

STRUCTURAL HEALTH MONITORING SYSTEMS

Technologies & Sensors for Real-Time Monitoring,
Risk Detection & Performance Insight

Integrated Monitoring Across the Infrastructure Lifecycle



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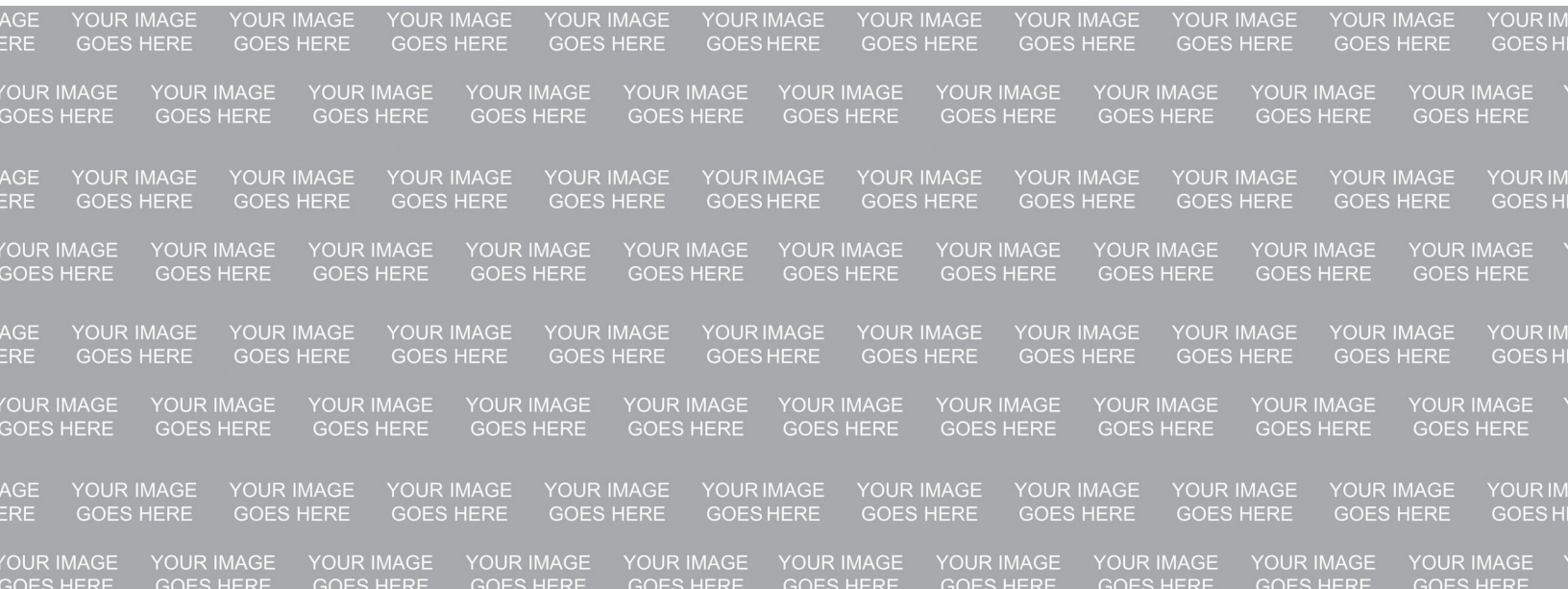
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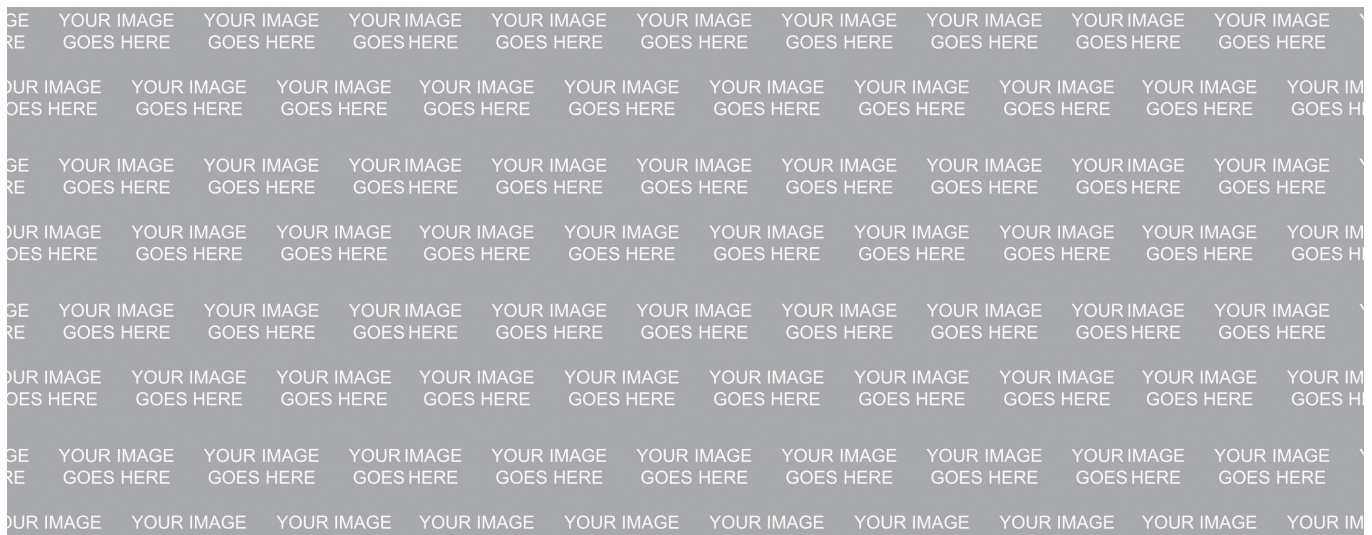
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- Tilt / Inclination Monitoring Sensors

