Newsletter #6 October 2025

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A lightweight software stack and synergetic metaorchestration framework for the next generation compute continuum

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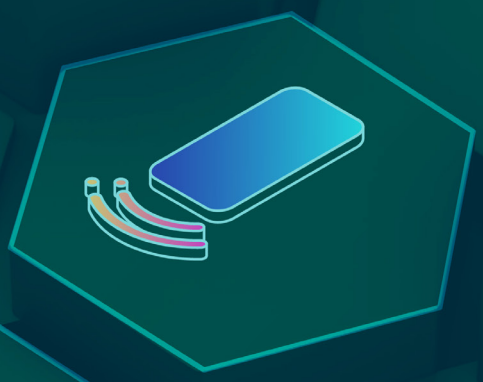
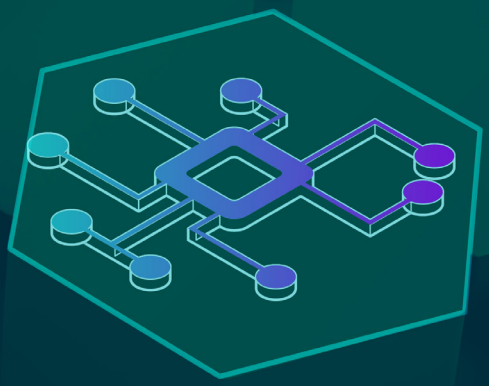




This project has received funding from the European Union's Horizon Europe research and innovation programme under grant agreement No 101070487.

Co-funded by the European Union

Farewell to the NEPHELE Project

As the calendar turns to September 2025, the NEPHELE project, a three-year Research and Innovation Action funded by the Horizon Europe programme, is drawing to a close. Its end marks a significant milestone in the journey towards the future of a truly converged and programmable compute continuum.

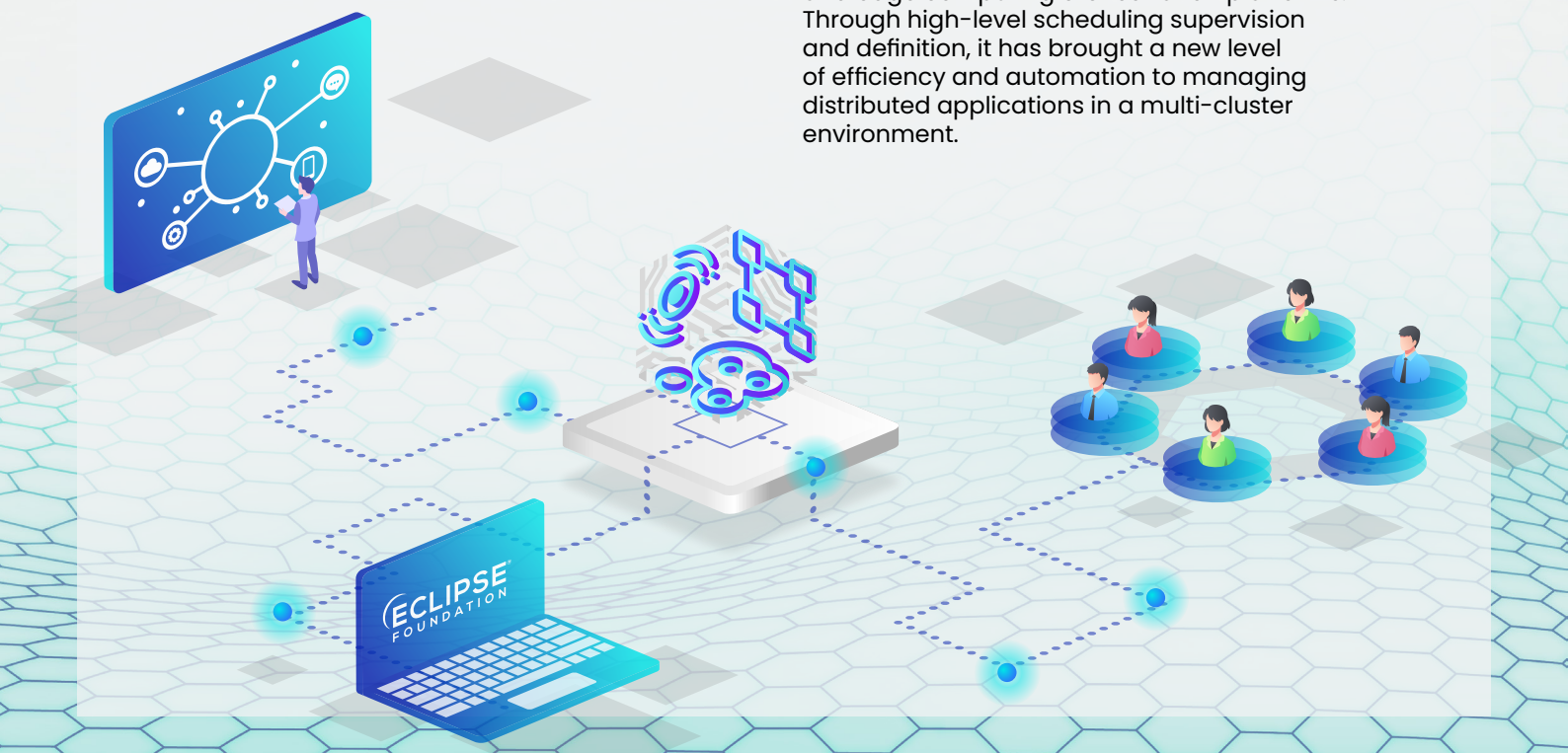
In the spirit of reflection and looking ahead, the consortium recently gathered for a fruitful meeting in the port of Koper. The session provided a crucial opportunity to look back on the progress made, review the final deliverables, and pave the way for the future legacy of NEPHELE's groundbreaking work.

