EXCELLERAT P2

EUROHPC Summit week
Industry Working Group- NCCs & CoEs

Monday 17th of March 2025, in Krakow, Poland

EXCELLERAT Relevance in the Industry
The European Centre of Excellence for Engineering Applications

- ✓ Research and Innovation in Horizon 2020
- ✓ Simulation Workflow at large scaling
- ✓ Challenges of reducing CO_2 and energy consumption
- ✓ 16 Partners
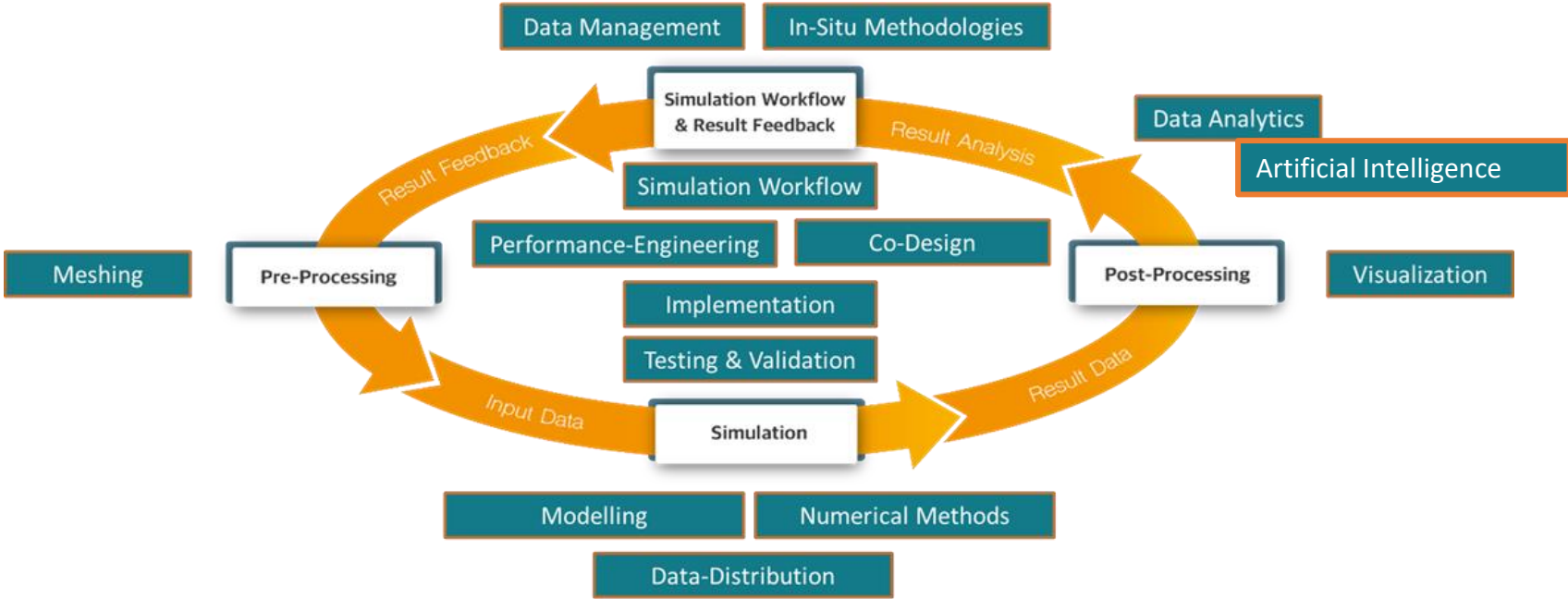
EXCELLERAT Relevance in the Industry
Objectives

- **Strengthen European competitiveness** in HPC and AI-driven engineering

- Demonstrate the benefits of using large-scale Simulation Workflows in **solving engineering challenges**

- Integrate the **CoE industrial users** of all perspectives in the EXCELLERAT P2 evolution

- Further establish the **EXCELLERAT brand** to be the central entry point for all stakeholders of HPC in engineering across Europe

- Provide provide **products and services** for potential industrial users

- Provide mandatory economic and **legal framework** for a sustainable operation of EXCELLERAT

EXCELLERAT Relevance in the Industry
Products and Services

EXCELLERAT P2

Software-Code
Data Asset
Training
Workshop
Whitepapers
Best Practice Guide
Consulting

