Use cases

# Supercomputing Market Trends

## MARKET INTELLIGENCE REPORT

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# Contents

# INTRODUCTION

## Aims and objective

This document was commissioned by **Supercomputing Luxembourg**, Luxembourg's High Performance Computing National Competence Centre, in the context of the EuroCC project. The **EuroCC project**, supported by European Union's Horizon 2020 programme, aims at establishing a single National Competence Centre in the area of high-performance computing (HPC) in each of the 33 countries taking part in this undertaking. The project covers all EU member states and aims at displaying a comprehensive and transparent map of supercomputing competences and institutions.

The aim of this report is to provide an overview of supercomputing applications in various key sectors spanning from automotive to finance, manufacturing and environment. The overall objective is to introduce concrete use cases to increase awareness among companies on the potential benefits of supercomputing applications in their fields of application. This analysis is based on open data gathered over the last two years from various sources, including success stories generated by the European Fortissimo and F4EuroHPC projects (**Source**).

## The Fortissimo Project

**Fortissimo** was a collaborative project that enabled European small and medium-sized enterprises (SMEs) to be more competitive globally through the use of simulation services running on a high performance computing cloud infrastructure. The project involved more than 100 partners including manufacturing companies, application developers, domain experts, IT solution providers and HPC cloud service providers from 14 countries. These partners were engaged in over 90 experiments (case studies) where business relevant simulations of industrial processes were implemented and evaluated. The project was funded by the European Commission through the I4MS (ICT Innovation for Manufacturing Small & Medium Enterprises) initiative. The project was coordinated by the University of Edinburgh.

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## F4FEuroHPC

**FF4EuroHPC** is a European initiative that helps facilitating access to all high-performance computing-related technologies for SMEs and thus increases the innovation potential of European industry. Whether it is running high-resolution simulations, doing large-scale data analyses or incorporating AI applications into SMEs' workflows, FF4EuroHPC connects business with cutting-edge technologies.

The FF4EuroHPC project started in September 2020 and will last three years. It is funded by the European Commission through Horizon 2020, the EU's framework programme for research and innovation, with a total budget of €9.9 million. The project is coordinated by the Universitaet Stuttgart (USTUTT, DE) and includes five other partners: Scapos AG (DE), Teratec (FR), CINECA (IT), CESGA (ES) and Arctur (SI).

**The main supercomputing benefits for SMEs can be summarised as follows:**

- Using supercomputing power for simulation, design and manufacturing processes can considerably reduce costs as well as the time needed to reach the desired result. This can make the access to a given market easier and quicker.

- Supercomputing can also be used to improve the quality of existing products as well as to design new products and services, which gives access to new markets and customers.

- Solving supercomputing-related challenges that SMEs are faced with often opens the door for involving several partners, including technology, application and software providers from one or several countries. Such cross-border partnerships help provide end users with tailor-made solutions that benefit their businesses and open opportunities to reach out to new markets.

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# USE CASES

## Supercomputing in the automotive sector

**Swedish SME Koenigsegg using HPC cloud-based simulation of sports car aerodynamics (Source: I4MS)**

**Challenge:** The challenge of Koenigsegg was to perform simulations of the flow over hypercars which were sufficiently detailed to model physical effects accurately.

