Rhode Island Department Of Transportation

Purchasing Unit

Purchase Order Encumbrance Detail Report

June 04, 2024
08:31 AM

Oracle PO Number	: 3891025	**Release**	:		
Contract/Blanket PO Number	: 3891025	**Release**	: 0000	**RIFANS PO Number**	: 0
Project	: BR - 2024-CB-012 WASHINGTON BRIDGE WEIGHT IN MOTION STATION AND STRUCTURAL HEALTH INSTRUMENTATION MONITORING				
Project Manager	: **KRISTEN SANTOS**				
Vendor/Vendor Site	: **KISTLER INSTRUMENT CORPORATION-01**				
Approval Status	: APPROVED	**Cancelled Status**	: NOT CANCELLED	**Closed Status**	: OPEN

Organization	:	BRIDGE ENGINEERING UNIT
PO Creation Date	:	June 4, 2024
PO Order Amount	:	$2,759,199.00
PO Cancelled Amount	:	$0.00
PO Billed Amount	:	$0.00
Encumbrance Balance		$2,759,199.00

Line Number	Line Status	Item Code	Item Description	UOM	Unit Price	Shipment Line	Qty Ordered	Qty Cancelled	Qty Billed	Qty Encumbered	Remaining Balance
1	O		2024-CB-012 WASHINGTON BRIDGE WEIGHT IN MOTION STATION AND STRUCTURAL HEALTH INSTRUMENTATION MONITORING	EACH	$1.00	1	2,759,199.00	0.00	0.00	2,759,199.00	$2,759,199.00

Notice of Contract Purchase Agreement

State Of Rhode Island
Department of Administration
Division of Purchases
One Capitol Hill
Providence, RI 02908-5860

VENDOR	**KISTLER INSTRUMENT CORPORATION** **75 JOHN GLENN DR** **AMHERST, NY 14228-2119** **United States**

SHIP TO	**DOT-BRIDGE DESIGN** **TWO CAPITOL HILL - RM 130** **PROVIDENCE, RI 02903** **United States**

DOT: 2024-CB-012 WASHINGTON BRIDGE WEIGHT IN MOTION STATION AND STRUCTURAL HEALTH INSTRUMENTATION MONITORING	
Award Number	**3891025**
Revision Number	**0**
Effective Period	**23-MAY-2024 - 22-MAY-2029**
Approved PO Date	**23-MAY-2024**
Vendor Number	**68244**

Type of Requisition	**SINGLE / SOLE SOURCE**
Requisition Number	
Change Order Requisition Number	
Solicitation Number	
Freight	**Paid**
Payment Terms	**NET 30**
Buyer	**- - Stephens, Michael**
Requester Name	
Work Telephone	

This Purchase Order is issued pursuant to and in accordance with the terms and conditions of the solicitation and applicable federal, state, and local law, including the State of Rhode Island's General Conditions of Purchase which are incorporated herein by reference contain specific contract terms applicable to this Purchase Order. See: https://rules.sos.ri.gov/regulations/part/220-30-00-13

PURCHASE AGREEMENT 3891025
2024-CB-012 WASHINGTON BRIDGE WEIGHT IN MOTION STATION AND STRUCTURAL HEALTH INSTRUMENTATION MONITORING

CONTROL VALUE:
$2,759,199.00

INVOICE TO

IMMEDIATE VENDOR ACTION REQUIRED:
Paperless Invoicing is now required.Vendors who do not currently invoice electronically must comply. Send all invoices in PDF format with PO numbers clearly marked to DOA.Invoices@doa.ri.gov

REGISTRATION REQUIREMENTS

IMMEDIATE VENDOR ACTION REQUIRED:
ALL vendors with an existing Purchase Order must be registered in OCEAN STATE PROCURES(OSP). Get Instructions at :https://www.ridop.ri.gov/osp/osp-vendor-registration.php

STATE PURCHASING AGENT

Nancy R. McIntyre

CONTRACT PERIOD:
5/23/2024 TO 5/22/2029

AGENCY CONTACT
JIHN PREISS, DOT
401-563-4105

VENDOR CONTACT
JAMES KIRKPATRICK
JAMES.KIRKPATRICK@KISTLER.COM

REASON/JUSTIFICATION: PER KISTLER QUOTE 20522298 DATED MAY 3, 2024

Reference Documents: (S) KISTLER quote 5-3-24.pdf
(S) Kistler Detailed Proposal.pdf

INVOICE TO

IMMEDIATE VENDOR ACTION REQUIRED:
Paperless Invoicing is now required.Vendors who do not currently invoice electronically must comply. Send all invoices in PDF format with PO numbers clearly marked to DOA.Invoices@doa.ri.gov

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STATE PURCHASING AGENT

Nancy R. McIntyre

Contract Terms and Conditions

Table of Contents

Terms and Conditions

PURCHASE ORDER STANDARD TERMS AND CONDITIONS

TERMS AND CONDITIONS FOR THIS PURCHASE ORDER

CAMPAIGN FINANCE COMPLIANCE

CAMPAIGN FINANCE: In accordance with RI General Law 17-27-2, Every person or business entity providing goods or services of $5,000 or more, and has in the preceding 24 months, contributed an aggregate amount in excess of $250 within a calendar year to any general officer, or candidate for general office, any member, or candidate for general assembly, or political party, is required to electronically file an affidavit regarding political contributions at: https://secure.ricampaignfinance.com/RhodeIslandCF/Public/VendorAffidavit.aspx

ARRA SUPPLEMENTAL TERMS AND CONDITIONS

For contracts and sub-awards funded in whole or in part by the American Recovery and Reinvestment Act of 2009. Pub.L.No. 111-5 and any amendments thereto, such contracts and sub-awards shall be subject to the Supplemental Terms and Conditions For Contracts and Sub-awards Funded in Whole or in Part by the American Recovery and Reinvestment Act of 2009. Pub.L.No. 111-5 and any amendments thereto located on the Division of Purchases website at www.purchasing.ri.gov.

DIVESTITURE OF INVESTMENTS IN IRAN REQUIREMENT:

No vendor engaged in investment activities in Iran as described in R.I. Gen. Laws §37-2.5-2(b) may submit a bid proposal to, or renew a contract with, the Division of Purchases. Each vendor submitting a bid proposal or entering into a renewal of a contract is required to certify that the vendor does not appear on the list maintained by the General Treasurer pursuant to R.I. Gen. Laws §37-2.5-3.

For all Purchase Orders issued on behalf of the University of Rhode Island, Community College of Rhode Island, and Rhode Island College, vendors will receive a confirming order from the respective entity prior to proceeding.

MASTER PRICE AGREEMENT CONTRACT ADMINISTRATIVE FEE

In 2017 the General Assembly amended the "State Purchases Act", R. I. Gen. Laws § 37-2-12 (b) to authorize the Chief Purchasing Officer to establish, charge and collect from vendors listed on master price agreements ("MPA") a contract administrative fee not to exceed one percent (1%) of the total value of the annual spend against their MPA contracts. All contract administrative fees collected from MPA vendors shall be deposited into a restricted receipt account which shall be used for the purposes of implementing and maintaining an online eProcurement system and other costs related to State procurement. In accordance with this legislative initiative the Division of Purchases is upgrading the State procurement system through the purchase and installation of an eProcurement system.

The contract administrative fee shall be applicable to all purchase orders issued relative to State MPA contracts. Therefore, effective January 1, 2020 all MPA contracts shall be assessed the 1% contract administrative fee.

MULTI YEAR AWARD

THIS IS A MULTI-YEAR BID/CONTRACT. PER RHODE ISLAND STATE LAW 37-2-33, CONTRACT OBLIGATIONS BEYOND THE CURRENT FISCAL YEAR ARE SUBJECT TO AVAILABILITY OF FUNDS. CONTINUATION OF THE CONTRACT BEYOND THE INITIAL FISCAL YEAR WILL BE AT THE DISCRETION OF THE STATE. TERMINATION MAY BE EFFECTED BY THE STATE BASED UPON DETERMINING FACTORS SUCH AS UNSATISFACTORY PERFORMANCE OR THE DETERMINATION BY THE STATE TO DISCONTINUE THE GOODS/SERVICES, OR TO REVISE THE SCOPE AND NEED FOR THE TYPE OF GOODS/SERVICES; ALSO MANAGEMENT OWNER DETERMINATIONS THAT MAY PRECLUDE THE NEED FOR GOODS/SERVICES.

BLANKET PAYMENT

DELIVERY OF GOODS OR SERVICES AS REQUESTED BY AGENCY. PAYMENTS WILL BE AUTHORIZED UPON SUBMISSION OF PROPERLY RENDERED INVOICES NO MORE THAN MONTHLY TO THE RECEIVING AGENCY. ANY UNUSED BALANCE AT END OF BLANKET PERIOD IS AUTOMATICALLY CANCELLED.

EQUAL OPPORTUNITY COMPLIANCE

THIS PURCHASE ORDER IS AWARDED SUBJECT TO EQUAL OPPORTUNITY COMPLIANCE.

TERMS AND CONDITIONS OF PRICING AGREEMENT

SCOPE AND LIMITATIONS - This Agreement covers requirements as described herein, ordered by State agencies during the Agreement Period. No additional or alternative requirements are covered, unless added to the Agreement by formal amendment by the State Purchasing Agent or his designee.

Under State Purchasing Law, 37-2-54, no purchase or contract shall be binding on the state or any agency thereof unless approved by the department [of administration] or made under general regulations which the chief purchasing officer may prescribe. Under State Purchasing Regulation 8.2.1.1.2, any alleged oral agreement or arrangements made by a bidder or contractor with any agency or an employee of the Office of Purchases may be disregarded and shall not be binding on the state.

PRODUCT ACCEPTANCE - All merchandise offered or otherwise provided shall be new, of prime manufacture, and of first quality unless otherwise specified by the State. The State reserves the right to reject all nonconforming goods, and to cause their return for credit or replacement, at the State's option.

a) Failure by the state to discover latent defect(s) or concealed damage or non-conformance shall not foreclose the State's right to subsequently reject the goods in question.

b) Formal or informal acceptance by the State of non-conforming goods shall not constitute a precedent for successive receipts or procurements.

Where the vendor fails to cure the defect promptly or replace the goods, the State reserves the right to cancel the Release, contract with a different vendor, and to invoice the original vendor for any differential in price over the original contract price.

ORDER AUTHORIZATION AND RELEASE AGAINST PRICING AGREEMENT

In no event shall the Vendor deliver goods or provide service until such time as a duly authorized release document is certified by the ordering Agency.

State Agencies shall request release as follows: All releases shall reference the Price Agreement number, the

Contract Issue number, the item(s) covered, and the unit pricing in the same format as described herein.

A Department Purchase Order (DPO) listing the items ordered shall be created by the agency. The agency may mail or fax a copy of the order to the Vendor. In some cases the agency may request delivery by telephone, but must provide the Vendor with a DPO Order Number reference for billing purposes. Vendors are encouraged to require written orders to assure payments are processed accurately and promptly.

DELIVERY If this is an MPA, Vendor will obtain "ship to" information from each participating agency. This information will be contained in the DPO. APA delivery information will be contained in the Notice of Award.

PRICING - All pricing shall be as described herein, and is considered to be fixed and firm for the term of the Agreement, unless specifically noted to the contrary herein. All prices include prepaid freight. Freight, taxes, surcharges, or other additional charges will not be honored unless reflected herein.

INVOICING All invoices shall reference the DPO Order Number(s), Price Agreement number, the Contract Issue number, the item(s) covered, and the unit pricing in the same format as described herein. If this is an MPA, Vendor will obtain "bill to" information from each participating agency. This information will be contained in the DPO. APA billing information will be contained in the Notice of Award.

PAYMENT - Invoices for items not received, not priced according to contract or for work not yet performed will not be honored. No payment will be processed to any vendor for whom there is no IRS W-9 on file with the State Controller.

B5

DC 5/17/24

Edit and Submit Requisition 1862224

* Indicates required field

Total 0.00 USD

*** Description** DOT: 2024-CB-012 WASHINGTON BRIDGE WEIGHT IN MOTION STATION AND STRUCTURAL HEALTH INSTRUMENTATION MONITORING

Justification SFY24 SOLE SOURCE PURCHASE AGREEMENT

P-Card Number

☐ Notify me with status updates for my Purchase Order

Additional Information

*** Document to Create** Purchase Agreement
Blanket or Contract Purchase Agreement

*** Type of Requistion?** SINGLE / SOLE SOURCE
Single / Sole Source

Prior PO#?

Change Order? N
No

PO to be Changed

Change will make PO over 5k? N
No

Agency Use

Details	Line	Item Number	Description	Quantity	Unit	Price	Amount (USD)	Need By Date	Deliver-To Location	Special Info	* Bill To Location	Employee Name (Initial contract)	Position Title	Consultant Type	Service Categories	Hours per Week	Under RI State Supervision	Extension of Previous Year	Effort	Factors in Decision	Atta
	1		DOT: WASHINGTON BRIDGE WEIGHT IN MOTION STATION AND STRUCTURAL HEALTH INSTRUMENTATION MONITORING	2759199	Each	0 USD	0.00	29-May-2024 00:00:00	07000-033 Enter one-time address		07000-007 DOT ACCOUNTS PAYABLE	UNKNOWN	UNKNOWN	Engineering Services Engineering Services	80% Federal/20% State 80% Federal/20% State	UNKNOWN	No	No	Effort made to recruit internally but current staff lacks specialized skills required Effort made to recruit internally but current staff lacks specialized skills required	Specialized Skills Required Specialized Skills Required	

Supplier

New Supplier No

Supplier KISTLER INSTRUMENT CORPORATION

Site 01

Contact Name

Phone

Fax

Email

Supplier Onboarding Status

Supplier Item

Manufacturer

Manufacturer Part Number

Note To Supplier

Delivery

Urgent No

Need-By Date 29-May-2024 00:00:00

Requester Smith, Brian K

Deliver-To Location 07000-033

Destination Type Expense

P-Card Used No

Distributions

Line	Charge Account	Project Number	Task Number	Award Number	Expenditure Type	Expenditure Organization	Expenditure Item Date	Percent	Quantity	Amount
1	24.12.070.3900110.02.634100.00000							80	2207359.2	0
2	24.12.070.3885101.09.634100.00000							20	551839.8	0

Total 0.00

Your requisition will be sent to the following list of approvers.

Approvals

0

Cruz, Dawn N

Notes And Attachments

Notes

Note To Buyer

Requisition Attachments

Seq	Title	Type	Description	Category	Last Updated By	Last Updated	Usage	Update	Delete	Publish to Catalog

10	KISTLER CERF, QUOTE AND JUSTIFICA...	File		Internal to Requisition	BKSMITH	17-May-2024	One-Time			
20	TECHNICAL SOLUTION DESCRIPTION.pdf	File		Internal to Requisition	BKSMITH	17-May-2024	One-Time			
30	ABOUT KISTLER.pdf	File		Internal to Requisition	BKSMITH	17-May-2024	One-Time			
40	WEIGHT IN MOTION.pdf	File		Internal to Requisition	BKSMITH	17-May-2024	One-Time			

STATE OF RHODE ISLAND
Department of Transportation
DIVISION OF FINANCIAL MANAGEMENT

CRITICAL EXPENSE REQUEST FORM

(To Be Completed by Financial Management)

5/17/24

DATE: 25 Apr 2024

REQUEST INFORMATION

AMOUNT: $2,759,199.00

MPA#: _____ **IT Request:** ☐

PROJECT # (if applicable): 2024-CB-012

MPA CONTRACT#: _____

AWARD # (FAP) if applicable: BHO-0700(008)

REQUESTING SECTION

AWARD # (FAP) if applicable: _____

DESCRIPTION OF CRITICAL REQUEST

Description of Critical Request:

This request is for a weigh in motion station and structural health instrumentation monitoring on the Washington bridge #200 (eastbound). The system will monitor live traffic vehicle weights, monitor live bridge conditions and reactions, and integrate the data from both systems to determine the condition of and impacts to the bridge. The system will also allow direct enforcement of overweight and speeding vehicles by State Police.

Reason/Justification of Critical Need:

The eastbound Washington Bridge has become considerably more sensitive since the closing of the westbound bridge. Ensuring the structural integrity of the bridge as well as identifying and removing overweight vehicles from the bridge is integral to ensuring the safety of the traveling public. The systems will provide data which will allow us to analyze the bridge in ways previously unavailable and understand in real time what vehicles are actually crossing the bridge and the impacts they have.

Contact/Requestor: John Preiss (Print Name) — John W. Preiss Digitally signed by John W. Preiss Date: 2024.04.26 08:18:47 -04'00' (Signature) — PHONE No: 401-563-4105

Division Administrator: Robert Roach Jr (Print Name) — _____ Division Administrator Signature — PHONE No: _____

IT TSM Administrator: Keith Graham — _____ Signature — PHONE No: 563-4329

IT AIM Administrator: Tom Lewandowski — _____ Signature — PHONE No: 563-4086

IT Chief: _____ — _____ Signature

IT Finance: _____ — _____ Signature

Agency CFO: _____

CFO Signature: _____

AGENCY DIRECTOR: Peter Alviti, Jr. PE DEPARTMENT OF TRANSPORTATION — Loren Doyle DOT DIRECTORS SIGNATURE (or Designee)

Revised Date 7/13/2022

Non-Competitive Bid Request
Sole Source Justification Form

State of Rhode Island, Department of Administration
Division of Purchases
One Capitol Hill, Providence Rhode Island, 02908
www.purchasing.ri.gov (401) 584-8100

Good or Service: Both
Requesting Agency: RIDOT

Proposed Vendor: Kistler & subs
Requisition No:

1. Is this the **only** product/service that can meet the agency's needs? ☒

2. How was it determined that this vendor is the only supplier of this product or service?
RIDOT Bridge Engineering has been researching and investigating weigh in motion (WIM) and structural health instrumentation monitoring(ShiM) equipment as technology improves. There are options for the equipment for each piece, but Kistler is the only company found who successfully integrates the systems, with their sensors, to work together and give a complete overview, analysis and live monitoring of a structures condition based on the live traffic conditions. We have had meetings with other companies in the industry, none of which provide the combined analysis we are pursuing.

3. Why the price is considered reasonable?
1. The type of sensors and technology integration for the WIM are more accurate, reliable, durable and enforcable than the current piezo sensor systems we use. The additional costs reflect this better lifespan, performance & integration.
2. The integrity of bridge 200, Washington Bridge EB, is crucial to the state and all of its residents, economy, commerce, etc.
3. The data collected will give us information and insight never before seen in RI. Live analysis of the traffic crossing the bridge and the actual impacts to the bridge will help to build better, safer and more efficient structures.
4. Live data will allow targeted enforcement and potentially automated enforcement making police efforts much more efficient and keeping the structure safe and sound.

4. What efforts were made to get the best possible price for the taxpayers?
RIDOT has worked with the supplier (Kistler) and negotiated a reduced cost for all the weigh-in-motion and structural health instrument monitoring sensors and equipment.

I certify that the above statements are true and complete to the best of my knowledge.

John Preiss — Requestor Name
State Bridge Engineer — Title
4/26/2024 — Date

Approved by:

☐ _____ Buyer — _____ Date

☐ _____ Chief Buyer — _____ Date

revised: August 12, 2005
pursuant to Rhode Island General Laws § 37-2-21

posted at: http://www.purchasing.ri.gov/agency/forms/solesource.doc

Non-Competitive Bid Request
Sole Source Justification Form

State of Rhode Island, Department of Administration
Division of Purchases
One Capitol Hill, Providence Rhode Island, 02908
www.purchasing.ri.gov (401) 584-8100

☐ _____ _____
Administrator Date

☐ _____ _____
Purchasing Agent Date

KISTLER

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Quotation

Customer
Rhode Island Department of
Transportation
Two Capitol Hill
Providence RI 02903
United States

Information

Document Number	**20522298**
Document Date	05/03/2024
Customer No.	5012222
Validity end date	05/31/2024
Administrator	James Thomas Kirkpatrick III
email	jt.kirkpatrick@kistler.com

Reference No.	
Date	
Payment terms	45 days net
Terms of delivery	FCA, Incoterms 2020 NOVI, MI
Shipping terms	Courier standard

THANK YOU FOR YOUR INTEREST IN KISTLER INFRASTRUCTURE SOLUTIONS -- WE ARE PLEASED TO PRESENT YOU WITH THIS OFFER.

THIS QUOTE IS SUBJECT TO DETAILS DEFINED IN:
1) PROJECT DESCRIPTION, SCOPE OF WORK, BILLS OF MATERIAL AND SERVICES, RESPONSIBILITIES, WARRANTIES, AND DISCLAIMERS DETAILED IN ATTACHED DOCUMENT "RIDOT WASH PROV RIVER PHASES 1 & 2 20240502.DOC".

2) PRICING DETAIL IN ATTACHED DOCUMENT "RIDOT PROJECT PRICING PHASES 1 & 2 20240502.PDF".

LEAD TIME: 8-12 WEEKS ARO PURCHASE ORDER FOR WIM; 12-24 WEEKS FOR SHM.

REMITTANCE SCHEDULE:
$1,763,117 FOR ALL HARDWARE AND YEAR 1 BRIDGE PERFORMANCE ANALYSIS SERVICES DUE UPON RECEIPT OF KISTLER ORDER CONFIRMATION.

$564,333 FOR WIM SITE SERVICES AND WARRANTY DUE UPON INSTALLATION OF WIM SITE, ESTIMATED JULY 31, 2024.

Quotation

$431,749 FOR SHM SITE SERVICES AND WARRANTY DUE UPON INSTALLATION OF WIM SITE, ESTIMATED OCTOBER 31, 2024.

FOR FURTHER INFORMATION PLEASE CONTACT YOUR SALES REPRESENTATIVE, OR:
CUSTOMER.CARE.US@KISTLER.COM

WE WOULD BE PLEASED TO RECEIVE YOUR ORDER. ALL PURCHASE ORDERS CAN BE SENT TO:
CUSTOMER.CARE.US@KISTLER.COM

HARDWARE WARRANTY:
2 YEAR AFTER INSTALLATION, DETAILED IN DOCUMENT CITED ABOVE.

PLEASE NOTE:
A 2% FEE WILL BE ADDED TO ALL ORDERS PAID BY AMERICAN EXPRESS.

Item	Material/Description	Origin	Quantity	Price USD	Amount USD
100	18042880	CH	1 PC	2,759,199.00	2,759,199.00
	WIM + SHM solution for RIDOT Wash.Bridge Phase 1 & 2: High-Speed Digital WIM system located on I195 between the Washington and Providence River Bridges, and SHM on the Washington Bridge, according to attached detail project description and scope of work. Phases 3 (Providence River Bridge) and 4 (Enforcement Custom Solutions and Enhancements) to be quoted separately.				
	Total amount USD:				2,759,199.00

Credit payment terms subject to credit approval.

Important Information:
Delivery times are subject to final clarification of all details of material procurement: Due to worldwide supply bottlenecks and delivery delays for electronic components and raw materials, deadlines may be postponed at any time and at short notice. Affected customers will be informed immediately.

Our General Terms of Delivery are valid for this and all our other purchase contracts which are available to our contracting parties on https://www.kistler.com/US/en/gtc or which will be sent to them free of charge upon request. Calibration acceptance criteria is based on published product specifications, excluding calibration uncertainty. You can find instruction manuals online at www.kistler.com.

