

USING MICROELECTRONIC SENSORS TO CONTINUOUSLY MONITOR VERTICAL INFRASTRUCTURE

April 2025

Florida
TaxWatch





106 North Bronough Street, Tallahassee, FL 32301 floridataxwatch.org o: 850.222.5052 f: 850.222.7476

Piyush Patel
Chairman of the Board of Trustees

Dominic M. Calabro
President & Chief Executive Officer

DEAR FELLOW TAXPAYER,

In the pre-dawn hours of June 24, 2021, the Champlain Towers South condominium building in Sunrise, Florida collapsed, resulting in the deaths of 98 persons. Millions of Americans gasped as they watched the collapse of the building, which had been captured on nearby security cameras, as it was broadcast on major media outlets later that same morning.

The Florida Legislature went into special session and enacted new condominium safety requirements intended to save lives and preserve property values, and they are to be commended for their prompt and responsible action. But more work remains to be done to provide additional relief to condominium owners and associations.

This raises the questions of “how safe are the hundreds of Florida’s high-rise buildings?” and “how do we know?” High-rise buildings notwithstanding, Florida has a significant number of bridges, dams, levees, and other vertical infrastructure that, if they were to fail, would result in significant personal and property damage.

Florida TaxWatch undertakes this independent research project to better remedy, review, and recommend how improved and timely technology (microelectronic smart sensors) can be used to identify potential infrastructure problems like structural fatigue, corrosion, or damage, before they become critical and before they fail.

This technology acts more like a streaming movie as opposed to one-time or periodic on-site inspections. This technology can save many millions of dollars in inspection costs and protect many lives, as well as save billions of dollars worth of public infrastructure and property.

Florida TaxWatch is pleased to present this report and its findings and looks forward to engaging policymakers in discussion during this and future legislative sessions.

Sincerely,

Dominic M. Calabro
President & CEO

TABLE OF CONTENTS

Introduction	1
Infrastructure	2
High Rise Buildings.....	4
Technology to the Rescue	5
<i>Microelectronic Sensors</i>	5
<i>The Internet of Things</i>	6
Application Scenarios	6
<i>Application Scenario—Dams and Levees</i>	6
<i>Application Scenario—Bridge Monitoring</i>	7
<i>Application Scenario—Building Columns</i>	8
Conclusion and Recommendations.....	8

INTRODUCTION

On March 15, 2018, a pedestrian bridge under construction connecting the Florida International University campus with the City of Sweetwater collapsed, killing five motorists who were waiting at the traffic light underneath the bridge as well as one construction worker on top of the bridge. At the time of the collapse, the pedestrian bridge consisted of a single 930-ton concrete truss spanning 174 feet and was put into place just five days before the collapse. The Occupational Safety and Health Administration determined that structural design deficiencies contributed to the collapse of the bridge, and that the engineer of record failed to recognize that the bridge was in danger of collapsing when it inspected it hours before the collapse.¹

On June 24, 2021, the Champlain Towers South condominium building in Sunrise, Florida collapsed, resulting in the deaths of 98 persons. Federal investigators identified hundreds of possible points of failure in the building before determining that the pool deck, located at ground level above an underground parking garage, collapsed several minutes before the rest of the building. Potential structural failures in the pool deck or columns supporting the building are the likely cause of the collapse. Investigators found deficiencies in the building's steel reinforcement placements, concrete alignment, and in the strength of the columns and floor concrete.²

In response to the collapse of the Champlain Towers South condominium building, the Florida Legislature created §553.899, Fla. Stat., which: (1) requires condominium and cooperative buildings above three stories in height and 30 years in age to undergo periodic milestone inspections and structural integrity reserve studies; (2) prohibits the waiver of funding for certain structural reserves; (3) repeals the ability of developers to waive the collection of all types of reserve funds; and (4) provides that structural integrity reserve studies, and inspection reports are a part of an association's official records and must be provided to a potential purchaser of a unit. Although these new requirements are intended to save lives and preserve property values, the costs of compliance exceed the ability of many condominium owners and associations to pay.