**End user:** **Koenigsegg** is a Swedish designer and manufacturer of high-performance sports cars.

**Technology providers:** **ICON CFD**, **National Technical University of Athens** (HPC experts), **CINECA**.

Koenigsegg, an SME based in Sweden and established in 1994, is a leading designer and manufacturer of high-performance sports cars. In order to develop its product line, Koenigsegg needed to understand how air flowed over its cars.
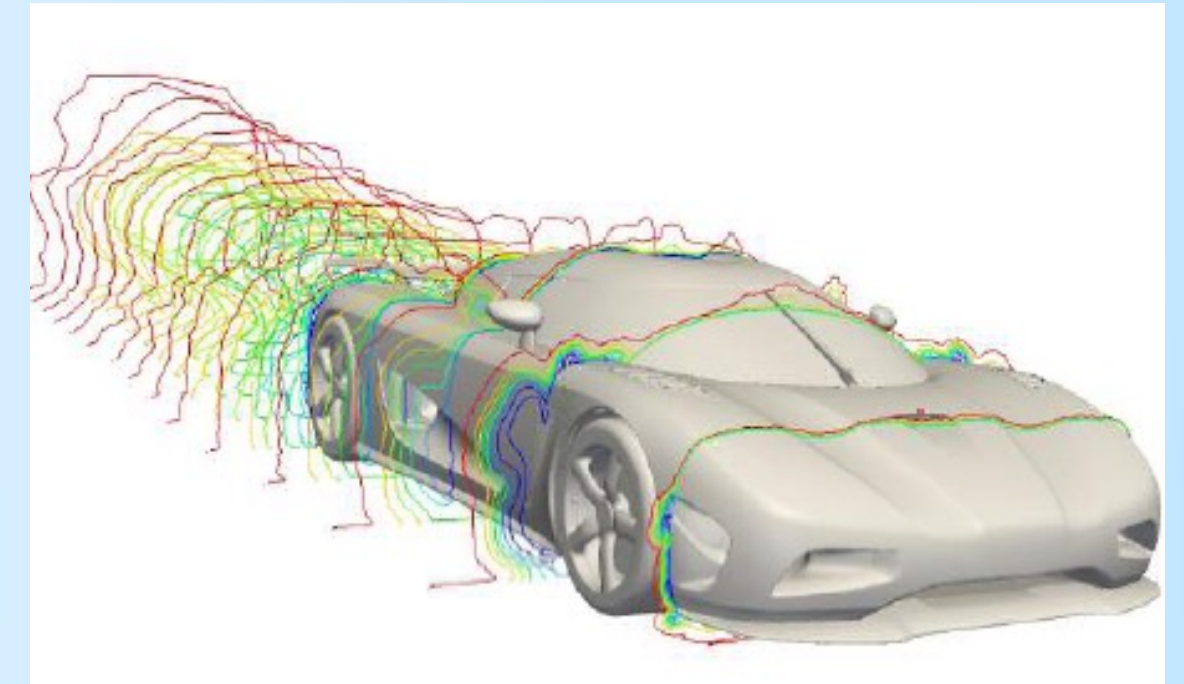
Two methods currently exist to run such analyses and tests: the first one, which is quite expensive, is a wind tunnel test of a physical body and the second, which is cheaper, is to simulate the flow of air in a computer using computational fluid dynamics (CFD). Choosing the second method, Koenigsegg had however no experience in supercomputing-based simulations and relied on services provided by ICON CFD, a long-time trusted partner for computational fluid dynamics engineering applications, and CINECA, the largest consortium of Italian universities. CINECA's aim is to accelerate scientific discovery by providing high performance computing resources, data management, as well as HPC services and expertise (Source).

Koenigsegg was able to **completely eliminate the expensive wind tunnel** tests thanks to the high fidelity of the HPC simulations, which allowed them to have confidence that the simulation results would transfer into real-world gains.



Computational Fluid Dynamics over sport simulated car
Source: Fortissimo Success Story 417 Koenigsegg

## Benefits

Tests have shown that the use of HPC-based simulations supported by external software and expertise led to a return on investment in less than three months for the production of a new car configuration. This meant that it was possible to reduce costs significantly and transfer resources to other critical parts of the development and production process.

- 5% savings in operational costs.

- 30% savings in design costs.

- 50% reduction in wind tunnel and physical testing.

- Savings in development were about €90,000 per year in the design process, which corresponds to a 1.5% reduction of the overall development costs.

## Supercomputing in the manufacturing sector

**Cloud-based HPC optimisation of manufacturing processes (Fortissimo Success Stories – 2019)**

**Challenge:** Overcome the current deficiencies in online monitoring and control of laser processing

**End user:** **EMO** is a Slovenian SME specialising in the production of tools and dies for stamping in particular sheet metal used in the automobile and aerospace industries.