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Project Offer

Rhode Island - Providence

Weigh in Motion System

May 3, 2024

Nr.	Position	Unit	Amount	Total USD
1	**Digital Weigh in Motion System**			**$ 415,300**
	KiTraffic Digital IPC with TDA Software	pieces	2	
	KiTraffic Digital 24-Port Switch	pieces	2	
	KiTraffic Digital 24-Port Switch - Extension	pieces	2	
	Router	pieces	2	
	Induction Loop Card	pieces	3	
	Remote Relay	pieces	3	
	Lineas Digital Sensor 9181, 1.75m, 90m cable	pieces	32	
	Lineas Digital Sensor 9181, 2.00m, 90m cable	pieces	8	
	Grouting Compound, Standard	pieces	60	
	Lineas Digital WIM Installation Tool Kit	pieces	1	
	Automated Tire Screening License	pieces	1	
2	**License Plate Recognition / Overview Cameras**			**$ 101,636**
	LPR camera (1 per lane)	pieces	10	
	DOT camera (1 for 2 lanes)	pieces	5	
	Overview camera (only livestream)	pieces	2	
	Standard mounting bracket	pieces	17	
	LPR software license	device	17	
3	**Enforcement Software**			**$ 222,222**
	Kistler DataMatcher Software	pieces	1	
	Kistler WebCheckpoint (Live UI)	licences	1	
4	**Electronics / Cabinet**			**$ 26,667**
	WIM Backpanel (w. clamps, cable, fuses and power)	pieces	2	
5	**Kistler Services**			**$ 38,611**
	Project management	days	5	
	Sensor installation certification training (for 2 people)	piece	1	
	Site assessment	piece	1	
	System commissioning & deployment	days	5	
	Calibration support (no vehicles or drivers included)	days	6	
6	**Road Work Services**			**$ -**
7	**Electrical Services**			**$ 24,000**
	Camera installation & commissioning	pieces	1	
8	**Warranty Extension**			**$ 52,333**
	Warranty extension on all hardware	years	2	
9	**Software Maintenance & Hotline Support**			**$ 214,389**
	Software maintenance & availability	years	5	
	Hotline support	hours	80	
10	**Travel Costs**			**$ 12,778**
	WIM Total			**$ 1,107,936**

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Project Offer

Rhode Island - Providence

Structural Health Monitoring Washington Bridge

May 3, 2024

Nr.	Position	Unit	Amount	Total USD
1	**Structual Health Monitoring - Software and DAQ**			**$ 272,488**
	SHM Controller with Software (Edge)	pieces	1	
	Cloud Computing SHM software (yearly license)	years	5	
	KiDAQ Controller	pieces	4	
	KiDAQ Analog module (for accelerometers)	pieces	15	
	KiDAQ Analog module (for temperature)	pieces	4	
	KiDAQ Analog module (for strain transducers)	pieces	13	
	12-port PTP/POE switch	pieces	4	
2	**Structual Health Monitoring - Dynamic Monitoring Sensors**			**$ 243,560**
	1-axis accelerometer	pieces	118	
	1-axis box	pieces	58	
	2-axis box	pieces	30	
	Cables for accelerometer box	pieces	88	
	Mounting kit for accelerometer box	pieces	88	
3	**Structual Health Monitoring - Static Monitoring Sensors**			**$ 213,609**
	Temperature sensor	pieces	14	
	Cable for temperature sensor	pieces	14	
	Strain transducer incl. 100m sensor cable	pieces	92	
	Mounting-kit for strain transducer (2 tabs per sensors)	pieces	184	
	Weather station	pieces	1	
4	**License Plate Recognition / Overview Cameras**			**$ 87,751**
	LPR camera (1 per lane)	pieces	12	
	Overview camera (only livestream)	pieces	4	
	Standard mounting bracket	pieces	16	
	LPR software license	device	16	
5	**Backpanel & Accesories**			**$ 63,000**
	SHM backpanel (w. clamps, cable, fuses and power)	pieces	4	
6	**Project Management & Installation Support Services**			**$ 62,222**
	Project management	days	10	
	Sensor installation training & supervision	days	15	
	System commissioning & deployment	days	10	
7	**Electrical Services**			**$ 28,000**
	Camera installation oversight & commissioning	pieces	1	
8	**Bridge Performance Assessment & Long Term Monitoring Services**			**$ 578,578**
	Bridge Assessment & Monitoring as defined in solution description	pieces	1	
9	**Warranty Extension**			**$ 67,333**
	Warranty extension on all hardware	years	2	
10	**Software Maintenance**			**$ -**
	Software maintenance & availability (included in SW license)	years	5	
11	**Travel Costs**			**$ 34,722**
	SHM Total			**$ 1,651,263**

FY24-1310

ROUTING SLIP

TO: Robert Roccio, PE, Chief Engineer

FROM: John Preiss, P.E., PMP, State Bridge Engineer

DATE: 25 April 2024

SUBJECT: Washington Bridge WIM, Bridge Condition Monitoring & integration $2,332,183.

*** **PLEASE ROUTE AS SHOWN BELOW** ***

ROUTING FOR APPROVAL

ROUTING FOR APPROVAL					
	NAME	**INITIALS**	**DATE**	**APPROVE**	**DISAPPROVE**
X	John Preiss, PE, PMP State Bridge Engineer	JPreiss	4/26/24	✓	
X	Robert Roccio, PE Chief Engineer	RC	4/26/24	✓	
X	Dawn Cruz Acting Chief Financial Officer	DC	4/29/24	–	
X	Loren Doyle Acting Chief Operating Officer	LD	5/1/24	✓	
	Return to: Finance For Processing				

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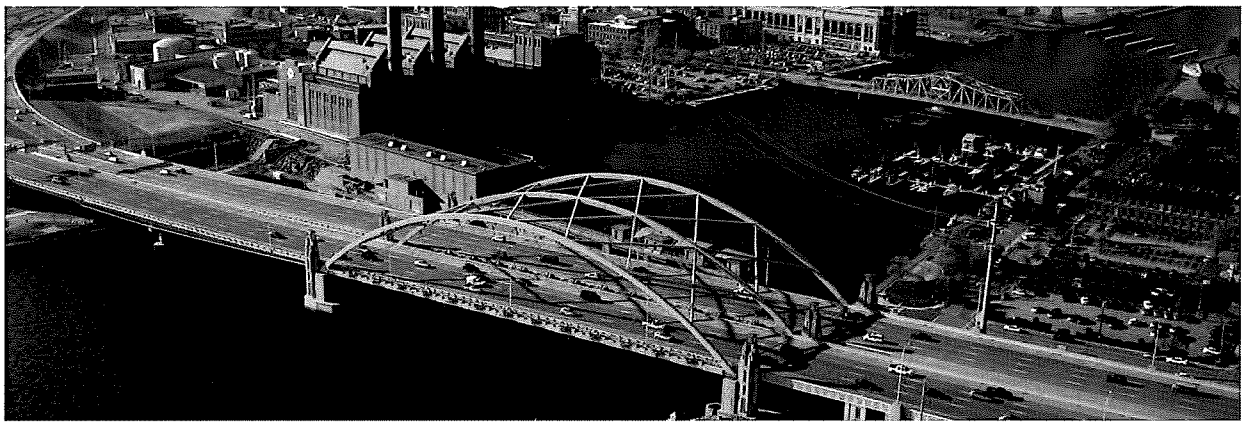
Technical Solution Description

Structural Health Monitoring &

Weigh-in-Motion Enforcement

Rhode Island DOT – Providence



Kistler Instrument Corp.
30280 Hudson Drive
Novi MI 48377
USA

info@kistler.com
www.kistler.com

Document Created	Document Released
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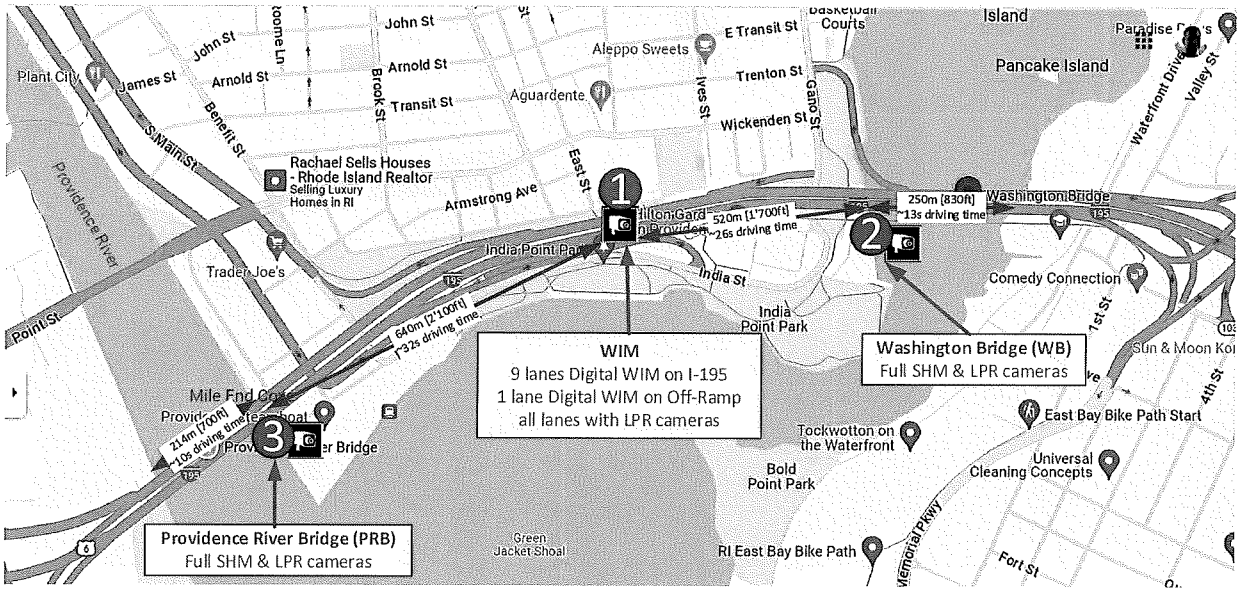
Content

1. Introduction

1.1 Project scope

Starting with the Washington Bridge (WB) and the Providence River Bridge (PRB), both in Providence, Rhode Island Department of Transportation (RIDOT) intends to begin a new state-wide Weigh-in-Motion (WIM) enforcement program. Each bridge has its unique situation and current struggles, so RIDOT desires full Structural Health Monitoring (SHM) instrumentation, diagnosis, and monitoring on each bridge. Due to the close proximity of these two bridges and the limited number of on- and off-ramps between, one major digital WIM system will provide load data for both bridges. Centrally located between the bridges, this single WIM site will be fully integrated into the SHM software systems of both bridges, providing RIDOT bridge engineers complete data for bridge analysis. To increase the service life of the bridges, RIDOT wants direct and virtual enforcement activated upon WIM installation (legislation for direct enforcement underway). Further, RIDOT requests Kistler to provide an annual 5-year Bridge Performance Assessment on each bridge.

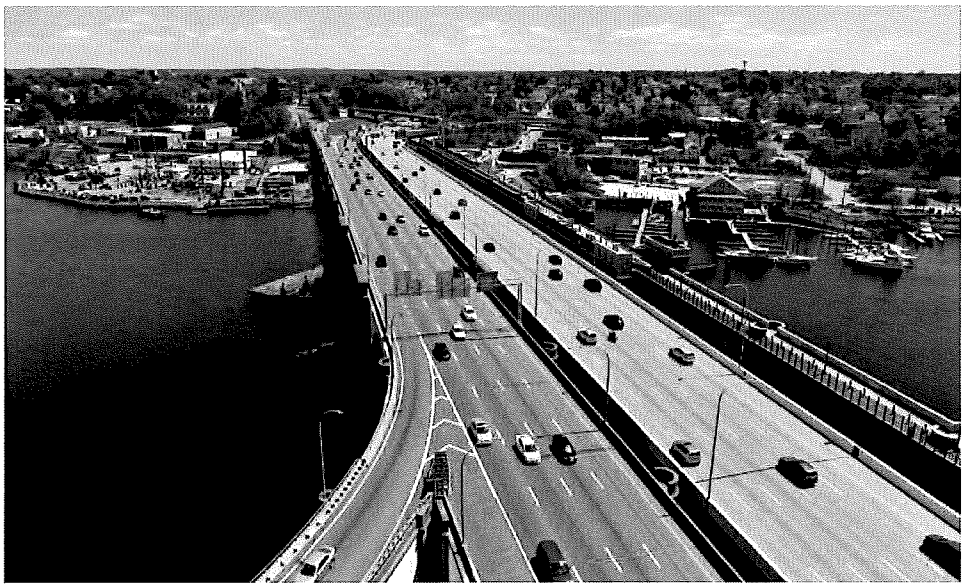


Map with locations for WIM (1) and for the SHM on Washington (2) Providence River (3) bridge

The project is divided into multiple phases. This offer tackles phase 1 and phase 2.

- Phase 1: WIM, License Plate Readers (LPR) at WIM site, and software with standard enforcement features
- Phase 2: SHM and Bridge Performance Assessment for Washington Bridge, LPR at entrance and exit of bridge, WIM integration into WB SHM

- Phase 3: SHM and Bridge Performance Assessment for Providence River Bridge, LPR at entrance and exit of bridge, WIM integration into PRB SHM
- Phase 4: Enforcement enhancements (bridge crossings / tracking of vehicles, lane violations, speed violations, tire screening, others to be defined)



Washington Bridge

Providence River Bridge

1.2 Customer information

Role	Staff
Company	Rhode Island Department of Transportation
Contact Person	John W. Preiss
Contact information	State Bridge Engineer Desk: (401) 563-4105 Cell: (401) 585-8616 john.preiss@dot.ri.gov

2. Key Requirements

The following requirements are the base for the further definition of the WIM & SHM solution:

Requirement	Value	Comment
Accuracy Gross Vehicle Weight (GVW)	± 6 %	ASTM Type III In case of stop-and-go or breaking/acceleration on the WIM sensors, the accuracy will drop. The off-ramp lane has a
Accuracy Axle Loads	± 15 %	
Speed range at the WIM site	20-80 mph	Traffic jams, walking speed, stop & go traffic will negatively affect the system performance
Confidence level weight	≥95%	of all detected vehicles, the GVW is measured within above stated accuracy range
Camera Detection Rate	≥95%	of all vehicles are successfully detected by the camera
Confidence level license plate read	≥90%	of the license plates of all detected vehicles are successfully processed through OCR and a text string is provided
Confidence level DOT number	NN	Due to multiple lanes each direction, and DOT #'s being on the sides of vehicles, the system will attempt to capture the DOT image but expects much interference with vehicles traveling in inner lanes.
Overall Vehicle detection rate of system	≥95%	of all vehicles that are "recognized" by the system, meaning that a reasonable, but not necessarily highly accurate value was

Requirement	Value	Comment
		provided.
SHM sensor data synchronization during data acquisition	microsecond milliseconds	All DAQ devices are capable of: Precision Time Protocol (PTP), and Network Time Precision (NTP).
Noise density of accelerometers (max. value)	0.007 $mg_{rms}/\sqrt{Hz}$	Low-frequency accelerometers with high precision to capture smallest amplitudes
Thermal stability of accelerometers (max. value)	±0.01 %/°C	High performance in extreme environmental conditions (-65 °F…260 °F)
Phase shift accelerometers (max. value) Range Degrees	 0…10 Hz 0…2	High accuracy for modal parameters extraction in operative conditions

3. Measurement Solution

3.1 Structural Health Monitoring (SHM) on Washington Bridge

This chapter describes the proposal for Structural Health Monitoring Services for the Washington Bridge for the Rhode Island Department of Transportation.

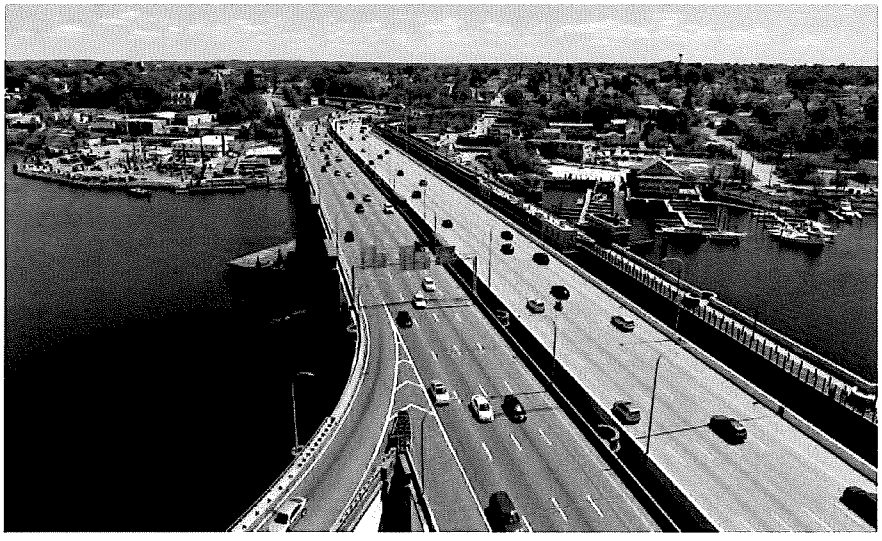
3.1.1 Introduction

The Washington Bridge has been identified as a structure in need of attention due to specific factors that require consideration to ensure its continued structural integrity. In addition to the aging of the structure the main driving factors are related to the increase of traffic conditions as described in chapter 3.1.2.

Kistler is specialized in providing advanced measuring solutions to evaluate and continuously monitor the structural performance of bridges.

This proposal aims to address the specific concerns by offering a complete static and dynamic characterization of the bridge structural behavior, with continuous collection of structural data, with correlation to the specific traffic loading passing over the bridge (SHM data correlated with WIM data) and to the environmental data (temperature and meteorological data).

The final product is aimed to provide RIDOT bridge engineers a complete sensor data stream on a dedicated dashboard with option for receiving automatic notification and alarms, when specific thresholds are surpassed, as well as regular reports that fully assess the specific bridge performance (see chapter 3.1.8 for specific details).



Washington Bridge (GPS: 41.81925724695367, -71.38656226982513)

3.1.2 Description of the Washington Bridge

The Washington Bridge consists of three different spans:

1. A pedestrian/bike path to the south, built in 1924 and preserved for its historical and aesthetic value (not in project scope);
2. A span to the north that previously carried four lanes of traffic (westward) and is currently undergoing demolition, targeted for completion in 2026 (not in project scope);
3. The middle bridge, originally built in the 1960s, originally designed for four lanes (eastward) but currently accommodating six lanes. This middle bridge is in the scope of this project.

The primary objective is performing load rating analysis of various structural members of the Washington Bridge utilizing site-specific live load data from Weigh-In-Motion (WIM), structural health monitoring (SHM) technologies, and refined analysis procedures. The monitoring program consists of a short-term monitoring phase to diagnose four spans in detail in combination with a long-term analysis phase to monitor and evaluate all spans (Bridge Performance Assessment).

3.1.3 Project Overview:

The proposed project duration is 5 years, with option for renewal. To ensure success, Kistler has enlisted a team of experts in the field of measuring technology and structural engineering and is also partnering with Advanced Engineering and Construction, LLC (AEC), the partners of which are world-renowned for bridge structural assessment. Dr. Hani Nassif is the principle driver of AEC, and he currently directs the "Bridge Resource Program (BRP)" sponsored by the New Jersey Department of Transportation (NJDOT) which aims to find practical solutions for design, evaluation, load rating, SHM, non-destructive testing (NDT), innovative materials, and emergency responses. To ensure cost-competitiveness and a thorough and successful analysis, Kistler may further enlist Bridge Diagnostics, Inc. (BDI) or Henningson, Durham, and Richardson, Inc. (HDR) to assist with the SHM process. With the advance approval of John Preiss, Kistler may enlist other structural engineering experts and/or companies to support the project..

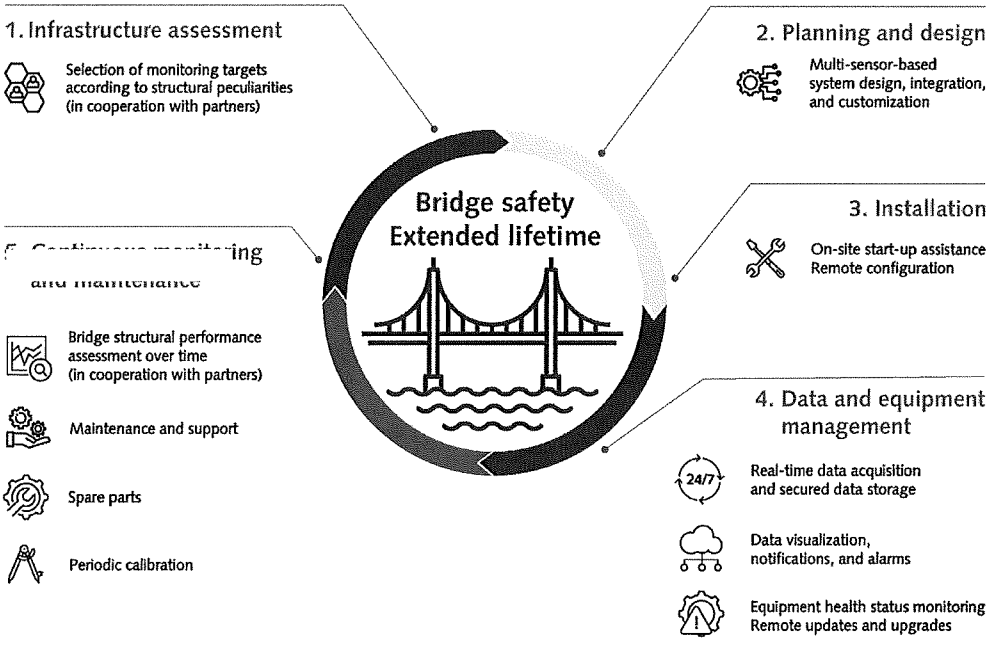
Kistler offers comprehensive services for the structural monitoring of bridges, supporting users and operators throughout all project phases and during the entire lifespan of the monitoring task.

The main 5 phases of Kistler's services (see also the picture below) are:

1. **Infrastructure Assessment**: Kistler starts by collecting customer requirements and defining project scopes. The monitoring targets are established based on an initial assessment of the infrastructure.
2. **Planning and Design**: Kistler's team designs and integrates a monitoring system tailored to the bridge's unique requirements. This includes selecting and integrating multiple sensors for both

static and dynamic monitoring, ensuring accurate and reliable data collection for comprehensive structural analysis.

3. **Installation**: Kistler provides on-site assistance during the installation process, ensuring a smooth and efficient setup. Our technicians guide users through the setup, calibration, and commissioning phases, ensuring the monitoring system is up and running quickly.
4. **Data and Equipment Management**: Kistler's solution includes services for real-time data acquisition with secure storage. Users benefit from customizable notifications and alarms that provide timely insights into the bridge's structural health. Continuous monitoring of overall functionality is performed, detecting and reporting any malfunctions. Remote updates and upgrades are easily implemented.
5. **Bridge Assessment & Continuous Monitoring**: Kistler collaborates with partners to provide continuous monitoring of the bridge's structural performance, in terms of Load Rating in alignment with ASHTTO guidelines. Maintenance and support services are offered to ensure a long-lasting operation of the SHM system.



Scope of services

The specific scope offered to RIDOT for the Washington bridge project is described in detail in the chapters below.

3.1.4 Phase 1: Infrastructure Assessment

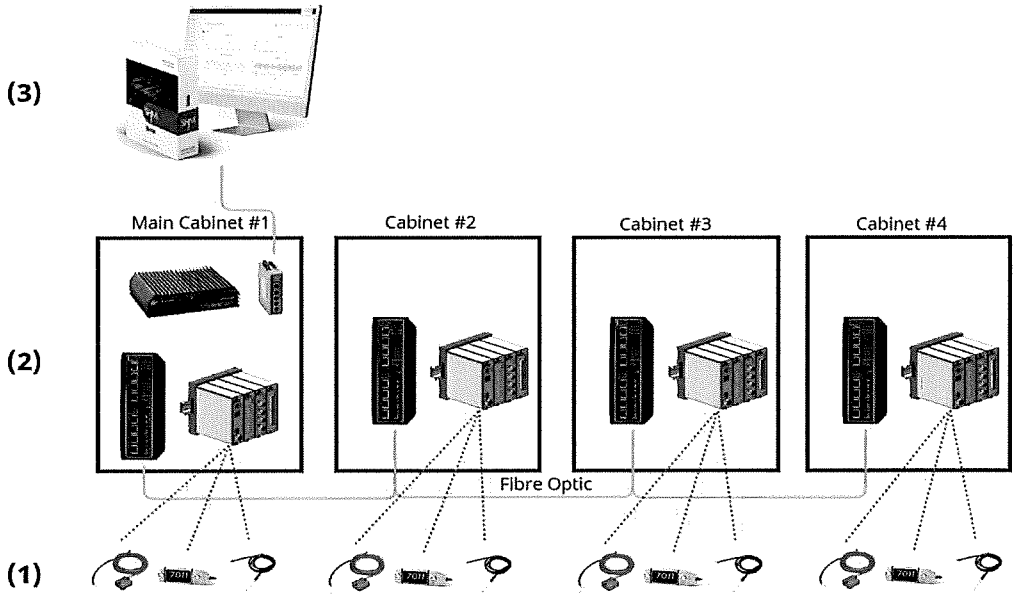
This phase involves an evaluation of the bridge design and current condition to develop the monitoring and analysis plan. The evaluation is based on information gathered during on-site visits to the bridge, by collecting customer requirements and by reviewing existing bridge documentation (e.g. annual inspection reports and on-site visual inspections and reports made by RIDOT bridge engineers).

