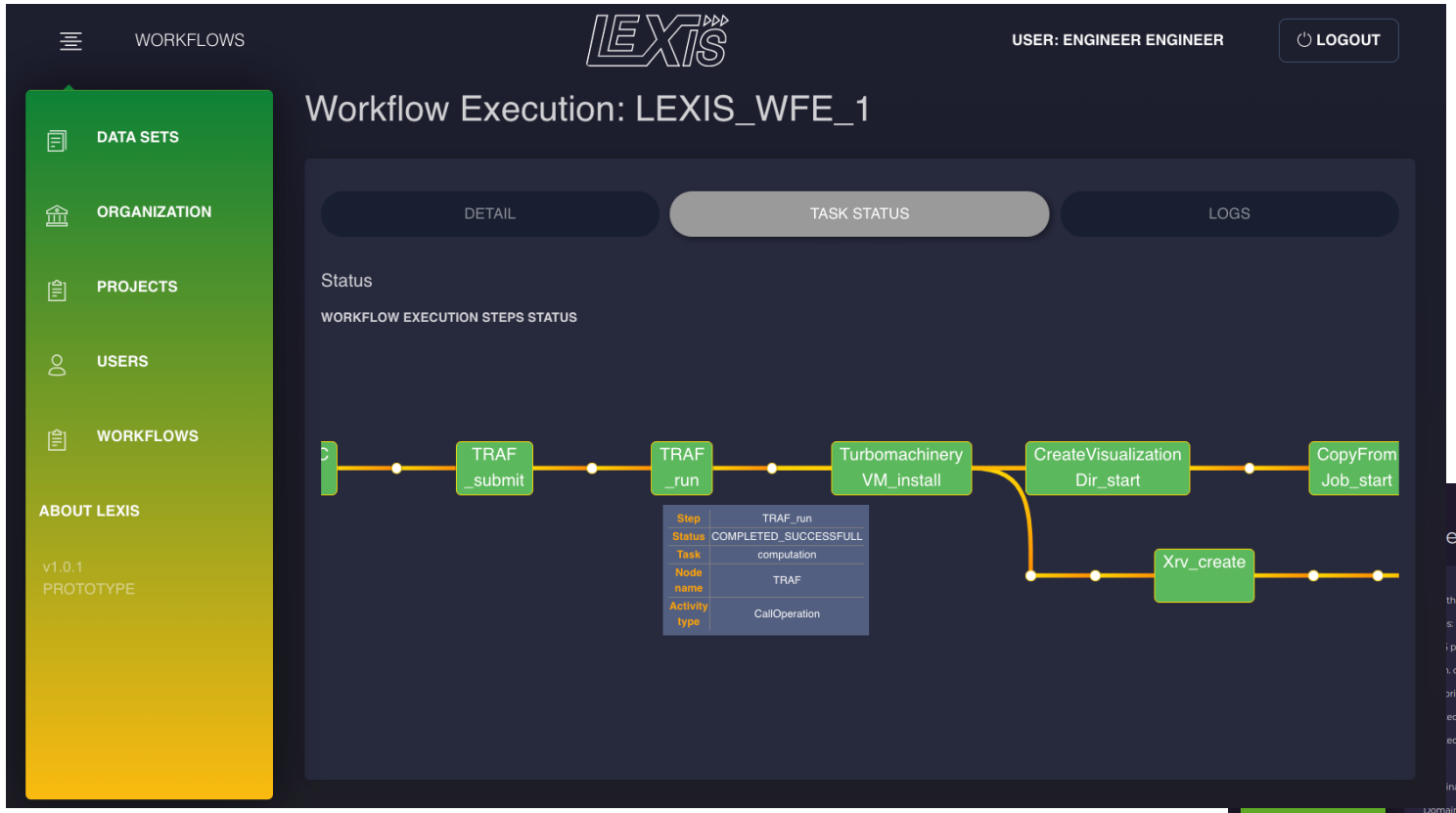


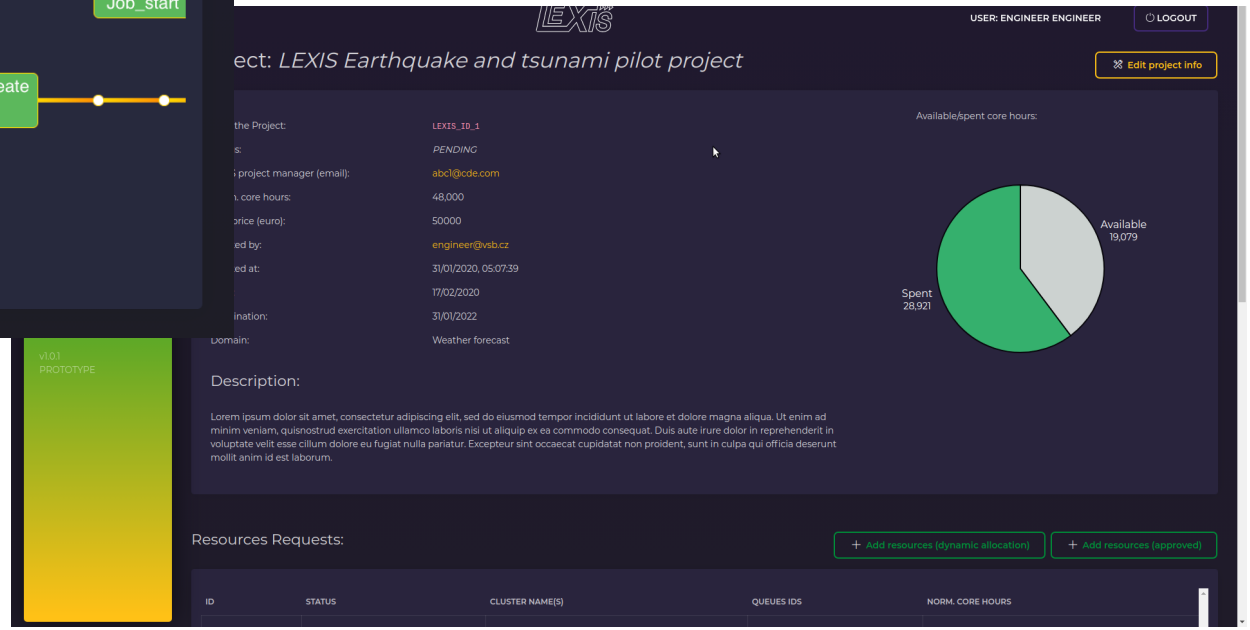
Well-defined REST APIs

workflowManagement Actions relating to management of Workflows and Workflow Executions

GET	/workflow	Return list of available LEXIS Workflows	getWorkflows
POST	/workflow	Create a new LEXIS Workflow on the system	createWorkflow
	/workflow/{workflowId}	Return detailed info on LEXIS Workflow for given Workflow ID	getWorkflow
	kflow/{workflowId}	Delete LEXIS Workflow on the system	DeleteWorkflow
	/workflow/{workflowId}/execution	List the current available LEXIS Workflow Executions.	listWorkflowExecutions
POST	/workflow/{workflowId}/execution	TODO: Needs implemented with TOSCA 1.3 Capabilitise. Create a new LEXIS Workflow Execution by providing remaining inputs	createWorkflowExecution
GET	/workflow/{workflowId}/execution/{workflowExecutionId}	Returns LEXIS Workflow Execution detail.	getWorkflowExecutionDetail
DELETE	/workflow/{workflowId}/execution/{workflowExecutionId}	Cancel a LEXIS Workflow Execution.	cancelWorkflowExecution