**Technology employed:** Real time quality control platform (Cyplam / TensorFlow)

**Technology providers:** **AIMEN** (domain expert), **CESGA** (HPC provider and expert)
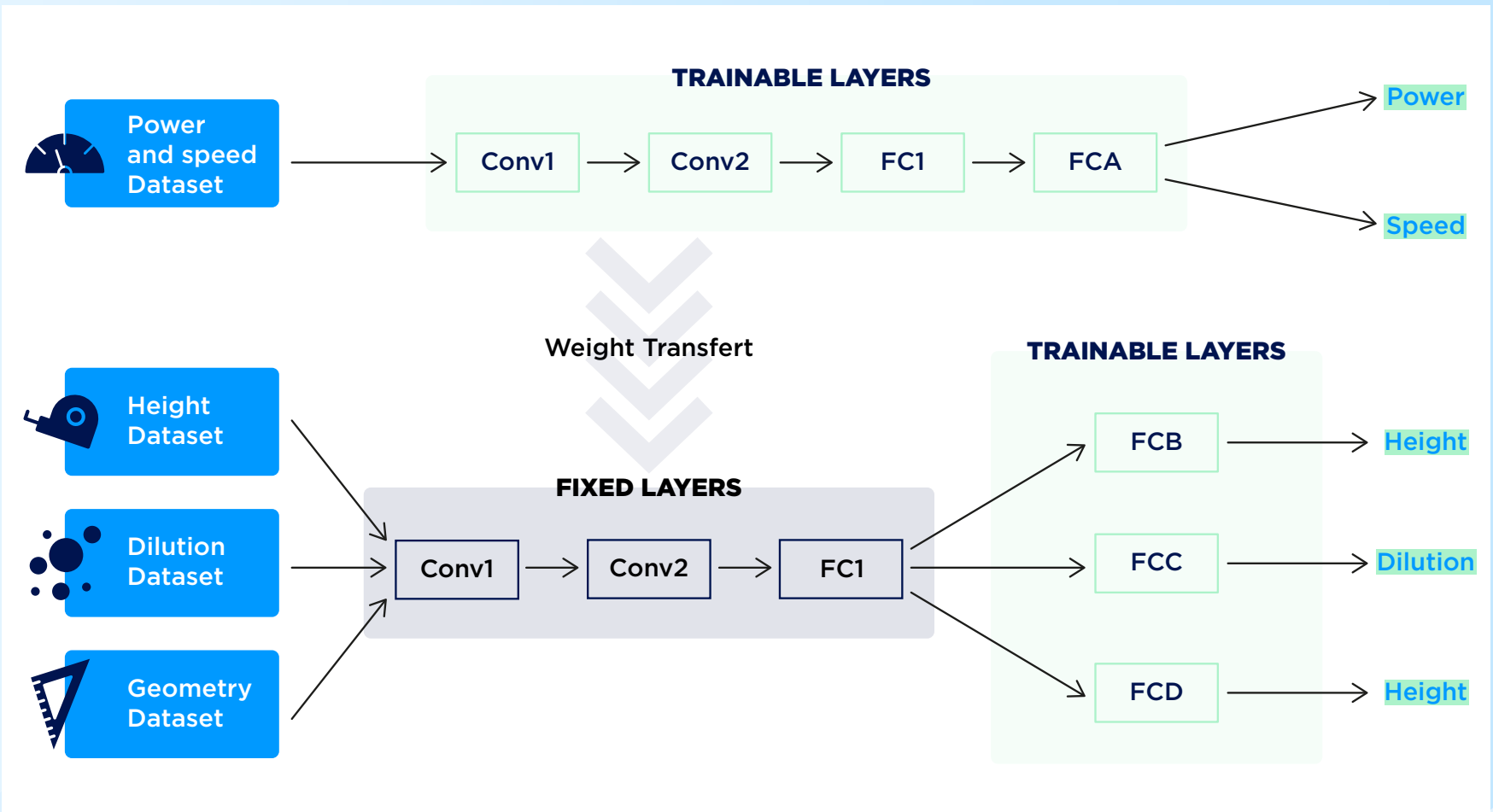
**EMO** OrodJarna uses laser metal deposition (LMD) technology. LMD is an additive manufacturing technology that enables the generic 3D printing of large metal parts. While additive manufacturing makes it possible to produce complex components with short lead times, the process lacks adequat control procedures, which results in unecessary reworking, increased waste and loss of time.

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This experiment aimed at overcoming the current deficiencies in online monitoring and control of laser processing, so that EMO could realise the full benefits of additive manufacturing and create better quality products.

To avoid the undesirable effects of LMD, data sets had to be collected and constructed for **online monitoring** using **deep learning** for **real time quality control** through a dedicated platform (CyPLAM). The platform was developed in cooperation with **AIMEN**, a non-profit Spanish private association whose prime objective is to develop and increase the technological competitiveness and innovation capacity of companies, and **CESGA** – Supercomputing Center of Galicia, a public foundation committed to the advancement of science and technical knowledge.

## Benefits

▪ EMO could reduce operational costs by 20% and save over 2,000 machine hours per year.

▪ The production time was reduced by 30%.

▪ CESGA is offering a new machine learning service (SaaS) based onTensorFlow.

▪ Users of CyPLAM can stay competitive in the global additive manufacturing market.



EMO Supercomputer enhanced manufacturing processes
Source: **Fortissimo Success Story 707 EMO**

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**Engine Power Components (EPC) using cloud-based HPC processing for knowledge generation in camshaft manufacture (Fortissimo Success Stories – 2019)**

**Challenge:** Engine Power Components (EPC) manufactures more than half a million camshafts a year and needed to ensure that it produced high-quality parts. The monitoring of the manufac-turing process generates a massive amount of data which could be used to improve the quality of the process.