This task provides various supports to develop the monitoring and analysis plan of the WB and to define the best selection and application of sensors and systems as described in next chapters.

3.1.5 Phase 2: Planning and Design

During this stage, a tailored SHM instrumentation plan is defined based on the findings from the infrastructure assessment (phase 1). Along RIDOT requirements and the monitoring objectives, appropriate sensor technologies are selected, and the optimal data acquisition system is designed.

The monitoring system developed by Kistler is built on a simple and efficient hardware architecture (see figure below). It is based on sensor clusters, consisting of both static and dynamic sensors, connected to a specific data acquisition unit placed into a protective cabinet. Each cluster is strategically positioned on different structural units (such as bridge spans). Different clusters are perfectly time synchronized and areconnected to a main edge computing device by mean of fiber optic cables. The data is then streamed from the edge device to the cloud-based SHM software platform which acts as user interface.

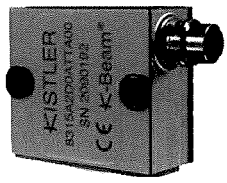


Architecture of Kistler SHM solution,
with sensor level (1), data acquisition level (2), cloud-based computing (3)

This architecture is scalable, can be extended, and guarantees reliable monitoring of infrastructure conditions.Three types of sensors will be employed and strategically placed in the main parts of the bridge as described in the chapters below.

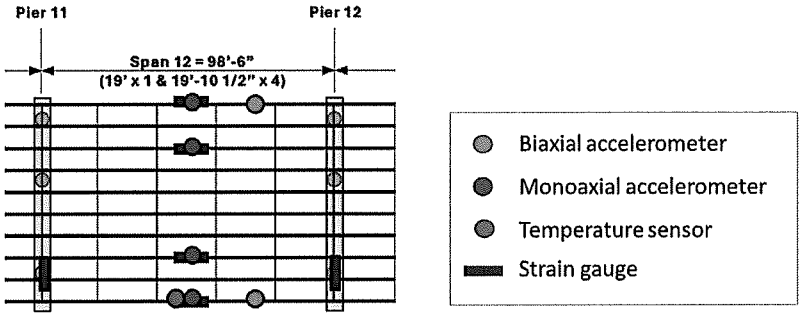
Dynamic monitoring – accelerometers:

The dynamic sensor setup for operational modal analysis of the bridge involves the use of **Kistler type 8316 K-Beam accelerometers**, known for their low noise levels, excellent thermal stability, and high phase accuracy.



Accelerometer capacitive K-Beam 8316

The instrumentation set-up consists in a combination of monoaxial accelerometers and biaxial accelerometers installed in the center of a span and respectively on the outer beams of a span as described below. The detailed instrumentation plan for the complete bridge is presented in chapter 3.1.6.



Details of instrumentation (span 12)

- **Center of span:**
  In the center of each span, 4 monoaxial accelerometers are positioned to measure vertical vibrations.

This setup captures the primary vertical modes of the bridge, providing valuable insights into its dynamic characteristics.

- **Outer beams:**
  2 biaxial accelerometers with vertical and horizontal components are utilized on each of the outer beams to characterize flexional, transverse, and torsional modes. This configuration allows for a comprehensive understanding of the structural behavior and response of the bridge in these critical areas with increased traffic loading.

By employing a combination of monoaxial and biaxial accelerometers, the monitoring system can capture a wide range of dynamic responses, providing valuable data for operational modal analysis and ensuring a comprehensive understanding of the bridge's structural dynamics.

The accelerometers are securely housed in ruggedized boxes to protect them from external elements. Each box is isolated from atmospheric agents and is specifically designed to be applied to the metal surface of the steel beams using an appropriate mounting kit.

Static monitoring - Strain Gauges:

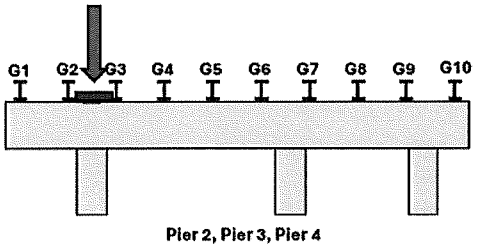
For the static measurements, strain gauges are used to measure the strain and deformation experienced by a material when subjected to external forces. The strain gauges needed for this application should have a measuring range (in strains) of 1'500 to 2000 με.

Strain gauge with range up to 2000 με.

The strain gauges come with an aluminum enclosure which is fully potted, making it resistant to harsh environmental conditions. Those static transducers are located into:

- **Deck:**
  The sensors are strategically placed within each span with special attention to the outer beams, which experience higher stresses due to increased vehicular traffic on the outer lanes. Specifically, each span will be monitored by 4 strain gauges, divided into two sets of two (with exception of span 1 to 4, which have more instrumentation, to support building up a reliable bridge model).
  This arrangement allows for comprehensive monitoring of the structural response to varying load conditions.

- **Pillars:**
  Several vertical structural elements are characterized by significant overhangs. To assess their integrity and evaluate potential torsional phenomena affecting the deck and potential settlement due to foundation mechanisms, a sensor will be placed at the support location of each pillar.



Bridge pier with overhang

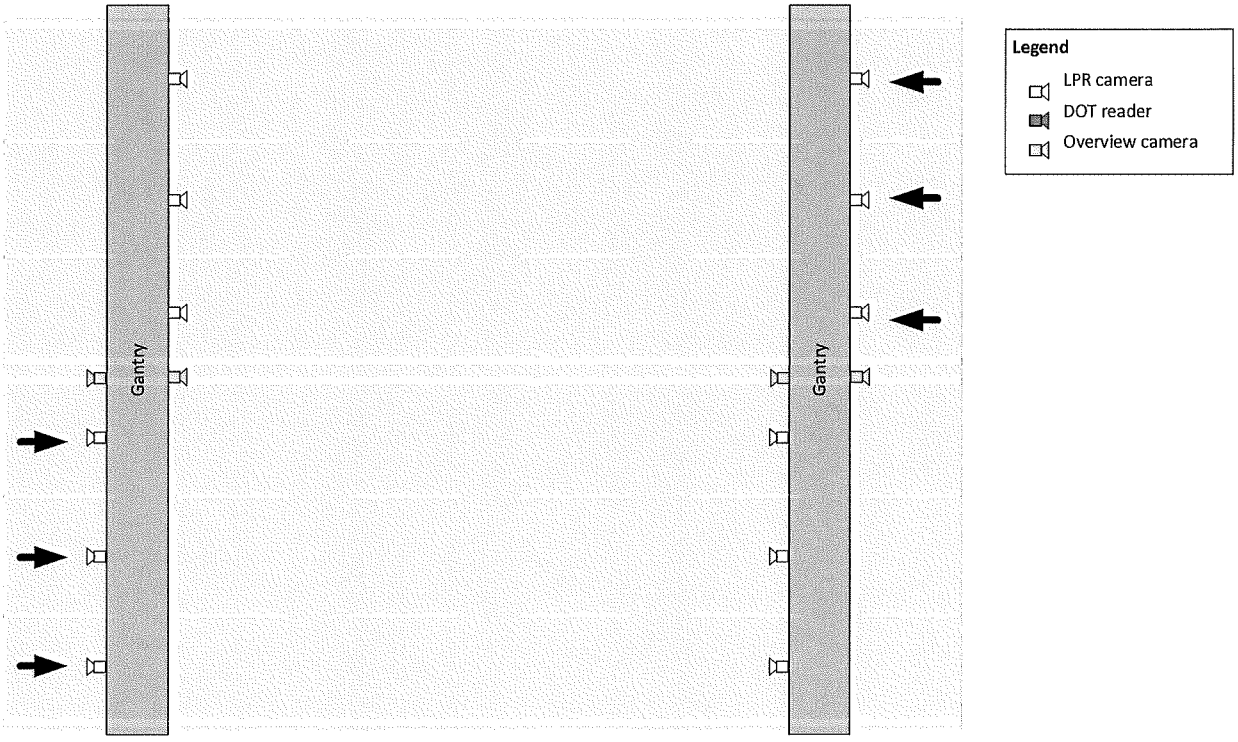
Weigh in Motion system for traffic load data

The bridge performance assessment will combine the structural resistance model with the site-specific live load. In other words, the bridge SHM will be combined with the traffic load data coming from the WIM site.

The KiTraffic Digital WIM system will collect real-time traffic data, in particular weight (axle and wheel loads, gross weight), speed, class, and license plate. More detailed description related to the WIM system is reported in chapter 3.2.

This WIM system is not installed in immediate proximity of the bridge, but approx. 1'700 ft westward, as shown on the map in chapter 1.1. To ensure synchronization of the traffic load data with the bridge SHM data, the bridge will be instrumented with cameras, reading license plates from traffic on all lanes and all directions. One camera per lane will be used at the bridge entrance and the bridge exit (in phase 4, these cameras will also enable vehicle lane detection and enforcement options). The SHM software will then match the readings from the cameras with the traffic load information from the WIM. The result of this combination is a comprehensive understanding of the traffic load on the bridge, with its distribution along the bridge and along the lanes in real-time.

By correlating the data from the KiTraffic Digital WIM system and the integrated cameras on the bridge, the SHM system will be able to monitor and analyze traffic flow and load distribution in real-time, providing a complete understanding of the bridge's usage and performance.



Camera installation layout Washington Bridge

Weather monitoring - temperature sensors and meteorological station:

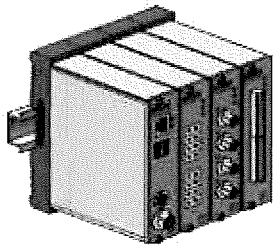
Temperature sensors are strategically placed all along the bridge. As illustrated in the instrumentation plan, there is one temperature sensor per span alternately placed on the outer beams, ensuring full coverage. The temperature data collected by these sensors helps in understanding the thermal behavior of the bridge, which can have significant implications for the structural integrity. Temperature changes can cause expansion or contraction of materials, leading to stress and potential damage.

A weather station will further capture overall temperature and other weather information such as wind speed, wind direction, and humidity. Wind poses additional loads to the structure which might induce vibrations and stress on the bridge components. By monitoring wind conditions, engineers can identify further potential risks.

Ideally, the weather station is positioned at the center of the bridge, laterally on the deck. This location ensures that the station captures accurate and representative meteorological data specific to the bridge's environment, enabling analysts to understand the bridge's performance under different weather conditions.

Data acquisition system

The main function of the data acquisition system is to collect and digitize signals from various sensor sources. The system converts analog signals into digital format for further processing and analysis by a computer with dedicated software. Kistler's data acquisition system called KiDAQ is a unique integrated data acquisition system, highly modular and easily customizable to monitor any type of bridge with any type of sensor technology. KiDAQ ensures high data quality thanks to high resolution, high sampling rates and precise data synchronization. Our KiDAQ data acquisition system features a modular design that gives flexibility to expand the solution. Multiple KiDAQ units can be deployed and daisy-chained along the bridge to build a highly reliable distributed system.

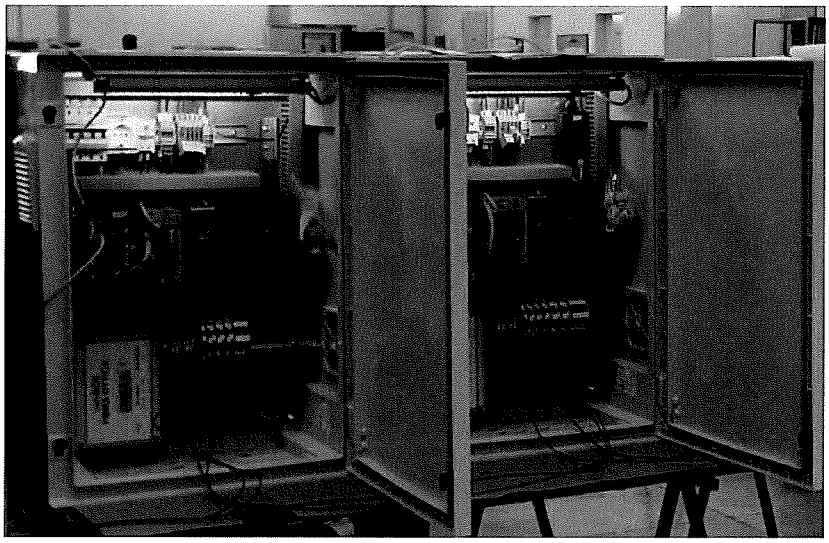


Data acquisition system KiDAQ

For this application, 4 KiDAQ are employed (one in each cabinet) to acquire the sensor signals installed over the full bridge length, ensuring a robust and perfectly synchronized dataset.

Additional components

The full solution also includes cabinets acting as protective enclosure for the electronic equipment on the roadside. All necessary electronics are mounted in 4 roadside cabinets (with KiDAQ, switch, router, power supplies, clamps, ...). One of the cabinets serves as the master cabinet and provides the industrial PC with cloud connector and as storage database unit. The cabinet housings are provided by RIDOT (via Arden Engineering).



Example of SHM electronics in roadside cabinet

Network

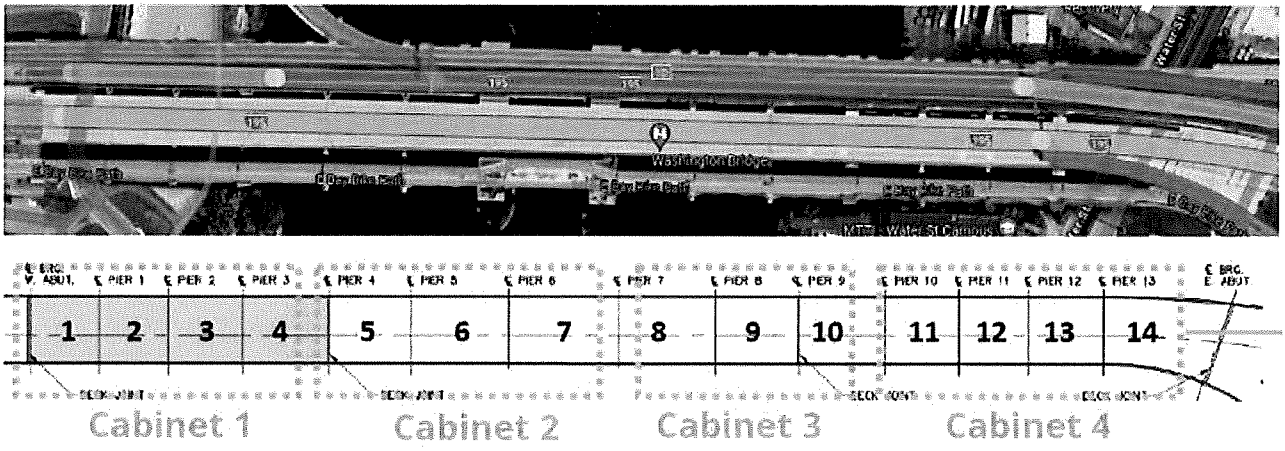
The whole measurement solution acts within a closed network connected by fiber between cabinets. The connection to the cloud is provided via LTE network and SIM card installed in the main cabinet together with the industrial PC. There will be also a link between WIM and SHM systems provided by LTE.

3.1.6 Phase 3: Instrumentation plan and installation

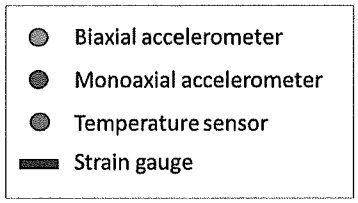
In this phase, the installation company directly contracted by RIDOT, Arden Engineering, will install the sensors and monitoring equipment on the bridge, specifically they will (i) mount strain sensors, accelerometers and temperature sensors to the bridge deck and pillars, with the help of a mounting kit, (ii) pull the cables from the sensors to the different electric cabinets, with appropriate cable conduits, (iii) install the cabinets and wire all cables, (iv) install cabinet and meteorological station to the pillar on the road side, and finally (v) provide power as well as internet communication to the cabinets.

Kistler, with support of AEC or other bridge experts mentioned herein, will be responsible for performing on-site verification and support during the installation to ensure that the installation specifications are met.

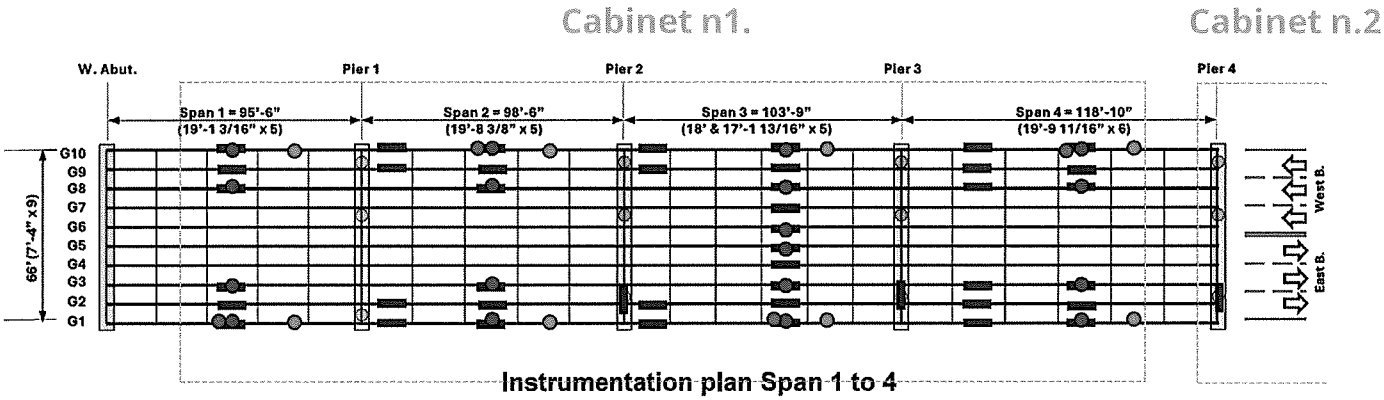
The instrumentation plan is illustrated in following five pictures.



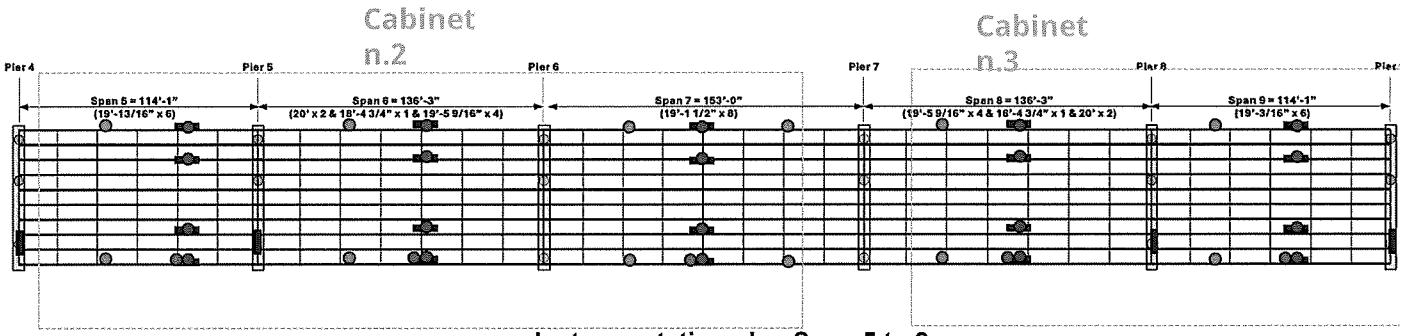
Washington bridge with all spans instrumented (1-14) and 4 cabinets for electronics.



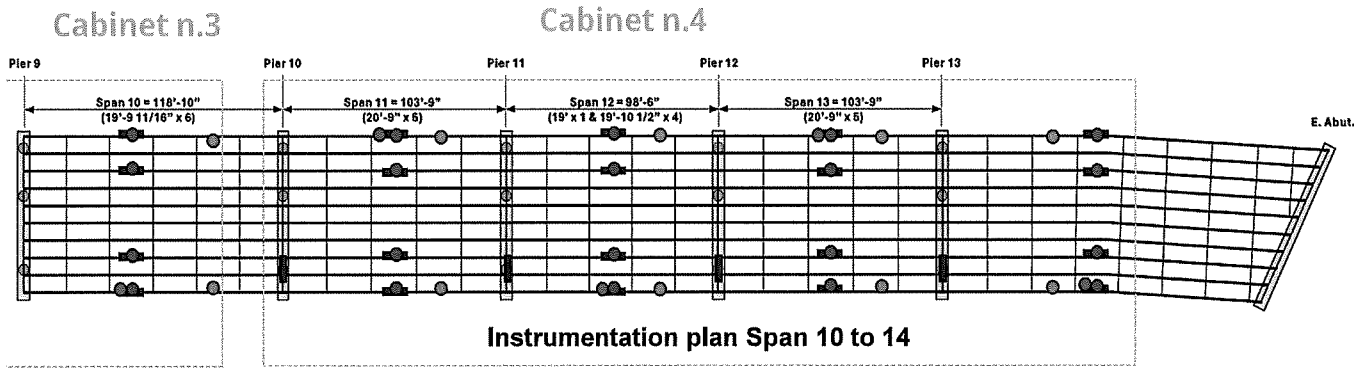
Type of sensors deployed to the 14 spans



Instrumentation plan Span 1 to 4



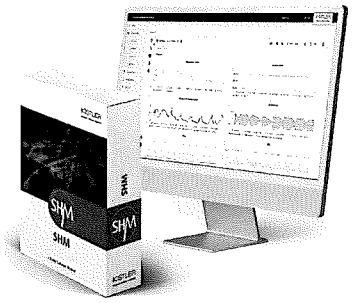
Instrumentation plan Span 5 to 9



Instrumentation plan Span 10 to 14

3.1.7 Phase 4: Data Management

Kistler will provide a robust data collection and data management system to handle the vast amount of information generated by the bridge instrumentation. Our SHM software is a comprehensive cloud-based platform that enables multiple functions such as distributed data acquisition, storage, structuring, visualization, indexing, and analysis.



