

EuroStack in action:

Libelium's architecture cementing European digital sovereignty

Libelium deploys the EU blueprint
at the Alhambra Living Lab.

1. Executive Summary

The strategic autonomy of the European Union has ceased to be an exclusively regulatory debate to become an industrial and national security priority. In our current times, digital infrastructure defines the democracy, independence, and sovereignty of nations, as well as their economy and competitiveness.

For this reason, the **EuroStack** initiative stands as the definitive flagship project to build a federated, secure, and fully European digital ecosystem, with a proposed investment of a €300 billion. This document establishes the framework for aligning our architecture with the EuroStack guidelines.

To illustrate this, we use the deployment of the **Alhambra Living Lab**, a pioneering project demonstrating that technological sovereignty is not a future aspiration, but an operational reality capable of performing in environments of maximum heritage, urban, and environmental complexity. Through this implementation, **Libelium** positions itself as the benchmark architect to project this digital sovereignty over territories and physical assets, operating natively and integrated across four critical layers of the unified blueprint.



2. Introduction: The Challenge of Infrastructure in a Multipolar Europe

The digital development model of the European Union faces a familiar vulnerability: **more than 80% of digital technologies and strategic infrastructures on European soil are imported.** This structural asymmetry subjects public administrations and key industrial sectors to dynamics of technological dependence, where three foreign corporations control nearly 70% of the cloud computing and storage market (IaaS). Under foreign extraterritorial legal frameworks (such as the U.S. CLOUD Act or China's Data Security Law (DSL)), confidentiality, control over essential public services, and resilience against cyber threats are compromised.

+80%

of digital technologies and strategic infrastructures on European soil are imported.

[1] Mario Draghi, the Future of European Competitiveness, Report commissioned by the European Commission (September 2024).



The European technological fabric is mostly small and medium-sized enterprises (SMEs like Libelium or your own company) operating in a scenario of competitive asymmetry against global Big Tech companies.

However, Europe has turned this structural competitive disadvantage into a virtue. Instead of the monopolistic centralization of global corporations or the vertical state control seen in other regions, Europe proposes a federated, open, and decentralized governance model; an ecosystem that innovates in an environment of collaborative

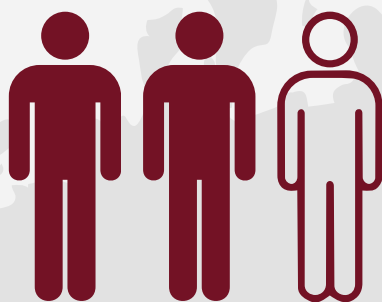
competition (*coopetition*).

This new European model requires agile, autonomous, and resilient companies capable of deploying capabilities that generate, retain, and protect data right from its origin.

Libelium has dedicated two decades to building the physical capabilities that Europe defines today as essential for sovereignty (such as Smart Europe IoT, causal AI, or data spaces), establishing itself, by track record and alignment, as the industrial benchmark capable of deploying the EuroStack vision across the territory.



99% of EU companies
are SMEs



2/3 of the people employed
by SMEs



...and produce 57 cents of
every euro of added value.

3. The EuroStack Framework: Layers and Federated Interoperability

The architectural design of the EuroStack envisions a dynamic ecosystem structured in interconnected layers, conceived to transform a fragmented market into a continuum of sovereign computing from the sensor to the cloud node.

DATA & ARTIFICIAL INTELLIGENCE
(SovereignAI)

SOFTWARE PLATFORMS
(EuroOS & Open Public AI Marketplace)

