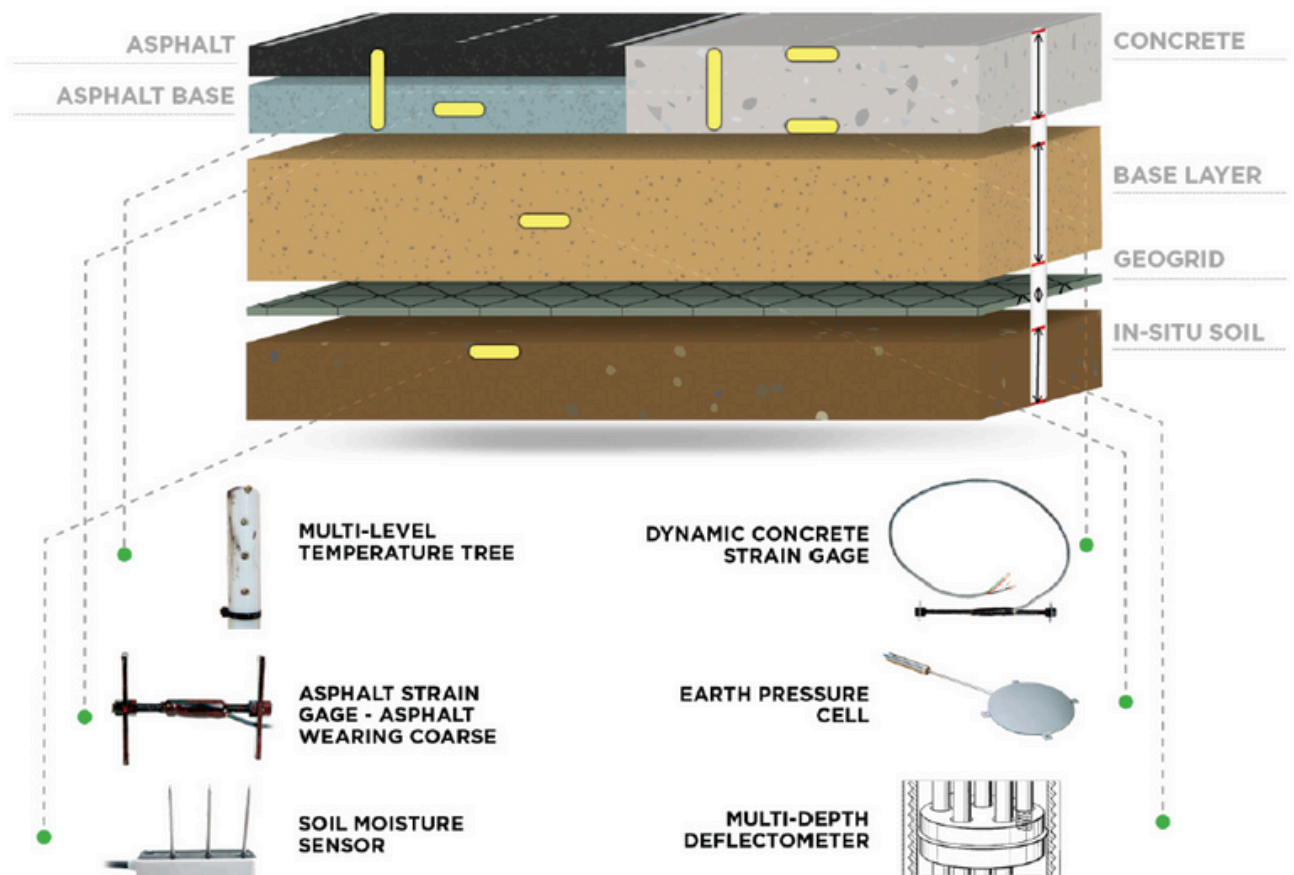


## PAVEMENT MONITORING INSTRUMENTATION



WE OFFER COMPREHENSIVE RANGE OF PAVEMENT INSTRUMENTS FOR MONITORING THE PAVEMENT STRUCTURE PERFORMANCE

# Pavement Monitoring Instrumentation and Services

## HOW DO YOU MEASURE PAVEMENT RESPONSES

### Pavements

- Asphalt Strain Gauges
- Concrete Strain Gauges
- Temperature Tree
- Multi-Depth Deflectometer