ABOUT STARMASS **19**



Smart SHM Systems

Integrated Monitoring for Structural Safety, Stability & Performance



A comprehensive portfolio of integrated monitoring technologies and smart sensor systems.

This document presents a comprehensive portfolio of integrated monitoring technologies and smart sensor systems designed for real-time assessment of complex infrastructure and built environments. Together, these technologies provide continuous insight into structural behavior, connection integrity, geometric stability, foundation response, and dynamic performance under varying operational and environmental conditions. The portfolio combines advanced survey, investigation, construction, and monitoring technologies with intelligent sensor systems to address multiple dimensions of structural health—ranging from

vibration, strain, displacement, and tilt to alignment, connection performance, and subsurface behavior. When deployed as an integrated framework, these solutions transform passive structures into actively monitored environments capable of early anomaly detection, predictive diagnostics, and data-driven decision-making.

Built around the principle of continuous awareness, the system leverages high-resolution data acquisition, real-time monitoring, and integrated instrumentation to deliver actionable intelligence. Engineers, operators, and asset managers gain a clear understanding of how structures respond to loads, usage patterns, environmental forces, construction activities, and long-term material behavior—enabling proactive risk management, improved operational confidence, and extended asset life cycles. Rather than functioning as isolated tools or instruments, the technologies and sensors are designed to operate as a unified ecosystem. Each data stream contributes

to a holistic understanding of structural performance, supporting comprehensive condition assessment, early warning of abnormal behavior, and informed maintenance and intervention planning.

CORE TECHNOLOGIES & INSTRUMENTATION

Survey & Spatial Intelligence

01 3D Laser Scanner

02 Aerial Drones

Subsurface Investigation & Material Diagnostics

03 Ground Penetrating Radar (GPR)

04 Interferometer

05 Diagraphy

06 Core Cutter

Construction & Ground Engineering Technologies

07 Piling Vibro

08 Diaphragm Wall / Piling Drilling Systems

Structural Monitoring & Field Instrumentation

09 Sensors

10 Data Loggers

11 Automated Meter Reading (AMR)

Digital & Embedded Systems

12 Digital Devices

01 3D Laser Scanner

High-precision geometric capture and deformation mapping



Purpose

- High-precision geometric capture of structures and terrain
- Establishment of accurate as-built and baseline models

What it Enables

- Generates dense 3D point clouds for geometry, alignment, and deformation analysis
- Enables comparison between design, as-built, and time-based changes
- Supports digital documentation and structural assessment workflows

02 Aerial Drones

Rapid aerial inspection and visual intelligence acquisition



Purpose

- Rapid aerial inspection and large-area visual documentation
- Access to hard-to-reach or hazardous locations

What it Enables

- Provides high-resolution imagery and video for condition assessment
- Enables mapping, progress monitoring, and visual anomaly detection
- Reduces inspection time, cost, and safety risks

03 Ground Penetrating Radar (GPR)

Non-destructive subsurface imaging and detection



Purpose

- Non-destructive subsurface investigation
- Detection of hidden structural and ground conditions