In addition to the hundreds of high-rise buildings in areas like Southeast Florida, Tampa, and Jacksonville, there are many components of Florida's massive infrastructure network that, if they fail, would cause significant personal and billions of dollars of property damage. Florida TaxWatch undertakes this independent research project to better understand how technology (microelectronic smart sensor networks) can be used to identify potential infrastructure challenges like structural fatigue, corrosion, or damage to intervene before they become critical and before they fail.

Enhancing Safety with Smart Sensor Networks

Recent collapses—from the FIU pedestrian bridge to Champlain Towers South—underscore the critical need for early warning systems in Florida's vertical infrastructure. Microelectronic smart sensor networks can continuously monitor structural health, detecting early signs of fatigue, corrosion, and other damages. By providing real-time data, these sensors enable proactive maintenance and timely interventions, potentially averting catastrophic failures, saving lives, and preserving property values.

¹ Occupational Safety and Health Administration, "Investigation of March 15, 2018 Pedestrian Bridge Collapse at Florida International University, Miami, FL," U.S. Department of Labor, July 2019.

² James Leggatte, "Pool Deck Deficiencies May Have Left Champlain Towers South Vulnerable Before Collapse," Engineering News-Record, June 15, 2023.

INFRASTRUCTURE

As the backbone of Florida's economy, public infrastructure is necessary for the safe and efficient movement of people and goods from one part of the state to another, and to provide effective and efficient public services. Florida's infrastructure system is aging and, as it ages, the risks of failure increase due to a number of factors, including:

- **Sea level rise**—Much of Florida's critical infrastructure—roads, bridges, airports, seaports, railways, water and sewer systems, power plants, schools, etc.—is at low elevations, designed and built without much consideration of future sea level rise. Although originally built far enough from the water's edge to provide some margin of safety, much of Florida's critical infrastructure will need to be relocated, elevated, replaced, hardened, or abandoned as sea levels rise, at considerable cost to Florida taxpayers.
- **More frequent and severe weather events**—As the current cycle of weather patterns leads to a warmer atmosphere, the frequency of intense Category 4 and 5 hurricanes is predicted to increase by 80 percent by 2080, or by roughly one percent per year. Over the same period the frequency of the less intense Category 1-3 hurricanes is expected to diminish by 38 percent.³
- **Rapid population growth**—In 2024, Florida's population increased by a net of 467,347 people, which was the second highest in the country, behind Texas.⁴ This increase in population places considerable strain on public infrastructure.
- **Aging systems**—Florida's energy, transportation, and water systems are old and need to be upgraded. Many of Florida's bridges are structurally deficient, and some are closed or weight limited.

Every four years, the American Society of Civil Engineers (ASCE) evaluates the investment needed to maintain public infrastructure in "good repair" and earn a grade of "B." A "B" grade means the infrastructure is "good for now." In its 2021 analysis, the ASCE evaluated Florida's infrastructure in terms of funding, condition, future needs, public safety, capacity, operation and maintenance, innovation, and

resilience, and provided an overall grade of "C" based on its findings. Grades for each individual category of infrastructure are explained below and shown in Table 1.⁵