### Base Layers

- Pressure Cells
- Multi-Depth Deflectometer
- Vertical Strain
- Soil Compression

### Geogrid

- Geogrid Strain
- Soil Compression
- Pressure Cell

### Sub-Base Layers

- Pressure Cells
- Multi-Depth Deflectometer
- Soil Compression
- Soil Moisture

## INTRODUCTION

Pavement instrumentation is the systematic deployment of sensors within or on a road structure to measure its mechanical response and environmental exposure. By embedding technology directly into the pavement, engineers can bridge the gap between theoretical design models and real-world performance, moving from reactive maintenance to proactive "Smart Road" management.

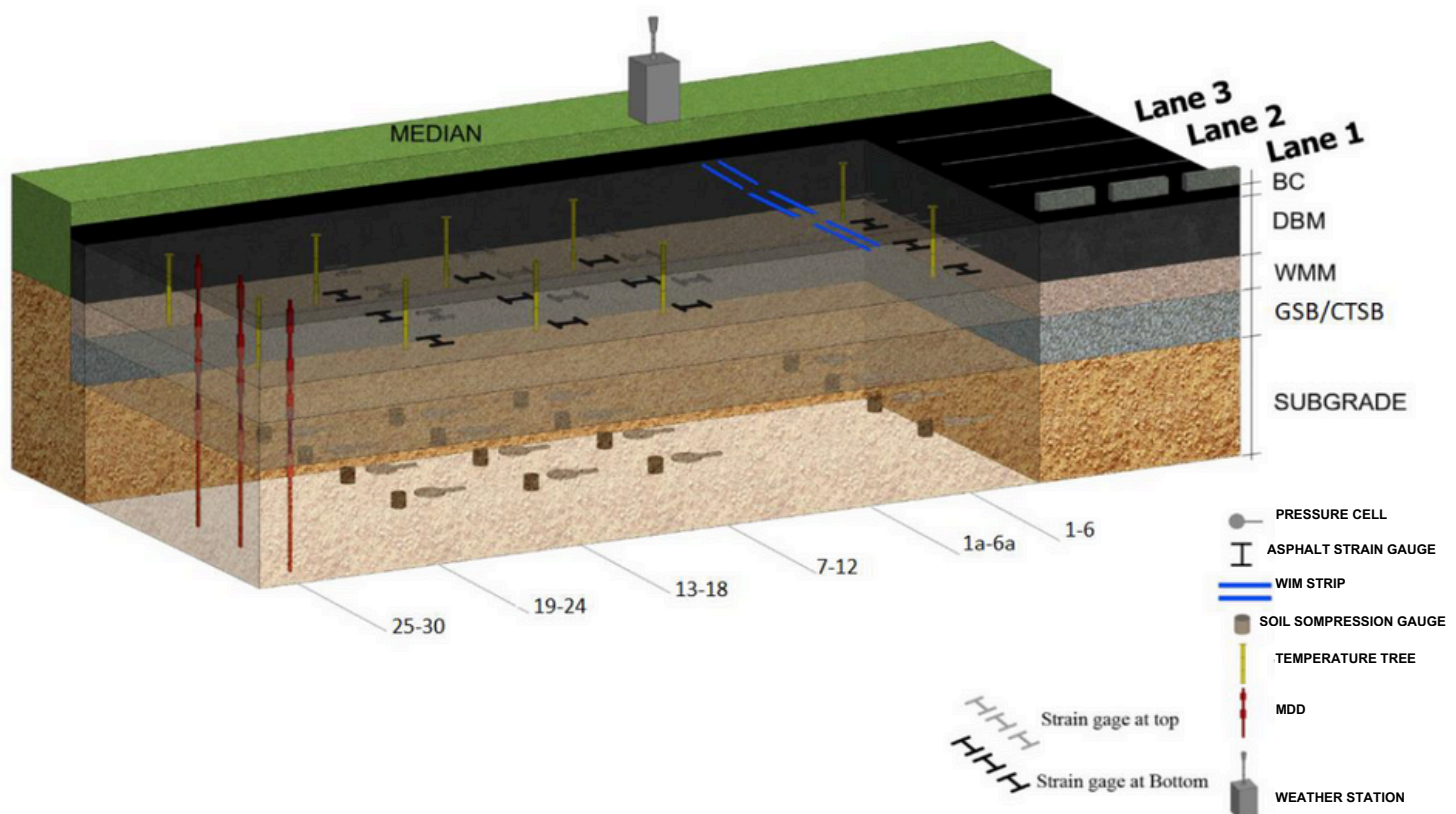
Pavement instrumentation is a critical tool for monitoring and evaluating the structural performance of pavements. By embedding various sensors within the pavement layers, engineers can collect real-time data on temperature, strain, moisture, deflection, and traffic loads.