**End user:** **Engine Power Components** (EPC) is a Spanish company specialising in the manufacture of camshafts.

**Technology employed:** Supercomputing-powered 3D optical scanning systems for dimensional quality control in manufacture (M3 Software)
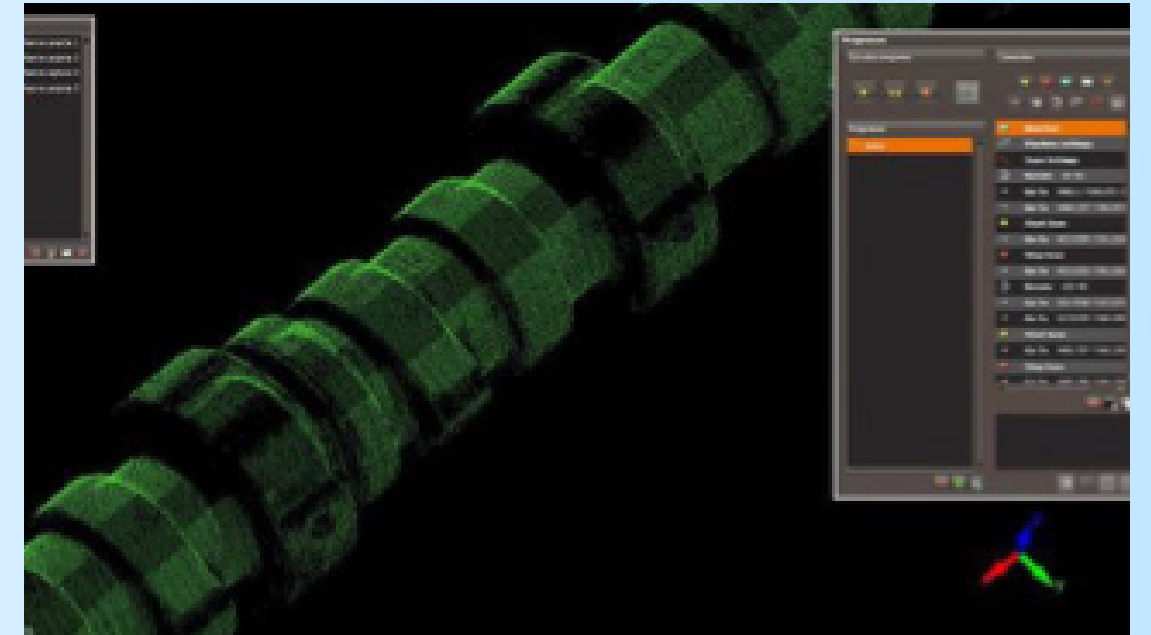
**Technology providers:** **TRIMEK**, a manufacturer of metrological equipment and digitalisation software solutions worldwide, developed a new software module for statistical analysis. **CESGA** (Supercomputing Center of Galicia) exploited the experiment results in its big data platform

**Engine Power Components** (EPC) produces camshafts – critical components in high power engines, where tolerances are very small. However, the company was worried by the product quality due to high demand.

TRIMEK developed a metrological module of its M3 software, which enables EPC to use big data resources for data analysis. The new module is able to analyse scanning and measurement data and compare parts much faster than before by using cloud-based HPC. The production process is therefore more time-efficient. The time savings enables more of the produced parts to be checked in the same amount of time, increasing the overall production quality.

**Benefits**

- 20% increase in turnover over five years for TRIMEK.

- EPC can save €1.5 million over five years using the new solution. The number of defective parts is reduced to almost zero.



M3 Camshaft Quality Control Software Module
Source: Fortissimo Success Story 707 EPC

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## HPE COXA simulation of additive manufacturing processes for the production of metal components (Fortissimo Success Stories – 2019)

**Challenge:** Reduce additive manufacturing processes errors

**End user:** HPE COXA, an Italian innovative provider of engineering solutions.

**Technology employed:** ABAQUS, an HPC-enabled cloud-based simulation tool (belonging to SImulia, a brand of Dassault Systemes)

**Partners:** EXAMPLAR SRL, an Italian company specialised in computer aided engineering project. Supercomputing expertise was provided by CINECA, the Italian supercomputing centre

The Italian company HPE Coxa is an innovative provider of engineering solutions and technology to the global automotive, motorsport, automation solution and defence sectors. The company wanted to avoid component failures in the 3D priting process. In association with CINECA and EXEMPLAR srl, the company developped a forcasting tool powered by HPC cloud-based instances to reduce additive manufacturing processes errors.

This experiment provided a numerical analysis environment which enables users to forecast the results of the additive manufacturing process using supercomputing simulation.

### Benefits

The impact of this experiment for HPE has been to increase the effectiveness of its optimised additive manufacturing solutions. The major benefits are a reduced time-to-market and a reduced number of defective parts, thanks to a closer match between the initial design and the manufactured part. This has consequently lowered costs.