- **Aviation (C+)**—From 2016 to 2019, the portion of Florida's overall airfield pavement in fair to good condition slipped from 93 percent to 81 percent. FDOT has identified \$2.2 billion in funding repair needs for airports.
- **Bridges (B)**—The condition of Florida's bridges has remained consistently and significantly above the national level. In 2020, nearly 65 percent of Florida bridges were in good condition compared to the national average of 45 percent. Only three percent of Florida's bridges in poor condition, compared to more than seven percent nationally.
- **Coastal Areas (C-)**—Although local governments are making strides in coastal restoration, natural erosion and coastal development threaten Florida's coasts. Approximately 62 percent of Florida's 825 miles of sandy shoreline shows signs of erosion, with 50 percent identified as critically eroded.
- **Dams (D-)**—Florida's nearly 1,000 dams are, on average, about 50 years old, compared to 57 years nationally. There are 98 High Hazard Potential (HHP) dams, meaning if it failed, loss of life or economic damage would be expected. Forty-one percent of HHP dams have an Emergency Action Plan on record, compared with 81 percent nationally.
- **Drinking Water (C)**—Few utilities inspect more than 20 percent of their distribution pipelines annually for leaks. Florida is a national leader in the reuse of reclaimed water, making up 35 percent of all water supply projects. Drinking water infrastructure improvements are estimated at \$22 billion over the next 20 years.
- **Energy (C+)**—Florida is among the five states nationally with the shortest outage duration, less than 90 minutes per outage. Major energy companies plan to spend billions of dollars annually to install underground lines, harden existing infrastructure against major storms, and optimize their grids. Energy companies in Florida continue to invest in renewable energy sources, such as solar.

³ Morris A. Bender et al., "Modeled Impact of Anthropogenic Warming on the Frequency of Intense Atlantic Hurricanes," *Science*; 327: 454-458, January 2010, retrieved from <https://www.science.org/doi/10.1126/science.1180568>, February 6, 2025.

⁴ U.S. Census Bureau, "Migration Drives Highest Population Growth in Decades," December 19, 2024.

⁵ American Society of Civil Engineers, "2021 Infrastructure Report Card: A Comprehensive Assessment of Florida's Infrastructure."

- **Levees (D+)**—Florida has more than 90 levee systems with more than 1,053 miles of infrastructure that has reached an average age of 58-years-old. Just 40 percent of Florida’s levees have been assessed for risk, although most of them are classified as low risk.
- **Ports (B)**—Over the last five years, Florida’s seaports have invested significantly in capacity and operational improvements to accommodate larger vessels, improve cargo/intermodal transfer efficiency, and enhance the cruise experience for millions of passengers. During the period from 2011 to 2018, Florida invested more than \$1.19 billion in improvements across its 15 seaports, helping ensure the ports are ready for the future.
- **Roads (C+)**—While Florida keeps pace with its growing needs, the state is also planning for the future with an increased focus on building resilience, attention to the evolving transportation needs of its growing elderly population, and a willingness to integrate innovations across the transportation system.
- **Schools (D+)**—As the average building age increases (currently at 31 years old), the need for repairs and rehabilitation grows. To address aging facilities and looming capacity needs, state funding from motor vehicles licensing and taxes has increased between 2016 and 2020 by a total of nearly \$40 million; however, available funding is not sufficient to meet the needs.
- **Solid Waste (B+)**—Increased populations of both permanent residents and visiting tourists are contributing to the amount of municipal solid waste (MSW) generated, which is nearly triple the national per capita average of 4.51 pounds per day. In general, the solid waste infrastructure in Florida is good, with opportunities to improve recycling and reuse programs.
- **Stormwater (C-)**—Thirty-five percent of the state’s local governing bodies reported having a stormwater program to fund and maintain the infrastructure; however, needs are significant, at about \$14 million per stormwater entity by 2023.
- **Transit (C)**—Florida’s local funds and multi-regional expansions have tracked with the changing operational needs while state and federal funds have increased to fill some gaps and contribute to

capital investments. Florida’s transit system benefits from adaptive planning, such as first and last mile options, to counteract challenges like population growth, impacts from climate change, and increased dependence on digital systems.

- **Wastewater (C)**—Florida is a national leader in reclaimed wastewater and climate adaptation frameworks thanks to partnerships among utilities, universities, and industry leaders. Smaller systems are increasingly overwhelmed by the frequent and extreme weather events.

TABLE 1.