## PURPOSE

- Provides real-world data (stress, strains, load and temperature) to validate design models
- Tracks in-situ material performance and detects early signs of failure like rutting, cracking, and fatigue under actual traffic and environmental conditions
- Improve maintenance & management by providing data for timely interventions, leading to better lifecycle management and budget efficiency
- Validate IRC strain limits for Indian conditions
- Support future improvement of pavement design guidelines

## KEY DELIVERABLES

- Long-term performance database (strain, stress, temperature, load and pressure)
- Validation of actual pavement life and strain limits
- Design calibration factors for IRC guidelines
- In-service monitoring of pavement structural parameters.



# Pavement Monitoring Instrumentation and Services



## ASPHALT STRAIN TRANSDUCERS

Asphalt Strain transducers are pavement sensors that measure axial strain in flexible pavement under high frequency (dynamic) conditions. These low modulus, ruggedized sensors are built to withstand the high temperature and vibratory rolled compaction required for asphalt placement.

Utilizing four active elements of a Wheatstone Bridge circuit, this gauge is easily adaptable to most data acquisition systems.

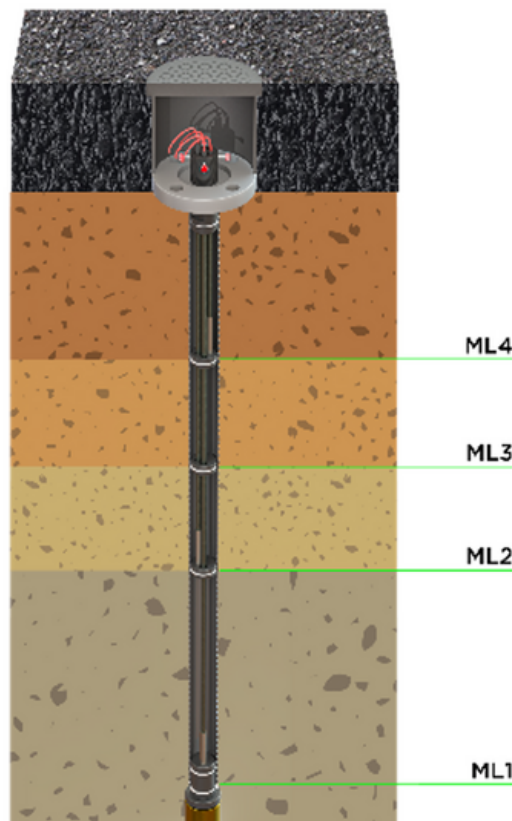
Each sensor is individually calibrated with high temperature resistant lead wire attached and is provided with QC documentation and Calibration plots.

## MDD MULTI-DEPTH DEFLECTOMETER

Multi-Depth Deflectometers (MDD) are pavement sensors used to measure in-situ elastic deformation and/or permanent deformations in the various pavement layers of a test section. The BDI MDD system is a series of parallel rods in a 50 or 75 mm diameter hole in the test section. The parallel rods are anchored at various depths inside the MDD tube wall. Each rod, starting from the bottom hydraulic anchor, passes up to the reference head where linear potentiometers measure rod (depth anchor) movements relative to the road surface.