What it Enables

- Identifies utilities, voids, reinforcement, and subsurface anomalies
- Supports foundation assessment and risk evaluation
- Enables informed decisions without excavation

04 Interferometer

High-precision displacement and deformation monitoring



Purpose

- Measurement of ground and structural displacement
- Monitoring of settlement and deformation trends

What it Enables

- Detects minute movements over time with high precision
- Useful for slope stability, excavation impact, and structural response analysis
- Supports early warning and risk mitigation

05 Diagraphy

Internal material and subsurface condition assessment



Purpose

- Assessment of internal material properties
- Evaluation of subsurface structural integrity

What it Enables

- Measures physical parameters within soil or structural elements
- Supports diagnosis of material consistency and defects
- Enhances understanding of foundation and ground behavior

06 Core Cutter

Physical material sampling and strength verification



Purpose

- Physical sampling of concrete and structural materials
- Verification of material strength and quality

What it Enables

- Extracts core samples for laboratory testing
- Confirms design compliance and in-situ material condition
- Supports structural evaluation and forensic analysis

07 Piling Vibro

Ground improvement and foundation installation technology



Purpose

- Installation and densification of ground and foundation elements
- Improvement of soil bearing capacity

What it Enables

- Uses controlled vibration to install piles or improve soil conditions
- Reduces settlement risk and enhances foundation stability
- Commonly used in deep foundation and ground improvement works

08 Diaphragm Wall / Piling Drilling Systems

Deep foundation and retaining structure construction



Purpose

- Construction of deep retaining and foundation systems
- Structural support during excavation and permanent works

What it Enables

- Enables precise execution of diaphragm walls and drilled piles
- Supports complex urban and deep excavation environments
- Ensures structural stability and groundwater control

09 Sensors

Continuous measurement of structural and environmental behavior



Purpose

- Continuous measurement of structural and environmental parameters
- Real-time condition monitoring

What it Enables

- Captures data on vibration, strain, tilt, displacement, and stress
- Enables early detection of abnormal structural behavior
- Forms the foundation of Structural Health Monitoring systems

10 Data Loggers

Reliable acquisition and storage of monitoring data



Purpose

- Reliable acquisition and storage of sensor data
- Continuous monitoring across multiple channels

What it Enables

- Collects, timestamps, and stores high-resolution monitoring data
- Supports wired and wireless sensor networks
- Ensures data integrity for analysis and reporting

11 Automated Meter Reading (AMR)

Remote and automated field data acquisition



Purpose

- Remote and automated data collection from field instruments
- Reduction of manual data acquisition

What it Enables

- Enables real-time or scheduled data transmission
- Improves operational efficiency and monitoring continuity
- Integrates with centralized monitoring platforms

12 Digital Devices

Embedded electronics for control, processing, and integration



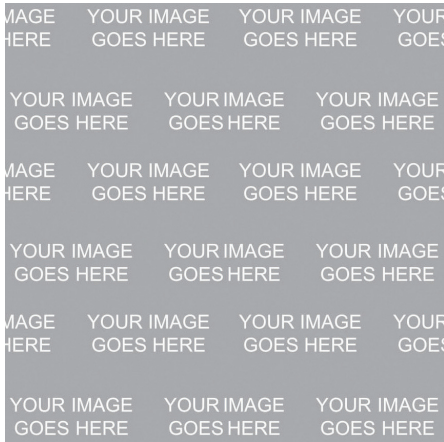
Purpose

- Signal processing, control, and system integration
- Edge-level intelligence and automation

What it Enables

- Custom electronic units for data processing and communication
- Supports integration of sensors, loggers, and platforms
- Enables scalable, intelligent monitoring systems

Integrated Monitoring Framework



Sensor Categories

- Dynamic Response Monitoring
- Load & Stress Monitoring
- Geometric Stability Monitoring
- Connection & Fastener
- Health Monitoring
- Foundation & Support
- Movement Monitoring
- Circumferential Stress Monitoring
- Tilt & Alignment Monitoring

Typical Applications

- Bridges and flyovers
- Stadiums and arenas
- Airports and transit hubs
- High-rise buildings
- Industrial facilities
- Temporary and modular structures
- Event infrastructure
- Public assembly spaces

Monitoring Philosophy

These sensor systems are designed to support a proactive monitoring approach, enabling:

- Continuous condition assessment
- Early anomaly detection
- Predictive maintenance planning
- Risk-based decision support
- Long-term performance evaluation

The system architecture incorporates robust data communication protocols such as MQTT and OPC UA to ensure reliable, secure, and scalable data transmission across distributed assets.