EXCELLERAT Relevance in the Industry
Automotive – Potential Key Applications and EXCELLERAT Offering

- **Crash & Safety Simulation**: HPC-driven crashworthiness testing for robust structural integrity

- **Aerodynamics & Drag Reduction**: Adjoint optimisation for fuel-efficient vehicle aerodynamics

- **Hydrogen & Combustion Engine Simulation**: High-fidelity modeling for cleaner, low-emission engines

- **Battery & EV Thermal Management**: Multi-physics approaches for optimal energy efficiency and lifespan

- **AI & Digital Twins for Predictive Maintenance**: HPDA and ML to enhance component durability and reduce downtime

- **Automotive Acoustics & Noise Reduction**: Aeroacoustic simulations to cut cabin, wind, and engine noise

- **Large-Scale Simulation**: HPC-powered multi-physics for crash, aero, combustion, EVs, and more

- **Data Management**: Consistent, traceable, and reusable simulation data

- **HPDA**: Rapid analysis of massive outputs for quick decisions

- **ML**: Predicts failures and optimizes battery/noise strategies

- **Digital Twin**: Real-time HPC replicas for monitoring and agile design

- **KI**: Merges domain expertise with simulation insights

- **Visualization**: 3D/VR for clear, collaborative design choices

EXCELLERAT Relevance in the Industry
Automotive – existing Use Cases

Phase	Use Case	Institution	Core Code	Key Focus
P1	UC-P1-1: Emission Prediction of Internal Combustion & Gas Turbine Engines	CERFACS	AVBP	Simulation of internal combustion for emission reduction
P1	UC-P1-2: Coupled Simulation of Fluid & Structure Mechanics for Fatigue & Fracture	BSC	Alya	Vehicle structural fatigue modeling
P1	UC-P1-3: Combustion Instabilities & Emission Prediction	CERFACS	AVBP	Noise & emission reduction for next-gen propulsion
P1	UC-P1-4: Explosion in Confined Spaces	BSC	AVBP	Automotive safety & accident prevention
P2	UC-P2-3: Mitigation of Aeroacoustic Noise	RWTH	m-AIA	Noise reduction, jet optimization
P2	UC-P2-5: High-Fidelity Simulations of Rotating Parts	KTH	Nek5000	Powertrain & motor simulations

EXCELLERAT Relevance in the Industry

Automotive – Success Stories – * to access directly on the Success Story click on it

Success Story *	Code(s)	Owner/Partner	Key Focus
High-fidelity simulation using Adaptive Mesh Refinement with Spectral Element Method solver Neko	Neko, Nek5000	KTH Royal Institute of Technology	HPC, CFD, High-fidelity simulations, Spectral Element Method, Adaptive Mesh Refinement
Advanced scalable workflow of ray tracing kernel for radiative heat loads assessment	L2G, OpenFOAM, Raysect	University of Stuttgart	Connecting codes, Digital Twins
Accelerating Alya engineering simulations by using FPGAs	Alya	Barcelona Supercomputing Center (BSC)	FPGA, Exascale, Engineering simulations, Incompressible flow, GPUs
A novel framework for online estimation of the uncertainties in turbulent flow statistics	Nek5000, UQit, In-Situ Toolbox	KTH Royal Institute of Technology	Turbulence simulation, Time-averaging uncertainty, In-situ algorithms
Enabling sustainable GPU acceleration on a Fortran legacy code	AVBP	CERFACS	CFD, Combustion simulation, Parallel performance, GPU computing, OpenACC
Enabling Nek5000 on GPU systems	Nek5000	KTH Royal Institute of Technology	GPU, NVIDIA, AMD, OpenACC, OpenMP, Spectral Element Method
Accelerating engineering codes using reconfigurable architectures	Nekbone, Nek5000, Alya	KTH Royal Institute of Technology, Barcelona Supercomputing Center (BSC)	FPGA testbed, Memory-bound code, Dataflow