Workflow & resource management in the LEXIS portal

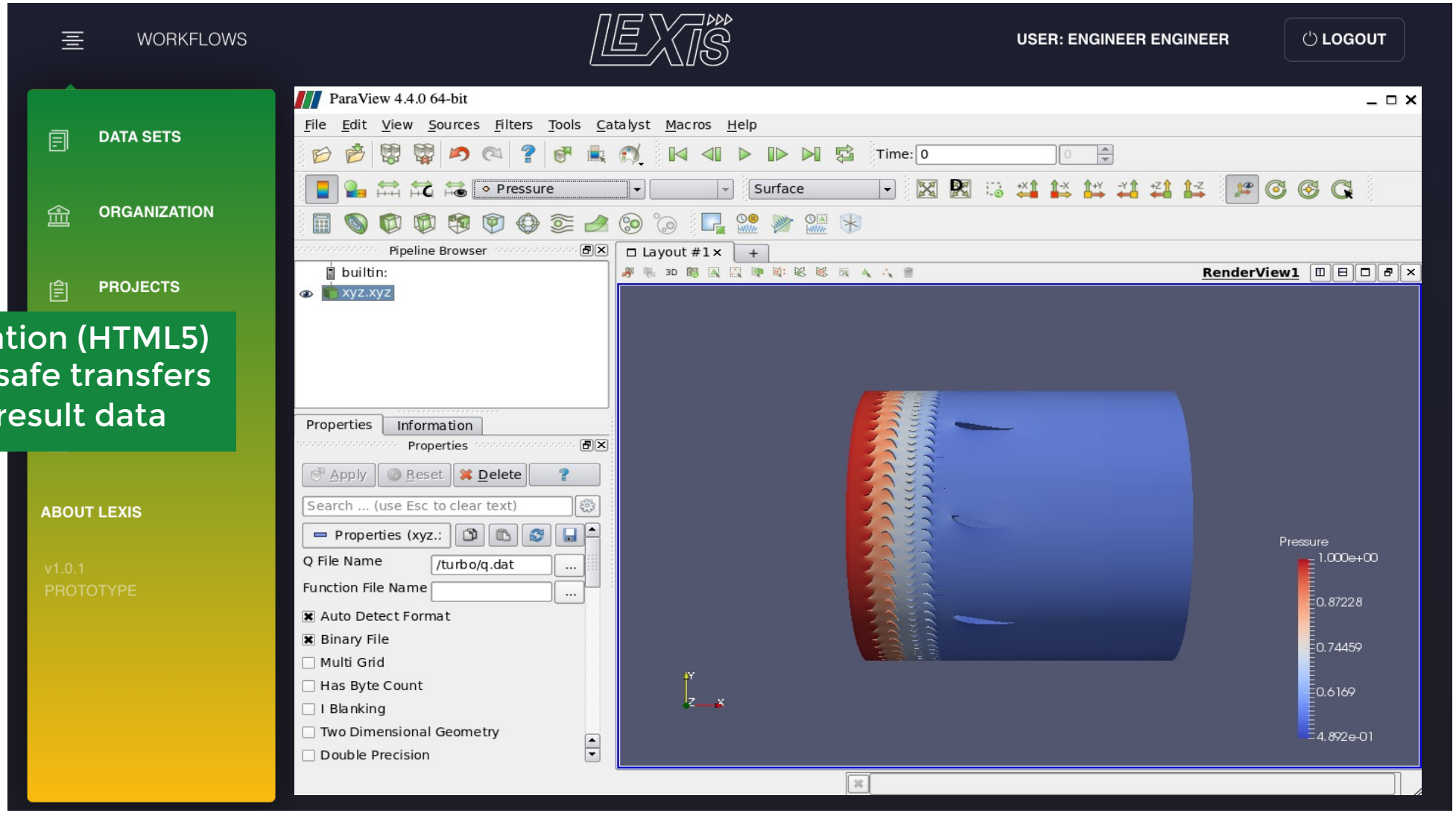




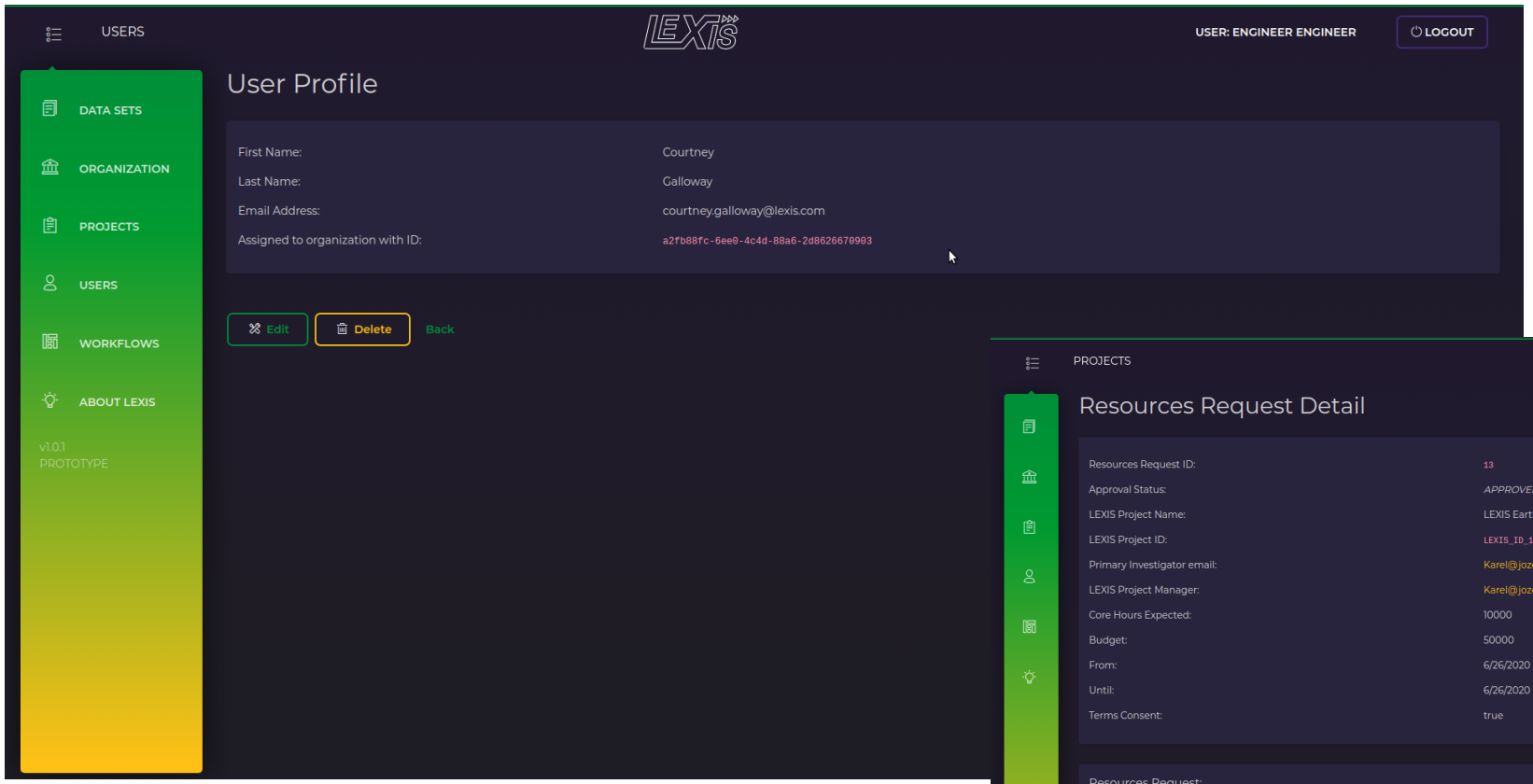
- **ALL-IN-ONE WEB INTERFACE**
  - Manage client organization
  - Manage projects
  - Provision and execute application workflows
  - Manage data
  - Interact with large 2D and 3D results remotely in real time