Category	Grade	Category	Grade
Aviation	C+	Ports	B
Bridges	B	Roads	C+
Coastal Areas	C-	Schools	D+
Dams	D-	Solid Waste	B+
Drinking Water	C	Stormwater	C-
Energy	C+	Transit	C
Levees	D+	Wastewater	C

Source: ASCE 2021 Infrastructure Report Card

What stands out in the infrastructure report card is the poor condition of Florida’s dams and levee systems. This is of concern because of the threat to life and property should a dam or levee breach. Florida has 996 dams, 80 percent of which are privately owned, and 98 percent are regulated by the state. Of the 996 dams, 98 are categorized as “High Hazard Potential,” which means loss of life or economic damage would be expected should the dam fail. Another 337 dams are categorized as “Significant Hazard Potential,” which means failure of the dam would likely result in significant property loss or significant economic damage or environmental impacts.⁶

With more than 1,000 miles, Florida’s 90 levee systems protect nearly \$100 billion in property, more than 1.6 million in population, and 481,000 structures. Only 40 percent of Florida’s levee system has been assessed for risk. Of the portion of the state’s levee inventory that has been assessed, 55 miles are moderate risk and nearly 37 miles are high risk levees. Sixty of the state’s levee systems have inspection ratings, with 70 percent of those inspections indicating an unacceptable rating.⁷

⁶ Ibid.
⁷ Ibid.

HIGH RISE BUILDINGS

FIGURE 1.



Source: City of Ft. Lauderdale

Images like Figure 1 are common throughout much of Florida. Florida Law⁸ defines a “high-rise building” as a building that is “greater than 75 feet in height where the building height is measured from the lowest level of fire department access to the floor of the highest occupiable level.” Miami has the country’s third-tallest skyline with more than 300 high-rises, 80 of which stand taller than 400 feet.⁹

A December 2024 University of Miami study of high-rise buildings along a 12-mile stretch from Miami Beach to Sunny Isles Beach identified 35 high-rise buildings that had sunk or settled by 0.8 to 3.1 inches. About one-half of these buildings were less than 10 years old. The researchers used a satellite-based remote sensing technique known as Interferometric Synthetic Aperture Radar (InSAR), to examine subsidence (sinking/settling) along the coast by precisely measuring ground surface deformation.

⁸ §718.1085, Fla. Stat.

⁹ Miami-Dade County, “About Buildings,” retrieved from <https://gis-mdc.opendata.arcgis.com/pages/buildings>, February 7, 2025.

¹⁰ Farzaneh Aziz Zanjani, et al, “InSAR Observations of Construction-Induced Coastal Subsidence on Miami’s Barrier Islands, Florida,” *Earth and Space Science*, Volume 11, Issue 12, December 2024.

¹¹ Ibid.

This research suggests that the subsidence is related to construction activities. The researchers attributed the observed subsidence to “load-induced, prolonged creep deformation of the sandy layers within the limestone, which is accelerated, if not instigated, by construction activities.”¹⁰ This suggests that the movement of tidal groundwater or stormwater injection—which is used for flood management—can rearrange sand under high-rise buildings.

The subsurface of the study area is made up largely of limestone interspersed with layers of sand. Over time, the weight of the high-rise buildings and the vibrations caused during foundation construction cause the sandy layers to shift. These shifts, coupled with daily tidal flows and the cracking of the subsurface limestone, contribute to the gradual and continuous sinking/settling of the buildings.



TECHNOLOGY TO THE RESCUE

The technology to perform the ongoing monitoring and provide that deeper understanding suggested by the University of Miami study is available today. This technology is transforming our everyday life in countless ways. From health care to automobiles to communications, microelectronics is the driving force behind our technological advances.

MICROELECTRONIC SENSORS

Microelectronic sensors are small, highly sensitive electronic devices that use microelectronic technology to measure certain physical parameters, such as pressure, acceleration, and temperature, in real time (see Figure 2). Microelectronic sensors have revolutionized industry with their small size and extraordinary accuracy. These sensors have the capability to drive highly integrated systems that monitor, control and optimize industrial processes while enabling real-time insights and informed decision making.¹²