EXCELLERAT Relevance in the Industry
Automotive - Potential Industry Users

Country	OEMs	Tier 1 Suppliers	Tier 2 Suppliers	Tier 3 Suppliers
Germany	Volkswagen, BMW, Mercedes-Benz	Bosch, Continental	ZF Friedrichshafen, Schaeffler	Leoni, Mahle
France	Renault, Stellantis	Valeo, Faurecia	Plastic Omnium, Michelin	Novares, FIEV
Italy	Ferrari, Stellantis	Magneti Marelli, Pirelli	Brembo, Sogefi	MTA, SILA
Spain	SEAT, Stellantis	Gestamp, Grupo Antolin	Ficosa, CIE Automotive	Maier, Teknia
Poland	Fiat Chrysler Automobiles (FCA), MAN Trucks	BorgWarner Poland, Valeo Poland	Gedia Poland, Kirchhoff Automotive Poland	Sapa Aluminium Poland, Hutchinson Poland
Hungary	Suzuki Hungary, Audi Hungaria	Knorr-Bremse Hungary, Bosch Hungary	ThyssenKrupp Hungary, TRW Hungary	Denso Hungary, Federal Mogul Hungary
Czech Republic	Škoda Auto, Hyundai Czech	Continental Czech Republic, Magna Bohemia	Brano Group, Bosch Czech Republic	Meopta Czech Republic, Kovolis Hedvikov
Slovakia	Volkswagen Slovakia, Kia Motors Slovakia	Schaeffler Slovakia, ZF Slovakia	Matador Group, Axxon Slovakia	ZF Slovakia, Matador Holding

EXCELLERAT Relevance in the Industry

Aeronautics and Aerospace – Potential Key Applications and EXCELLERAT Offering

- **Aerodynamic Analysis & Design**: HPC-powered simulations for drag reduction, fuel efficiency, and stability.

- **Structural Integrity & Crashworthiness**: Multi-physics modeling for fatigue, material failure, and crash resilience.

- **Propulsion & Combustion**: High-fidelity modeling of jet engines, turbines, and next-gen propulsion systems.

- **Flight Dynamics & Control**: AI-powered digital twins for real-time monitoring and predictive analytics.

- **Spacecraft & Rocket Launch Systems**: HPC-driven CFD for trajectory optimization and thermal protection.

- **Large-Scale Simulation**: HPC-driven multi-physics for aerodynamics, propulsion, and structures.

- **Data Management**: Centralized, reusable storage for aerodynamic, propulsion, and mission datasets.

- **HPDA**: Rapid post-processing of flight simulations for improved performance.

- **ML**: AI-enhanced flight control, predictive maintenance, and anomaly detection.

- **Digital Twin**: Real-time aircraft and spacecraft virtual models for enhanced decision-making.

- **KI**: Merging aerospace engineering expertise with HPC-powered design refinements.

- **Visualization**: 3D/VR tools for immersive aerodynamic and structural analysis.

EXCELLERAT Relevance in the Industry
Aeronautics and Aerospace – existing Use Cases

Phase	Use Case	Institution	Core Code	Key Focus
P1	UC-P1-5: Adjoint Optimization for External Aerodynamics Shape Optimization	BSC	Alya	Aircraft shape optimization for fuel efficiency
P1	UC-P1-6: Design Process & Simulation of Fully Equipped Aircraft	BSC	Alya	Full-aircraft simulation frameworks
P2	UC-P2-1: External Aircraft Aerodynamics	DLR	CODA	Full-flight envelope simulations
P2	UC-P2-2: Hydrogen Combustion for Propulsion	CERFACS	AVBP	Hydrogen propulsion & emissions modeling
P2	UC-P2-3: Mitigation of Aeroacoustic Noise	RWTH	m-AIA	Noise reduction & thrust balance
P2	UC-P2-4: Fully Integrated Aircraft Simulations with Emission Models	BSC	Alya	AI-driven flow control & emissions reduction
P2	UC-P2-6: Active Control for Drag Reduction of Transonic Airfoils	CINECA	FLEW	Optimized airfoil design for drag reduction

EXCELLERAT Relevance in the Industry

Aeronautics and Aerospace – Success Stories – * to access directly on the Success Story click on it