SHM software - a comprehensive cloud-based platform

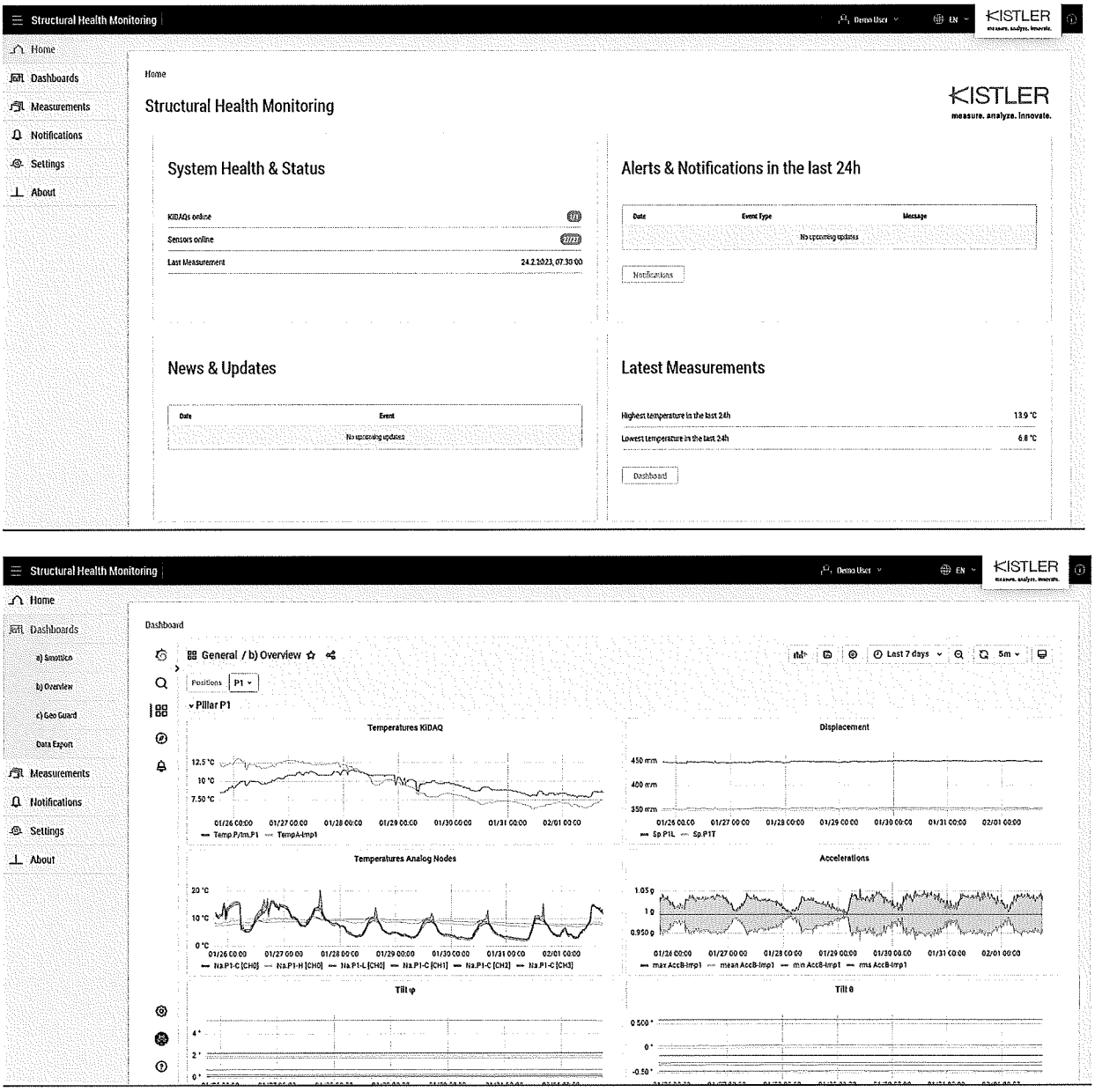
The software for Structural Health Monitoring (SHM) offers a range of functions and benefits summarized below:

- **Access rights and security**
  The software provides a web-based interface, which enables remote access to the bridge data very easily and from any location. This feature provides flexibility and convenience for different teams and stakeholders.
  Access rights can be managed and users defined. The software incorporates a granular OAuth 2.0-based access management system, offering full control over user access levels and permissions that will be defined by RIDOT.

- **Measurements data storage and visualization**
  The software ensures data availability by buffering all measured data on the edge PC. Only relevant data is then uploaded to the cloud, optimizing storage and bandwidth usage. The data is continuously aggregated and visualized on an intuitive cloud dashboard.

- **Notifications**
  Users are promptly notified whenever an event occurs on the structure, based on pre-set triggers. Users stay informed regardless of their location and can filter notifications to receive only relevant ones. Notifications and events can be defined based on sensor values and system status.

- **System status**
  The software includes continuous monitoring of all sensors and devices for abnormal behavior. Defects and anomalies are identified and flagged, making it easy to locate them on the bridge.
- **Setting and configuration**
  The system is fully configurable from the cloud, with remote control on the systems like the data acquisition and edge computers. SW updates can also be applied remotely to ensure the system is always up to date and secure. The configuration and updates will be managed by Kistler.



Examples of SHM dashboards

3.1.8 Phase 5: Bridge Performance Assessment and continuous monitoring

The primary objective is to evaluate the bridge capacity of the Washington Bridge using site-specific loads from the WIM system and structural responses from the SHM system, and to perform load rating calculations for the bridge over a span of 5 years.

An initial intensive monitoring phase will focus on diagnostics through in-situ testing using the SHM and WIM technologies described earlier. The on-site diagnostic test results are used to calibrate and validate the computational models with advanced structural analysis. This phase specifically applies to four spans. From this phase, a load rating analysis will be generated for the four spans. The results obtained from this analysis sets the base for an extensive long-term monitoring plan to be implemented throughout the entire bridge, with the load rating estimation for the whole structure over 5 years.

The detailed procedure is described below:

1. The first step consists in **creating, calibrating, and validating the structural model** with dedicated simulation software using on-site investigations and data collected from the SHM system, from calibration trucks and from the WIM system. Four spans are intensively instrumented and tested with several trucks with known weights.

2. The second step is based on **advanced structural analysis to estimate the Load Rating of various structural members**, initially focused on four spans.
   A load rating analysis of various structural members for various scenarios and future traffic trends will be performed. This includes the development of a site-specific resistance model based on the SHM and diagnostic test with advanced analysis procedure.
   The results will be detailed in a report (Load rating report) for RIDOT.
   The following analyses will be conducted:
   - Analysis of *Girder Distribution Factor* (GDF) for all through girders using SHM and diagnostic test data, compared to AASHTO Manual for Bridge Evaluation (MBE).
     Note: the GDF is a coefficient used to determine the distribution of loads among multiple girders in a bridge based on their stiffness and location.
   - Evaluation of *Dynamic Amplification Factor* (DAF) using SHM and diagnostic test data, compared to AASHTO Manual for Bridge Evaluation (MBE).
     Note: the DAF represents the amplification of dynamic loads on the bridge compared to static loads.
   - Estimation of *bridge capacity* using SHM and diagnostic test data.
   - Development of a *site-specific live load (from WIM) and resistance model.*
   - Analysis of *various load scenario* using the calibrated advanced analysis approach.

3. The third step consist in defining **trigger levels** on selected sensor channels based on the SHM model, diagnostic test and load rating performed earlier. The triggers will be configured into the software. Automatic notification will be sent to RIDOT when trigger levels are exceeded. Trigger levels will be updated after routine load rating and analysis are performed every year, or on an as-needed basis.

4. The fourth and last step involves utilizing the results and models gained from the previous phases specifically focused on the four spans initially analyzed, to the rest of the bridge. Analyses and calculations performed in steps two and three to determine the **load rating** and **trigger levels** will be expanded to cover the **entire bridge (all spans) and performed on an annual basis** (year 2 to 5). The results will be detailed in a report (Load rating report) on an annual basis.

Technical and forensic engineering support (remote or on-site) during the monitoring period is not included and can be provided on an as-needed basis.

3.2 Weigh in Motion (WIM)

3.2.1 Introduction

A major single WIM site shall be installed on the highway connecting the two bridges (I195). The intention is to use this WIM site for direct and virtual enforcement purposes. When the WIM system finds that a vehicle has exceeded the weight parameters (the percentage parameters for this can be configured), it will gather all the camera information, combine that with the full WIM record, and populate a restricted database "in the cloud" – called the "Red Flag Database" (RFD).

This single WIM site can further provide load data for both bridges (Providence River Bridge and Washington Bridge), yet vehicles entering the roadway via an on-ramp between the bridges, or exiting via an off-ramp between the bridges, should be accounted for.

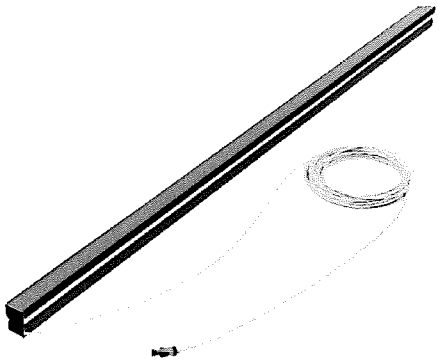
The WIM software provides following information:

- Gross vehicle weight
- Axle loads
- Vehicle speed
- Vehicle classification acc. FHWA
- Single / dual tire detection
- Advanced Automated Tire Screening
- License plate picture & read (string)
- DOT image (if possible – note earlier comment re. difficulties with multi-lane sites)
- Overview picture

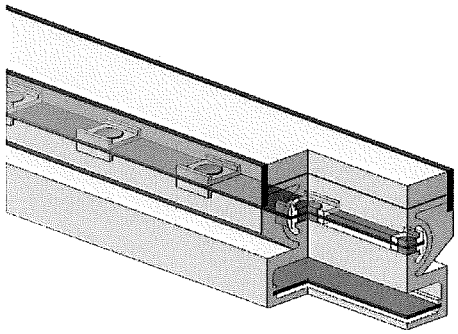
The system is fully scalable if more traffic lanes shall be added later. Furthermore, the electronics can be fully recommissioned if the road is re-paved or otherwise restructured and new sensors installed.

3.2.2 Digital WIM sensors

The new Lineas Digital WIM sensor is the core element of the WIM enforcement system. It contains quartz disc elements which provide an electrical signal proportional to the load on the sensor. These signals are digitized directly inside the WIM sensors, thus allowing calibration and compensation of the output of each single quartz disc along the whole sensor. This sensor design is based on Kistler's experience in Weigh in Motion of more than 25 years.

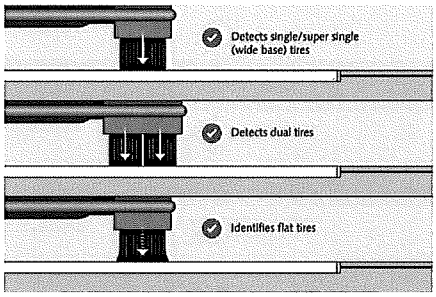


Lineas Digital WIM Sensor



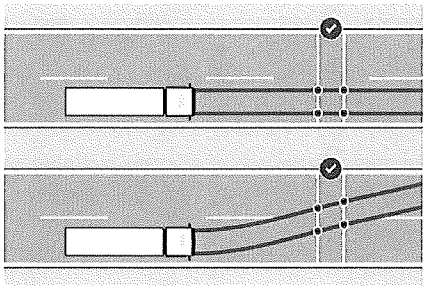
Lineas Digital – drawing with quartz disc

Other than the force measuring elements, Lineas Digital contains many additional sensing elements which provide additional information of each passing vehicle. These sensing elements are used for vehicle presence detection, sensor health monitoring or improving the weighing accuracy. This makes Lineas Digital world's most advanced and accurate WIM sensors.



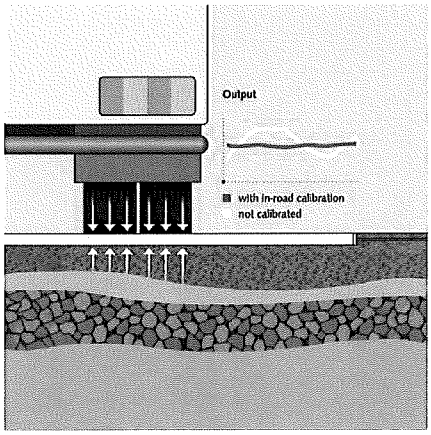
Automated tire screening

- Delivers tire type information (dual/single) and detects underinflated or flat tires
- Enables tire screening with no need for additional software or tilted sensors



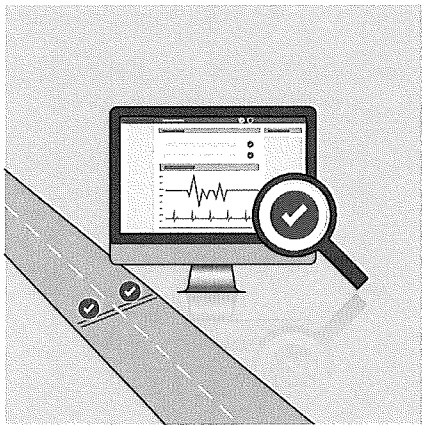
Interlane driving

- Delivers correct weight measurements and reliable data – even when vehicles switch lanes at high speeds.



Smart road calibration

- Each quartz crystal within a Lineas Digital WIM sensor is calibrated separately thus compensating for the influence of varying road substructure properties across the lane. The availability of this dynamic calibration along the length of the sensor helps guarantee highly accurate results in all driving positions.

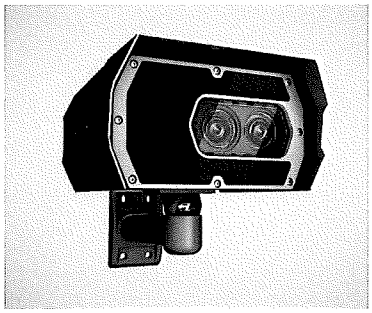


System status monitoring

- Continuous health status monitoring assures users that the system is consistently operational.
- Early detection of potential issues minimizes disruptions to operation

3.2.3 Camera system

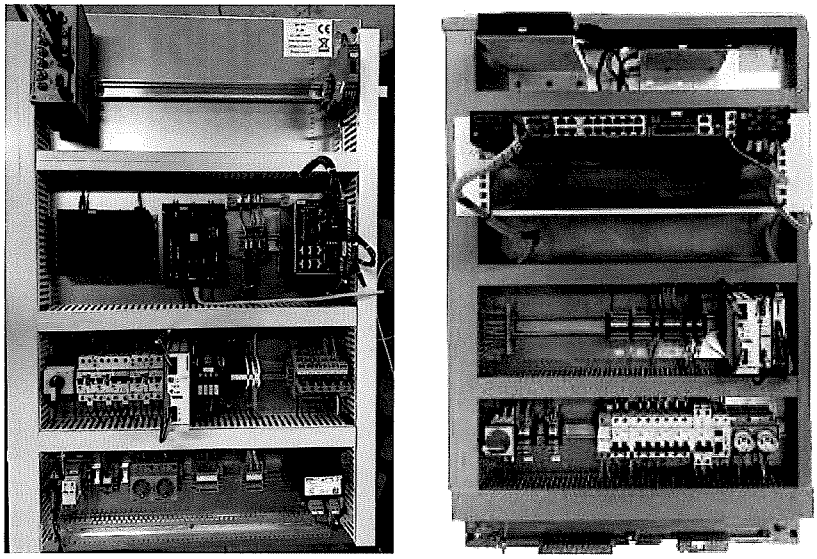
The camera system is capturing the license plate number (the image and converted to text), front image, side image (for DOT number identification), a short video clip of the vehicle passing over the site and will provide an overall overview camera for a live view in each direction.



ANPR camera

3.2.4 Electronics & Cabinets

All necessary electronics are mounted in two roadside cabinets (industrial PC, switch, router, power supplies, etc.). One cabinet serves as the master cabinet and provides the industrial PC with the enforcement software and a storage in a database. The cabinet housings are provided by RIDOT via Arden Engineering.



Example of WIM electronics in roadside cabinet

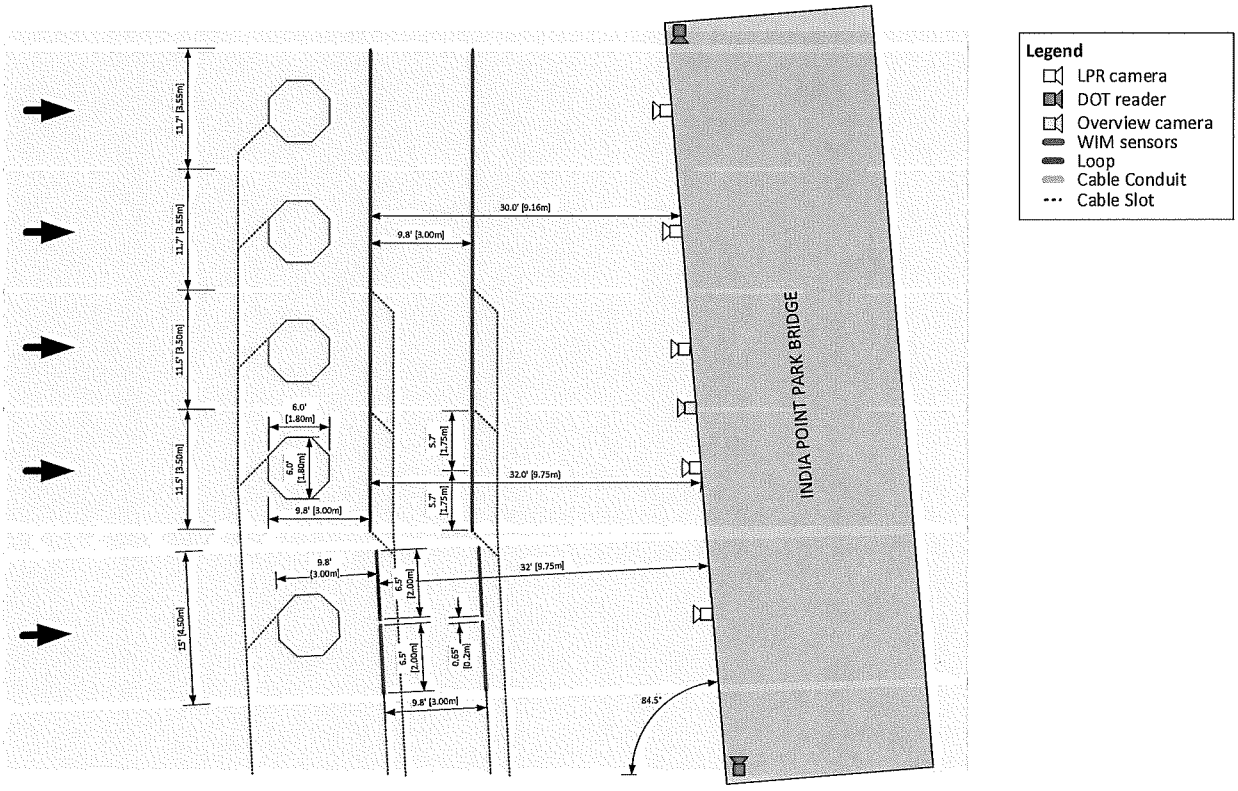
3.2.5 Network

The whole measurement solution acts within a closed network provided by the router in the roadside cabinet. The two cabinets are connected via fiber provided by RIDOT. From the router in the main cabinet there is a connection to a 4G modem (also supplied by RIDOT) to make the enforcement software and WIM data available to RIDOT. This 4G modem also ensures remote access for Kistler service engineering during commissioning and troubleshooting.

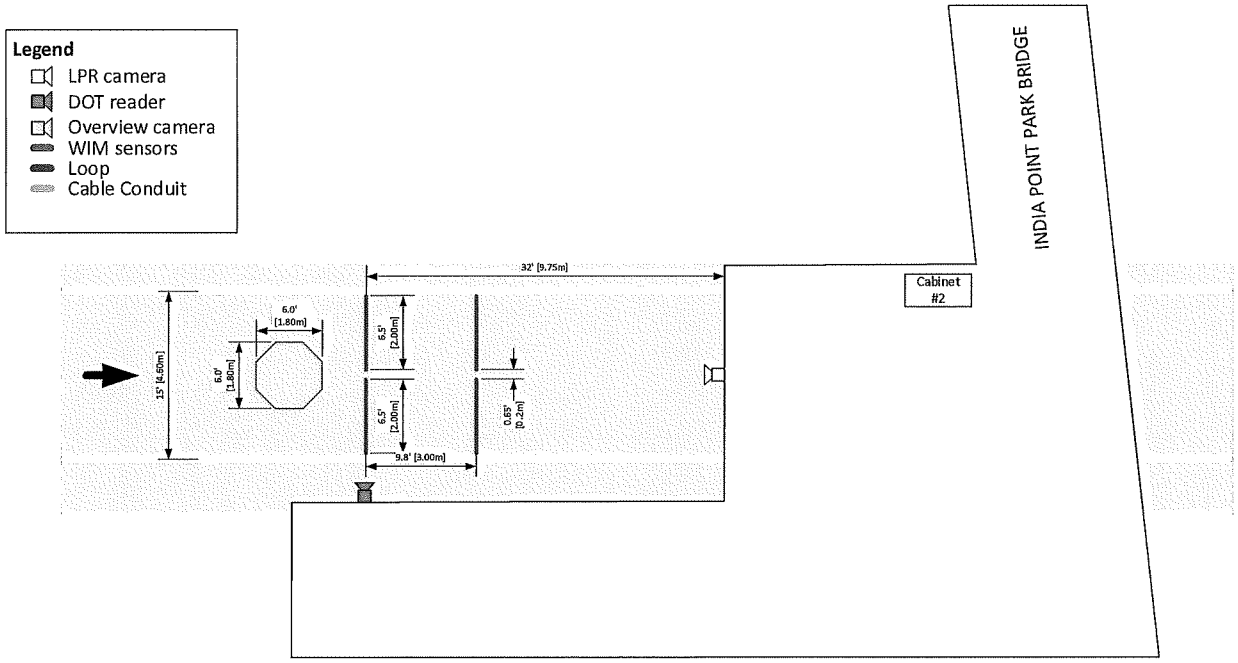
3.2.6 Description of the WIM installation

System Information	Value	Comment
Number of lanes	10	
Directions	2	
WIM Layout	double array with 1 loop per lane	
Features	Gross Vehicle Weight Axle Loads Vehicle Speed Axle counting & axle spacing Vehicle Classification acc. FHWA Single / Dual Tire Detection Automated Tire Screening	

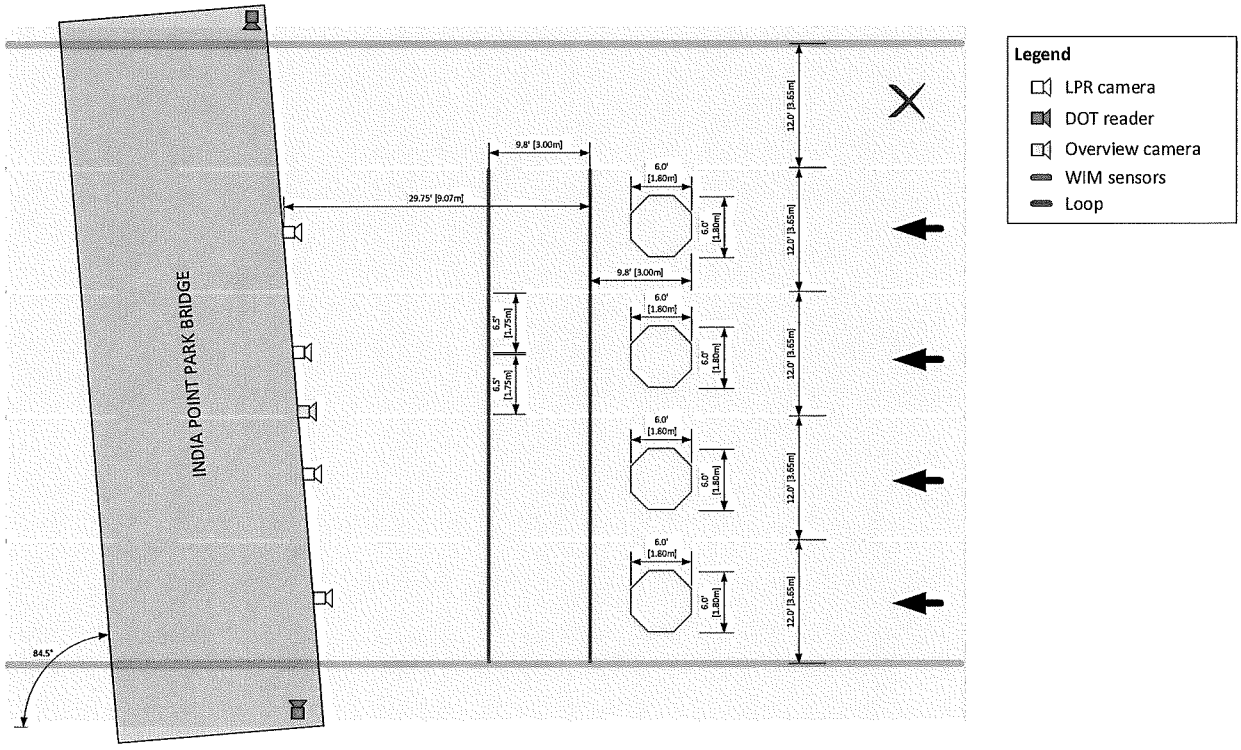
WIM site overview



WIM layout eastbound (final cable routing to be rechecked)