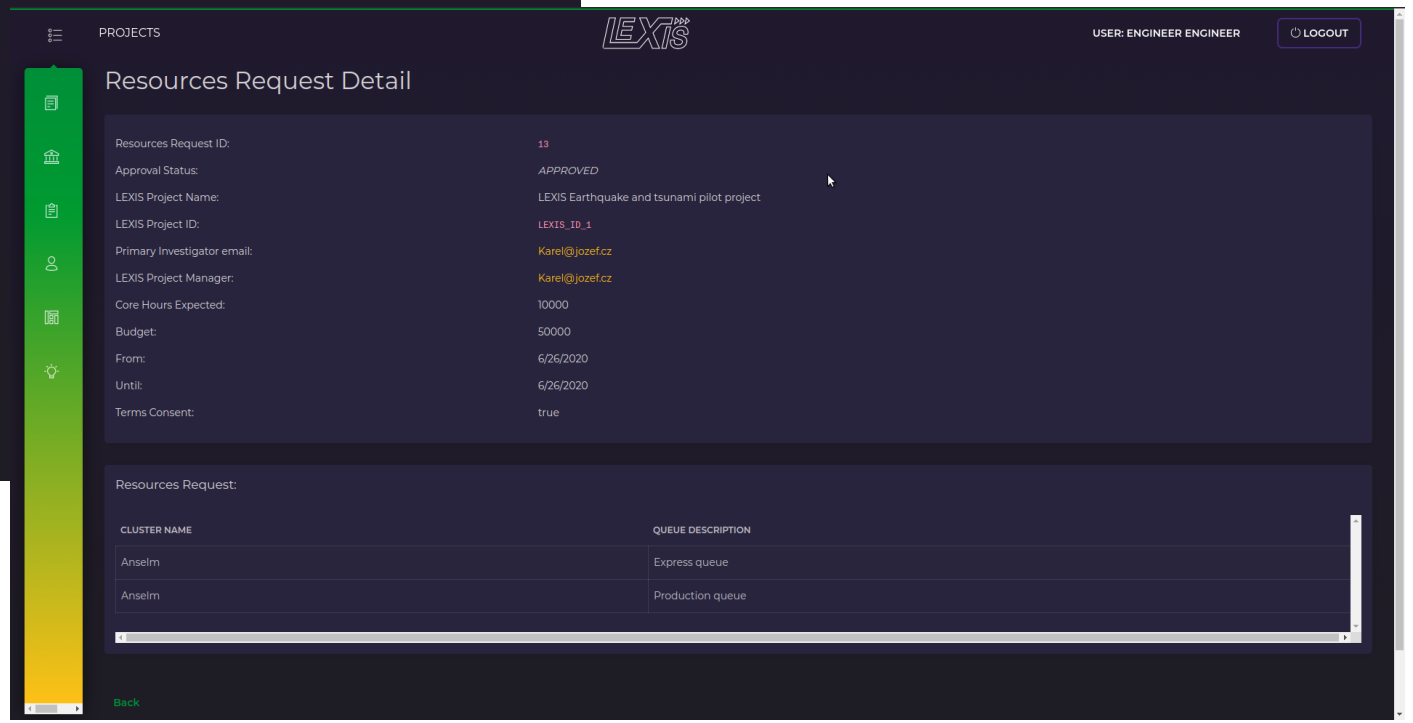
3D remote visualization in LEXIS Portal

Interactive 3D visualization (HTML5) avoiding costly and unsafe transfers of large computing result data



User experience





THANK YOU!

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