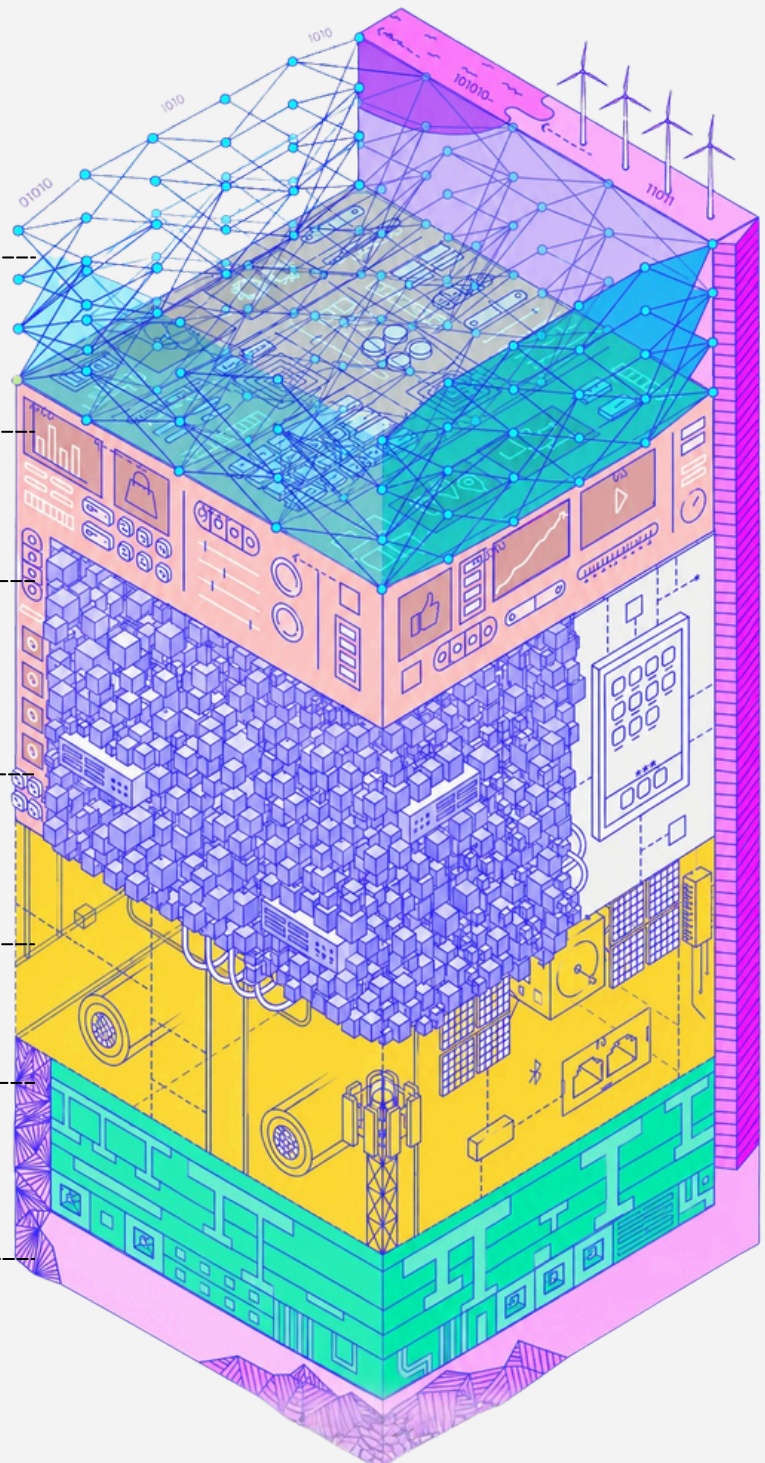
CLOUD INFRASTRUCTURE
(SovereignCloud)

CONNECTED DEVICES & CRITICAL IoT (SmartEurope IoT)

NETWORKS (EuroConnect – standalone 5G / SCION Architecture)

CHIPS (EuroChips – RISC-V Open Standard Architecture)

CRITICAL RESOURCES (Raw Materials, Green Energy & Water Monitoring)