In parallel, stringent data validation and QA/QC processes are implemented to ensure data integrity, consistency, and reliability for downstream analysis and decision-making.

By combining distributed sensing, standardized communication frameworks, real-time analytics, and centralized visualization, the portfolio provides a robust foundation for intelligent infrastructure management.

System Capabilities

REAL-TIME DATA ACQUISITION

Continuous, high-resolution sensing of structural and environmental behavior.

DISTRIBUTED SENSOR NETWORK

Multi-type sensor deployment across critical structural zones.

CENTRALIZED VISUALIZATION

Unified dashboards for live status, trends, and alerts.

PREDICTIVE DIAGNOSTICS

Early identification of anomalies before failure occurs.

RISK-BASED ALERTS

Automated thresholds for proactive intervention.

SCALABLE ARCHITECTURE

Expandable for future growth and additional sensor layers.

Technology-Neutral Systems Integration

Starmass operates as an independent systems integrator.

Our role is to design and implement complete monitoring and infrastructure intelligence solutions by combining the most suitable technologies available in the market, ensuring that each component contributes effectively to a reliable, integrated, and future-ready monitor-

ing system for long-term infrastructure performance.

Unlike equipment manufacturers, we do not promote or depend on any single product, sensor, or brand. Our responsibility is to the performance of the overall system and the long-term success of the project, ensuring that the selected technologies work together efficiently and reliably.

Many technology vendors promote their

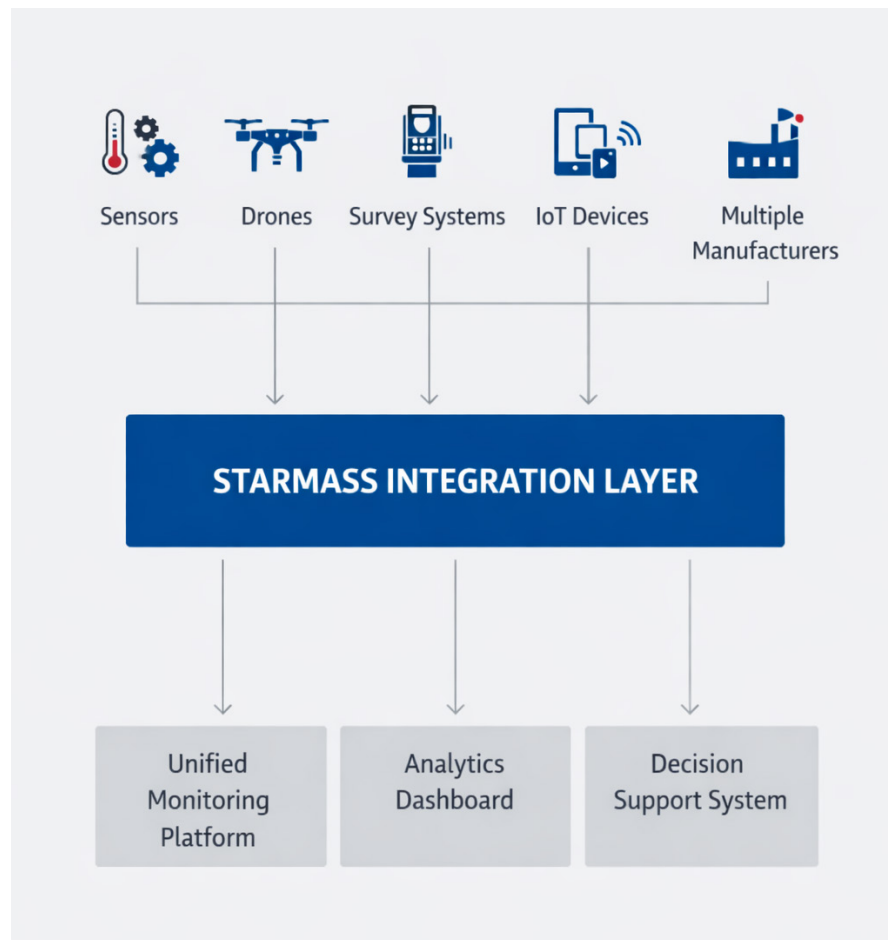
own devices regardless of whether they are the best fit for a client's infrastructure. This approach often results in fragmented systems, unnecessary costs, and limited flexibility in the future.