### Users of this type of MDD

- FAA
- USACE
- Minnesota DOT
- Pennsylvania DOT
- CALTRANS
- Caterpillar



## Features

### ASPHALT STRAIN TRANSDUCERS

- Range:  $\pm 3000 \mu\epsilon$
- 350 $\Omega$  Fully Active Wheatstone bridge
- Sensitivity: 1.3 mVout/mVext
- Waterproof
- Temperature Range: -50 $^{\circ}\text{C}$  to +200  $^{\circ}\text{C}$
- Crushed/cut lead wires
- 350 deg HMA
- Paving train dragging/pulling on sensor/wire
- Rolling operation
- Vibratory rolling

### MDD MULTI-DEPTH DEFLECTOMETER

- Gauge Length: Customer Specified
- Measurement depth: Up to 3 m, user-specified
- 3- to 4-wire potentiometer
- Temperature Range: -20  $^{\circ}\text{C}$  to +85  $^{\circ}\text{C}$
- Measurement range: 1" stroke (resettable)
- Parallel Array
- Easily replaceable
- Compressible tube with external ribbed surface
- Pre-fabricated with anchor and road box
- Grounded Sensors

# Pavement Monitoring Instrumentation & Services

## Features

### EARTH PRESSURE CELL

- Proven and reliable technology
- Wide variety of pressure ranges and configurations
- Automatically provides total soil & water pressure
- Heavy-duty instrumentation cable pre-installed
- Excellent stability for long-term measurements
- Stainless steel construction resists corrosion

### MULTI-LEVEL TEMPERATURE TREE

- BDI temperature trees are custom built to specific measurement spacing using either thermistors or thermocouples dependent on User's data acquisition configuration. These can be configured with high temperature lead wire for insertion in flexible pavements or standard lead wire for use in rigid pavements or soils.

### EARTH PRESSURE CELL

The Earth Pressure Cells are designed to measure total pressure in earth fills and embankments. All cells consist of two circular stainless steel plates welded together around their periphery and spaced apart by a narrow cavity filled with de-aired oil. Changing earth pressure squeezes the two plates together causing a corresponding increase of fluid pressure inside the cell. Pressure transducer converts the pressure into an electrical signal which is transmitted to the readout location.

#### Applications

- Bridge abutments
- Retaining walls
- Sheet piling
- Tunnel linings
- Pile tips

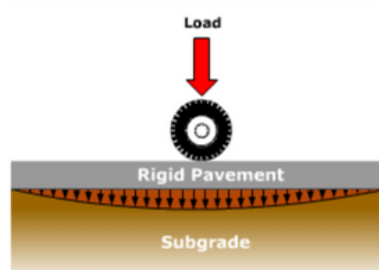
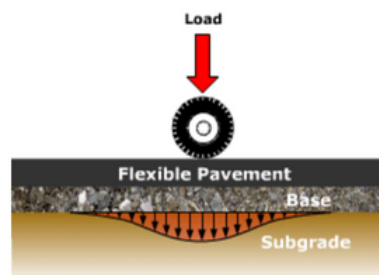


### MULTI-LEVEL TEMPERATURE TREE

Temperature measurements through pavement and soil layers provide a method for determining thermal gradients that can affect flexural strains and material stiffness. By providing fixed spacing of the thermal measurements in specific layers in pavements and soils help to better model pavement-soil interaction and/or effects from thermal differences of pavement surfaces.

#### Applications

- Slab curvature can be computed or predicted with the use of temperature trees, moisture and strain measurements through slab thickness during curing. This helps better understand interaction of slab jointing with dowels
- Temperature trees are used to measure influence of climatic conditions of daily and seasonal variations of temperature differentials through slab depths related to surface temperatures from solar radiation
- Measurements of temperature differentials between pavement and subgrade help to better understand deflection behavior of pavements
- Measurements of temperature variation through flexible pavements helps to better understand stress/strain in flexible pavements as material stiffness changes with temperature



# Pavement Monitoring Instrumentation and Services

## INTELLIDUCER NODES

The STS4 Intelliducer node is the 4th generation of our structural testing system that has been designed by civil engineers expressly for structural testing in harsh and difficult field environments.