- Reduced time to market of the product / Reduction of defective parts

- Operational costs reduction up to €90,000 per year



Laser path used for AM process simulation in specimen base

Laser path used for AM process simulation in specimen supports
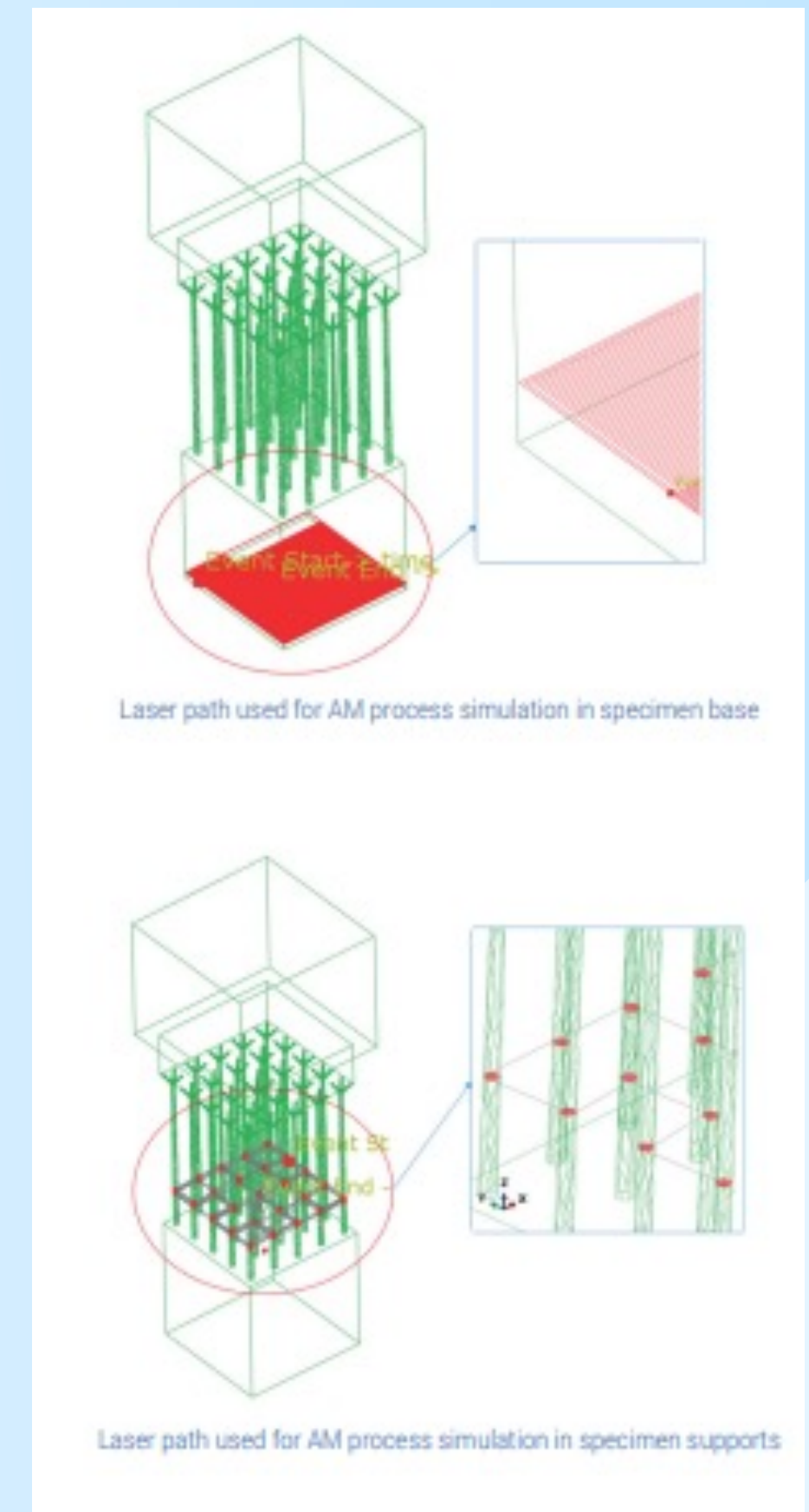
Source: Laser Path Used for AM process simulation in the specimen base
Fortissimo Success Story 804 HPE

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# Supercomputing in healthcare

**Iktos and Qubit Advanced Supercomputing drug discovery with converged deep physics and artificial intelligence (Source: F4FEuro HPC 2022)**