The Vision Realised: Orchestrating the Compute Continuum

The core vision of NEPHELE was to enable the efficient, reliable, and secure end-to-end orchestration of hyper-distributed applications across the entire Cloud-to-Edge-to-IoT continuum. The project's success lies in removing existing openness and interoperability barriers that have long plagued the convergence of IoT technologies and cloud/edge computing platforms.

The NEPHELE consortium has delivered on its promise by introducing two core innovations:

- **An IoT and Edge Computing Software Stack**: This lightweight Virtual Object (VO) software stack provides a device-independent layer that leverages virtualization of IoT devices at the edge. By supporting openness and interoperability, it allows for the unified management of a vast range of IoT devices and platforms, effectively side-stepping the need for complex, proprietary middleware.
- **A Synergetic Meta-Orchestration Framework**: Adopting a "system of systems" approach, this framework enables the intelligent coordination between distinct cloud and edge computing orchestration platforms. Through high-level scheduling supervision and definition, it has brought a new level of efficiency and automation to managing distributed applications in a multi-cluster environment.



These outcomes have been rigorously demonstrated, validated, and evaluated in a diverse set of real-world scenarios:

- Emergency/Disaster Recovery
- AI Logistic Operations in Ports
- Energy Management in Smart Buildings
- Remote Healthcare Services

Leaving a Lasting Legacy

Beyond the core platform and framework, NEPHELE's impact extends into the wider research and industry community. The project has actively contributed to the open-source community and engaged with standardisation bodies, ensuring its architectural insights and codebase are available for future development. Our commitment to growth was further solidified through two successful Open Calls, which brought in third-party innovators to develop new industry-specific solutions across areas like agriculture, electric vehicles, and climate optimisation. The plethora of papers accepted at prestigious conferences also reflect the high-level, cutting-edge research conducted by NEPHELE partners.

The NEPHELE platform is more than just a proof of concept; it is a solid foundation for the next generation of hyper-distributed applications, making the promise of the computing continuum a tangible reality.

A Note of Gratitude

As the project coordinator, we take this final opportunity to offer our profound thanks.

Over the past three years, the NEPHELE consortium, comprising 17 partners across Europe, has demonstrated exceptional commitment, technical expertise, and collaborative spirit. Tackling a challenge as complex as unifying the entire Cloud-to-Edge-to-IoT continuum required the combined vision and hard work of every researcher, engineer, and administrator involved.

We are incredibly proud of the open-source software stack and the powerful meta-orchestration framework that we have collectively designed, built, and validated. These results will not only contribute to the European research landscape but also create genuine market opportunities in critical vertical industries.

Our gratitude goes to all consortium partners, the European Commission for their support, and the wider community that engaged with our Open Calls. The work stops here, but the legacy of an efficient, reliable, and secure compute continuum will continue to soar beyond the project.