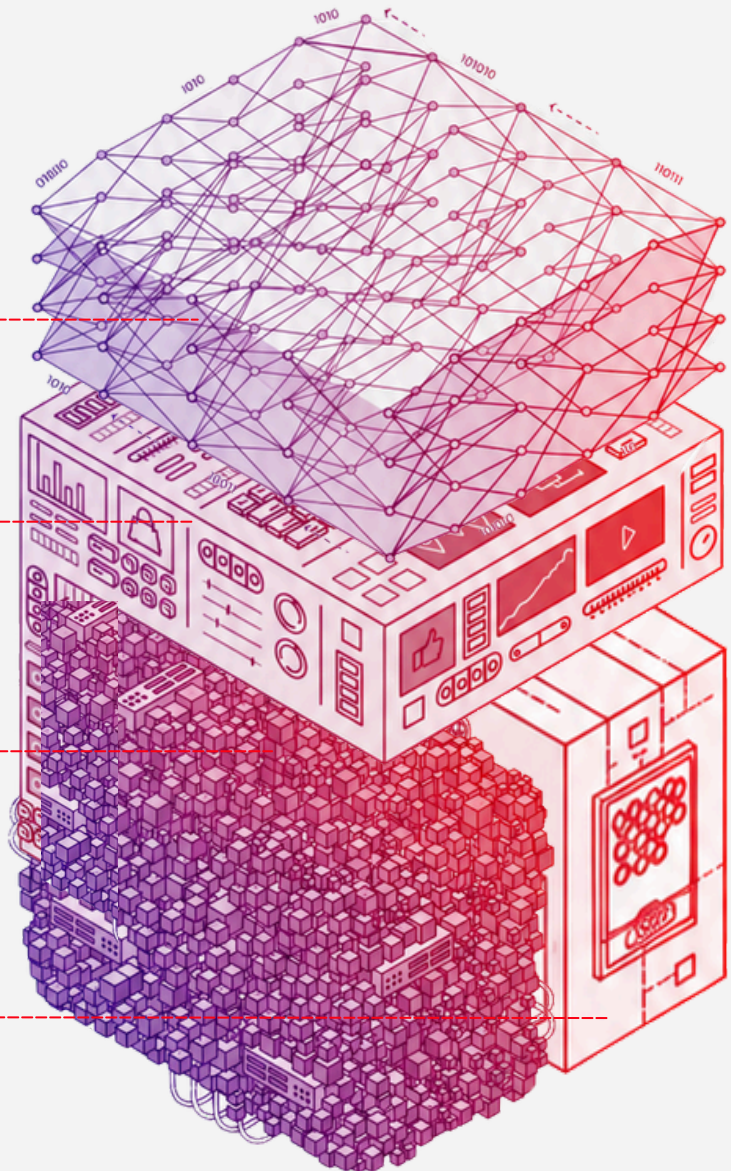
Libelium provides guarantees across four layers of the EuroStack: IoT, Data Commons, Sovereign Cloud, and Sovereign AI.

DATA & ARTIFICIAL INTELLIGENCE (SovereignAI - Mistral/ALIA)

SOFTWARE PLATFORMS (EuroOS & Open Public AI Marketplace / iris360)

CLOUD INFRASTRUCTURE (SovereignCloud - OVHcloud / ENS High)

CONNECTED DEVICES & CRITICAL IoT (SmartEurope IoT / Libelium One & Smart Spot / FIWARE)



Libelium offers guarantees across four of the EuroStack layers: IoT, DataCommons, SovereignCloud, and SovereignAI. The operational instrument to materialize this vision into real deployments is the **EuroStack Challenge**, a European Commission program aimed at funding and boosting highly scalable cross-border Minimum Viable Products (MVPs) within an 18-month timeframe (which in the tech sector equates to 5 minutes), coinciding with the funneling of public investment and IPCEI-CIS projects.

4. European Regulation as an Industrial Quality Seal

The expression "the United States innovates, China copies, and Europe regulates" is starting to smell like mothballs.

To begin with, the American model has evolved from dynamic and daring software innovation to the absolute concentration of financial power and structure. Its innovation today is extractive, designed to generate a global network effect aimed at subordinating the computing capacity of sovereign States to its proprietary platforms (lock-in).

Furthermore, China has moved past the reverse engineering phase to lead supply chain autonomy and extreme algorithmic efficiency. When trade blockades forced its hand, it demonstrated its capacity to innovate much more efficiently, surprising the world, as proven by the DeepSeek phenomenon.

What about Europeans?