Success Story*	Code(s)	Owner/Partner	Key Focus
Transparent Integration of Emerging HPC Technologies into the Computational Fluid Dynamics Software CODA	CODA, Spliss	German Aerospace Center (DLR)	Computational Fluid Dynamics, High Performance Computing, GPU, Linear equation systems, Aircraft aerodynamics
A novel framework for online estimation of the uncertainties in turbulent flow statistics	Nek5000, UQit, In-Situ Toolbox	KTH Royal Institute of Technology	Turbulence simulation, Time-averaging uncertainty, In-situ algorithms
Enabling sustainable GPU acceleration on a Fortran legacy code	AVBP	CERFACS	CFD, Combustion simulation, Parallel performance, GPU computing, OpenACC
Enabling Nek5000 on GPU systems	Nek5000	KTH Royal Institute of Technology	GPU, NVIDIA, AMD, OpenACC, OpenMP, Spectral Element Method
Accelerating engineering codes using reconfigurable architectures	Nekbone, Nek5000, Alya	KTH Royal Institute of Technology, Barcelona Supercomputing Center (BSC)	FPGA testbed, Memory-bound code, Dataflow

Industrial Aerospace Success Story- Airbus and Onera Multi-disciplinary analysis and design optimization

- CFD software for solving the RANS equations on unstructured grids based
  - Core Code CODA
  - Integrated in the *FlowSimulator* framework for multi-disciplinary analysis and design optimization (MDA/MDO)

- Led by DLR (jointly developed with ONERA and Airbus, from 2017)

- Ambition & Challenges
  - very large simulations, use of very large numbers of cores and data sets
  - executing very large sets of medium scale simulations

- Maturity & Exascale Readiness
  - good parallel efficiency for 10^5 cores in a strong scaling scenario
  - estimated efficient scaling up to 10^6 - 10^7 cores for production meshes

- Success Story published by Airbus and Onera
  - https://www.dlr.de/en/latest/news/2017/20170621_dlr-agrees-strategic-partnership-with-onera-and-airbus_22913
  - https://www.youtube.com/watch?v=RE6TxILHveY

DLR (CC-BY 3.0)

Industrial Aerospace Success Story- Safran and Akira technology Full Engine with large-eddy simulation

- Compressible fine element Navier-Stokes solver dedicated to reactive flows
  - Core Code AVBP
  - Solve complex gaseous and two phase-flow problems

- CERFACS leads the development
  - academic partners contribute adding physical models and validations

- Ambition & Challenges
  - Meshes containing 5 to 10 billion mesh points for highly complex geometries using AMR
  - New models require GPU acceleration and introduction of hybrid CFD/Machine learning approaches for sub-grid or wall models

- Maturity & Exascale Readiness
  - tested on Arm/x86, RISC and GPU platform
  - enhanced on new platforms (AMD & Intel GPUs, AWS Graviton processors)

- Success Story : https://prace-ri.eu/scientists-provide-the-first-full-view-into-an-aircraft-engine/

First full engine computation with large-eddy simulation
Project FULLEST - C. Pérez Arroyo et al. - 2020

CERFACS AVBP
PRACE dgac SAFRAN AKIRA

EXCELLERAT Relevance in the Industry
Aeronautics and Aerospace - Potential Industry Users

Country	OEMs	Tier 1 Suppliers	Tier 2 Suppliers	Tier 3 Suppliers
France	Airbus, Dassault	Safran, Thales	Zodiac, Latécoère	MBDA, Daher
Germany	Airbus, MTU Aero Engines	Diehl, Liebherr	Premium AEROTEC, Rohde & Schwarz	Rohde & Schwarz, Test-Fuchs
Spain	Airbus Defence & Space	Aernnova, Aciturri	Sener, Red Eléctrica	Elecnor, Soltec
Sweden	Saab AB	GKN Aerospace, RUAG	Eolus Vind, Svenska Kraftnät	SKF, Alfa Laval
Poland	PZL-Świdnik (Leonardo), WSK PZL-Rzeszów	WSK PZL-Rzeszów, Pratt & Whitney Poland	Hispano-Suiza Poland, Hamilton Sundstrand	AeroTech Poland, Sonaca Poland
Hungary	Magnus Aircraft, Aero Vodochody Aerospace	Thyssenkrupp Components, FACC Aero HU	Borsodi Muhely, Magnus Aircraft Components	Graphisoft Hungary, Comtech Aero Hungary
Czech Republic	Aero Vodochody, GE Aviation Czech	PBS Velká Bíteš, AeroTech Czech	Jihostroj, MESIT Czech Republic	Czech Aerospace Research Centre, Zlin Aircraft
Romania	Romaero, IAR Brasov	Turbomecanica, Aerostar	Avio Aero Romania, RATEN ICN Nuclear Research	Turbomecanica Romania, Aerostar Components

EXCELLERAT Relevance in the Industry
Energy – Potential Key Applications and EXCELLERAT Offering

- **Renewable Energy Systems**: HPC-based wind, solar, and hydro simulations for efficiency optimization.