Microelectronic sensors can be physically integrated (embedded) into the structure of a building, bridge, or other component of infrastructure to continuously monitor and collect data on critical parameters within the infrastructure material itself, offering a more accurate picture of its condition compared to surface-mounted sensors. Embedded sensor technology has

been developed by the Florida Department of Transportation (FDOT) and the University of Florida, and is known as embedded data collectors (EDCs). An EDC system consists of a sensor embedded inside a concrete structural element, a wireless radio transmitter, a radio receiver, a laptop computer, and the software to analyze the data.¹³

FIGURE 2.
MICROELECTRONIC WATER LEVEL SENSOR



Source: Waterline Controls

Advanced microelectronic sensors, developed through collaborations like those between FDOT and the University of Florida, are transforming how we monitor critical infrastructure. These compact, highly sensitive devices can be embedded directly into structures to continuously track key parameters—such as pressure, acceleration, and temperature—in real time. By enabling seamless wireless data collection and advanced analytics, these sensors offer unparalleled insights into a structure’s internal health, paving the way for proactive maintenance and safer, more resilient infrastructure.

¹² ES Systems, “A Comprehensive Guide to MEMS Sensors,” retrieved from <https://esenssys.com/news/comprehensive-guide-to-mems-sensors/>, February 25, 2025.

¹³ Achyut Kumar Allady, “We’re Asking the Wrong Questions About Vertical Infrastructure,” Journal, Florida Engineering Society, November 2021.

THE INTERNET OF THINGS

The Internet of Things (IoT) is a network of physical devices embedded with sensors. These devices are connected via the Internet and are capable of exchanging data with other devices in real time (see Figure 3). Driven by the Internet of Things, data collected from the sensors are typically transmitted wirelessly to a central monitoring system (e.g., cloud data centers) where they are analyzed to identify potential issues like structural fatigue, corrosion, or damage before they become critical. Artificial intelligence and enhanced analytics enhance sensor data, enabling predictive maintenance and the prioritization of risk. Embedded sensors can transform infrastructure management into a proactive, data-driven process, while aligning with Florida’s unique infrastructure challenges.

FIGURE 3.
THE INTERNET OF THINGS



Source: Central Data Technology

APPLICATION SCENARIOS

The following discussion is by no means an exhaustive list of applications that would benefit from the use of microelectronic sensors, but it does provide clear insight into the benefits of wireless sensor networks.

APPLICATION SCENARIO—DAMS AND LEVEES

In a February 2022 report entitled “*A River (No Longer) Runs Through It*,” Florida TaxWatch published an analysis on the public policy debate around whether the Kirkpatrick Dam and reservoir should remain in place or whether the dam should be breached to restore the natural flow of the Ocklawaha River. Florida TaxWatch noted that the dam has surpassed its 50-year life expectancy leaving it at risk for total failure. Total failure of the dam could impact as many as 539 properties with flood damages estimated at \$57 million. Collateral damage would also include damage to roadways, bridges, and other downstream structures.¹⁴

Water seepage and internal erosion are the main factors contributing to the risk of an earthen dam’s failure. The water level of the lake and the water content inside the embankment can be used to detect early signs of embankment failure. Embedded wireless underground soil moisture sensors can monitor changes in water content inside the embankment in real time, which can then be compared to real-time data collected by water level sensors, to more effectively ensure the safety of downstream areas.¹⁵

The Kentucky Division of Water (DOW) was awarded a grant from the Department of Homeland Security to establish a means of monitoring critical infrastructure, particularly dams. After researching appropriate methods and available technology to assess dam-related failures, the DOW tested and installed an extensive number of water level sensors at high and moderate hazard dams. Connected to a centralized data management platform, the system will increase warning and reduce response time in order to reduce the risks to life and property and ultimately make communities downstream more resilient to flooding.¹⁶

¹⁴ Florida TaxWatch, “A River (No Longer) Runs Through It,” February 2022.

¹⁵ Min-Chih Liang, et al, “The Application of Wireless Underground Sensor Networks to Monitor Seepage Inside an Earth Dam,” *Sensors* 2023, 23, 3795.

¹⁶ U.S. Department of Homeland Security, “Report of Findings: Kentucky Division of Water, Critical Infrastructure and Flood Risk Management Innovation for Dam Safety Monitoring,” September 30, 2020.