**Challenge:** Cut drug discovery time and costs.

**End user:** **Iktos** is a French SME specialising in AI applied to drug discovery. It has developed a retro-synthesis algorithm and generative AI for drug design.
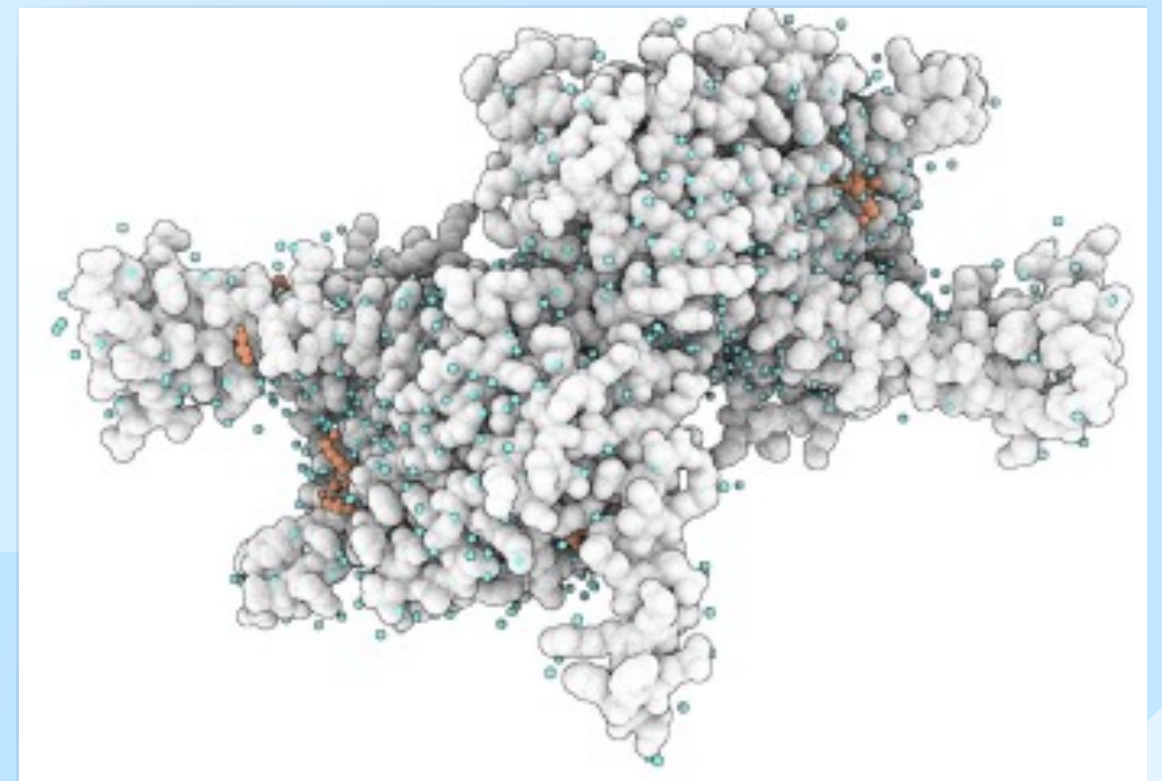
**Technology employed:** HPC, machine learning, artificial intelligence, molecular dynamics simulations.

**Technology providers:** **Qubit Pharmaceuticals**, a company using advanced simulation software and AI-enhanced medicinal chemistry.

Time constraints and the need for agility in costly drug discovering processes are crucial challenges within the pharmaceutical industry in order to stay competitive. Therefore, in association with **Qubit Pharmaceuticals**, the French SME Iktos combined supercomputing power with artificial intelligence-based algorithms to develop an in silico framework for drug discovery which improves the quality of the generated compounds. This shortened and generally improved the entire drug discovery process.



Molecular Dynamics Simulations
Source: F4FEuro HPC 1002_Success Story Flyer

## Benefits

- Cuts in the drug discovery time by 25%

- Reduction of the cost drug development by 20% (potentially saving several millions of euros).

- Development of novel, highly profitable services to be offered to SMEs.

- Discovery of promising compounds which could lead to new cancer drugs, potentially generating substantial income for the SMEs.

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# Supercomputing in finance / insurance

## Aon Securities Inc. (ASI) Case Study (Source: AWS)

**Challenge:** Enhance the risk assessment process

**End user: Aon Securities Inc. (ASI)** a registered broker-dealer focused on securities and other financial products of interest to insurance companies, including catastrophe bonds, contingent capital, sidecars, collateralised reinsurance, industry loss warranties, and derivative products. ASI offers services such as underwriting and placement of new debt and equity issues, financial and strategic advisory services, and a leading secondary trading desk.

**Technology employed:** HPC, machine learning, GPUs

**Technology providers: Amazon Web Services**

Supercomputing in finance / insurance is primarily used for fraud detection, risk management, regulatory reporting, portfolio optimisation and securities pricing.

For a financial services provider like ASI, it is crucial to provide clients with effective business risk management solutions. ASI helps insurance companies price their investment products, analyse the risk and address regulatory requirements by using a financial modelling tool called PathWise that simulates millions of potential economic scenarios and uses stochastic simulations to evaluate potential outcomes.

ASI found out that using Amazon Web Services (AWS) pay-as-you-go pricing could give it access to large numbers of graphichal processing units (GPUs) quickly and inexpensively. The company built a front end on AWS for its processing solution, using Pathwise Modeling Studio and proprietary algorithms to generate economic simulations that span decades. By using AWS, ASI is now able to deliver client solutions more quickly than ever before, with richer risk assessments (**Source**).

## Benefits

- Runs five million policies in minutes instead of overnight
- Reduces the process for completing calculations from 10 days to 10 minutes
- Provides completely up-to-date information to clients

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## Supercomputing in environment

**Numtech climate simulation meteorology and air quality prediction (Source: Fortissimo Success Stories – 2019)**

👨‍🔬 **Challenge:** Demonstrate the use of cloud-based-HPC services to investigate air quality.