- **Thermal & Nuclear Power**: Multi-physics modeling for reactor performance, safety, and energy output.

- **Oil & Gas Reservoir Simulation**: Large-scale subsurface modeling for exploration and CO_2 sequestration.

- **Smart Grids &** Storage: AI-powered grid stability, demand forecasting, and battery optimization.

- **Energy Infrastructure & Materials**: Structural and fatigue analyses of turbines, pipelines, and storage facilities.

- **Large-Scale Simulation**: HPC-based modeling of renewables, power plants, and grid systems.

- **Data Management**: Organized, traceable databases for energy production, grid stability, and material durability.

- **HPDA**: Fast analysis of sensor data for efficient energy management.

- **ML**: Predictive maintenance for turbines, reactors, and smart grids.

- **Digital Twin**: Real-time models of energy assets for performance monitoring and risk assessment.

- **KI**: Integration of domain expertise for optimized, real-world energy solutions.

- **Visualization**: 3D/VR tools for infrastructure monitoring and decision-making.

EXCELLERAT Relevance in the Industry
Energy – existing Use Cases

Phase	Use Case	Institution	Core Code	Key Focus
P1	UC-P1-1: Emission Prediction of Internal Combustion & Gas Turbine Engines	CERFACS	AVBP	Hydrogen & conventional fuel combustion efficiency
P2	UC-P2-2: Hydrogen Combustion for Propulsion	CERFACS	AVBP	Hydrogen combustion for clean energy applications
P2	FA-P2-1: Engineering Design & Digital Twin of Tokamak Fusion Reactor	UL	OpenFOAM, Elmer	Digital twin for fusion energy research

EXCELLERAT Relevance in the Industry

Energy – Success Stories – * to access directly on the Success Story click on it

Success Story	Code(s)	Owner/Partner	Key Focus
Advanced scalable workflow of ray tracing kernel for radiative heat loads assessment	L2G, OpenFOAM, Raysect	University of Stuttgart	Connecting codes, Digital Twins
Accelerating Alya engineering simulations by using FPGAs	Alya	Barcelona Supercomputing Center (BSC)	FPGA, Exascale, Engineering simulations, Incompressible flow, GPUs
A novel framework for online estimation of the uncertainties in turbulent flow statistics	Nek5000, UQit, In-Situ Toolbox	KTH Royal Institute of Technology	Turbulence simulation, Time-averaging uncertainty, In-situ algorithms
A POP proof-of-concept allows a Bunsen flame use case from EXCELLERAT to run two times faster	L2G, OpenFOAM, Raysect	University of Stuttgart	Performance optimisation, Assessment, PoC, MPI, DLB, Load imbalance
Accelerating engineering codes using reconfigurable architectures	Nekbone, Nek5000, Alya	KTH Royal Institute of Technology, Barcelona Supercomputing Center (BSC)	FPGA testbed, Memory-bound code, Dataflow

EXCELLERAT Relevance in the Industry
Energy - Potential Industry Users

Country	OEMs	Tier 1 Suppliers	Tier 2 Suppliers	Tier 3 Suppliers
France	EDF, TotalEnergies	Framatome, Schneider Electric	Saint-Gobain, Technip Energies	Suez, Engie
Germany	Siemens Energy, RWE	E.ON, EnBW	MAN Energy, Wacker Chemie	Nordex, Varta
Italy	Enel, Eni	Prysmian, Ansaldo Energia	Saipem, Italgas	Fincantieri, Terna
Denmark	Ørsted, Vestas	Danfoss, Haldor Topsoe	BWSC, LM Wind Power	Grundfos, Topsoe
Poland	PGE (Polska Grupa Energetyczna), Orlen	TAURON Polska Energia, Siemens Poland	Grupa Azoty, ABB Poland	Solaris Bus & Coach, Energoinvest Poland
Hungary	MOL Group, MVM Group	Ganz Transformers, Schneider Electric HU	Tungsram Group, Siemens Hungary	Ganz Transformer Manufacturing, GanzAir
Czech Republic	ČEZ Group, EPH	ABB Czech Republic, Siemens Czech Republic	ČEPS (Czech electricity transmission), ABB CZ	Skoda JS, EGU Brno
Romania	Electrica, Hidroelectrica	General Electric Romania, Schneider Romania	Electrogrup, E.ON Romania	Electromagnetica, Rompetrol