APPLICATION SCENARIO—BRIDGE MONITORING

A pile is a vertical support structure that is used to hold up and support a bridge. Piles are usually made of wood, concrete, or steel and are hammered/driven into the soil below the bridge until the end of the pile reaches a hard layer of rock or compacted soil below. The grip and friction of the soil surrounding the pile help to hold it in place and part of the load of the bridge deck.

Driving a bridge pile correctly is critical not only to the integrity of the pile, but to the overall integrity of the entire bridge structure. Microelectronic sensors connected to cloud computing technology through the IoT can be used to measure, analyze, and validate in real time every hammer stroke of the pile driver, eliminating the time-consuming and error-prone manual data entry processes.

During and after construction of a bridge, periodic (usually visual) inspections are conducted to identify any problem areas that require immediate attention. Once flaws start to or become critical, the bridge owner has limited options. This has prompted a growing interest in cost-effective structural health monitoring systems, where a network of wireless microelectronic sensors monitors the structure of interest in real time 24/7 in order to flag, locate, and quantify damage as it happens.¹⁷

The wireless sensors would be connected to dedicated hardware/software for storage and, ideally, for real-time assessment and measurement of external loading (wind, seismic, and traffic), structural responses (strain, displacement, and acceleration), environmental parameters (temperature, humidity, and rain), and environmental effects (corrosion).¹⁸ The benefits include early detection of structural issues, cost savings on repairs, increased bridge lifespan, and improved safety for users.¹⁹

Wireless instrumentation was embedded in the precast, prestressed concrete piles used in the construction of the Key Royale Bridge on Anna Maria Island. Sensors were used to monitor loading capacities in real time at four locations during pile driving. All sensors were connected to two independent antennas to increase the reliability of data transfer. Traditional pile driving analysis (PDA) provides data on loading capacities; however, the accuracy of retrieved stress readings is limited. The University of Florida researchers conducting the study found that, whereas PDA and the wireless sensor readings of the total pile loading capacities were very close, more pronounced discrepancies (e.g., stress anomalies) were noted in stress predictions.²⁰



Leveraging microelectronic sensors integrated with IoT and cloud computing, bridge monitoring is transformed from reactive visual inspections to continuous, real-time oversight. Embedded sensors capture every detail—from the precise hammer stroke during pile driving to ongoing assessments of load, strain, and environmental impacts. This proactive system not only streamlines data collection and enhances accuracy but also facilitates early damage detection, reduces repair costs, and bolsters overall bridge safety and lifespan.

17 Piervincenzo Rizzo and Alireso Enshaeian, “Challenges in Bridge Health Monitoring: A Review,” *Sensors* 2021, 21(13), 4336.

18 Ibid.

19 Encardio Rite, “Bridge Monitoring Sensors: Types and Applications,” retrieved from <https://www.encardio.com/blog/bridge-monitoring-sensors-types-and-applications>, February 12, 2025.

20 Szyniszewski, Stefan & Hamilton, H. & Chih-Tsai, Yen. (2008). Wireless Sensors in Prestressed Concrete Piles - Combining Driving Control with Long Term Monitoring. IABSE Symposium Report. 94. 38-42. 10.2749/222137808796106693.

APPLICATION SCENARIO—BUILDING COLUMNS

As evidenced in the Champlain Towers South condominium building collapse, federal investigators found deficiencies in the building's steel reinforcement placements, concrete alignment, and in the strength of the columns and floor concrete. Potential structural failures in the pool deck or columns supporting the building were identified as the likely cause of the collapse.

Steel and concrete structures form the skeleton of numerous infrastructure developments, including buildings, bridges, and highways. As these structures age and are subjected to a number of environmental and operational factors, their durability and safety become more of a concern.