Our approach focuses on integrating the right combination of sensing technologies, communication systems, data platforms, and analytical tools into one unified monitoring architecture that supports accurate data collection, analysis, and informed decision-making.

Starmass follows a different model.

We begin by evaluating project requirements. Based on engineering objectives, environmental conditions, and operational constraints, we select the most appropriate combination of sensors, communication technologies, data platforms, and analytical tools.

This technology-agnostic approach allows us to integrate multiple manufacturers and technologies into one unified monitoring and decision-support system.



KEY ADVANTAGES FOR STAKEHOLDERS

Starmass's technology-neutral integration approach provides several **strategic advantages** for infrastructure owners, operators, and project stakeholders.

By focusing on system performance rather than individual products, we ensure that monitoring solutions remain flexible, scalable, and aligned with long-term operational needs.

Stakeholder Benefits

- **ENGINEERING BASIS**
Independent technology selection based on engineering requirements.
- **UNIFIED ECOSYSTEM**
Integration of multiple sensor brands and technologies within one unified platform.
- **VENDOR FREEDOM**
Avoidance of vendor lock-in and dependence on proprietary systems.
- **FUTURE FLEXIBILITY**
Long-term scalability and upgrade flexibility as technologies evolve.
- **PERFORMANCE ALIGNMENT**
Objective recommendations aligned with project performance and operational goals.

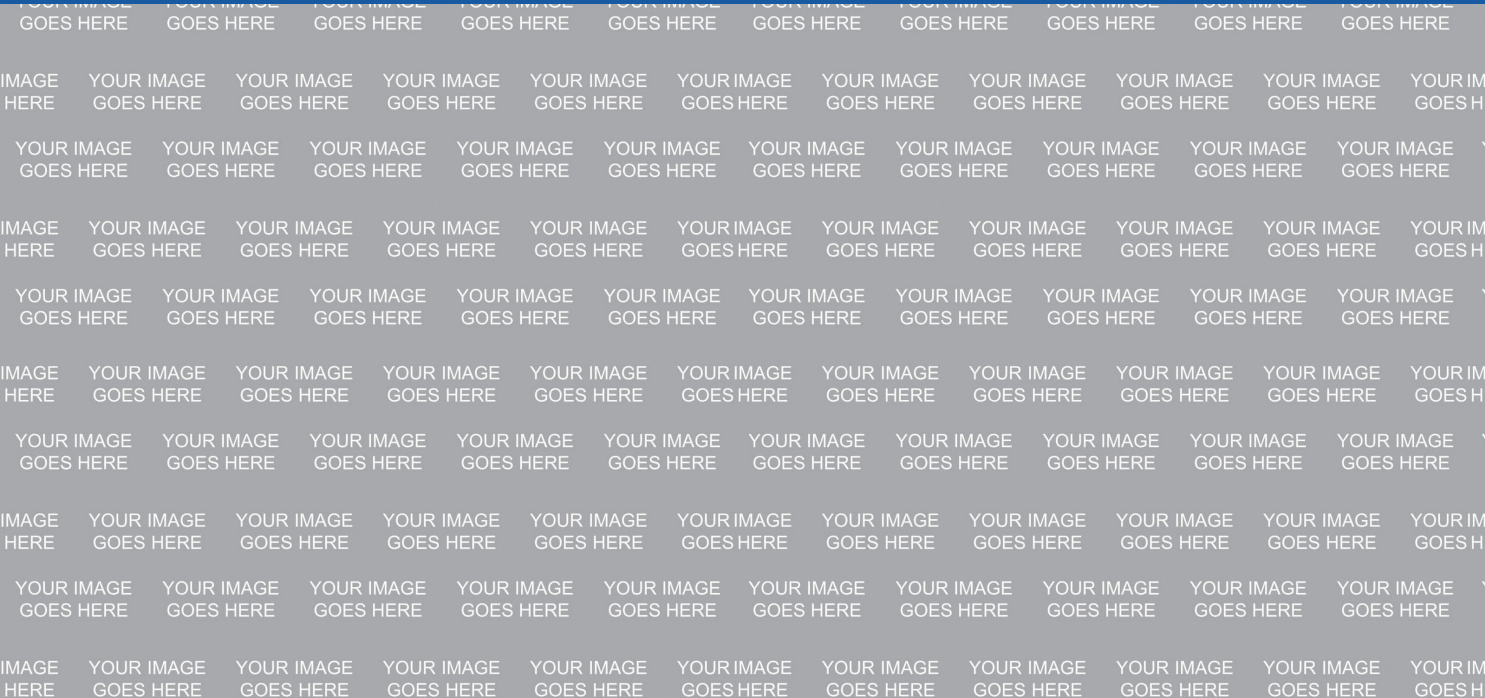
Our focus is not the promotion of equipment.