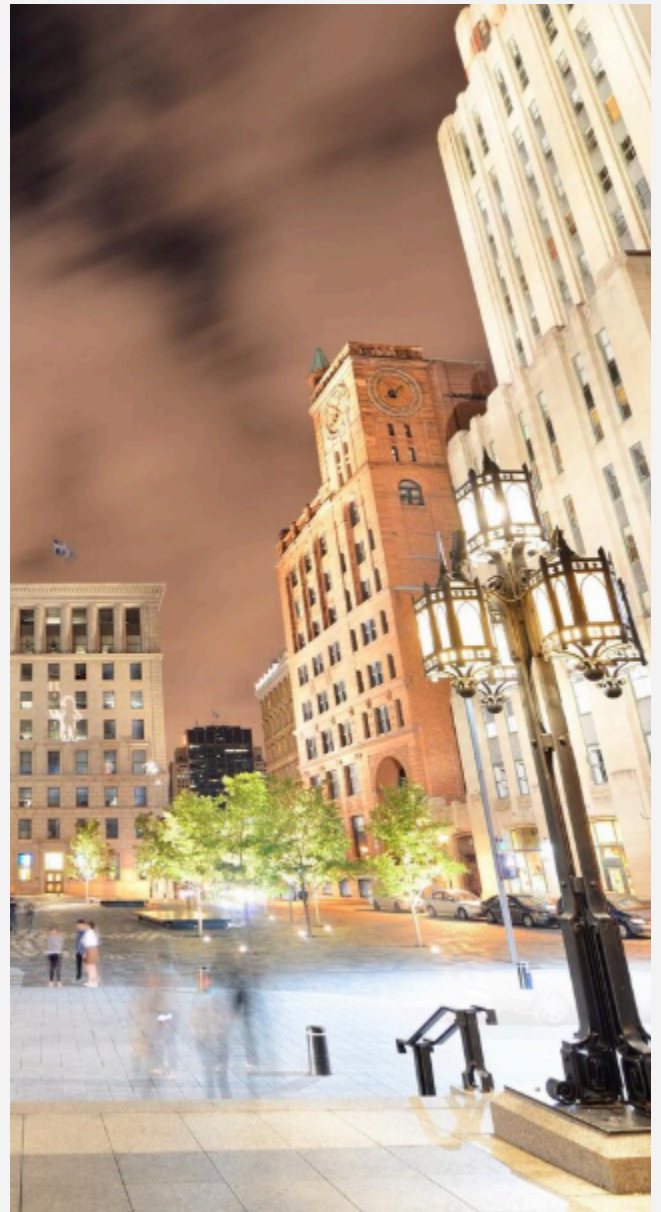
Facing an American bloc dominating through hyper-centralized accumulation and a Chinese bloc dominating through supply chain control, the question arises: What is the European Union's role in this competitive space? The answer is not to compete in a massive infrastructure subsidy war that Europe cannot win in isolation.



The European response stands on two pillars:

- **Standardization based on quality, trust, and public value:** This is where Critical IoT and data veracity become the keystone of European digital sovereignty. European technology must be synonymous with guaranteed resilience, legal reliability, and the protection of citizen and corporate rights, turning regulation into an immediate and structural competitive advantage for governments, industries, and citizens.
- **Simplifying technology adoption processes:** Some people bristle at the word "regulation," but it's important to distinguish between regulation and bureaucracy. An agile legal framework is the best ally of digital transformation.

Especially if it's accompanied by less red tape, such as one-stop shops, interoperability between government platforms and between countries, or software that already complies with regulations from the outset, automating the creation of audit reports, for example.



The EuroStack

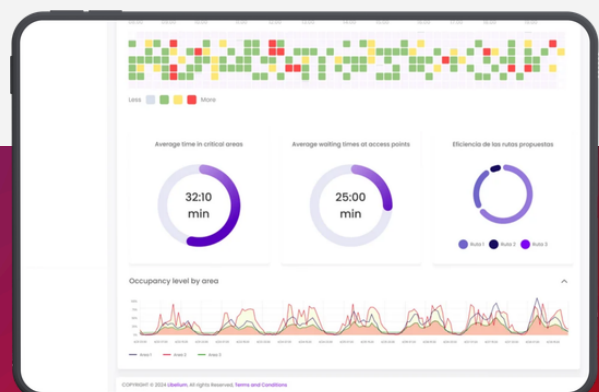
With a proposed investment of €300 billion over the next decade, EuroStack aspires to deliver transformative economic, social, and environmental benefits

5. The Auditable Data: Quality and Veracity as Pillars of Sovereignty

This digital sovereignty framework provided by the EuroStack for data control and sovereignty is sterile if the original information has been manipulated, degraded, or falsified. True technological sovereignty demands absolute certainty regarding the quality, veracity, and governance of data from the exact moment of its physical capture.