WIM layout offramp eastbound (final cable routing to be rechecked)



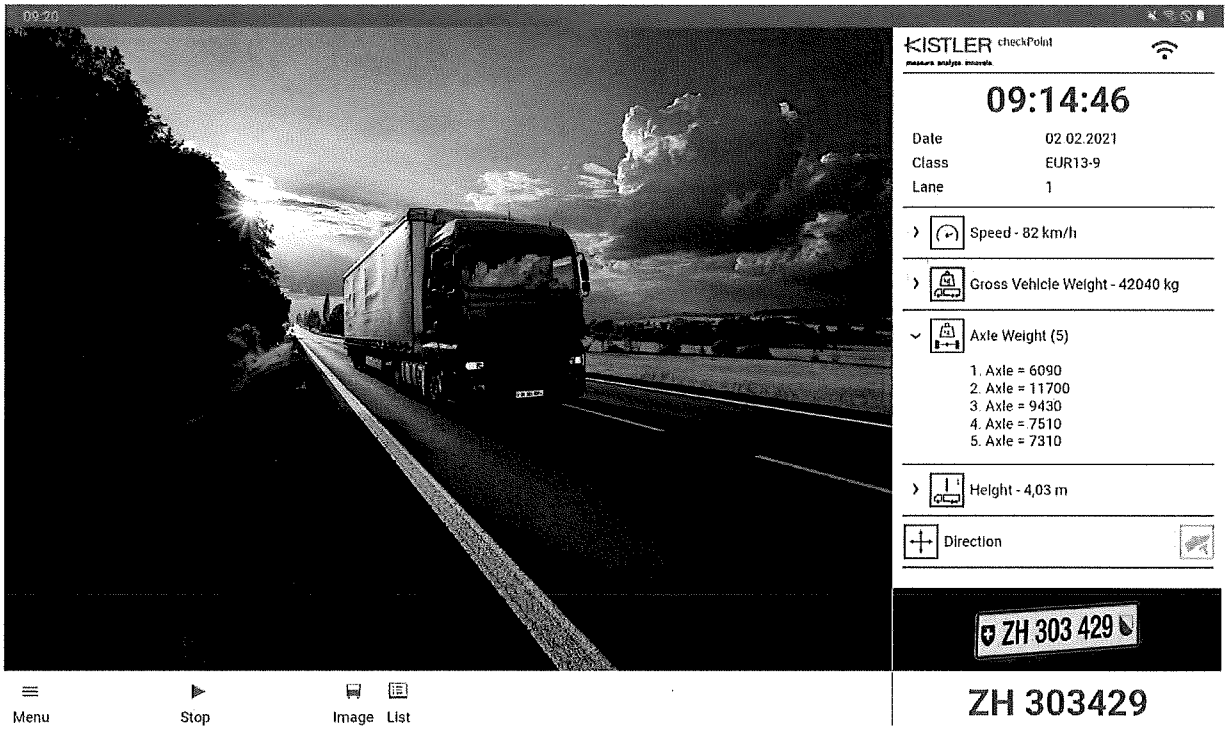
WIM layout westbound (final cable routing to be rechecked)

3.2.7 Enforcement software user interface

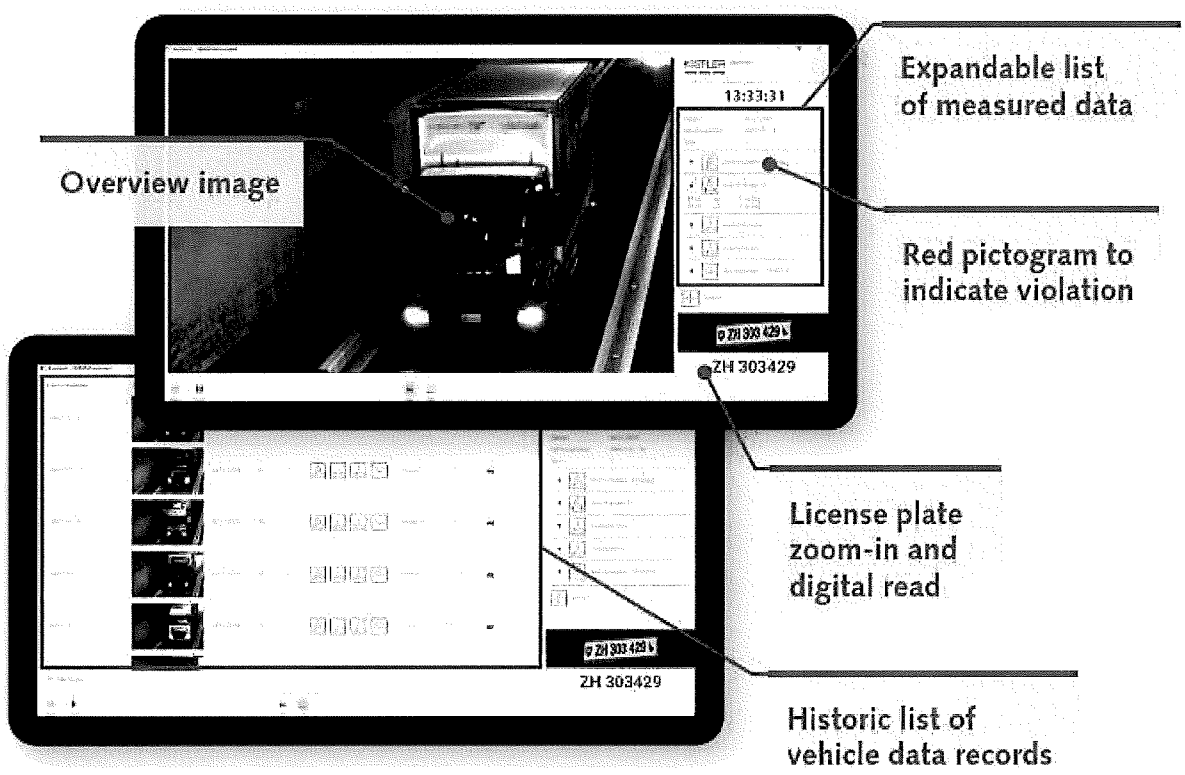
The Kistler WebCheckpoint is a browser-based user interface offering a live view of all vehicles passing the WIM site. Following data is shown to the user:

- Overview picture (color)
- Zoomed in picture of license plate
- License plate read as text
- Date & Time
- Vehicle class
- Measurement data (gross vehicle weight, axle loads, speed, tire status, etc.)

All violation limits can be defined in the settings (i.e., weight limit per vehicle class). In case a threshold is surpassed, the WebCheckpoint shows a red pictogram indicating that a violation was recognized.



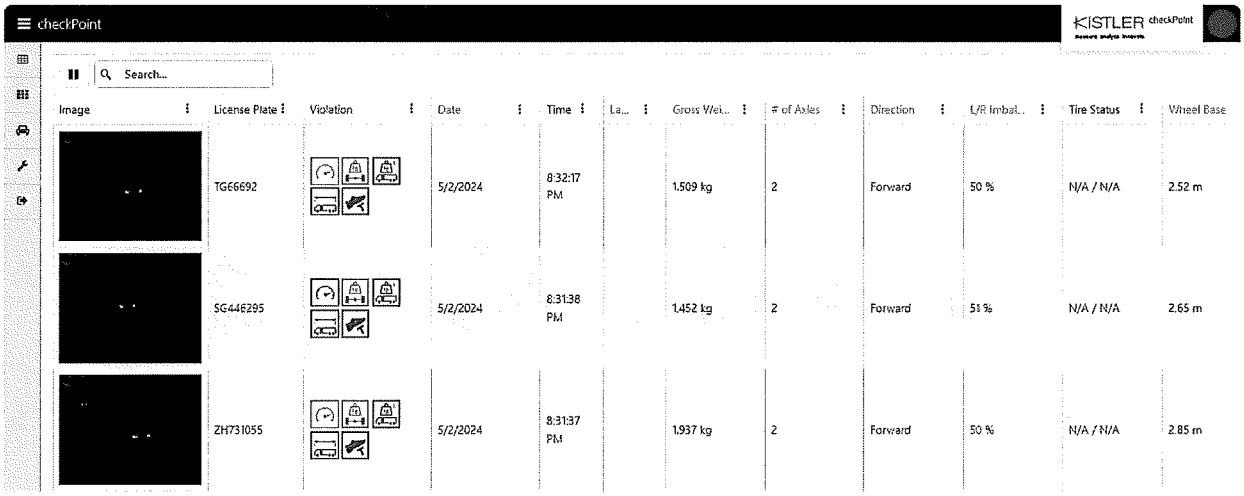
Kistler WebCheckpoint



Kistler WebCheckpoint

The user can easily switch between different screens.

- **Live detail view**
  - picture of truck is maximized.
  - all measurements for this specific truck are shown.
- **Live list view**
  - a list of all recently passed trucks is shown.
  - the list refreshes automatically when a new truck is driving over the WIM site.
- **Live enforcement view**
  - the four most recent trucks are shown with measurement details.



Kistler WebCheckpoint – List View

Kistler WebCheckpoint – Enforcement View

3.2.8 Red Flag Database (RFD)

The RFD will contain not ALL vehicle records, but only those fitting the definition of "overweight" thus worthy of potential ticketing. When records are added to the RFD, multiple enforcement options begin. The system is designed as a "hybrid" to provide a full spectrum of enforcement options.

3.2.8.1 Option 1: Virtual Enforcement

Virtual Enforcement is "virtual" in the sense that the WIM data is not used directly to ticket, but the data is sent to an enforcement officer staged downstream who may then visually identify, pull over, and inspect the vehicle using traditional methods. This physical inspection can be used to ticket the owner, not only for weight but for other violations found as well. When the WIM system finds an overweight vehicle and populates the RFD as described, officers staged down the road will see the new record on their laptops / tablets already installed in their cruiser. The system is browser-based, so no special software installation is required, and it is accessible under your existing network and machine security measures. As the RFD is populated with new records, the visual and detail data records appear sequentially on the officer's computer – they make the choice which vehicle to pursue and inspect.

3.2.8.2 Option 2: Direct Enforcement with WARNING LETTER

RFD is designed in a way such that anyone that was granted access may see the data. Retention is also a parameter that can be set. In this case, RIDOT may establish a department / function (or even outsource the operation) to take the RFD records, identify the vehicle owner via license plate lookup from the Federal database, and send a warning letter to the owner which could contain the vehicle image, the offending weight data, any other data that might want to be included, and a letter warning the owner of their violation.

3.2.8.1 Option 3: Direct Enforcement with TICKETING

Opposed to Virtual Enforcement, Direct Enforcement is using the WIM data to send a ticket directly to the offending vehicle owner without a physical inspection or enforcement officer. Direct Enforcement is available from the system in the same way as Option 2 – yet rather than sending a Warning Letter, an actual Ticket is sent. This option requires appropriate legislation, and a collection process is further required. However, the efficiency and effectiveness of Direct Enforcement, Ticketing is not only outstanding, but logical and practical.

Kistler does not currently provide back-office processing software for Option 2 and 3. However, the RFD is designed in a way to be open and accessible for any kind of back-office software. Further, phase 4 of this project may include a 3rd party backoffice processing solution.

4. Service Offerings

4.1 Project Management

Project Management includes all coordination and management efforts from Kistler from project initialization until successful hand-over to RIDOT.

Included activities:

- Project planning (time schedule, system design and scope, cost controlling)
- Gathering of requirements for potential customizations
- Coordination of purchasing, assembly & testing
- Shipping of components and solutions to customer
- Coordination of service activities
- Transparent and regular communication to RIDOT and sub-suppliers

4.2 System Installation (on-site)

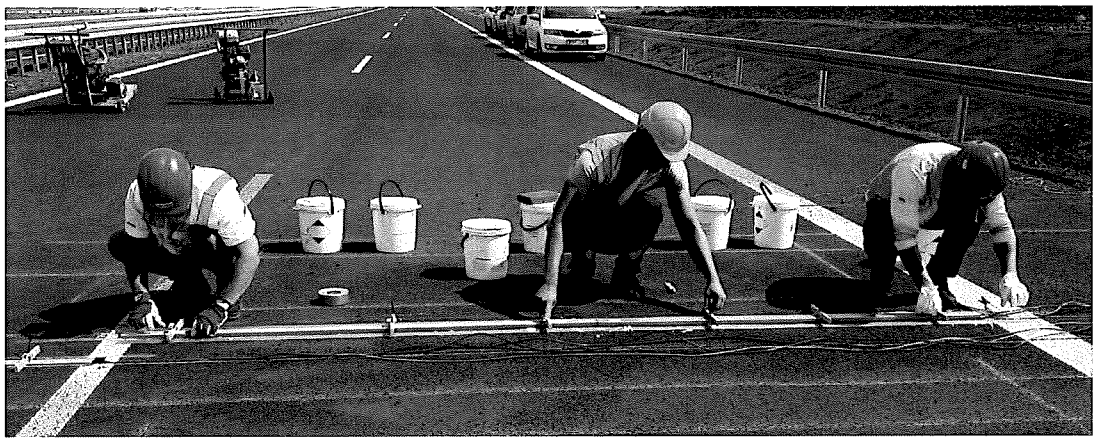
Kistler Service Engineers will supervise the installation works of all core components of the SHM and WIM solution. RIDOT will provide specialized workers to perform all installation works, includingthe installation of (i) bridge SHM sensors, (ii) Lineas WIM sensors and the induction loops, (iii) field devices like cameras, (iv) cabling, (v) cabinets, (vi) power and electrical connections into the cabinet and to the gantries, etc.

Included Activities:

- Supervision of SHM bridge sensors installation
- Supervision of Lineas WIM sensor and inductive loops installation
- Supervision of field device installations (cameras, etc.) on gantries or poles
- Supervision of backpanel and cabinet installation
- Supervision of electrical connection installation

Not included:

- Provision of skilled workforce to execute the installation steps mentioned above.
- Provision of workforce to execute further tasks (road closures, fundaments, pulling cables & conduits)
- Provision of tools and working materials for tasks not performed by Kistler



Installation of Lineas sensors in the road

4.3 System Commissioning (on-site)

After installing all hardware on the bridge and on the road, the cabinet and gantry, a Kistler Service Engineer will commission and configure all subsystems of the SHM and of the WIM solution and will ensure that the system provides accurate data.

Included Activities:

- Supervision of cabling all field devices
- Measurement of exact distances between all field devices and corresponding region of interests
- Configuration of all field devices
- Configuration of software
- In-field testing of the SHM and WIM solution

4.4 System Calibration & Verification (remote / on-site)

The calibration support is intended to support RIDOT in defining the best calibration strategy and supervise the execution of the calibration on-site.

Included Activities WIM calibration:

- Support during the preparation of calibration campaign with definition of suitable calibration procedure and selection of right calibration vehicles
- Support during execution of calibration & verification (cross-check calibration results, calculate calibration factors, etc.)
- On-site presence of Kistler Service Engineer.

Included Activities SHM calibration:

- The bridge model requires calibration to be performed by positioning test vehicles on the bridge on specific locations temporarily with closed traffic. Kistler will perform the calibration, while the client will provide the test vehicles (and drivers) of a known static weight.

4.5 End User Training

Kistler will train RIDOT in handling the Kistler SHM Software and the WIM WebCheckpoint, to understand the basic principles and the general functionality of the installed SHM and WIM enforcement solution. The training is carried out by a Kistler expert on RIDOT's premises.

4.6 Warranty Extension

The standard warranty period for all WIM Equipment is 12 months. The warranty starts from the date of installation. In addition to the standard warranty of 12 months, Kistler has offered the option to purchase a warranty extension of 24 months. The Kistler terms & conditions for warranty apply.

4.7 Software availability & hotline support

Kistler will maintain and update all installed software components over the duration of 5 years. The updates will be provided via remote access. During the update periods, the system might not be available to RIDOT. The timeframes for updates will be closely aligned and communicated with RIDOT.

The software maintenance will guarantee that the software continues to work with high reliability and is available to RIDOT for use. In case of troubles or questions, RIDOT can reach out to the Kistler service hotline during office hours.

5. Scope of delivery

5.1 In Scope of Kistler responsibility

Following components, information and activities are in responsibility of Kistler:

No	Element	Supplier
01	Hardware components according to bill of materials (Appendix B and C)	Kistler Instrument Corporation
02	Software and/or software licenses according to bill of materials (Appendix B and C)	Kistler Instrument Corporation
03	Service efforts according to bill of materials (Appendix B and C)	Kistler Instrument Corporation

5.2 Out of Scope of Kistler responsibility

Following items are not included in the offer and are not delivered by Kistler.

No	Element	Comments
01	WIM site installation efforts (sensors, loops, cabling, conduit, cabinets, related electronics, road closure management, site cleanup and recommissioning, etc.).	Kistler is providing certification for RIDOT installation contractors, and is providing site project management.
02	Structural Health Monitoring system installation efforts (sensors, cabling, conduit, cabinets, related electronics, lane closures as required, site cleanup and recommissioning, etc.).	Kistler is providing oversight assistance for RIDOT installation contractors, and is providing site project management.

5.3 In Scope of the responsibility of RIDOT

Following components, information and activities are in responsibility of RIDOT:

No	Subject	Comments
01	Approve precise installation location defined by Kistler and verify road quality for WIM site.	WIM site general location is agreed (India Point Park pedestrian bridge over I195). RIDOT will pave and define lanes prior to WIM installation and ensure road quality.
02	Organization, execution, and recommissioning of lane closures as required for installation of both WIM and Bridge sensors, cameras, cabinets, cabling, calibration, etc.	With planning and on-site project management from Kistler per services defined.
03	Installation of the WIM sensors including preparation of wiring of sensor cables to the cabinet.	With on-site support and training by Kistler.
04	Install the WIM roadside cabinets (incl. foundations).	Locations agreed during Kistler site assessment, April 2024.
05	Electrical installation of WIM cabinet (including provision and installation of power and ethernet connection and related cabling) and mounting of the backpanel into the cabinet. Provision and installation of fiber optic connection between the 2 WIM cabinets.	Kistler will pre-load the backpanel prior to installation.
06	Execution of the WIM site calibration and the acceptance testing, including procurement of test vehicles with known static weight, and drivers, with road closure during calibration.	With planning and on-site support from Kistler per services defined.
07	Gantry for installation of LPR cameras for WIM site and for Bridge entrances and exits, including necessary cabling and conduit (if required) for powering and communicating with the cameras	
08	Permanent remote access to the systems for Kistler for project management, for system configuration, for	

No	Subject	Comments
	assistance and remote support. The SHM cloud-based software requires a permanent remote access to the edge devices.	
09	Installation of Bridge sensors, cabinets, cable conduits and cabling, power requirements, etc. in accordance with the accepted Bridge Instrumentation Plan.	With on-site support and training by Kistler.
10	Electrical installation of SHM cabinets (including provision of power and ethernet connection and related cabling) and mounting of the backpanel into the cabinet. Provision and installation of fiber optic connection between the 4 SHM cabinets.	
11	Provision of test vehicles (and drivers) with known static weight on the bridge (with road closure), for the bridge SHM model calibration.	

6. Demarcations

No	Delimitation
01	Warranty period on all hardware is extended to 24 months in this quotation. Kistler warranty does not apply to damages caused by non-Kistler personnel during installation or otherwise handling of hardware.
02	If RIDOT cancels this order, Kistler reserves the right to recover its incurred costs up to the date of cancellation. Such costs include, but are not limited to, expenses for raw materials purchased for the order, overhead applied to manufacturing, any work in process, and any services performed related to this order. The Customer agrees to pay these costs upon receipt of Kistler's invoice detailing the charges.
03	To reach the accuracy targets (defined in the requirements) it is necessary that the road meets the requirements for an enforcement site in accordance with the Kistler White Paper "Influence of road properties". Worse road conditions have a negative impact to the accuracy. Kistler Structural Road Analysis Service will help to assess road properties prior to installation.
04	Actual WIM site, lane definitions, and traffic pattern conditions at time of installation may affect performance aspects defined in this offer. Certain digressions from earlier site observations and related assumptions made to prepare this offer may require revisions to the offer.
05	The location of the cabinet and poles, as well as the cable routing to the cabinet is not yet precisely defined for the WIM site. We assumed a close and direct wiring from sensors and cameras to the cabinet for the calculation of the cable length. In case of another position, some additional cost can occur for longer cables. The cable length of the quoted sensors is 90 meters.
06	In case RIDOT wants to change agreed requirements or add new requirements, Kistler will analyze the impact on the original pricing. If a price revision is necessary, Kistler will provide an updated Technical Solution Description and corresponding financial offer to RIDOT.
07	The Bridge Performance Assessment represents an expert opinion derived from a reasonable sampling of data from various sensors, obtained within a defined timeframe. During this period, the bridges were subject to varying loads that were random and uncontrollable. The loads and conditions observed during the evaluation may differ significantly from those experienced at other times. Furthermore, the bridges may be subjected to unforeseen events such as earthquakes, severe weather, or other force majeure occurrences that could affect their structural integrity.

No	Delimitation
	Structural deficiencies may only become apparent under specific conditions or combinations of circumstances. Given these limitations, Kistler cannot be held liable for any bridge failures or structural issues that may occur before, during, or after the Bridge Performance Assessment. This disclaimer includes any damages or losses resulting from factors beyond our control, unexpected events, or conditions not present or detected during the evaluation.
08	Kistler's role in providing the Bridge Performance Assessment is limited to the scope of work described in this agreement. Responsibility for the performance, load rating, structural integrity, maintenance, and safety of the bridge remains solely with RIDOT. Kistler does not assume any liability for these aspects of the bridge's operation and condition. While our Bridge Performance Assessment may identify issues or concerns, it is RIDOT's responsibility to take appropriate actions based on the findings and ensure compliance with all applicable safety regulations and standards. Kistler shall not be liable for any outcomes, incidents, or failures arising from the bridge's use, maintenance, or operation, as these are the sole responsibility of RIDOT.
09	Kistler's Bridge Performance Assessment evaluation does not constitute a guarantee or warranty of the bridge's performance, safety, or durability.
10	Kistler's Bridge Performance Assessment may use data or information from third-party sources, including previous reports, government records, or customer-provided materials. While we strive to ensure the accuracy and reliability of these sources, we cannot guarantee their completeness or correctness. Kistler shall not be liable for any issues arising from inaccuracies, omissions, or misrepresentations in third-party data.
11	Kistler's Bridge Performance Assessment provides a snapshot of the bridge's condition at the time of the evaluation. Regular maintenance, ongoing inspections, and further assessments are the sole responsibility of RIDOT or the bridge owner. Kistler's evaluation does not include ongoing maintenance recommendations or future inspection schedules. We encourage RIDOT to conduct regular maintenance and additional inspections as required to ensure the bridge's continued safety and performance.
12	To the fullest extent permitted by law, Kistler's liability arising from the Bridge Performance Assessment, whether in contract, tort, or otherwise, is limited to the total amount paid for the evaluation services. Under no circumstances shall Kistler be liable for any indirect, consequential, punitive, or special damages, including but not limited to lost profits, loss of use, business interruptions, physical injuries including death, even if advised of the possibility of such damages.