EXCELLERAT Relevance in the Industry
Manufacturing – Potential Key Applications and EXCELLERAT Offering

- **Additive Manufacturing (3D Printing) Optimization:** AI-enhanced simulation for material properties & structural integrity.

- **Digital Twins for Smart Factories:** AI-driven predictive maintenance and process optimization.

- **High-Performance Machining Simulations:** Large-scale HPC workflows for cutting, drilling, and shaping materials.

- **Supply Chain & Logistics Optimization:** HPDA & AI for real-time tracking and efficiency improvements.

- **Thermal & Structural Analysis for Industrial Equipment:** Simulation of heat transfer in manufacturing processes.

- **Large-Scale Simulation:** HPC-powered multi-physics for additive manufacturing, machining, thermal analysis, and industrial equipment.

- **Data Management:** Structured, traceable data pipelines for manufacturing and logistics optimization.

- **HPDA:** Real-time analytics for monitoring machining, 3D printing, and process efficiency.

- **ML:** AI-driven defect detection, predictive maintenance, and adaptive machining strategies.

- **Digital Twin:** Live digital replicas for real-time monitoring and process optimization.

- **KI:** AI-enhanced automation and decision-making in factory operations.

- **Visualization & VR/AR:** 3D, immersive digital twins for collaborative design and real-time monitoring.

EXCELLERAT Relevance in the Industry
Manufacturing – existing Use Cases

Phase	Use Case	Institution	Core Code	Key Focus
P2	UC-P2-5: High-Fidelity Simulations of Rotating Parts	KTH	Nek5000	Turbine & industrial motor modeling
P2	FA-P2-1: Engineering Design & Digital Twin of Tokamak Fusion Reactor	UL	OpenFOAM, Elmer	HPC for manufacturing processes

EXCELLERAT Relevance in the Industry
Manufacturing – Success Stories

Success Story	Code(s)	Owner/Partner	Key Focus
Running AVBP Industrial code on Arm architectures	AVBP	CERFACS	ARM architectures, Porting HPC codes, Computational Fluid Dynamics (CFD)
Accelerating Alya engineering simulations by using FPGAs	Alya	Barcelona Supercomputing Center (BSC)	FPGA acceleration, HPC, Engineering simulations
A POP proof-of-concept allows a Bunsen flame use case from EXCELLERAT to run two times faster	OpenFOAM, L2G, Raysect	University of Stuttgart	Load balancing, Performance optimization
Enabling parallel mesh adaptation with Treeadapt	Treeadapt	RWTH Aachen University	Adaptive mesh refinement, Large-scale simulation
Mesh optimising by using an a posteriori adjoint based error estimation	CODA	DLR	Mesh optimization, Error estimation, Aerodynamics

Discover EXCELLERAT Service Portal

- For more details about the use cases
  - **Register on the EXCELLERAT Service Portal – free of charge**
  - Then, https://services.excellerat.eu/en/use-cases/
  - **New Use Case Onboarding request**

- For more details about the code and software
  - **Register on the EXCELLERAT Service Portal – free of charge**
  - Then, https://services.excellerat.eu/en/services/application-software/
  - And https://services.excellerat.eu/en/services/tool/

Advanced information about EXCELLERAT

- **For more details about EXCELLERAT services**
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    - https://bsky.app/profile/excellerat.bsky.social
  - Podcasts and Videos
    - https://open.spotify.com/show/4XLwnA23wmG3GAhxazAfSW
    - https://www.youtube.com/channel/UCOn4jASZtlxFrN_49RhdKZg

Industrial Impact

- **Be an Interest Group member**
  - Interaction
  - First Informed
  - Feedback
  - Early Collaborator
  - Early Adopter

- **Be a product and service User**

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EXCELLERAT P2

Co-funded by
the European Union

EuroHPC
Joint Undertaking