Prof. Symeon Papavassiliou

NEPHELE Coordinator, NTUA

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NEPHELE KEY EXPLOITABLE RESULTS

Key Exploitable Results (KERs) are the project's tangible or intangible assets—such as knowledge, technology, software, or methodologies—that possess a realistic potential for use or commercialisation both during and after the project's lifecycle.

In NEPHELE project, these KERs comes from the development of the core environment and platform components, but also from the project Use Cases (UCs). The joint KERs developed across the project are significant as they collectively represent a major advancement in integrating IoT, Edge, and Cloud computing into a seamless, highly-distributed continuum, offering novel solutions for complex, real-world challenges in areas like disaster management, logistics, and smart energy.

VOSTACK

KER Short Description: An open-source, multi-layer software stack that defines a Virtual Object (VO) as a virtual counterpart of an IoT device, providing abstractions and augmented functionalities. It has three layers: Physical Convergence, Edge/Cloud Convergence, and Backend Logic.

Problem Addressed: IoT interoperability challenges, the convergence of IoT with Edge/Cloud computing, and abstraction for Digital Twins development.

Beyond State of the Art: Achieved through orchestration interfaces and mechanisms for VOs, semantic interoperability, Software Defined Networking (SDN), Time Sensitive Networking (TSN), and enhanced security.

Partners in Charge: NEPHELE WP3 partners (NTUA, CNIT, SIEMENS, ATOS, INRIA, UOM, ODINS, SMILE, ININ, WINGS, IBM, ERCIM, ZHAW)

License Type: Open-source, MIT License.

SYNERGETIC META-ORCHESTRATOR

KER Short Description: The Synergetic Meta-Orchestrator (SMO) facilitates the efficient deployment and orchestration of distributed application graphs over computing and network resources across the computing continuum. It handles deployment requests, creates plans based on infrastructure status and requirements, and continuously monitors for necessary optimisations.

Problem Addressed: Multi-cluster resource management and orchestration of complex, distributed applications.

Partners in Charge: NEPHELE WP4 partners (IBM, ATOS, CNIT, NTUA, ODINS, SMILE, UOM, ZHAW, ECL).

License Type: Open-source, MIT License.

DEVELOPMENT ENVIRONMENT FOR HIGHLY-DISTRIBUTED APPLICATIONS

KER Short Description: A combination of the Development Sandbox (providing utilities for developing and customising Hyper Distributed Application (HDA) graphs) and the HDA Registry & Verification Engine (standardising the storage, distribution, catalogue, and verification of all services and artifacts).

Problem Addressed: The efficient creation, verification, and distribution of HDAs, and the need for a unified registry system for managing diverse artifacts (e.g., OCI artifacts, Helm charts, Docker images, VOs) across Telco and Cloud stakeholders.

Beyond State of the Art: Provides a consistent registry system that unifies artifact handling based on common standards and technology roadmaps. It automates the creation and validation of artifacts to enable efficient service placement by the SMO.

Partners in Charge: ATOS.

License Type: Open Source, Apache 2.0.

UC#1: A SET OF INTEROPERABLE MODULES DESIGNED TO SUPPORT POST-DISASTER MANAGEMENT

KER Short Description: A set of interoperable, mainly Python-based, modules built on or extended from VOStack to support post-disaster management solutions. They are open-source and documented via academic publications.

Problem Addressed: The "silos-based" approach in post-disaster scenarios where heterogeneous first responder hardware/software (drones, robots, sensors) and communication protocols make hardware/software and data sharing very difficult,

hindering overall situational awareness.

Beyond State of the Art: This KER uses VOStack to implement VOs for heterogeneous IoT devices, allowing them to cooperatively enhance situational awareness. Data is collaboratively exposed, and end-users interact with advanced hardware/software via user-friendly web solutions.

Partners in Charge: Inria, ZHAW.

License Type: MIT (for code sources).

UC#2: DIGITAL TWIN FOR PORTS

KER Short Description: A limited/incomplete Digital Twin for port operations that provides a baseline for real-time data collection, analysis, simulations, and data visualisation of port activities, aiming for a unified view and improved decision-making.

Problem Addressed: Lack of real-time insight into port activities, which is necessary for operational awareness and optimal decision-making across business, safety, and environmental processes.