Appendix A: Document History

Version	Date	Description
V1.0	May 2, 2024	Initial version, pending review
V2.0	May 3, 2024	Final version

Appendix B: Bill of Material SHM solution

Nr.	Position	Unit	Amount
1	**Structual Health Monitoring - Software and DAQ**		
	SHM Controller with Software (Edge)	pieces	1
	Cloud Computing SHM software (yearly license)	years	5
	KiDAQ Controller	pieces	4
	KiDAQ Analog module (for accelerometers)	pieces	15
	KiDAQ Analog module (for temperature)	pieces	4
	KiDAQ Analog module (for strain transducers)	pieces	13
	12-port PTP/POE switch	pieces	4
2	**Structual Health Monitoring - Dynamic Monitoring Sensors**		
	1-axis accelerometer	pieces	118
	1-axis box	pieces	58
	2-axis box	pieces	30
	Cables for accelerometer box	pieces	88
	Mounting kit for accelerometer box	pieces	88
3	**Structual Health Monitoring - Static Monitoring Sensors**		
	Temperature sensor	pieces	14
	Cable for temperature sensor	pieces	14
	Strain transducer incl. 100m sensor cable	pieces	92
	Mounting-kit for strain transducer (2 tabs per sensors)	pieces	184
	Weather station	pieces	1
4	**License Plate Recognition / Overview Cameras**		
	LPR camera (1 per lane)	pieces	12
	Overview camera (only livestream)	pieces	4
	Standard mounting bracket	pieces	16
	LPR software license	device	16
5	**Backpanel & Accesories**		
	SHM backpanel (w. clamps, cable, fuses and power)	pieces	4
6	**Project Management & Installation Support Services**		
	Project management	days	10
	Sensor installation training & supervision	days	15
	System commissioning & deployment	days	10
7	**Electrical Services**		
	Camera installation oversight & commissioning	pieces	1
8	**Bridge Performance Assessment & Long Term Monitoring Services**		
	Bridge Assessment & Monitoring as defined in solution description	pieces	1
9	**Warranty Extension**		
	Warranty extension on all hardware	years	2
10	**Software Maintenance**		
	Software maintenance & availability (included in SW license)	years	5
11	**Travel Costs**		

Appendix C: Bill of Material WIM solution

Nr.	Position	Unit	Amount
1	**Digital Weigh in Motion System**		
	KiTraffic Digital IPC with TDA Software	pieces	2
	KiTraffic Digital 24-Port Switch	pieces	2
	KiTraffic Digital 24-Port Switch - Extension	pieces	2
	Router	pieces	2
	Induction Loop Card	pieces	3
	Remote Relay	pieces	3
	Lineas Digital Sensor 9181, 1.75m, 90m cable	pieces	32
	Lineas Digital Sensor 9181, 2.00m, 90m cable	pieces	8
	Grouting Compound, Standard	pieces	60
	Lineas Digital WIM Installation Tool Kit	pieces	1
	Automated Tire Screening License	pieces	1
2	**License Plate Recognition / Overview Cameras**		
	LPR camera (1 per lane)	pieces	10
	DOT camera (1 for 2 lanes)	pieces	5
	Overview camera (only livestream)	pieces	2
	Standard mounting bracket	pieces	17
	LPR software license	device	17
3	**Enforcement Software**		
	Kistler DataMatcher Software	pieces	1
	Kistler WebCheckpoint (Live UI)	licences	1
4	**Electronics / Cabinet**		
	WIM Backpanel (w. clamps, cable, fuses and power)	pieces	2
5	**Kistler Services**		
	Project management	days	5
	Sensor installation certification training (for 2 people)	piece	1
	Site assessment	piece	1
	System commissioning & deployment	days	5
	Calibration support (no vehicles or drivers included)	days	6
6	**Road Work Services**		
7	**Electrical Services**		
	Camera installation & commissioning	pieces	1
8	**Warranty Extension**		
	Warranty extension on all hardware	years	2
9	**Software Maintenance & Hotline Support**		
	Software maintenance & availability	years	5
	Hotline support	hours	80
10	**Travel Costs**		

KISTLER

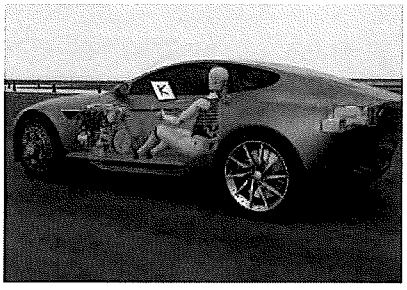
measure. analyze. innovate.

Weigh In Motion

The key to sustainable road management and protection

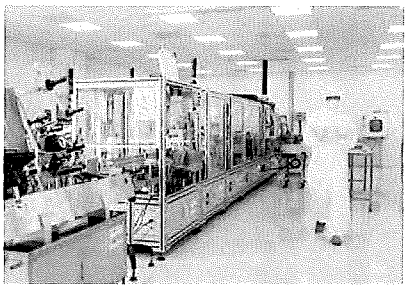
Absolute Attention for tomorrow's world

Kistler develops solutions for challenges in measurement technology with a portfolio that comprises sensors, electronics, systems and services. We push the frontiers of physics in fields such as emission reduction, quality control, mobility and vehicle safety: our products deliver top performance to meet the standards of tomorrow's world, providing the ideal basis for Industry 4.0. This is how we pave the way for innovation and growth – for our customers, and with our customers.



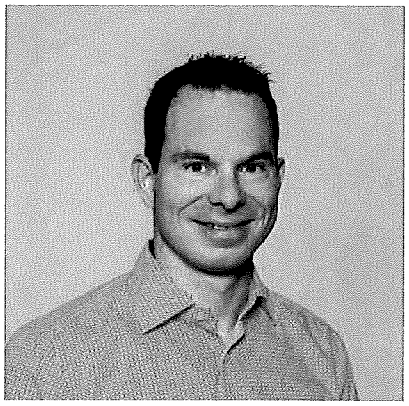
Kistler: the byword for advances in engine monitoring, vehicle safety and vehicle dynamics. Our products deliver data that plays a key part in developing efficient vehicles for tomorrow's world.

Measurement technology from Kistler ensures top performance in sport diagnostics, traffic data acquisition, cutting force analysis and many other applications where absolutely reliable measurements are required despite extreme conditions.



By supporting all the stages in networked, digitalized production, Kistler's systems maximize process efficiency and cost-effectiveness in the smart factories of the next generation.

Editorial

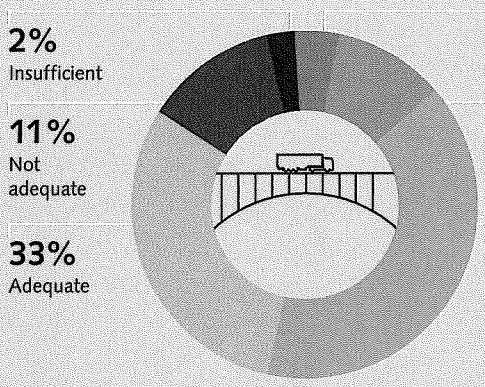


David Cornu,
Head of Business Unit Traffic Solutions

Transport facilitates mobility. It connects people and places, enables the exchange of goods, and is a key factor in our quality of life. So it comes as no surprise that transport is gaining importance all over the world. But at the same time, soaring traffic volumes are increasing the strain on roads and transportation infrastructure. Highway owners and operators must respond by taking action to prevent road damage and ensure safety. Diligent and sustainable management of road use has to be their top priority.

Kistler offers the solution: our state-of-the-art Weigh In Motion (WIM) systems collect and process traffic data with no impact on traffic flow. Certified solutions featuring KiTraffic Digital and our new Lineas Digital sensors can deliver accuracy of up to ±2% GVW (gross vehicle weight), with the advantage of extremely long lifetimes. Drawing on our expertise in measurement technology, we offer solutions that cover the entire measuring chain: from sensors through to software. Reliable data on traffic volumes, axle loads and total weight is the key to identifying overloaded vehicles – so users can protect their infrastructure, improve road safety and collect charges efficiently in line with the "causer pays" principle. To complement our Weigh In Motion portfolio, we also offer a full range of additional services including Structural Road Analysis (SRA) and calibration.

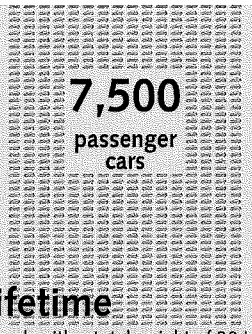
Contents



Germany's bridges – in need of refurbishment

Structural condition of bridges on Federal highways, in percent
Not adequate: a repair must be carried out in the near future
Insufficient: stability is severely impaired, or the bridge is no longer stable

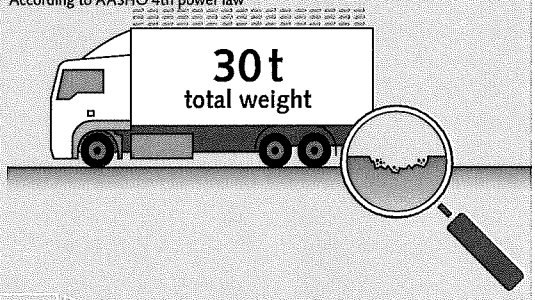
Source: German BMVI, 2018



Road lifetime

A three-axle truck with a total weight of 30 t causes the same amount of damage to the road surface as 7,500 passenger cars.

According to AASHO 4th power law

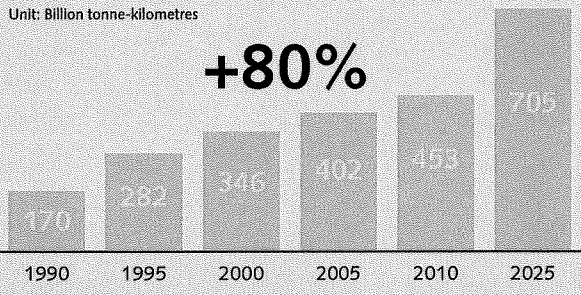


More safety on the roads

Truck traffic until 2025

By 2025, the Federal German government expects a total increase of over 80 percent in long-haul goods transport by road, as compared to the level in 2004.

Unit: Billion tonne-kilometres

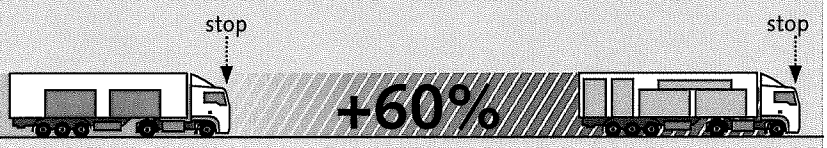


Danger on the roads

32,189 truck accidents on German roads in one year, with 759 lives lost (2017 figures) – trend is upwards.

Long braking distance caused by incorrect loading

The braking distance of an incorrectly loaded truck is up to 60 percent longer than for a correctly loaded vehicle.



Source: Forschungs- und Technologiezentrum Ladungssicherung Selm gGmbH, 2015

Protecting infrastructure and improving road safety

Overloaded or incorrectly loaded trucks are more likely to be involved in accidents and cause more road damage than legally loaded vehicles. This makes it essential to identify violators and remove them from the road. To achieve these goals, many highway authorities opt for complete WIM systems from Kistler – the key to improving road safety and cutting maintenance costs.

Overloaded trucks pose a real threat to highways and roads. A vehicle's impact on the road surface is related to its weight by a power of four. According to the Fourth Power Law, which was derived from road tests in the US during the 1950s, the increase in the force acting on the road is not linear, but exponential – by a power of four. So each additional kilogram vastly increases the hazard.

Risk to other road users

Incorrectly loaded trucks are less stable and more difficult to control, so they are more likely to be involved in accidents. Overloaded trucks cause brakes to overheat, leading to longer braking distances. An overloaded vehicle will often have a greater impact on other road users in case of an accident, with the risk of more serious damage and casualties.

Kistler WIM equipment is the key to detecting trucks that violate the loading regulations so they can be excluded from traffic – making the roads safer for everyone. And WIM technology from Kistler offers another benefit: roadside inspectors can automatically screen tire pressures on all passing vehicles to identify potentially unsafe or flat tires.

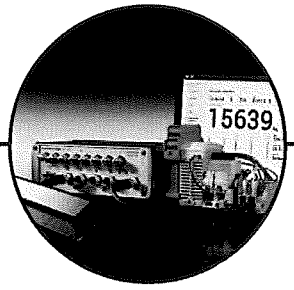
Reducing road infrastructure damage

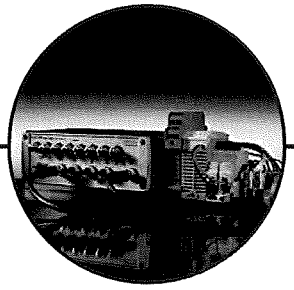
WIM systems from Kistler provide enforcement authorities with an efficient solution for excluding overloaded vehicles. Less damage is inflicted on the road infrastructure, so maintenance costs can be greatly reduced. Another unwelcome problem for road operators is toll evasion – but a WIM system offers an effective way of detecting vehicles that attempt to use the highway without paying. WIM systems also optimize toll collection: available options include free-flow collection from vehicles moving at high speeds as well low-speed manual or electronic toll collection (ETC) at toll plazas.

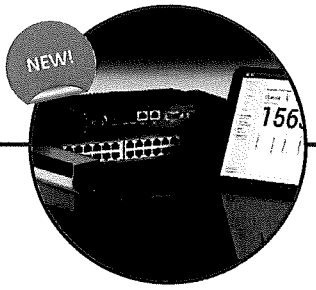
The complete WIM system – from one single source

As well as single components, Kistler offers its customers complete and fully integrated systems. Covering the entire range from high-end solutions to entry-level equipment, customized solutions from Kistler ensure that every WIM system precisely meets the requirements of each user's specific application.

WIM application	Required GVW accuracy	Recommended WIM system
Traffic data collection and bridge protection	±10-15%	KiTraffic Statistics see page 16
Preselection for weight/tire enforcement and bridge protection	±5-10%	KiTraffic Basic see page 17
Direct weight and tire enforcement	±2-5%	KiTraffic Digital see page 14



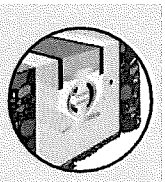




System components

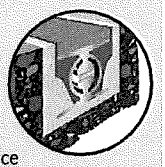
Quartz WIM sensor

Lineas Compact



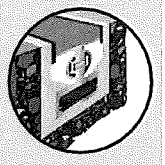
- Excellent price-performance ratio
- Wide measuring range thanks to quartz technology
- Compact design for fast and simple installation in all types of road paving

Lineas Type G



- Wide measuring range thanks to quartz technology
- Meets OIML R134 (class 2) and ASTM E1318 Types I & III
- Very long lifetime with low maintenance
- Withstands temperature fluctuations
- Fast, simple installation in all types of road paving
- Compatible with Automated Tire Screening (ATS)

Lineas Digital



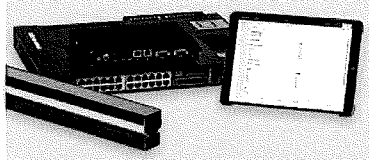
- Ultra-high precision quartz WIM sensor
- Reliable data in free-flow traffic (e.g. lane changes)
- Capable of screening tire properties (single/dual and flat tires)
- Digital output and Power over Ethernet (PoE)
- No loops required

Roadside equipment

Reliable weight and tire data with Kistler's WIM Data Logger

- High weighing accuracy (certified to OIML R134, classes F10 and F5 and ASTM E1318 Types I & III)
- Can monitor up to 4 traffic lanes
- Handles stop-and-go traffic
- Wide speed range (0 to 250 km/h)
- Measuring range up to axle loads of 50 tonnes
- Detects single/dual and flat tires
- Fast setup thanks to modern web interface

see page 19



Industrial grade standard electronics.

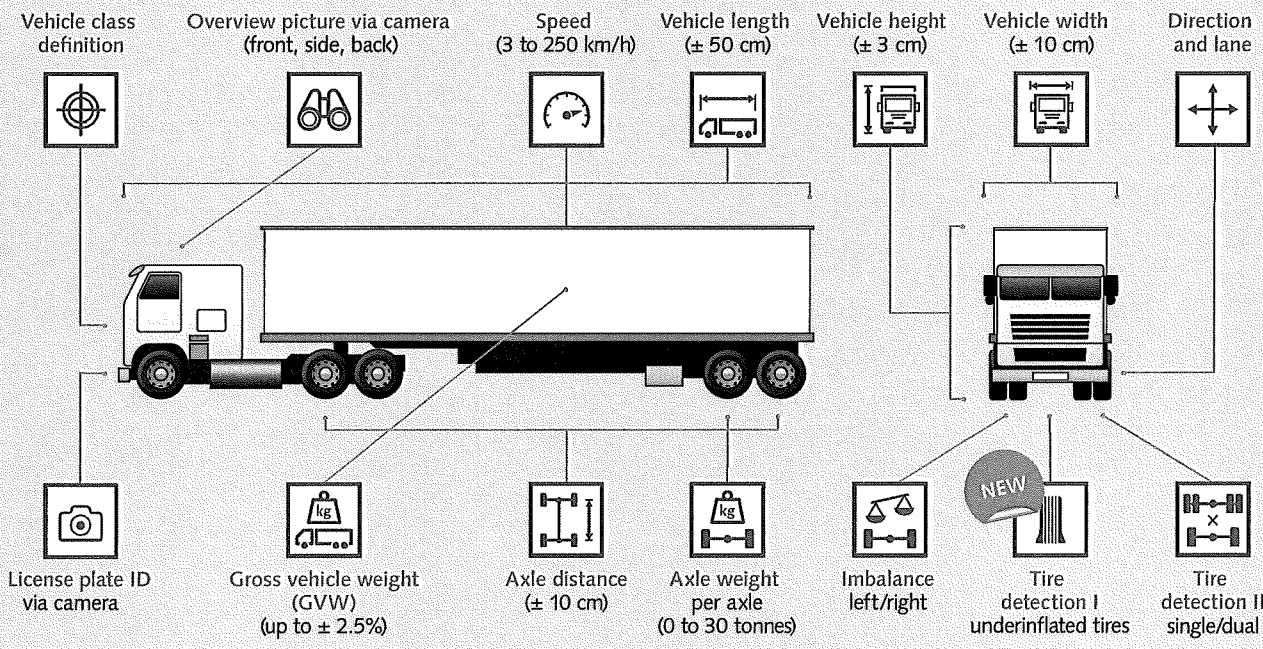
- Covers unlimited number of lanes

User interfaces

User-friendly interface of WIM systems from Kistler

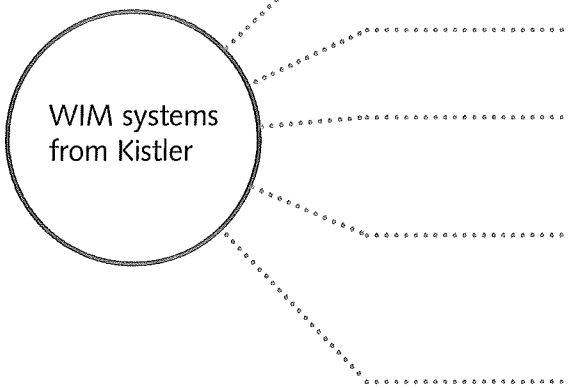
- equipped with a state-of-the-art web-based user interface
- Operators can set up the entire system, read out measurement data and change settings with no need to install additional software
- all relevant information is available to other systems via the machine-readable REST API interface and Ethernet stream.

What data does a WIM system deliver?



One system – multiple applications

WIM systems from Kistler can measure much more than just weight. They collect critical information from vehicles traveling at widely varying speeds. Thanks to highly accurate measurement data, customers can monitor traffic in real time and collect vehicle data (such as number of axles, weight per axle or axle distance) as well as information on tire issues. With these capabilities, WIM systems from Kistler cover a diverse spectrum of applications:



- **Traffic data collection** page 9
  for pavement design or load rate factor calculations; for bridge fatigue calculations
- **Bridge protection** page 10
  to extend bridge lifetimes and reduce risk
- **Weight and tire enforcement** page 11 and 12
  (preselection or direct enforcement) to increase traffic safety
- **Industrial truck weighing** page 13
  for ports, mines, logistics zones and other industrial facilities; to invoice industrial goods by weight and check axle loads or total loads
- **Toll collection** page 13
  (manual or electronic toll-by-weight) for fair weight-based charging

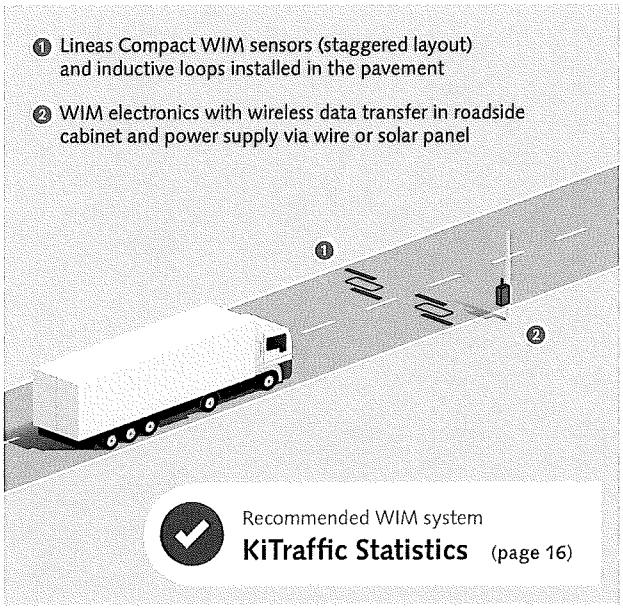
Traffic data collection

Information on traffic loads helps to optimize road and bridge maintenance, improve traffic safety, and enhance road and bridge design. Kistler's WIM technology delivers automated real-time traffic monitoring without disrupting the traffic flow.

Automated traffic monitoring delivers a comprehensive overview of traffic flows. The results: optimized road infrastructure, better maintenance planning and lower costs. Kistler's KiTraffic Statistics system is easily integrated into existing traffic monitoring solutions to collect a wide range of traffic data in real time. It delivers years of detailed and reliable data on traffic volume, vehicle classification, axle loads and gross vehicle weight for all vehicles passing a WIM site.

Benefits of traffic data collection with Kistler:

- Automated non-stop traffic data collection
- Optimized infrastructure and maintenance planning
- Tracking of special transports



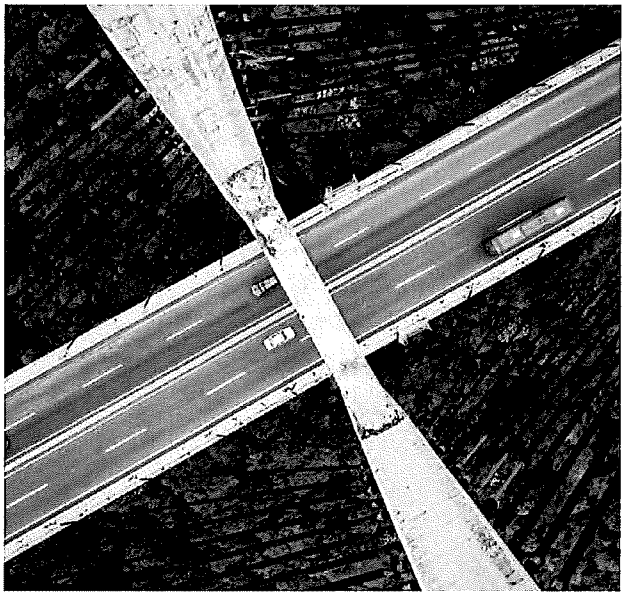
Bridge protection

Bridges are sensitive components of the traffic infrastructure, and their lifetimes are limited. WIM equipment from Kistler monitors real traffic loads and can detect overloaded vehicles. WIM systems ahead of a bridge can stop and divert overloaded vehicles, so the bridge is protected from excessive stress.

Traffic volumes are soaring all over the world, and many bridge structures are in the process of aging – two factors that combine to create a hazardous situation. Weigh In Motion systems from Kistler are the solution of choice for bridge protection: by supplying reliable data about actual loads on bridges, they ensure that maintenance is scheduled accurately. WIM can also detect overloaded vehicles before they drive onto the bridge, so access can be restricted.