If data feeds Common Data Spaces (**Data Commons**) and trains Sovereign Artificial Intelligence (**SovereignAI**) models tasked with managing critical assets, data veracity becomes a matter of national security. Corrupted or manipulated data at the source invalidates predictive decision-making; data outside European infrastructure weakens the ecosystem's autonomy.

Libelium integrates **edge auditing** of data quality as a key architectural component. Through the **iris360** data intelligence platform, every information flow undergoes automated processes for integrity validation, metadata traceability, and algorithmic anomaly detection right at the physical node. By ensuring an immutable chain of custody from the sensor to the data space, Libelium guarantees that European decision models operate on accurate, auditable, and scientifically high-quality information.



All of this is backed by European regulations:

Cyber Resilience Act (CRA)

Libelium natively assumes security-by-design and security-by-default mandates throughout the connected hardware lifecycle, guaranteeing automated vulnerability mitigation and freeing users from complex source audits.

NIS-2 Directive:

Absolute shielding of the edge data supply chain in essential sectors and utilities, protecting flows against risks of espionage and physical or digital sabotage.

EU Data Act:

Technical elimination of closed silos and vendor lock-in practices, ensuring portability and free data sharing through open and interoperable APIs.



6. Reference Architecture: Libelium's Multi-Layer Integration

Libelium has spent years positioning itself as a trusted partner in Europe, unifying the physical environment with the EuroStack blueprint, and natively covering four of its fundamental layers:

EuroStack Layer	Blueprint Guideline	Libelium Architecture	Role in the Sovereign Ecosystem
SmartEurope IoT	• FIWARE open standards • Security-by-design certification (CRA) • Industrial cybersecurity (NIS-2)	• 20 years designing hardware. Libelium One as a plug-and-play IoT device for diverse use cases. • Validated global deployment capacity in +120 countries • Active regulatory approval	Acts as the physical and intelligent layer at the data source for strategic asset monitoring.
DataCommons	• Gaia-X specifications • EU Common Data Spaces • Data portability and sovereignty	• Member of the Gaia-X Board of Directors • +€2M in direct revenue from Data Spaces projects in 2025.	Serves as a board member in Fiware, Eclipse, and Gaia-X, leading benchmarks of European industry in designing federated exchange architectures
SovereignCloud	• Decentralized and interoperable cloud • Edge data processing • Immunity to extraterritorial laws	• Deployment of iris360 on OVHcloud • Strict data residency within EU borders • High-level ENS security certification (ENS Alto)	Guarantees an auditable and sovereign computing environment, fully protected against unauthorized cross-border access.
SovereignAI	• Inference with open-source models • Local analytical frameworks (ALIA / Mistral) • Strict compliance with the AI Act	• Integrated Causal AI engine • Chat and LLMs with ALIA and Mistral • Compliance under ISO 42001 standard	iris360 allows running advanced analytics and automated decision-making, eliminating foreign operational dependencies.

Libelium's capability to integrate cybersecurity mandates (CRA, NIS-2), data management regulations (Data Act), as well as ISO standards and European guidelines directly into its hardware and software design allows Libelium to deliver native, immediate legal trust and resilience to the EuroStack.

7. Field Validation: Alhambra Living Lab as a EuroStack MVP

The reliability, consistency, and viability of Libelium's proposed architecture are demonstrated in the **Alhambra Living Lab** project. This monumental site, classified as one of the most sensitive and complex heritage and environmental spaces internationally, serves as a real, implemented Minimum Viable Product (MVP) of the EuroStack guidelines.

The goal of this public procurement for innovation was to naturally integrate various next-generation technologies, from Critical IoT to AI, including the use of European LLMs.

7.1. Real Use Cases for Developing the Alhambra Living Lab Digital Twin

The project has deployed 9 practical applications that are already transforming the management and conservation of the site.

1. Intelligent Tourist Flow Control:

With over 30 counting sensors and cameras, the system detects crowds, optimizes access, and predicts critical moments, protecting heritage while improving visitor experience.