Beyond State of the Art: This KER moves beyond multiple separate IT systems by providing a unified view of all port activities, enabling analysis of mutual dependence among processes, which is a step forward in port digitalisation.

Partners in Charge: ININ, Luka Koper (Port of Koper), UOM, WINGS.

License Type: Copyright (closed source software) and MIT (for part of the code sources).

UC#2: AI-ASSISTED LOGISTICS OPERATIONS SERVICE

KER Short Description: A service that optimises the routing of cargo containers within the port area (Container terminal yard/Depo to Container Freight Stations and vice-versa). It uses the NEPHELE platform to collect operational, environmental, and video-based data, visualising the data and generating optimal delivery plans.

Problem Addressed: The sub-optimal routing of cargo containers, which leads to increased costs, reduced efficiency, reduced truck/forklift utilisation, higher CO2 emissions, and lower workforce safety.

Beyond State of the Art: This KER exploits the synergetic potential of multiple data types (operational, environmental, network performance) via AI-driven algorithms to produce optimal delivery plans, going beyond the current state-of-the-art reliance on only schedules and time plans. It also uses the Cloud-Edge-IoT approach of the NEPHELE platform.

Partners in Charge: ININ, Luka Koper (Port of Koper), UOM, NTUA, WINGS.

License Type: Copyright (closed source software) and MIT (for part of the code sources).

UC#3: IOT-EDGE-CLOUD PLATFORM FOR SECURE AND INTELLIGENT ENERGY MANAGEMENT IN SMART BUILDINGS AND CITIES

KER Short Description: A distributed IoT-Edge-Cloud platform integrating IoT sensors, edge nodes with VOs, and cloud services for smart, safe, and real-time energy management. It uses embedded AI (TinyML and microCEP engines) for presence/occupancy detection to optimise HVAC systems and incorporates decentralised identity technologies for security and access control.

Problem Addressed: Energy inefficiency in buildings and cities caused by centralised and inflexible systems. This results in an inability to dynamically react to actual environmental conditions and creates interoperability/security issues when exchanging data between heterogeneous systems.

Beyond State of the Art: This KER uses VOStack to deploy VOs on Edge nodes, enabling real-time local decision-making (reducing latency/energy) versus traditional centralised solutions. It integrates advanced features like TinyML/microCEP for intelligent HVAC control and decentralised identity (DIDs) and Distributed Ledger Technology (DLT) for secure data sharing and access control.

Partners in Charge: ODINS, SIEMENS.

License Type: MIT.

UC#4: DEMATERIALIZED ULTRASOUND MEDICAL SOLUTION FOR REMOTE SUPPORT

KER Short Description: A dematerialized ultrasound medical solution that enables remote ultrasound exams supported by a distant physician/operator. It facilitates remote control of the ultrasound equipment via a dedicated web application and provides real-time video streaming of the exams, significantly reducing local hardware resource consumption by relocating key components.

Problem Addressed: The challenge of performing remote ultrasound exams, which

involves relocating ultrasound equipment features from the equipment itself to delocalized services, thus enabling remote control and video streaming to various remote locations.

Beyond State of the Art: Standard ultrasound equipment typically uses an all-in-one, stand-alone paradigm with high local hardware resource consumption (CPU/GPU). This KER moves various key components outside the ultrasound equipment, shifting the paradigm towards an ultrasound medical platform operating on-edge or on-cloud. This change allows for reduced power consumption of on-board hardware components, with minimal components (like the probe) functioning as IoT devices.

Partners in Charge: ESAOTE, CNIT.

License Type: Copyright (closed source software) and MIT (for part of the code sources).

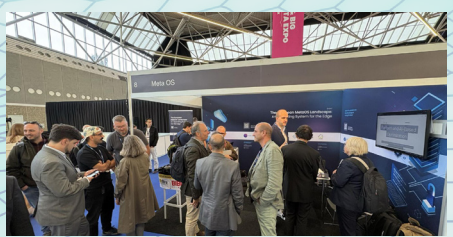
HIGHLIGHT OF THE PERIOD

NEPHELE FINAL EVENT AT IOT TECH EXPO 2025

Horizon Europe's NEPHELE Project Closes with Major Presence at IoT Tech Expo 2025

The landscape of the compute continuum took a significant step forward as the **NEPHELE** project marked its formal conclusion with a prominent exhibition and speaking engagement at the **IoT Tech Expo 2025** in Amsterdam on September 24-25, 2025. This premier European event served as the final showcase for NEPHELE's groundbreaking contributions to a lightweight software stack and synergetic meta-orchestration framework.