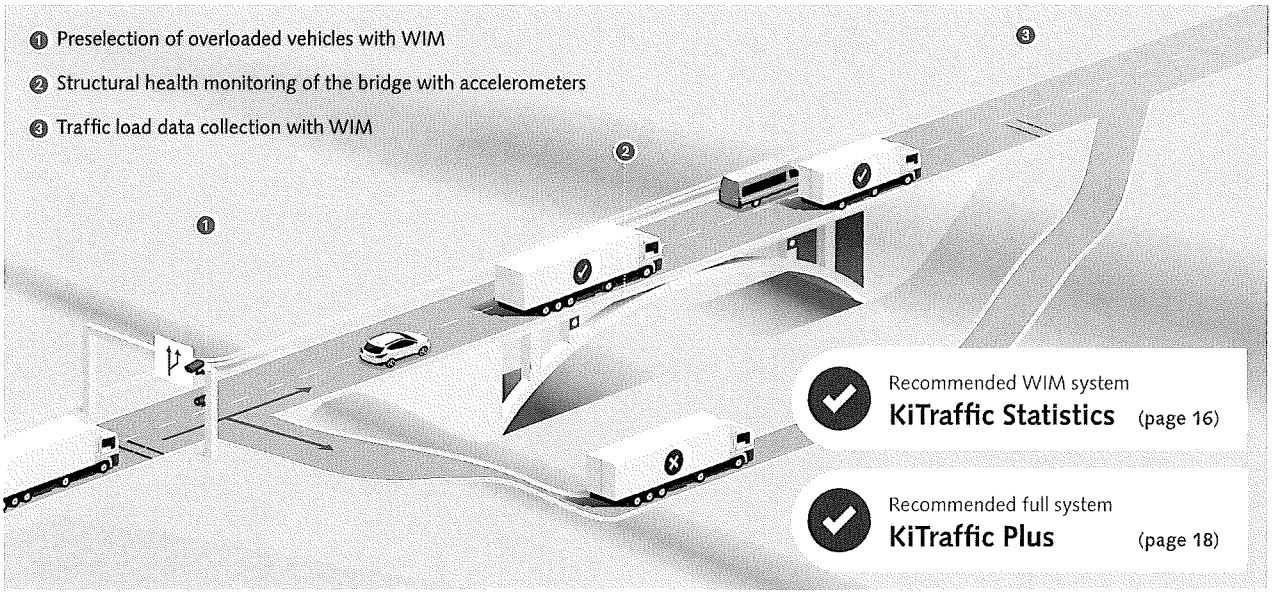
Kistler offers three approaches to protecting bridges, depending on the phase of the structure's lifetime:

- Before a bridge is identified as critical: real traffic load monitoring with Weigh In Motion. Traffic loads have a direct impact on bridge fatigue, so real traffic load analysis is an important factor in calculating a bridge's remaining lifetime.
- Structural health monitoring: strain gage sensors, accelerometers and many more technologies from Kistler are optimal solutions for monitoring changes in a bridge's structural behavior – so faults are detected at an early stage.
- Once a bridge is identified as critical: preselection of overloaded/heavy vehicles with Weigh In Motion. Identified trucks are rerouted via a detour.



Benefits of bridge protection with WIM by Kistler:

- Reliable calculation of remaining bridge lifetime: thanks to monitoring of real traffic loads
- Reduced risk: early detection and continuous monitoring of critical structures
- Longer bridge lifetimes: overloaded vehicles are prevented from crossing the bridge

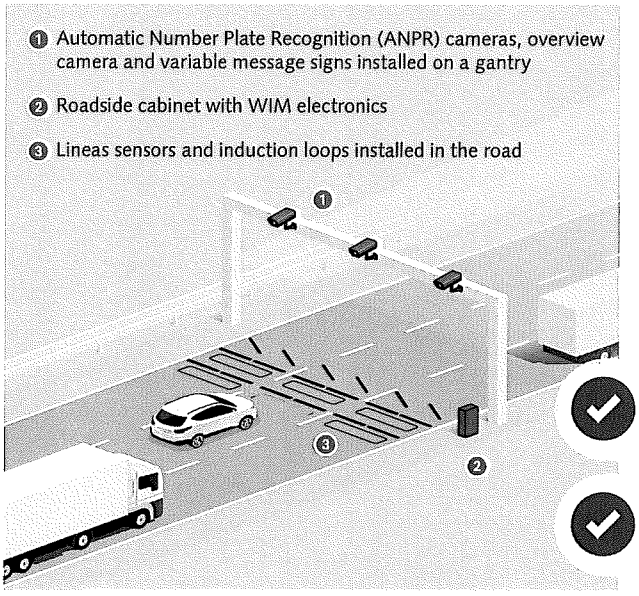


Preselection for weight and tire enforcement

Local authorities are required to identify and fine overloaded vehicles. Increasing road traffic volumes make it crucial to select the right vehicles for checking. Preselection or screening with WIM is an efficient method of sorting traffic so that legally compliant vehicles can be distinguished from potential violators. Inspection and evaluation can then focus on high-risk operators.

Screening is deployed to make more efficient use of enforcement resources. Quantifiable performance measurements eliminate the risk of stopping vehicles that are compliant with legal weight thresholds. This makes the authority's weight enforcement campaigns more efficient, leading to better hit rates for penalizing overloaded vehicles.

Cost-efficient detection of overloaded vehicles
Kistler's KiTraffic Plus system delivers cost-efficient detection of overloaded vehicles at any driving speed. The WIM system can easily be upgraded with the new Automated Tire Screening (ATS) solution by Kistler. This technology can automatically screen tire pressures on all passing commercial vehicles to identify potentially unsafe or flat tires. The combination of WIM and tire screening is a highly cost-effective solution: simply adding two extra sensors to the WIM site is enough to ensure reliable detection of flat tires.



Benefits of preselection with WIM by Kistler:

- Automatic preselection of overloaded vehicles
- 24/7 recording of overloaded vehicles
- Better planning to make weight enforcement campaigns more efficient
- Less road damage, so public spending is reduced
- Illegal competition between transport companies is prevented
- A cost-effective solution: WIM combined with Automated Tire Screening (ATS)

Recommended WIM system
KiTraffic Basic (page 17)

Recommended full system
KiTraffic Plus (page 18)

Direct weight enforcement

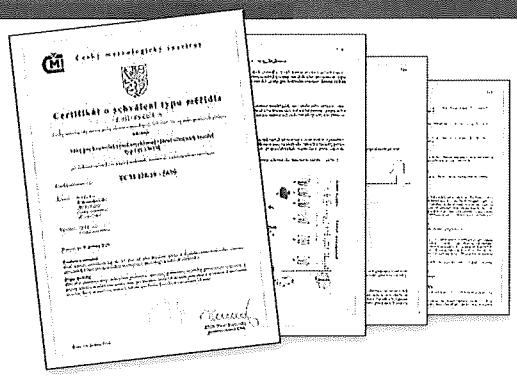
Overloaded vehicles are not only dangerous for other road users – they are also responsible for most of the damage caused to road surfaces and bridges. Direct enforcement systems with Kistler's WIM equipment offer the most efficient way of enforcing overloaded vehicles in real time.

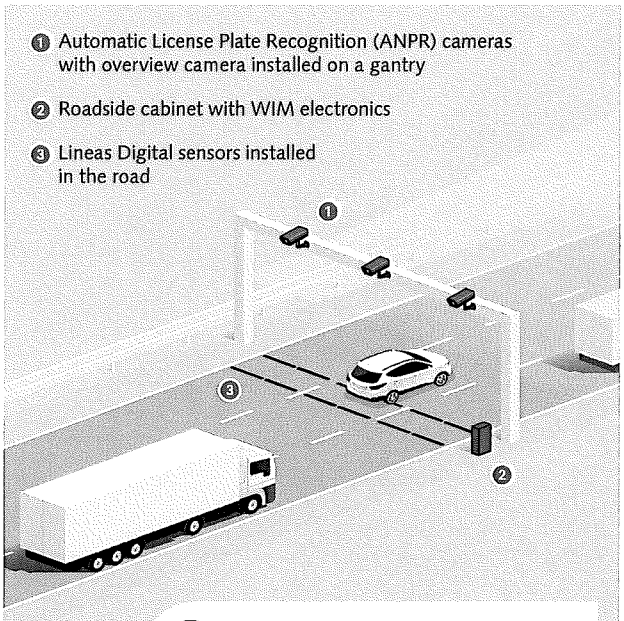
For vehicle identification, WIM solutions from Kistler can be combined with overview cameras and Automatic Number Plate Recognition (ANPR) systems. These additional subsystems are triggered automatically, providing an efficient tool for direct enforcement that eliminates the need to install a static scale. The KiTraffic system notifies the authority's office of any vehicle that exceeds the weight limit: the message includes the exact weight as well as a photograph of the vehicle including its license plate. Staff can then locate the owner in a national database and print a standard penalty letter. These systems have been already been implemented with successful results in Hungary, Russia and the Czech Republic. Direct enforcement is also under preparation in a number of other countries in Europe and Southeast Asia.

Benefits of direct enforcement with WIM by Kistler:

- Maximum hit rate to identify overloaded trucks
- 24/7 direct enforcement of overloading violations
- Direct fining of overloaded trucks – no need to install static scales
- Simplified planning for mobile weight controls
- Reduced road damage saves public spending
- Improved traffic safety

Kistler WIM systems and components are integral elements of **certified solutions** for direct enforcement in all countries where this procedure is permitted by law.





Recommended WIM system
KiTraffic Digital (page 14)

Recommended full system
KiTraffic Plus (page 18)

Industrial truck weighing

Industrial trucks are usually weighed for two reasons: to invoice industrial goods by weight, or to check axle and gross vehicle weight so as to prevent overloading and avoid the risk of heavy fines. With WIM equipment from Kistler, trucks can be weighed without stopping. This saves time and money: the investment pays for itself in a matter of months or even weeks.

Efficient and fast weighing of large numbers of trucks is a key advantage at industrial production sites such as cement plants or mines, and also in ports. Kistler's OIML-certified WIM Data Logger and piezoelectric Lineas quartz strip sensors can be used to weigh trucks moving at any speed. The WIM system increases throughput to several hundred trucks per hour and generates legally compliant commercial data for billing goods by weight. Kistler offers a complete WIM package for industrial weighing that includes all the components needed to set up the system.

Industrial truck weighing with WIM from Kistler:

- Certified to OIML R134 for legally compliant weighing
- Unique quartz measurement technology for extreme precision
- Rapidly installed with minimal disruption – ideal for ports, industrial facilities and mines
- Maintenance-free, even during continuous long-term usage

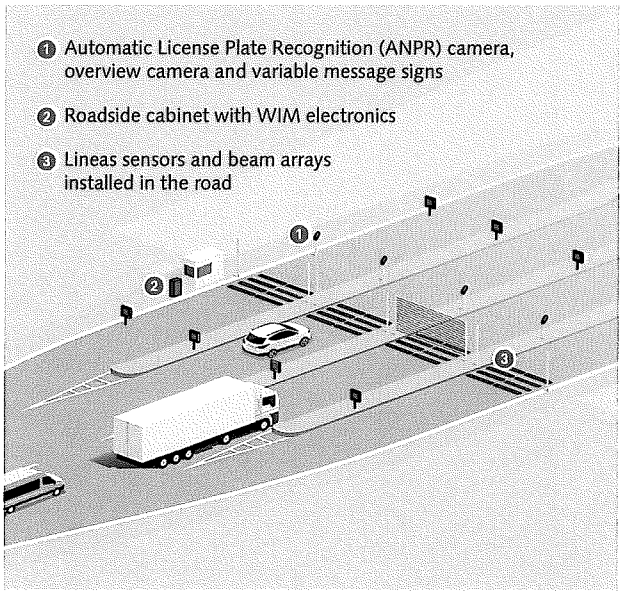
Toll-by-weight

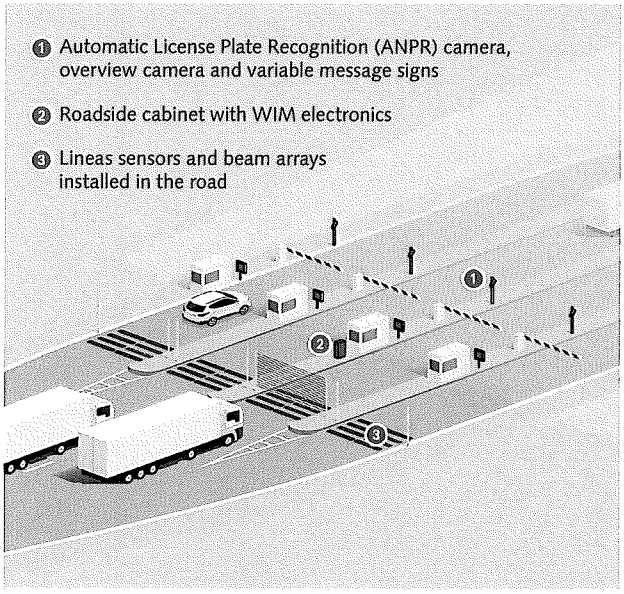
In line with the "causer pays" principle, the fee for using a toll road should be proportional to the wear caused by the vehicle. Toll-by-weight solutions with Kistler's WIM equipment generate additional revenue to finance infrastructure and ensure fair road prices. With weight-based road tolls, road users pay according to the actual weight of their vehicles.

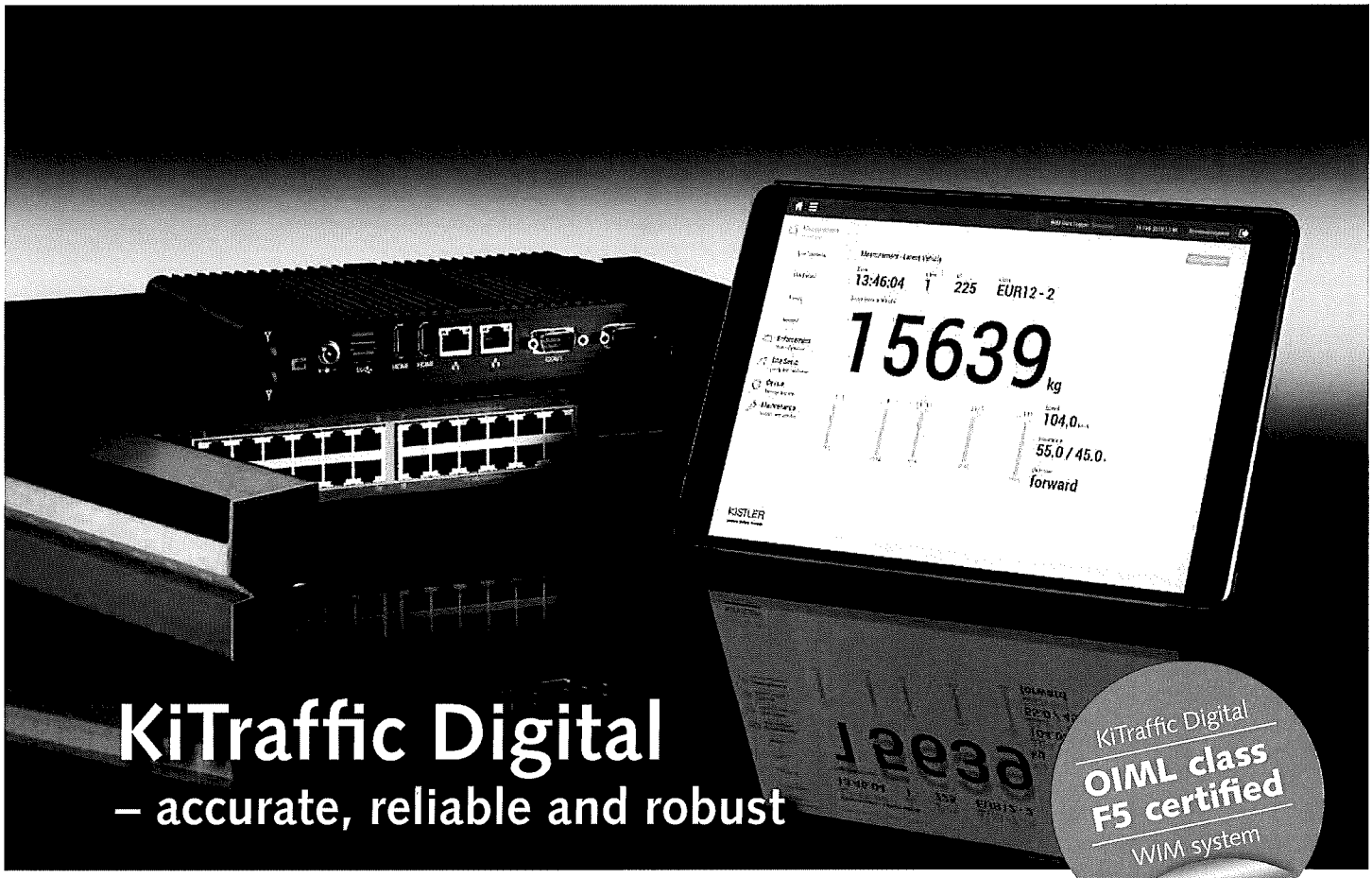
The WIM system for weight-based tolling helps to generate additional revenue for road construction and ensures that road usage fees are fair. Aided by these accurate and reliable systems, road owners and operators can sanction weight limit violations immediately. The WIM system uses integrated cameras to identify vehicles directly, so tolls can be levied automatically without hindering traffic flow.

Toll-by-weight with WIM from Kistler:

- Fair calculation of tolls
- Higher revenue to cover maintenance expenses
- Penalization of weight limit violations
- Denial of access for overloaded vehicles
- Systems for free flow or open road tolling available







KiTraffic Digital
– accurate, reliable and robust

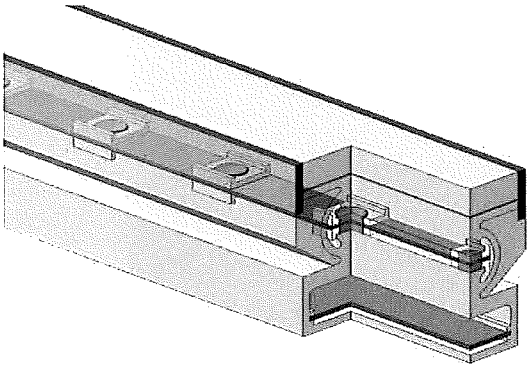
KiTraffic Digital: the robust new solution from Kistler delivers top performance with the advantage of a fully digitized measuring chain.

Kistler has achieved a breakthrough in WIM with the robust, all-new KiTraffic Digital system: we have now combined our tried-and-tested quartz-based sensors with cutting-edge digitalization technology.

KiTraffic Digital calculates wheel and axle loads as well as total vehicle weight with absolute precision, regardless of driving maneuvers. Multiple quartz crystals supply data independently via a digital interface, so each crystal can be calibrated individually with no signal interference on the transmission path. The new system promises accuracy of up to ±2% GVW, so weight violations can be identified immediately and penalized directly.

The design of KiTraffic Digital includes groundbreaking features to ensure robustness thanks to sensor health status monitoring, standard industrial grade electronics, digital signal transmission and Power over Ethernet. And KiTraffic Digital operates without the induction loops that were necessary in the past – in the new solution, the sensor itself detects the presence of vehicles and their classes.

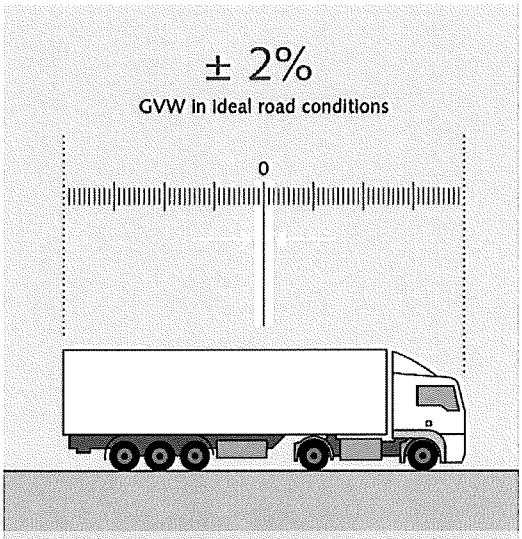
The list of benefits goes on: the position of the force signal is also used to reliably detect single and dual tires and compensate road influences. The same sensor that is already installed in the road can reliably detect flat tires. And standard interfaces ensure easy integration into higher-level or third-party systems (e.g. for weight enforcement, toll-by-weight or traffic monitoring)



All-new Lineas Digital sensor:
absolute accuracy because each single quartz is digitalized and calibrated

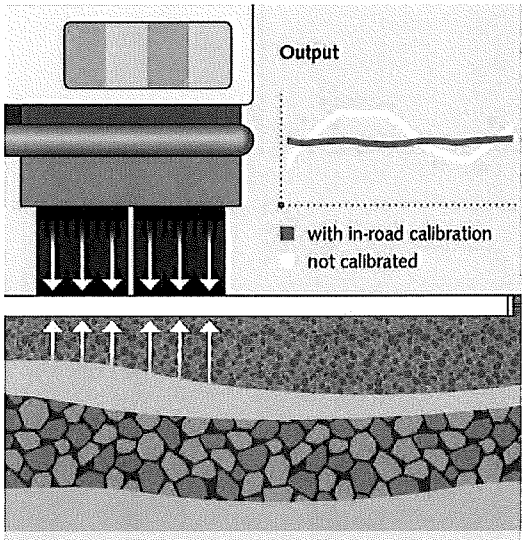
	KiTraffic Digital	
Typical system performance	**Standard**	**Advanced**
Gross vehicle weight (GVW)	±5%	up to ±2%
Speed	±1%	±1%
Axle distances	±5 cm	±5 cm
Vehicle length	±50 cm	±50 cm
System components		
Lineas Digital sensors	4 per lane	8 per lane
Inductive loop	0	0
Roadside cabinet with backpanel	1	1

Why is KiTraffic Digital the world's most advanced WIM system?



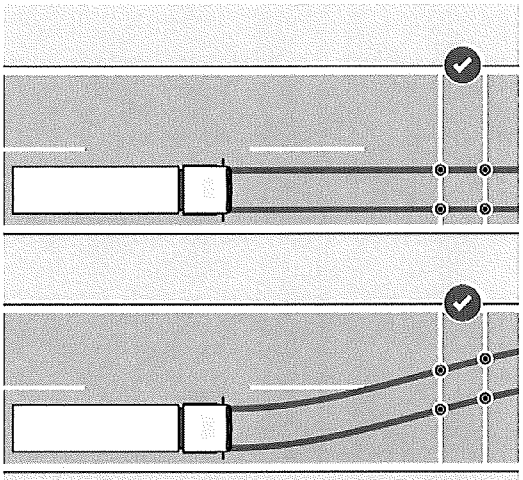
World's most accurate WIM sensor

- ± 1% in laboratory qualification tests
- ± 2% GVW in ideal road conditions
- < 5% GVW in almost any road conditions



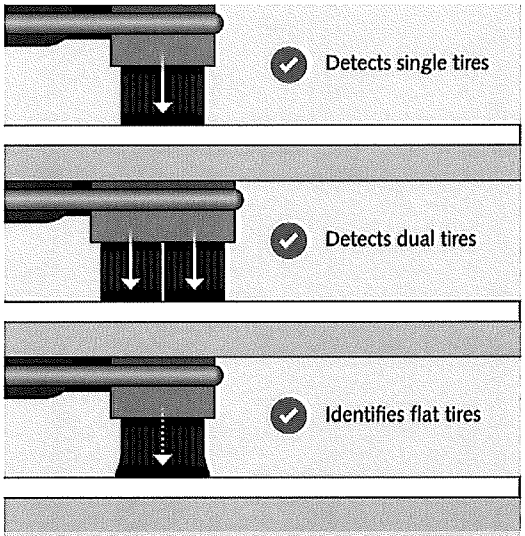
Can be adapted flexibly to WIM sites of all types

- Can be installed on an unlimited number of lanes
- Compensates influence of poor road quality



Guaranteed reliability in open-road traffic

- Regardless of driving maneuvers (lane changes)
- Regardless of lateral driving position



Cost-effective tire screening solution

- Detects single and dual tires
- Identifies flat tires

KiTraffic Statistics
– for optimized maintenance and protection

KiTraffic Statistics is the solution of choice for reliable, cost-effective vehicle counting and classification.