The early detection of structural degradation and performance issues is imperative to prevent catastrophic failures, ensure public safety, and optimize maintenance efforts. The use of wireless microelectronic sensors connected to cloud computing technology through the IoT can be used to assess the integrity and performance of concrete structures, specifically to monitor in real time cracking, corrosion of reinforcing steel, and excessive deflections.²¹

Researchers at Ghent University conducted laboratory-scale tests of reinforced concrete columns to test: (1) the effects of embedded devices on the strength and microstructure of the concrete; (2) the data collection and transmission in the presence of steel reinforcement; and (3) the antenna range under more realistic conditions. Each column had two embedded devices—one for the collection of electrical resistivity and a second to test the range of the antenna for data transmission. The researchers concluded that the sensors and attendant hardware performed in a stable and reliable way during data collection and transmission for the cement types used under realistic conditions, which means that the system could be used for many applications within the concrete industry (different cement types and different environmental conditions).²²

CONCLUSIONS AND RECOMMENDATIONS

What if.. the Champlain Towers South condominium building in Sunrise, Florida, had embedded in the pool deck and columns supporting the building a system of wireless microelectronic sensors connected to cloud computing technology through the IoT? We will address this later.

Research shows that wireless sensor networks are more scalable than wired networks, may be quickly deployed, reduce construction difficulty, and can increase system flexibility. The sensors are typically small and low-power devices, and are capable of monitoring a number of conditions, including environmental, seismic, low-sampling-rate magnetic, thermal, and visual.²³ As this report has shown, they can be deployed in a wide range of applications.

Wireless microelectronic sensors can provide construction firms with critical real-time data on a structure's strength and integrity during construction. This not only helps to optimize quality control and safety but also helps to reduce construction costs. Embedded sensors help to ensure that the structure's design incorporates "just enough" construction materials to accommodate probable risks, thereby reducing steel and concrete consumption and life cycle costs.²⁴

Microelectronic sensors play an important role after construction in monitoring stresses induced by weather and normal wear and tear, and in determining which elements of a structure are damaged (and to what extent) by a natural or man-made disaster. Electronic sensors can provide real-time data during hurricanes, assessing structural integrity for rapid response. Baltimore's Francis Scott Key bridge collapsed in March 2024 after being struck by a container ship. Determining the extent to which the bridge was damaged was hampered by the absence of a reliable assessment tool. If the bridge had sensors embedded in the piles, officials would have factual data on bridge conditions before and after its collapse. The rebuild of the bridge is expected to cost \$2 billion and take 3-4 years to complete.

21 José Roberto Tenório Filho, et al, "An Automated Wireless System for Monitoring Concrete Structures Based on Embedded Electrical Resistivity Sensors: Data Transmission and Effects on Concrete Properties," *Sensors*, 2023 Oct 27;23(21):8775.

22 Tenório Filho JR, Goethals J, Aminzadeh R, Abbas Y, Valdez Madrid DE, Cnudde V, Vermeeren G, Plets D, Matthys S. An Automated Wireless System for Monitoring Concrete Structures Based on Embedded Electrical Resistivity Sensors: Data Transmission and Effects on Concrete Properties. *Sensors (Basel)*. 2023 Oct 27;23(21):8775. doi: 10.3390/s23218775. PMID: 37960475; PMCID: PMC10650034.

23 Akyildiz I.F., Su W., Sankarasubramaniam Y., Cayirci E. Wireless sensor networks: A survey. *Comput. Netw.* 2002;38:393–422. doi: 10.1016/S1389-1286(01)00302-4.

24 Supra, see footnote 13.

Let's go back to the "what if" question posed above. The continuous real-time monitoring capability provided by wireless sensor networks allows for the early identification of potential issues before they escalate. Embedding sensors in infrastructure offers significant cost savings. By identifying areas of concern (e.g., cracks, corrosion, etc.) early, maintenance can be targeted and scheduled proactively. This could mean the difference between spending thousands for a minor fix or spending millions for a major repair.

