Microclimate monitoring of Lucca Cathedral with LSI LASTEM sensors for the protection of the Holy Face



Technology and cultural heritage, a delicate balance

In the heart of the **Cathedral of Lucca**, amid history, faith and art, a **project** is underway that combines **technological innovation and heritage conservation**. The restoration of the Volto Santo, one of the oldest wooden crucifixes in the West, has made environmental monitoring of the involved spaces necessary. It is a complex scientific challenge, with a clear objective: to ensure stable microclimatic conditions for the preservation of a millennial work.



The context: a unique work in a complex environment

The Holy Face is a polychrome wooden crucifix dating between the 8th and 9th centuries, made from a single walnut trunk. Its preservation is particularly delicate as the **wood** is highly **sensitive to changes in temperature and relative humidity**.

The **complexity** increases when **considering the context**. The Cathedral of Lucca is a living, open space, visited each year by about 300,000 people. Air draught, the constant opening of entrances, and the religious function make it impossible to completely isolate the work as in a museum.

From this arises the **need for continuous environmental monitoring**, capable of analyzing the microclimate without interfering with the architecture and the use of space.





Monitoring project objectives: prevent, understand, decide

The project has three main objectives:

1. **Monitor the microclimate** in the restoration laboratory, the small temple, and the cathedral as a whole;
2. **Prevent deterioration phenomena** related to temperature and humidity variations;
3. **Support strategic decisions**, such as the possible introduction of air conditioning systems before the artwork's permanent relocation.

It's not just about collecting data, but transforming it into useful information for long-term conservation.

The LSI LASTEM solution: non-invasive and continuous microclimatic monitoring

To meet the project's needs, **LSI LASTEM's multiparametric radio sensors** were installed, designed for museum applications and complex historical settings.

These sensors operate at a frequency of 868 MHz, ensuring **reliable transmission** even through thick walls such as those of the cathedral. The **wireless technology** allows for a non-invasive installation, which is essential in an environment of high historical and religious value.

Supporting the hardware infrastructure, the **Indoor Cube platform** enables **real-time data management and visualization**. Accessible from both desktop and mobile devices, it allows all stakeholders to consult dynamic dashboards and share information easily and immediately.



Installation and coverage: precise mapping of the microclimate

The sensor distribution was designed to analyze **air behavior** at **different heights and in different areas**. In the temple, the devices were positioned on three levels, while in the cathedral, on two. This configuration allows for the identification of any thermal stratification and humidity variations.

The addition of an **outdoor sensor** is also being **evaluated** to provide a direct reference to outdoor climate conditions, with the aim of understanding whether and to what extent they also influence the internal microclimate.

Data analysis: from monitoring to decision-making

The main **parameters** recorded are **temperature and relative humidity**, which are essential for wood preservation. Among the most relevant indicators analyzed was the **dew point**, which is important for preventing moisture formation on wall surfaces and the work itself.

The collected data is transmitted via a gateway to the Indoor Cube platform, where it is archived, analyzed, and made available to experts. Data analysis is entrusted to the **CNR** (National Research Council), while operational decisions involve the **Cathedral Church Authority**, the **Superintendency**, and the **Opificio delle Pietre Dure of Florence**, responsible for the restoration.

This **multidisciplinary approach** ensures that every decision is supported by scientific data and specific expertise, minimizing the risk of inappropriate interventions.

After the first six months of monitoring, it emerged that the microclimatic conditions of the temple and the laboratory were very similar to those of the cathedral, with occasionally high but normal humidity levels.





A replicable model for cultural heritage

There are contexts in which **technology** serves not only to innovate, but also to **protect** and the Lucca Cathedral project clearly demonstrates this. Indeed, understanding the behavior of the environment means taking on the responsibility of preserving what cannot be replaced.