👤 **End user:** **Numtech** is a French SME specialised in the development and use of innovative digital tools for air quality, meteorological simulations. It carries out global-scale missions ranging from research into the atmospheric dispersion of emissions linked to human activities, through to producing or forecasting air quality figures or providing expert assessments of meteorological events.

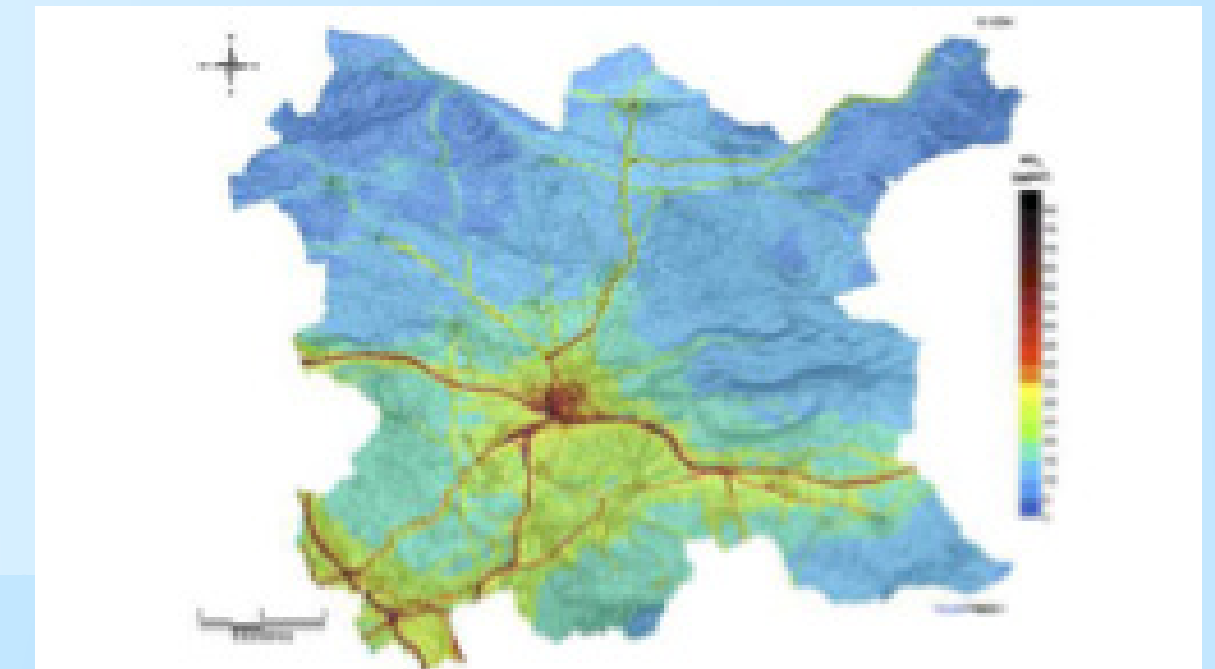⚙️ **Technology employed:** ADMS-Urban software

🦾 **Technology providers & Partners:** **Cambridge Environmental Research Consultants Ltd** (CERC – software provider), **BULL** (supercomputing technology provider)

European regulations on the protection of air quality require more and more the testing and evaluation of adaptation and reduction scenarios. From the traditional evaluation of 2-3 scenarios, consulting companies and regional air quality agencies are now facing the need to evaluate tens of scenarios.

This case study used the ADMS-Urban software from CERC running on the Extreme Factory HPC offering by BULL. ADMS-Urban was adapted to run on a cloud-based supercomputing system and allow for proper climate simulation and prediction (**Source**).



Air Quality Simulation by Geographical Area
Source : Fortissimo Success Story 410 Numtech

### Benefits

🔹 Using a cloud service on a pay-for-use basis is less expensive on the long term for non frequent supercomputing users.

🔹 Production costs are considerably lowered in case of cloud-based HPC services use.

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## Bettair Cities S.L. AI-aided windblow and gas dispersion simulations in cities: Monitoring street pollution and the distribution of polluants (F4FEuroHPC project)

**Challenge:** Reduce the computational cost of air quality simulations in urban environments and give Bettair Cities access to affordable and accurate state-of-the-art real-time air quality modelling tools

**End user:** **Bettair Cities S.L.** is a Spanish SME focused on deploying **hyper-local real-time air quality monitoring networks** (winner of AIrlab Microsensor Best Accuracy for Ozone).