2. Environmental Sensors for Non-Invasive Conservation:

Libelium One devices monitor structural and environmental conditions. Algorithms like LSTM, ARIMA, or FEM anticipate risks without requiring physical intervention.



3. Augmented Reality and Gamification:

Using BLE beacons, GPS, and QR codes, the system offers an immersive and educational tour featuring historical reconstructions, cultural challenges, and content tailored to age and language.

4. Digital Biodiversity Inventory:

In green areas, sensors monitor local flora and fauna, generating a live species map useful for ecological decisions and environmental management.

5. Energy and Resource Optimization:

Real-time measurement of water, electricity, and HVAC consumption enables fine-tuning of resource usage, reducing costs and environmental impact.

6. Multilingual Interactive Assistants:

Powered by generative AI, information points detect the visitor's language and adapt content to their needs, improving cultural accessibility.

7. Evacuation Simulation:

Análisis dinámico de rutas de evacuación gracias a la movilidad detectada por sensores, útil en simulacros, planes de emergencia y protección civil.

8. A 360° Virtual Tour and an Immersive Metaverse Experience:

This case combines two complementary technologies that expand visitor experience and digital twin value: on one hand, a virtual tour based on 360° captures for accessible, educational exploration; on the other, an immersive metaverse conceived as a proof of concept in the Palace of Charles V, utilizing Gaussian Splatting technology to explore new interactive visualizations and participation.

9. Climate Impact Prediction:

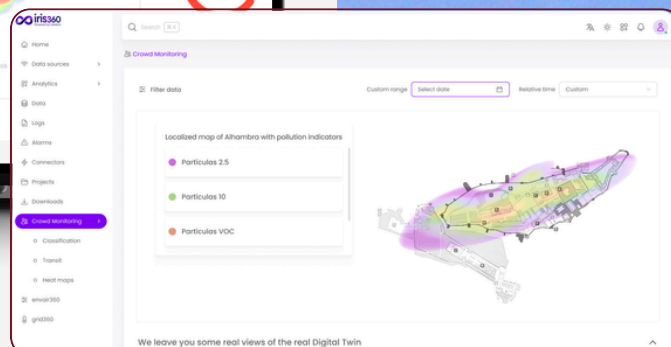
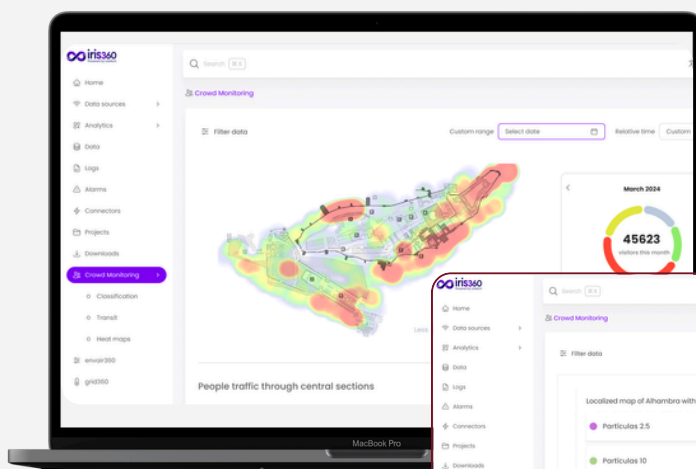
More than ten weather stations and Smart Spot Air & Noise sensors predict the impact of tourism and weather on the monument's surroundings.

7.2. Multi-Layer Project Operation

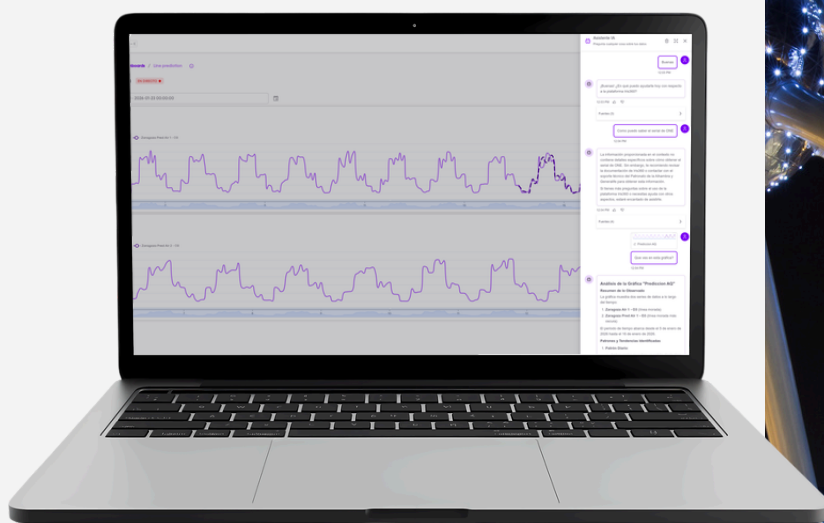
The Alhambra Living Lab transcends basic environmental monitoring to establish a high-availability edge digital twin structured under the EuroStack layers:

- **Robust Acquisition and Connectivity Layer (SmartEurope IoT):** The project deploys Libelium IoT devices and communication gateways non-invasively throughout the monument site. The system captures real-time critical variables including atmospheric pollution, microclimate, vibrations, visitor flows, water quality, noise, or air quality, among other parameters.

- **Cloud Infrastructure Layer (SovereignCloud):** Libelium implements the iris360 deployment over OVHcloud for the Alhambra Living Lab, ensuring data residency within European Union borders and immunity to extraterritorial laws. This choice, aligned with decentralized and interoperable cloud guidelines, is backed by the high-level ENS certification (ENS Alto), completely protecting the iris360 platform against unauthorized cross-border access and complying with stringent European regulatory standards.



- **Artificial Intelligence and Language Models Layer (SovereignAI):** Data analytics are processed natively and independently within European territory. The project applies Libelium's Causal AI engines directly at the edge for Predictive Heritage Conservation and Automated Biodiversity Inventory. Additionally, the Living Lab deploys advanced Generative AI capabilities and sovereign Large Language Models (LLMs) like ALIA or Mistral for Dynamic Multilingual Tourist Adaptation. These models run on local servers under strict public administration control, avoiding the transmission of sensitive data to third-party infrastructures that compromise institutional sovereignty.



- **Data Assurance Layer (DataCommons):** Every variable captured across the monumental site is automatically submitted to Libelium's veracity audit engine. The system verifies device calibration, filters physical noise anomalies, and cryptographically signs each data packet at the source. Consequently, the Alhambra's data is ready for interoperable integration into European Data Spaces, providing managers with a highly reliable scientific public repository free from captive foreign licenses.



7.3. The Value of Libelium as a Trusted Partner

Technological intervention in an asset of such historical, political, and environmental relevance as the Patronato de la Alhambra y el Generalife requires a partner that combines industrial solidity with public interest alignment. In this scenario, Libelium demonstrates its capacity to:



1. Guarantee Continuity of Operations: Through hardware optimized for harsh environments (like deserts) or difficult access locations (like the Panama Canal), alongside highly efficient redundant power systems using solar panels, batteries, or cables.



2. Simplify Technological Complexity: By absorbing the regulatory requirements of the Cyber Resilience Act and NIS-2 directly into the platform's design, allowing public managers to focus on conservation and decision-making.



3. Ensure Return of Public Value: Giving absolute control of strategic data back to the administration, fostering transparent management, and protecting shared heritage through auditable and accurate evidence.



4. Facilitate Entry into European Data Spaces: Putting our leadership role in defining exchange architectures at the service of our projects, thereby technologically guaranteeing data quality and interoperability to cover the EuroStack's DataCommons layer.

8. Leading European Infrastructure

The digital sovereignty of the European Union is not a distant goal relying solely on future theoretical developments; it is an industrial capability already taking place across the territory. The **Alhambra Living Lab** project developed by Libelium proves that European physical infrastructure is already prepared.

Faced with the necessity to protect strategic infrastructures and guarantee the veracity of the data that will govern our societies, Europe requires reliable technological partners with a proven track record of industrial excellence and an unequivocal commitment to common public values. Libelium possesses the reference architecture, technical expertise, and institutional solidity to lead the ecosystem that will form the backbone of the continent's autonomy. The digital future of Europe is built from the physical origin, in a sovereign, auditable, and trusted manner.





libelium20

20 years behind the change



v2 - June 2026