Our focus is the delivery of **reliable, integrated infrastructure intelligence systems** that support safe operation and **informed decision-making throughout the asset lifecycle.**

SENSOR SYSTEMS PORTFOLIO

Sensor Categories

- 01** Vibration Monitoring Sensors
- 02** Strain Monitoring Sensors
- 03** Geometric Integrity Monitoring Sensors
- 04** Bolt Loosening Monitoring Sensors
- 05** Bracket Integrity Monitoring Sensors
- 06** Pillar Base Movement Monitoring Sensors
- 07** Pillar Hoop Stress Monitoring Sensors
- 08** Tilt / Inclination Monitoring Sensors



01 Vibration Monitoring Sensors

Dynamic Behavior & Human Comfort Monitoring



Purpose

Vibration sensors continuously measure dynamic movements of the structure caused by crowd motion, walking, running, or sudden load changes.

Why it Matters

Excessive vibrations can cause discomfort to pilgrims and may indicate structural resonance or instability. These sensors help ensure human comfort, detect abnormal oscillations, and support timely corrective action.

Installed at

Mounted on deck slabs, inner pillars, outer pillars, and mid-beams on both upper and lower decks.

What it helps detect

- Excessive deck vibrations
- Resonance conditions
- Crowd-induced dynamic effects
- Sudden impact or abnormal motion
- Long-term changes in structural behavior

02 Strain Monitoring Sensors

Structural Load & Stress Monitoring



Purpose

Strain sensors measure the deformation of structural members under load, providing precise information on how forces are distributed through the structure.

Why it Matters

Abnormal or increasing strain levels can indicate overstressing, fatigue, or potential failure zones. These sensors provide early warning of structural distress before visible damage occurs.

Installed at

Installed on critical pillars at entrance and exit bays, with provisions for additional bays on the upper deck.

What it helps detect

- Overstressed structural elements
- Uneven load distribution
- Fatigue accumulation
- Long-term material degradation
- Structural overstress during peak loads

03 Geometric Integrity Monitoring Sensors

Structural Shape & Alignment Monitoring



Purpose

Geometric integrity sensors monitor changes in the relative positions of key structural elements, ensuring that the original shape, alignment, and geometry of the structure are maintained.

Why it Matters

Even small geometric shifts can indicate foundation movement, uneven settlement, or progressive deformation. Early detection helps prevent long-term damage and maintains the structural configuration as designed.

Installed at

Installed on inner and outer ring pillars on the upper deck.

What it helps detect

- Excessive deck vibrations
- Resonance conditions
- Crowd-induced dynamic effects
- Sudden impact or abnormal motion
- Long-term changes in structural behavior

04 Bolt Loosening Monitoring Sensors

Connection Integrity & Fastener Health Monitoring



Purpose

Bolt loosening sensors monitor the tightness and integrity of bolted connections in real time, ensuring that critical joints remain secure under dynamic loading.

Why it Matters

Loose bolts can significantly reduce structural stiffness, introduce unwanted movement, and increase the risk of progressive damage or failure. These sensors provide early warnings before visible loosening becomes dangerous.

Installed at

Installed on pillar connections at entrance, exit, and selected bays on both upper and lower decks.

What it helps detect

- Loss of bolt pretension
- Progressive loosening
- Joint slippage
- Fatigue-related connection issues
- Dynamic load effects on joints

05 Bracket Integrity Monitoring Sensors

Support Connection & Load Transfer Monitoring



Purpose

Bracket integrity sensors monitor the condition and performance of structural brackets that connect primary and secondary members, ensuring proper load transfer between elements.

Why it Matters

Brackets play a critical role in distributing loads. Any weakening or failure can lead to localized damage and progressive structural issues.

Installed at

Installed on pillar brackets at selected bays on the lower deck.