**Technology employed:** Complex fluid dynamics simulations

**Technology providers:** **Barcelona Supercomputing Center**-Centro Nacional de Supercomputación (BSC) is the national supercomputing centre in Spain specialising in high-performance computing (HPC). It manages MareNostrum, Europe's most powerful supercomputer.
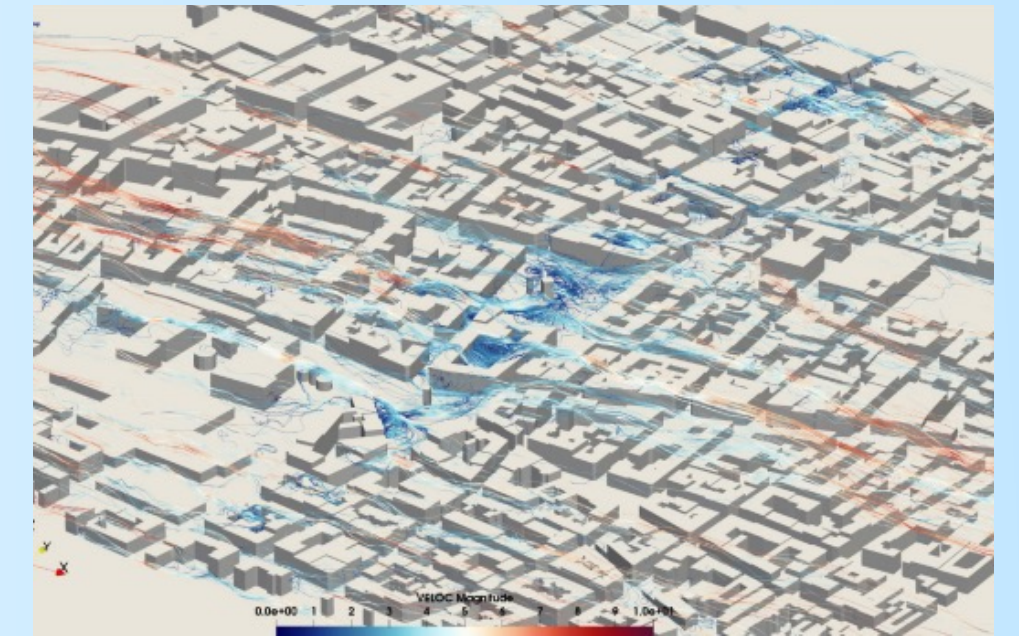
Bettair's goal is to provide accurate and actionable air quality data to assist local communities in improving the current environemental state. In collaboration with Barcelona Supercomputing Center, Bettair created an computationally efficient low-cost AI solution to model air quality in cities with up to 1 $m^2$ resolution, in near real-time.

Using a complex dataset of urban geometries and windflow patterns, deep neural networks were trained to learn the results of these simulations at different heights to predict wind and gas dispersion in urban areas.

Thanks to this experiment, Bettair was able to combine sensor measurements with AI simulations and extract precise information about the local emissions and pollutant concentrations in the cities.



Artificial Intelligence aided windblow and gas dispersion simulations in Cities
Source: F4FEuroHPC 1012 Success Story Flyer

### Benefits

- The simulation cost per $km^2$ was reduced from €1,850 to less than €1.

- The spatial resolution of the real-time modelling capabilities was enhanced from 100 $m^2$ to 1 $m^2$.

- The experimental setup time for new cities was reduced by 80% from 3 weeks to 4 days.

- Access to new markets for Bettair Cities: municipalities and regional governments that could not afford classical modelling before.

- Bettair's expected turnover for 2023 will increase by a factor of at least two.

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# Supercomputing in energy

**Artelys power system maintenance planning via stochastic optimisation and supercomputing (F4FEuroHPC project)**

👷 **Challenge:** Develop optimal maintenance plan for power grids systems.

👤 **End user: Artelys** is a French SME specialising in **applying data science, artificial intelligence**, mathematical modelling and numerical optimisation to the analysis of power systems.

⚙ **Technology employed:** HPC, Monte Carlo Simulations.

🦾 **Technology providers:** INRIA-Aviz Team



European power system
Source: **F4FEuroHPC 1015 Success Story Flyer**

Power plant maintenance planning has very high economic and environmental stakes for energy producers. Given the potential high volatility of the energy market, scheduling maintenance at an unsuitable time can cost millions of euros. Thus, finding an optimal maintenance plan requires answers to numerous "what if" questions.

**Artelys**, which has developed expertise in the simulation and optimisation of energy networks and conducts studies for clients all along the energy value chain, teamed up with **INRIA's Aviz group** in order to develop a predictive maintenance tool relying on complex data sets of maintenance scenarios and timings compared to the European power system fluctuations.

## Benefits

🔹 Artelys gained the ability to conduct quantitative prospective studies on behalf of its clients for a large number of scenarios that cover uncertainties.

🔹 The experiment also opens the possibility for Artelys to bundle the HPC-based optimisation with their portfolio of optimisation software available to advanced customers.

🔹 The company's additional sales are expected to be  up to €4 million over the next 5 years.

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## SOURCES

**Amazon Web Services – Use Cases**
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Fortissimo Success Stories – 2019
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