NEPHELE, which was also a **sponsor** of the event, leveraged the Expo's high visibility to accelerate the adoption of its final results, which include the **Virtual Object Stack (VOStack)** and its synergetic **meta-orchestration platform** for managing distributed applications across the Cloud-Edge-IoT continuum.



MetaOS Ecosystem Unites for Final Demonstration

A major highlight of the Expo was the collective exhibition of the European Commission-funded **MetaOS** projects. NEPHELE was showcased in a unified booth alongside its sibling initiatives: **aerOS, FluidOS, ICOS, NEMO,** and **NebulOuS.** This joint presence underscored the collaborative effort to establish a unified and open-source European technological foundation for next-generation smart systems and IoT applications. Attendees at the dedicated booth had the opportunity to view videos and live demonstrations of the projects' diverse use cases, spanning verticals such as logistics, smart buildings, and disaster management.

The importance of this European initiative was further cemented by the participation of NEPHELE European Commission's Project Officer, **Svetoslav Mihaylov,** who provided an opening address to the MetaOS ecosystem joint session entitled "The European MetaOS Landscape: An Operating System for the Edge". The presence of Mr. Mihaylov highlights the strategic importance the European Union places on these Horizon Europe projects as they transition their innovations from research into marketable, open-source solutions to foster technological sovereignty.

NEPHELE's robust participation in the IoT Tech Expo, culminating with its final event, signals a successful shift from development to exploitation, providing the industry with critical open-source assets for managing hyper-distributed applications across the entire computing continuum.

The atmosphere at the IoT Tech Expo was one of intense collaboration and high-level networking, perfectly aligning with NEPHELE's mission to bridge gaps in the compute continuum. As a flagship European event for enterprise technology, the Expo drew an impressive audience of over **8,000 attendees,** featuring **200+ expert speakers** and **200+ innovative exhibitors.** This vast and influential gathering of researchers, stakeholders and decision-makers made the Expo an **essential platform** for NEPHELE. Attending this event, especially as a project drawing to a close, was crucial for showing the results of its four use cases and the winners of its two open calls, maximizing the **impact and sustainability** of NEPHELE's open-source assets, securing visibility among potential commercial adopters, and fostering the industry connections necessary for the long-term uptake of its Meta-Operating System framework.

NEWS & EVENTS

PAST EVENTS

W3C Web of Things Community Group Online Meetup

28, 17 July 2025, online meeting

Our colleagues **Dimitris Spatharakis** and **Nikos Filinis** from the Network Management and Optimal Design Laboratory (NETMODE Lab) at the National Technical University of Athens (NTUA) promoted NEPHELE during their presentation on "An Open-source Software Stack for IoT Virtualization and Convergence with Edge Computing Technologies".

89th Thessaloniki International Fair (TIF)

11 September 2025, Thessaloniki (Greece)

Our colleague **Panagiotis Papadimitriou** from our partner **University of Macedonia** presented NEPHELE during his talk, **"**NEPHELE: A lightweight software stack and synergetic meta-orchestration framework for the next generation compute continuum.**"**

IoT Tech Expo 2025

24-25 September 2025, Amsterdam (The Netherlands).

NEPHELE joined an exhibition booth with all the other sibling projects of the MetaOS ecosystem - aerOS, FluidOS, ICOS, NEMO and NebulOuS - that received funding by the European Commission under the same Horizon Europe topic. Videos and demos of the projects' use cases were exhibited in booth n.8 of this Expo.

MEET OUR PARTNERS

THIS SECTION WILL BE PRESENTING THE PARTNERS OF THE CONSORTIUM, THEIR PROFILE, MAIN EXPERTISE AND CONTRIBUTION TO THE PROJECT.

ERCIM

ERCIM
European Research Consortium for informatics and Mathematics

ERCIM, based in Sophia Antipolis, France, hosts the W3C (World Wide Web Consortium) team in Europe since 2003. ERCIM's main objective is to contribute to a leading role of Europe in ICT. W3C provides technical standards and guidelines to ensure that the Web remains open, accessible, and interoperable for everyone around the globe. That work is created in the open, provided for free and under the groundbreaking W3C Patent Policy. ERCIM and W3C aim to strengthen research relationships to better support the development of Web technology and to increase web research cooperation in Europe.


