Wireless sensor node for Infrastructure health monitoring - iCities2026

However, different structures respond differently to external stimuli, and effective monitoring requires technologies capable of capturing the specific motion patterns associated with each use case. A hospital building, for example, may be affected by slow settling, thermal expansion, or low-amplitude vibrations from equipment and occupancy, while bridges are more exposed to repeated dynamic excitations generated by passing vehicles or trains. Earthquake-related motion introduces yet another behavior, often characterized by rapid and potentially severe shaking. As a result, monitoring systems must be able to distinguish between normal structural behavior and abnormal events that may indicate damage, misalignment, or degradation.

Structural monitoring is particularly important in schools, where it helps protect students and staff and ensures that buildings remain safe after seismic activity. This is especially relevant in areas such as the Campi Flegrei near Naples, where continuous small earthquakes and ground movements make long-term monitoring essential. In hospitals, the stakes are even higher, since any structural issue can directly affect patient safety, medical operations, and emergency response capabilities. In bridges, monitoring is used to assess structural integrity under repeated dynamic loads, detect early signs of deterioration, and support preventive maintenance. The collapse of Ponte Morandi in Genoa some years ago highlighted how critical it is to continuously assess the condition of major bridges and detect signs of weakness before failure occurs. For these reasons, health infrastructure monitoring has become an essential part of modern resilience strategies, combining sensing, data analysis, and connectivity to identify risks early and maintain reliable service over time.

The core challenge in this domain is not simply detecting movement but measuring small variations in inclination and vibration at multiple points across a structure, with the added requirement that all sensor nodes remain synchronized at millisecond level. These measurements are typically found in low-frequency and low-level ranges, where accuracy and stability are essential to avoid false alarms and to identify meaningful changes over time. In this framework, MEMS sensor nodes, long-range connectivity technologies, and microcontrollers with AI capabilities for edge computing provide a compelling answer. ST offers these key technologies, including ultra-high-accuracy digital accelerometers and inclinometers that combine low power consumption, compact form factor, and high-performance sensing capabilities, as well as ultra-low-power microcontrollers and a broad range of connectivity solutions.

ST accelerometers achieve the sensitivity, noise performance, and dynamic range needed to detect positioning and movement across a wide variety of infrastructure applications. Together with embedded digital capabilities, they can convert raw measurements into angles and identify events directly inside the device. A key differentiator is the ability to embed intelligence locally, on the edge, where the sensor node can categorize motion and distinguish natural movements, generated by normal or physiological settling of the monitored structure, from abnormal movements that require attention. When a meaningful event is detected, the system generates a supervision request to the host platform. Performing this classification at the sensor significantly reduces the amount of data to be transmitted and lowers the overall system power consumption, enabling a sustainable architecture in which the system remains asleep unless conditions warrant it being awakened. This event-driven model is particularly well suited to infrastructure deployments where long-term autonomy, reliability, and minimal maintenance are essential.

Another important aspect of practical deployment is measurement accuracy after integration into the final system. Even when each ST accelerometer is factory calibrated to match the specification, the accuracy of the inclination angle measurement can be affected by assembly processes, including the thermal stress introduced during soldering and board integration. For applications requiring higher accuracy, ST provides software libraries for calibration that compensate for these assembly-related effects and improve the performance of the complete solution. This capability is especially valuable in healthcare infrastructure monitoring, where structural changes may be subtle and where measurement confidence is critical to operational decision-making.

Beyond sensing itself, the development of a complete monitoring node also depends on the connectivity technology used to link each node to a central gateway that collects and aggregates the data. Connectivity is a central element in modern infrastructure monitoring because it enables remote supervision, alarm reporting, real-time data consolidation, and fleet management across multiple sites. In healthcare environments, connectivity must be both reliable and energy-efficient, while also supporting integration into broader maintenance and safety workflows. Wireless connectivity can be implemented through sub-GHz proprietary protocols or LPWAN technologies such as LoRaWAN or NB-IoT, which provide long-range communication with ultra-low power consumption and make battery-powered deployments practical for continuous monitoring applications.

ST provides the building blocks needed to move from simple measurement to a complete system solution. This system-level approach is supported by a broad ecosystem of development tools, evaluation boards, and connectivity options. Through both wired and wireless boards, together with dedicated software and development tools, ST helps engineers evaluate performance and design end-to-end systems with greater efficiency. In practice, this enables customers to quickly validate technologies within their specific application vertical by leveraging proof-of-concept and reference design solutions that simplify evaluation, accelerate development, and reduce integration risk.

In conclusion, health infrastructure monitoring relies on precise sensing, edge intelligence, energy-efficient connectivity, and robust system integration. MEMS-based digital accelerometers and inclinometers provide a scalable way to detect structural motion, identify abnormal behavior, and support preventive maintenance. Together with calibration and connectivity solutions, they help improve safety, resilience, and continuity of healthcare services.