The new condominium safety requirements passed by the 2022 Florida legislature require periodic comprehensive inspections by a licensed professional to assess structural integrity, including load-bearing walls and primary structural systems. Condominium associations are required to maintain adequate reserve funds to cover the cost of identified repairs and maintenance needed based on the inspection findings. Owners of older condominiums, many of which are in South Florida, are facing hefty increases in their condominium association dues to fund the reserves and identified repairs. These increases come at a time when condominium owners are wrestling with higher property insurance rates and higher inflation. Data from wireless sensor networks can be used to optimize asset lifecycle and resource allocation, thereby reducing the costs to the condominium owners. While upfront costs may raise eyebrows, the long-term savings outweigh them.

place in the pool deck and columns supporting the Champlain Towers South condominium building, chances are good that the structural deterioration that caused the building to collapse would have been identified sooner and corrected at the lowest cost. The chances are also good that many of the 98 people who died in the pre-dawn hours of June 24, 2021 would be likely alive today.

It is critical that Florida move to a system of proactive, data-driven infrastructure management. Embedded sensors will enable this shift and ensure public safety and resilient infrastructure.

FLORIDA TAXWATCH RECOMMENDS POLICYMAKERS:

1. Mandate that new infrastructure projects (e.g., high-rise buildings, bridges, dams, etc.) include embedded microelectronic sensors.
2. Implement a program of incentives (e.g., tax credits, grants, etc.) to retrofit existing vertical infrastructure.
3. Create a statewide sensor data platform for real-time oversight.



²⁵ Supra, see footnote 13.

ABOUT FLORIDA TAXWATCH

As an independent, nonpartisan, nonprofit taxpayer research institute and government watchdog, it is the mission of Florida TaxWatch to provide the taxpayers of Florida and public officials with high quality, independent research and analysis of issues related to state and local government taxation, expenditures, policies, and programs. Florida TaxWatch works to improve the productivity and accountability of Florida government. Its research recommends productivity enhancements and explains the statewide impact of fiscal and economic policies and practices on citizens and businesses.

Florida TaxWatch is supported by voluntary, tax-deductible donations and private grants. Donations provide a solid, lasting foundation that has enabled Florida TaxWatch to bring about a more effective, responsive government that is accountable to the citizens it serves since 1979.

FLORIDA TAXWATCH RESEARCH LEADERSHIP

Dominic M. Calabro	President & CEO
The Hon. Jeff Kottkamp	Executive Vice President & General Counsel
Bob Nave	Senior Vice President of Research
Kurt Wenner	Senior Vice President of Research

FLORIDA TAXWATCH VOLUNTEER LEADERSHIP

Piyush Patel	Chairman
James Repp	Chairman-Elect
Marva Brown Johnson	Treasurer
David Casey	Secretary
The Hon. George LeMieux	Immediate Past Chairman

RESEARCH PROJECT TEAM

Bob Nave	<i>Senior VP of Research</i> Lead Author
George Kantelis	<i>Director of Communications</i> Layout & Design

All Florida TaxWatch research is done under the direction of Dominic M. Calabro, President, CEO, Publisher & Editor.

The findings in this Report are based on the data and sources referenced. Florida TaxWatch research is conducted with every reasonable attempt to verify the accuracy and reliability of the data, and the calculations and assumptions made herein. Please contact us if you believe that this paper contains any factual inaccuracies.

The research findings and recommendations of Florida TaxWatch do not necessarily reflect the view of its members, staff, Executive Committee, or Board of Trustees; and are not influenced by the individuals or organizations that may have sponsored the research.

The **EYES** and **EARS** of Florida Taxpayers.

See more at FloridaTaxWatch.org/Research

Florida  TaxWatch

Stay Informed

 FloridaTaxWatch.org

 Florida TaxWatch

 @FloridaTaxWatch

 @FloridaTaxWatch

 @FloridaTaxWatch

 FloridaTaxWatch

106 N. Bronough St
Tallahassee, FL 32301

o: 850.222.5052

Copyright © 2024
Florida TaxWatch
Research Institute, Inc.
All Rights Reserved

Have a Research Inquiry?

Contact Jeff Kottkamp at jkottkamp@floridataxwatch.org