Marie-Claire Forgue


Francois Daoust


David Raggett


Pascale Peyrol

ERCIM is very experienced in participating in European Commission funded projects. Its skills cover dissemination, training and outreach; standardisation, including workshops, community groups and transitioning to standards track working groups; and proof of concept demonstrators. ERCIM technical expertise relates to web browser technologies and standards, Web of Things (virtual objects for the IoT), graph databases, RDF and Linked Data, and human-like AI and plausible reasoning with imprecise and imperfect knowledge.

In NEPHELE, ERCIM leads the standardisation task and is also involved in dissemination, communication, exploitation, requirements, reference architecture and use cases. Additionaly, ERCIM helps with the Open Call Management and Support Programme.

ERCIM website , w3.org.

ZHAW

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ZHAW Zurich University of Applied Sciences is one of the leading universities in Switzerland. It offers teaching, research, continuing education and other services that are both practice-oriented and science-based. With locations in Winterthur, Zurich and Wädenswil, the ZHAW is firmly anchored in its region whilst collaborating with international partners.

With its expertise in sustainable development and digital transformation, the ZHAW imparts forward-looking knowledge and takes an active part in shaping the digital and ecological

transformation.

The ZHAW Institut für angewandte Informationstechnologie (InIT) (Institute of Applied Information Technology) stands for research and development in a broad range of topics in computer science and develops practical solutions for challenging problems in cooperation with companies and university partners. It is a flexible and efficient partner for R&D projects with around 85 employees with backgrounds in various fields and with a modern research infrastructure.


Leonardo Militano


Giovanni Toffetti

The Distributed Systems research group which is participating in NEPHELE is part of the InIT. It focuses on applied research in national and European projects. Its core expertise is mainly IAAS, PAAS, virtualization and robotics. Some research initiatives are centered in cloud (infrastructure, platform, CI/CD, DevOps, CNA) and Robotics (cloud robotics, ROS).

In NEPHELE, ZHAW is in charge of data management, use cases specification and data processing requirements, and dissemination activities. ZHAW also takes part in several project tasks like reference architecture and continuous technology watch; iot devices virtualised and supportive functions; federated compute resources management; AI-assisted synergetic orchestation; platform integration testing and refinement; use cases framework definition, planning, monitoring and coordination; emergency/disaster recovery use case design, implementation and evaluation; and communication activities.

Learn more about ZHAW.

Learn more about the Distributed Systems research group.

ATOS - EVIDEN

EVIDEN, a part of the Atos Group as software and hardware brand present in 36 countries with over 4,200 engineers and experts and with more than 2,100 patents, offers AI-enabled technologies across four key domains: advanced computing, mission-critical systems, cybersecurity products and vision AI to unleash data value in secured environments.


Guillermo Gómez Chávez


Sergiy Remezov Grynchenko


Sonia Castro


Belén Gallego Puyol


Carmen San Román

EVIDEN's research and innovation outcomes in NEPHELE is funneled through R&D Spain, part of Strategy & Innovation of our Advanced Computing business, to develop innovative software features for present and future high-performance products, solutions and services. These innovative outcomes will bring added value specifically for EVIDEN's High Performance Computing customers, helping large enterprises and governments master the race to simulation, AI and Quantum.

ATOS IT offers business and IT services consulting as well as vertical solutions in financial, utilities and telecom services. Some of its more relevant clients belong to the public sector, such as the Spanish Defense Ministry or the Education and Universities Regional Ministry, and also many private entities in the banking sector and telecom operators. Atos uses an innovative approach to transform organisations, delivering sustainable business growth through the design, implementation and ongoing support of leading-edge technology solutions.

ATOS SPAIN SA is a company of Atos group that offers business and IT services consulting as well as vertical solutions in financial and telecom services in Iberia. ATOS SPAIN SA uses an innovative approach to transform organizations, delivering sustainable business growth through the design, implementation and ongoing support of leading-edge technology solutions. Their R&D groups are currently working in recent research and innovation projects in IT services, cloud and telecom sector.

More information.

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