This ruggedized data acquisition system is upgraded with the latest wireless and battery technology to improve data transmission range and testing time.

We have always developed our STS hardware based on 30+ years of field-testing experience as well as feedback from all of our clients around the world.

The software is simple to operate, and the built-in sensor verification routines ensure you'll collect quality data.

### Applications

- Diagnostic or Static Load Testing of bridges
- Hydraulic Structures: Radial gates, navigation locks, miter gates, spillways, etc.
- Towers: Wind or tele-communication tower testing
- Laboratory Testing: Ideal to help students understand the capabilities of sensor measurements and data acquisition equipment



## WIRELESS BASE STATION

The STS4-WBS is the ruggedized device that generates the wireless local area network (WLAN) that is the heart for our wireless STS4 hardware. The STS4-WBS relays all wireless and wired communications between STS- live running on the operator's pc and all other STS4 components including up to 128 STS4 nodes and the optional automatic load position tracker (ALPT). The internal li-ion battery will power the sts4-wbs unit for approximately 12 hours of continuous use. The unit is tripod- mounted for easy placement between the pc and the STS4 nodes attached to the structure.

### Features

- Long-lasting, rechargeable Li-Ion battery
- Water-resistant and ruggedized for use in adverse field environments
- Tripod-mounted to allow for optimal field placement between PC and STS4 hardware
- Broadcasts standard IEEE 802.11a/b/g wireless network
- Backup wired Ethernet (LAN) connection
- Onboard wireless backhaul link (5.0 GHz) for wirelessly connecting multiple STS4-WBS units together to increase wireless network range
- Manages up to 128 STS4 no

## CORE DATA LOGGER

The STS4 core data logger is a ruggedized custom-built industrial computer that is designed to facilitate data acquisition in the harshest of environments. The core data loggers are field-proven to provide continuous and reliable operation for structural monitoring applications. The core data loggers are preconfigured to run the STS- core application that processes all raw data from our distributed data acquisition hardware. An STS4 core data logger is typically delivered along with a turn-key structural monitoring system.

### Features

- STS-CORE OS controlling Windows 8 Embedded Standard™
- Intel Atom processor with 2 GB RAM
- 128 GB Solid State Drive (expandable)
- Two Intel Gigabit Ethernet interface cards
- 12v DC operation, 10w max operating power
- STS-MONITOR application for system configuration
- Ambient operation temperature - 40° to +85 °C
- Convection cooling requires no internal or external cooling fans in operating temp range
- Humidity 5 to 95% non-condensing
- Vibration resistant Custom device drivers for third party hardware



# Pavement Monitoring Instrumentation and Services

## PAVEMENT MONITORING EXPERIENCE

BDI's pavement sensor design Engineer has been providing this line of pavement instrumentation to research institutions for more than 20 years. These institutions include the accelerated pavement test facilities for the FAA, FHWA, NCAT, MnRoad, USACE, Korean Highway Department and Universities across the globe. Coupled with BDI's data acquisition hardware and software capabilities, complete pavement instrumentation solutions can be provided.

We along with our OEM BDI provide instrumentation and services for pavement performance evaluation by providing sensors, monitoring systems and nondestructive evaluation services to help understand pavement performance and under lying support conditions.

This service is provided to Accelerated Pavement Test (APT) facilities, construction road and airport projects and in-service roads where existing conditions may need repairs and/or rehabilitation.

While similar instruments may be supplied by others, only BDI provides the in-house expertise for the design, installation and integration of complete turn-key system solutions based on user experience and feedback from these leading institutions.

## DYNAMIC CONCRETE STRAIN GAUGE



Embedment strain transducers measure axial strain in rigid pavement under long-term static (slab curling) or high frequency dynamic (pavement response to vehicular traffic) conditions.

These ruggedized sensors are built to withstand the harsh conditions of concrete placement and vibration. Utilizing four active elements of a wheat stone bridge circuit, this gauge is easily adaptable to most data acquisition systems plots.