What it helps detect

- Bracket deformation
- Connection weakening
- Stress concentration zones
- Progressive connection failure
- Abnormal load redistribution

06 Pillar Base Movement Monitoring Sensors

Foundation & Support Stability Monitoring



Purpose

Pillar base movement sensors measure translational or rotational movement at the base of pillars, which are critical load-bearing points of the structure.

Why it Matters

Small movements at the base can indicate settlement, foundation distress, or soil-structure interaction issues. Early detection helps prevent large-scale misalignment or progressive instability.

Installed at

Installed at the bases of selected pillars at entrance, exit, and key intermediate bays.

What it helps detect

- Differential settlement
- Foundation movement
- Base rotation or tilt
- Support instability
- Progressive misalignment

07 Pillar Hoop Stress Monitoring Sensors

Circumferential Stress & Confinement Monitoring



Purpose

Pillar hoop stress sensors measure circumferential stresses in cylindrical or curved structural elements, helping assess how internal forces are distributed around the pillar.

Why it Matters

Excessive hoop stress can indicate abnormal load concentration or confinement issues. Continuous monitoring helps prevent cracking and progressive failure.

Installed at

Installed on selected pillars at entrance, exit, and key intermediate bays.

What it helps detect

- Circumferential overstressing
- Crack initiation zones
- Localized material fatigue
- Abnormal load concentration
- Long-term degradation

08 Tilt / Inclination Monitoring Sensors

Verticality & Alignment Monitoring



Purpose

Tilt and inclination sensors measure angular deviations of structural elements from their original vertical or horizontal alignment.

Why it Matters

Even minor tilts can indicate foundation movement, uneven settlement, or progressive structural instability. Early detection helps prevent cascading failures.

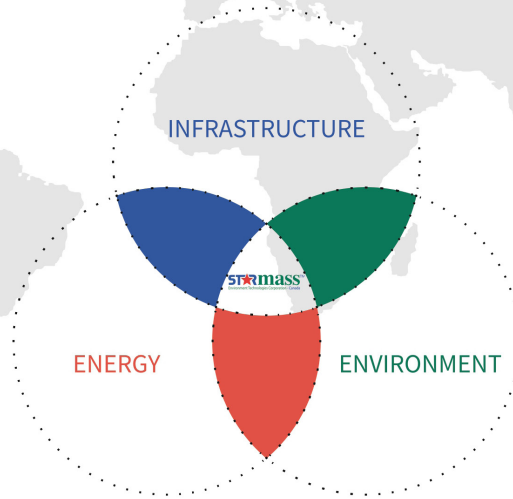
Installed at

Installed on inner and outer pillars on both upper and lower decks.

What it helps detect

- Pillar tilting
- Progressive misalignment
- Foundation movement
- Structural drift
- Long-term geometric changes

We understand the relation between
Infrastructure, **Energy** and **Environment**



We Understand The	Safety	Of Physical Infrastructure
	Stability	
	Integrity	
	Health	
	Risk	
	Vulnerability	
	Hazard	
	Smartness	
	Intelligence	
Preservation		

ABOUT STARMASS

Company Background



Starmass began as a specialist contract division.

1984

Starmass began its activities over 30 years ago.

1994

Incorporated as a separate entity in the USA.

Founded in 1984 as a specialist contract division, Starmass became an independent entity in 1994 following strong market response. Since then, it has built deep domain expertise across Infrastructure, Environment, and Energy. Starmass focuses on the intersection of these disciplines, delivering turnkey solutions in infrastructure technologies, environmental systems integration, built environments, energy and waste management, and geospatial technologies. Its customized solutions are designed to preserve the integrity and stability of infrastructure while adapting to energy cycles and environmental conditions.

Strength

Starmass's strength lies in providing customized, non-conventional solutions through an interdisciplinary approach combining infrastructure sciences, instrumentation, communication, and geospatial technology, with a focus on zero waste.

Turnkey Solutions

Starmass offers single-point turnkey solutions covering investigation, monitoring, design, analysis, rehabilitation, and protection of infrastructure, environment, and energy systems.

Guarantees

In line with international standards, Starmass and its associates issue work integrity guarantees—typically ten years for successfully executed turnkey projects, subject to contractual terms.

Network

Starmass maintains strong ties with specialized consultants from industry, academia, and research institutions, ensuring cost-effective and practical solutions.

Partnerships

Believing in collaboration, Starmass shares its domain expertise and partners with other specialist entities to deliver comprehensive and innovative outcomes.



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A **Starmass Group Company** – *Specialists in Infrastructure Lifecycle Integrity*

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