## HOW WE MANAGE DATA

### PLATFORM INTERACTIVE DATA HOSTING

Data hosting through Microsoft® Azure that allows:

- + Simple and secure data measurement
- + 24/7 staffed service center
- + Custom alerts and notifications
- + Advanced graphing options

### DATA TRANSFER

- + STS-BRIDGE: Microsoft® Windows® application to collect data on a defined schedule.
- + Client Servers: The Core Data Logger can be configured to push data to a client designated server.

### SETUP/CONFIGURATION

- + STS-MONITOR is used for configuring the system, either remotely or through direct on-site connection.
- + Systems can be preconfigured by BDI or by the Client.



# Pavement Monitoring Instrumentation and Services

## WEIGH-IN-MOTION (WIM)

Weigh-in-Motion (WIM) technology measures the weight of a vehicle while it is moving across a detection point. It is strategically placed in or on the pavement to detect the dynamic force of tires. It can be paired with ANPR (Automatic Number Plate Recognition) cameras to link weight data with specific vehicle identities for enforcement.

Weigh-In-Motion (WIM) is a system for weighing vehicles with no impact on traffic flow and the most complex solution for data collection in transportation. It helps with traffic management, road maintenance planning and can be applied to actively protect the road infrastructure.

### Key Applications

- Enforcement: Screening for overloaded trucks to prevent road/bridge damage, fines, and safety issues.
- Infrastructure Planning: Gathering accurate data on traffic loads for road design and maintenance.
- Toll Collection: Calculating tolls based on weight and vehicle class.
- Traffic Monitoring: Statistical analysis, freight corridor identification, and improving traffic flow.

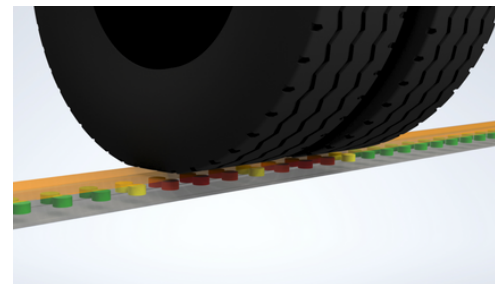
### Core Technologies

WIM systems use various sensors to capture dynamic forces and convert them into estimated static weights:

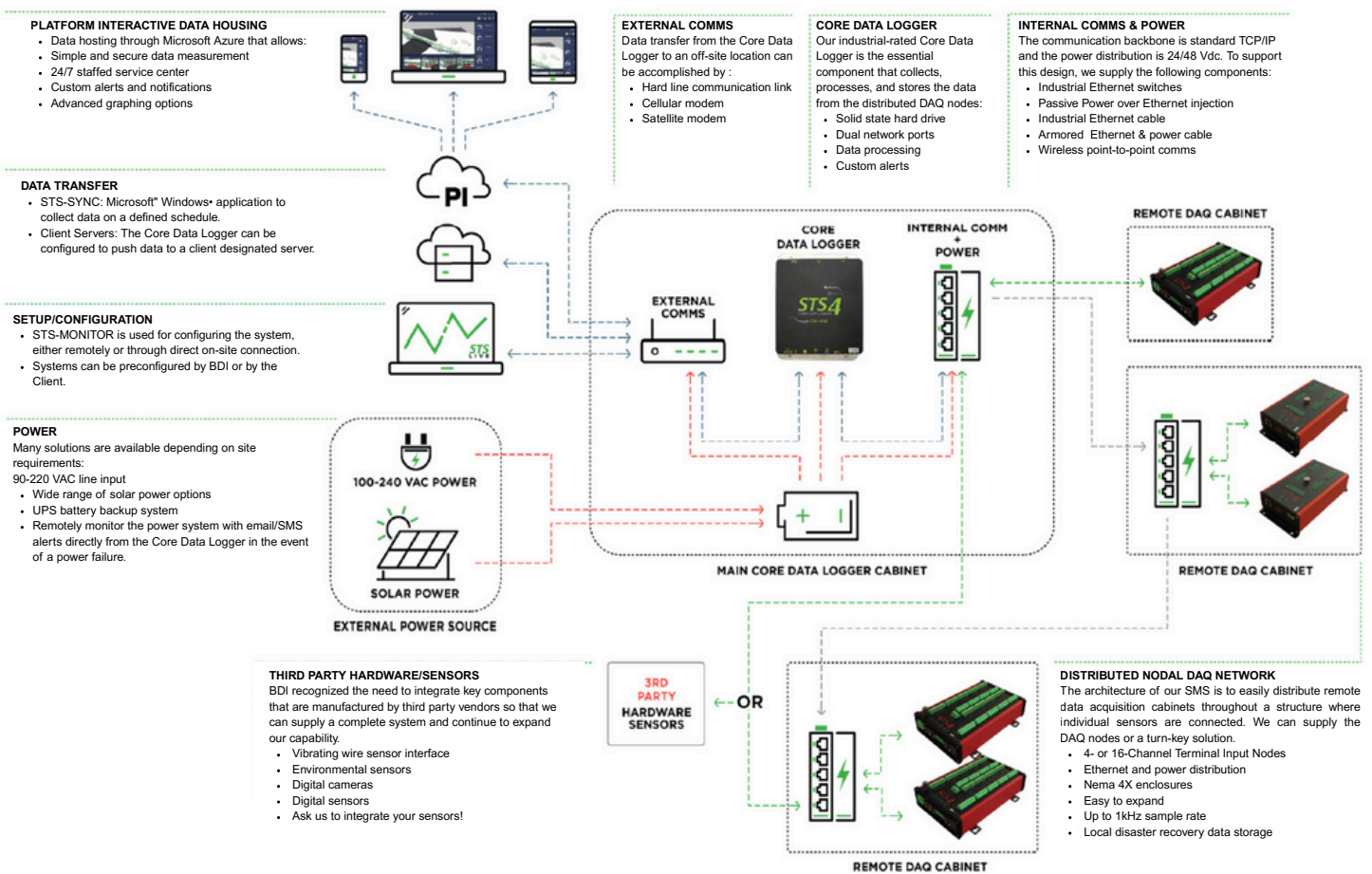
- Piezoelectric Sensors: Use materials like quartz or ceramics that generate an electric charge when under pressure from a vehicle's tires.
- Bending Plates: Metal plates with strain gauges on the underside that deform under weight, altering electrical resistance to measure the load.
- Load Cells: Precise platforms supported by sensors that convert mechanical force into electrical signals. These are considered highly accurate but are more expensive to install.

## FEATURES

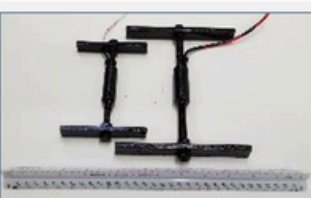
- Weighing sensor independence
- Speed and dimension enforcement
- Tire pressure and axle weight measurement
- Advanced validation process
- Central data server support
- Tire footprint reconstruction



# HOW IT WORKS



# SENSOR TECHNOLOGY



**ASPHALT STRAIN**

- Two Sizes
- Range:  $\pm 3000 \mu\epsilon$
- 1000  $\Omega$  Fully Active Wheatstone bridge
- Sensitivity: 1.3 mVout/mVext
- Temperature Range: -50 to +200 °C



**VERTICAL STRAIN**

- Range:  $\pm 3000 \mu\epsilon$
- 1000 $\Omega$  Fully Active Wheatstone bridge
- Sensitivity: 1.3 mVout/mVext
- Temperature Range: -50 to +200 °C



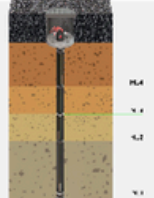
**TEMPERATURE TREE**

- Temperature Range: -50 to +200 °C
- Depth of Measurement: User defined
- Sensor Type: Thermistor or Thermocouple



**SOIL COMPRESSION SENSOR**

- Gauge Length: Customer Specified
- Measurement Range: up to 2-in (50mm)
- 3- to 4-wire potentiometer
- Temperature Range: -20 °C to +85 °C



**MULTI DEPTH DEFLECTOMETER**

- Range:  $\pm 0.5$
- Up to 6 positions (5 depths + anchor)
- Depth up to 12-ft
- Linearity:  $< \pm 0.5\%$  F.S.
- Resettable transducers for pavement rutting