Valuable infrastructures such as roads and bridges demand efficient monitoring, optimized maintenance and long-term development planning. These goals can be achieved with automated systems to measure axle load and total weight – known throughout the world as WIM technology. KiTraffic Statistics, the complete package from Kistler, makes the job as simple as possible.

All over the world, traffic flows are soaring. Heavy and overloaded vehicles are exerting extreme stress on roads that are often subject to aging. A 30-tonne truck has the potential to cause just as much damage as 7,500 ordinary passenger cars. WIM systems from Kistler are the solution of choice for keeping track of road use, so operators can develop effective measures to protect and maintain bridges and highways. At relatively low cost, Kistler's systems deliver informative data about vehicle numbers and classes, axle loads and total weight throughout their long service lifetimes.

Real-time traffic data collection made easy with KiTraffic Statistics
Information on traffic volume and load plays a key part in long-term infrastructure planning, traffic safety improvement and road maintenance optimization. The WIM system from Kistler is the ideal choice for automated real-time traffic data collection.

The KiTraffic Statistics package contains all the necessary electronics, a WIM Data Logger and Kistler's latest Lineas Compact quartz sensors. These sensors are based on proven quartz technology and Kistler's large WIM experience, but come at an attractive price/performance ratio for statistical applications. KiTraffic Statistics is supplied as a pre-wired system that includes the induction loop detector, power supply and connectors – so setup is exceptionally fast.

Benefits of KiTraffic Statistics:

- Vehicle counting and classification, including weight data
- Wide measuring ranges for speed as well as weight
- Unique, tried-and-tested quartz sensor technology
- Quick and easy installation of sensors in road pavement
- Excellent price-performance ratio

	KiTraffic Statistics
Typical system performance	
Gross vehicle weight (GVW)	±15%
Speed	±5%
Axle distances	±10 cm
Vehicle length	±60 cm
System components	
Lineas Compact sensors	2 per lane
Inductive loop	1 per lane
WIM Data Logger	1 for up to 4 lanes

KiTraffic Basic
– the OIML-certified WIM system

KiTraffic Basic includes the WIM Data Logger with the vehicle separator and power supply unit, all pre-wired on a DIN rail for immediate operation.

Kistler's WIM package for basic traffic data collection contains all the key equipment you need to set up your high-performance WIM system. KiTraffic Basic includes the WIM sensors and grouting compound for the in-road installation as well as the roadside equipment, comprising the WIM Data Logger with loop card and the power supply unit, all pre-wired on a DIN rail for immediate operation.

KiTraffic Basic gives you the same accuracy, reliability and durability as all WIM systems from Kistler. Our maintenance-free quartz crystal Lineas WIM sensors are easily grouted into a slot in asphalt or concrete pavements. Throughout their long lifetimes, the sensors operate across very wide measuring ranges to ensure the same accuracy for light and heavy vehicles. And at the roadside, the WIM Data Logger is specifically designed to process signals from Lineas WIM sensors. It is easily integrated into existing solutions to deliver highly accurate data on gross vehicle weight, axle loads, wheel loads, vehicle length, axle distances, vehicle imbalance, speed, and driving behavior.

Everything you need for WIM – in one single package
KiTraffic Basic: one solution that performs multiple functions – traffic data collection, weight enforcement, toll collection and industrial truck weighing. The ideal way to protect road infrastructure and improve traffic safety.

Benefits of KiTraffic Basic:

- High accuracy and reliability thanks to unique quartz crystal technology
- Long-term stability (no aging), insensitive to temperature variations
- Robust design for high durability
- Can monitor up to four traffic lanes
- OIML-certified performance
- Digital inputs and outputs to interface with various peripherals

	KiTraffic Basic	
Typical system performance	**Standard**	**Advanced**
Gross vehicle weight (GVW)	±10%	±5%
Speed	±5%	±3%
Axle distances	±10 cm	±5 cm
Vehicle length	±50 cm	±50 cm
System components		
Lineas 9195G sensors	2 per lane	4 per lane
Inductive loop	1 per lane	2 per lane
WIM Data Logger	1 for up to 4 lanes	1 for up to 2 lanes

KiTraffic Plus
– the flexible solution for overload detection

A new and comprehensive solution for traffic monitoring based on Weigh In Motion: KiTraffic Plus gives you full control over direct enforcement or preselection of vehicles, bridge and tunnel protection, and many other applications.

With road usage and heavy truck traffic escalating all over the world, automated systems play a more important part than ever before: as well as monitoring traffic, they also have to enforce vehicles that violate laws or regulations governing weight, speed, dimensions and other parameters. KiTraffic Plus gives you a flexible solution that can be tailored to your specific scenario and application: you, the customer, are free to choose which components you need for preselection or direct enforcement of noncompliant vehicles.

As an open ecosystem, KiTraffic Plus can integrate field and measurement devices of all types. Standard options include:

- WIM system based on piezoelectric quartz sensors to capture axle load, gross weight, vehicle class and tire anomalies
- Integrated or external speed measurement
- Camera with ALPR (ANPR) capability for vehicle photos and license plate recognition
- Dimension scanner to capture a vehicle's width, length and height
- Software from Kistler to display preselection data live during traffic spot checks or post-processing of offenses

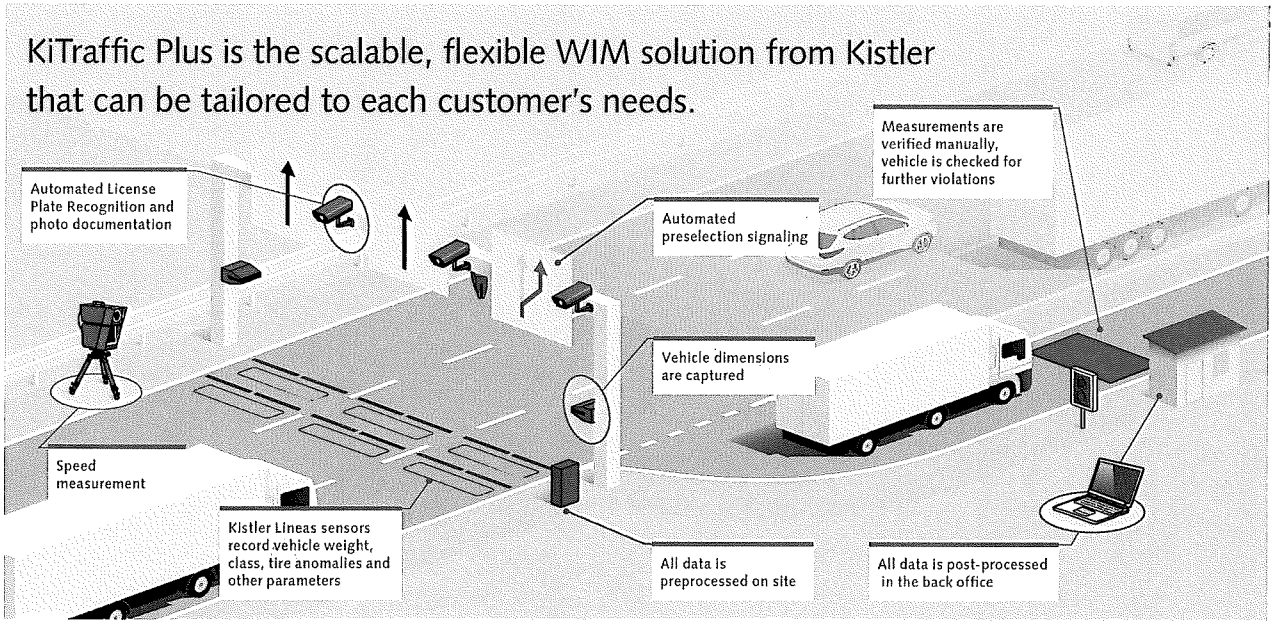
Main benefits of KiTraffic Plus:

- Efficient preselection of dangerous vehicles
- Open and adaptable system
- High reliability in all weather conditions
- Intuitive user interfaces
- Configurable alarms for different violations
- Versatile software packages
- Comprehensive Kistler services

Based on decades of WIM experience, KiTraffic Plus comes with full-scope WIM capability adaptable to your needs. Lineas piezoelectric sensors capture axle loads, overall weight and even tire anomalies with utmost precision.

Overloaded vehicles are one of the main causes of road damage, and they are also more likely to cause accidents. KiTraffic Plus helps to improve infrastructure protection and prevent accidents by capturing each vehicle's identity and class, along with key parameters such as axle load, gross weight (GVW), speed and dimensions; it can even detect tire imbalance and underinflated or flat tires. KiTraffic Plus: the solution of choice for vehicle monitoring and enforcement.

KiTraffic Plus is the scalable, flexible WIM solution from Kistler that can be tailored to each customer's needs.



Specifically designed to process signals from Lineas WIM sensors, the WIM Data Logger is the key to reliable traffic monitoring and accurate vehicle data.

WIM Data Logger – for dynamic vehicle weighing

The WIM Data Logger is the perfect match for Lineas WIM sensors. It offers multiple interfaces for a varied range of peripheral devices to monitor traffic and gather accurate vehicle data.

The WIM Data Logger is specifically designed to interface with Lineas Type G and Lineas Compact WIM sensors in real-time traffic monitoring and vehicle data collection applications. Thanks to enhanced conditioning and processing of signals from the WIM sensors, optimal weighing accuracy and maximum reliability are guaranteed – regardless of driving speed. The WIM Data Logger is easily integrated into the overall system as part of a customized solution tailored to the specific needs of each user. A simple firmware update also enables the logger to detect underinflated or flat tires.

Variable solution for individual requirements
Both the Lineas Type G and Lineas Compact sensors from Kistler can be connected directly to the WIM Data Logger. Various digital inputs and outputs are also provided to interface with peripheral devices such as loop cards, beam arrays, traffic signals, camera triggers and barriers. In Kistler KiTraffic Plus systems, multiple WIM Data Loggers can be combined to monitor a virtually unlimited number of lanes, and each lane can be equipped with two to eight WIM sensors – but for maximum ease of operation, the end user only needs to interact with one single interface.

Key product features and user benefits at a glance:

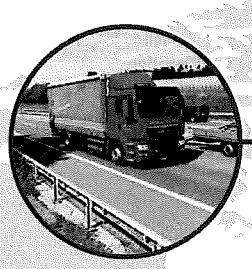
- High weighing accuracy (certified to OIML R134)
- One device can monitor up to four traffic lanes
- Compact design with integrated amplifier
- Fast setup thanks to modern web interface
- Can detect flat and underinflated tires
- Low energy consumption allows powering by solar cells

Kistler as a provider of Traffic Monitoring Solutions around the globe

Lineas WIM sensors from Kistler operate reliably all over the world under a variety of conditions and in many diverse environments.

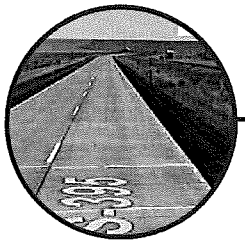
Switzerland: preselection of overloaded trucks

- Multiple sites for preselection at crucial traffic points
- Kistler KiTraffic Plus solution with ANPR, overheight/dimension control and customized user interface for police authorities
- Kistler: the full-scope provider, from planning and implementation through to maintenance



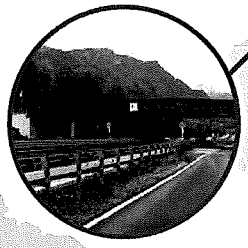
USA: traffic data collection

- Kistler Lineas sensors are installed in 48 states
- First sensor was installed in 2003
- Kistler equipment is in widespread use to collect traffic data for statewide and federal programs
- Many weigh stations (including virtual stations for preselection) use Kistler WIM for weight enforcement



Italy: bridge protection

- Kistler KiTraffic Plus solution with WIM and ANPR to prevent infrastructure damage caused by overloaded trucks



Mexico: bridge protection

- Overloaded trucks are preselected before entering the bridge and are redirected to a toll station

Turkey: traffic load monitoring

- The weight of vehicles approaching or transiting the bridge is monitored

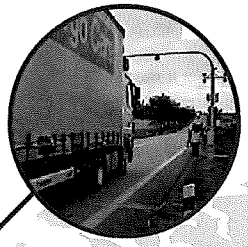
70,000
WIM sensors installed worldwide

50+
countries where Kistler WIM sensors are present

20+
years of experience with unique quartz technology

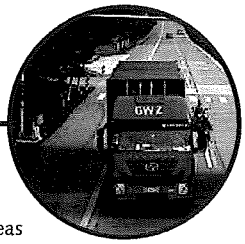
Czech Republic: direct weight enforcement

- 20 sites / 60 lanes / 240 Lineas sensors
- First European country to introduce direct high-speed enforcement with WIM
- Kistler sensors and Data Loggers for local WIM partners



Russian Federation: statistics and direct weight enforcement

- Installations in many locations including Moscow, Saint Petersburg, Novgorod, Novosibirsk, Kaliningrad and Tatarstan



China: weight enforcement

- > 1,500 lanes / > 5,000 Lineas sensors installed
- Preselection of overloaded vehicles ahead of the expressway entrance
- Direct free-flow enforcement of overloaded vehicles on provincial highways and local roads

Indonesia: container terminal in a port

- Trucks are weighed and identified on entering and exiting the port
- Even in monsoon season, the Lineas sensors still function reliably

Australia: aircraft identification

- 4 Lineas sensors are deployed to distinguish between A380s and smaller planes by measuring the nose wheel weight
- Pilots are warned if they are on the wrong taxiway
- Loads of up to 38 tonnes per double wheel

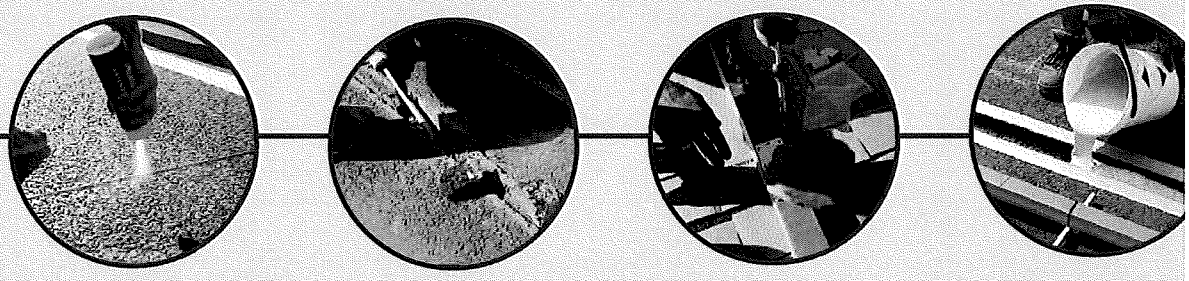
Highly skilled professionals assemble Lineas sensors with the utmost care.

Quartz crystal technology from Kistler – at the core of every sensor

Lineas WIM sensors from Kistler are renowned for their consistently high performance over time under all possible traffic and weather conditions. They have proven their durability in different pavements on all continents: under harsh and extreme winter conditions in northern Europe and North America, in the hot desert environments of the Middle East, and even when exposed to high humidity levels in China and Southeast Asia. Thanks to their wide measuring range, Lineas WIM sensors can measure both light and heavy vehicles with the same high levels of accuracy. The secret of their outstanding performance: Kistler quartz crystal technology combined with advanced sensor design and high-quality manufacturing processes.

WIM installation procedure

Installation in six easy steps

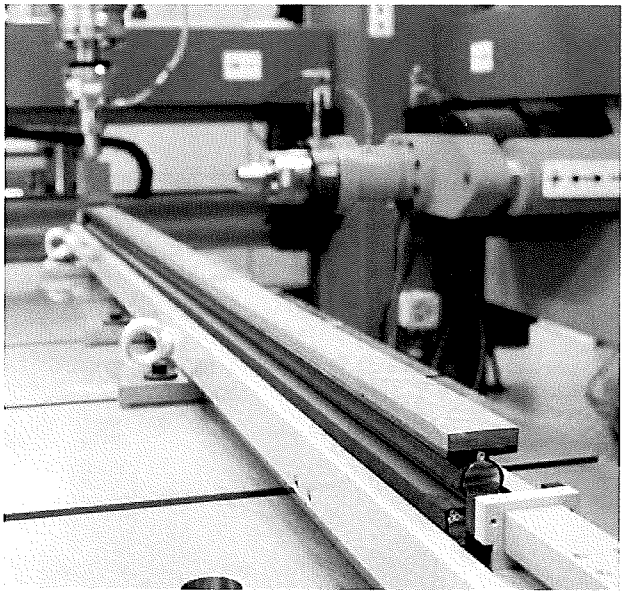


1. Mark **2. Break open** **3. Prepare** **4. Fill the slot**

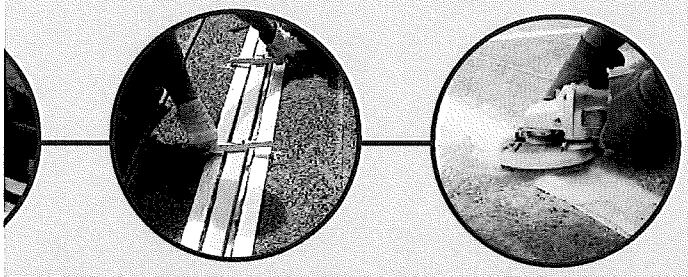
The first step in installing Kistler Lineas quartz sensors is to mark the layout on the road. This helps the installers to cut the slots and break out the pavement. Before the sensors are installed in the road, they must be prepared and checked for correct operation. Two sensors are mounted together in a row, and then the leveling beams are fitted.

The next step is to mix the grouting compound and pour it into the slot. After this, the sensors are inserted into the slot and ground until they are level with the pavement. Finally, the cables are connected to the WIM Data Logger – and now the sensors are ready for calibration.

Quartz at the core
Quartz crystals are at the heart of every Lineas sensor. Up to 50 disk-shaped crystals, the same size as a contact lens, are installed in one sensor. The basic structure consists of an extruded aluminum profile. The dimensions and condition of the profile are checked with the utmost precision. Tolerances are extremely tight because the sensor will operate for a long period. Once the quartz crystals are installed, final assembly of the sensor can take place. This includes installing the cables and sealing the sensor to make it airtight and waterproof. As the last step, the aluminum profile is enclosed in a foam casing that dampens lateral forces. In-depth final inspection of the sensor includes a tightness check and various function tests. Uniform sensitivity throughout the sensor's entire length is verified on the calibration system.

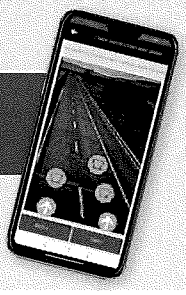


High-precision tools check the quality of each sensor before it leaves our factory.



5. Insert the sensor

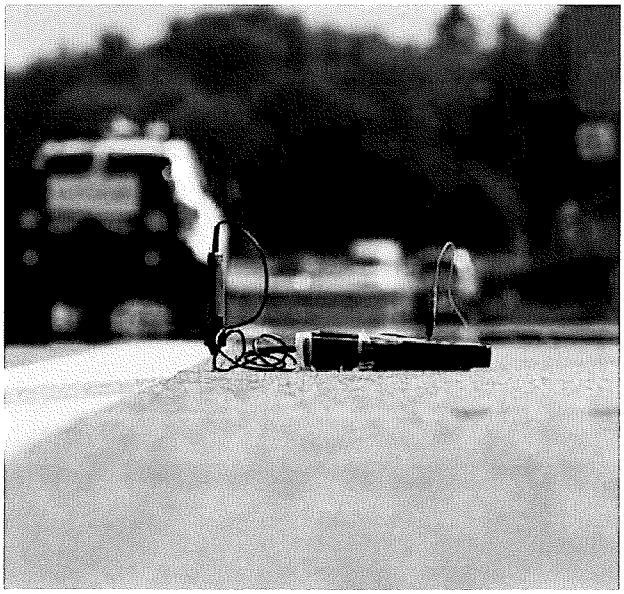
6. Grind

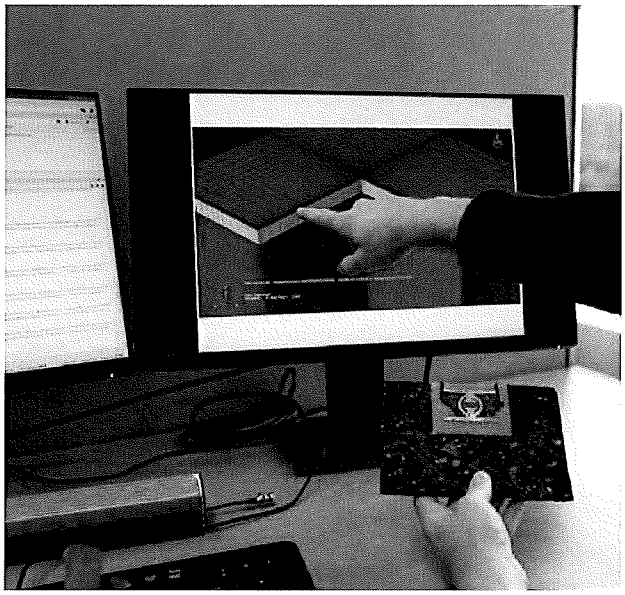


Don't forget to register your site with the WIM Service app.

Weigh In Motion system installation by Kistler
Scan the QR code or enter the address below to see a video of a recent installation of four Lineas G-type WIM Sensors in the Czech Republic.

https://www.kistler.com/wim





Structural Road Analysis (SRA) is the key to defining the ideal location for a WIM installation.

Comprehensive range of WIM services

Kistler offers a portfolio of added-value services to maximize the performance of every WIM solution. Customers can choose from a range of options to enhance their WIM user experience and prolong their system's lifetime.

Structural Road Analysis (SRA)

Structural Road Analysis (SRA) helps customers to identify and qualify the most suitable locations for installing their WIM systems.

Procedure for identifying the optimum location
The first step is to select a road section on the basis of a desk survey of envisaged usage requirements for the WIM system, together with local road and traffic conditions. This service includes on-site measurements as well as off-site assessments. The results are based on detailed measurements of road pavement properties and state-of-the-art assessment methods.

A certified Kistler Partner then performs in-depth measurements of pavement roughness and stiffness. This data is evaluated to narrow down the range of potential road sections for the planned WIM site.

The next step consists of measurements to assess the structural characteristics of the pavement and the potential locations, resulting in the final selection of the best available WIM site. SRA is based on innovative mathematical models developed by Kistler specialists to collate all data gathered during the process.

Aided by in-depth analysis of this data, a Kistler expert will then issue final recommendations for the best sensor layout and an appropriate calibration procedure, together with an assessment of expected performance under local conditions and the exact location for the WIM site.

Benefits of Structural Road Analysis at a glance:
- Defines the most suitable installation location for a WIM system
- Provides information about achievable performance at the selected location before the equipment is installed
- Avoids future WIM performance issues due to road properties that fail to meet the requirements
- Extends the WIM site's lifetime and reduces maintenance costs

Hands-on training by a Kistler expert

Installation training and certification

This service trains customers to install their own WIM equipment. A Kistler expert is present on site to provide hands-on training and ensure that the installation is executed correctly.

Benefits of installation training and certification:

- Customers' staff are trained and certified to perform high-quality installations
- Efficient and reliable installation optimizes WIM performance
- Customers can easily set up future WIM sites and systems without guidance from Kistler technicians

Calibration

This service ensures the appropriate calibration procedure for each customer's WIM system, application and budget. The calibration procedure is performed to professional standards and the calibration factors are calculated correctly.

Benefits of calibration:

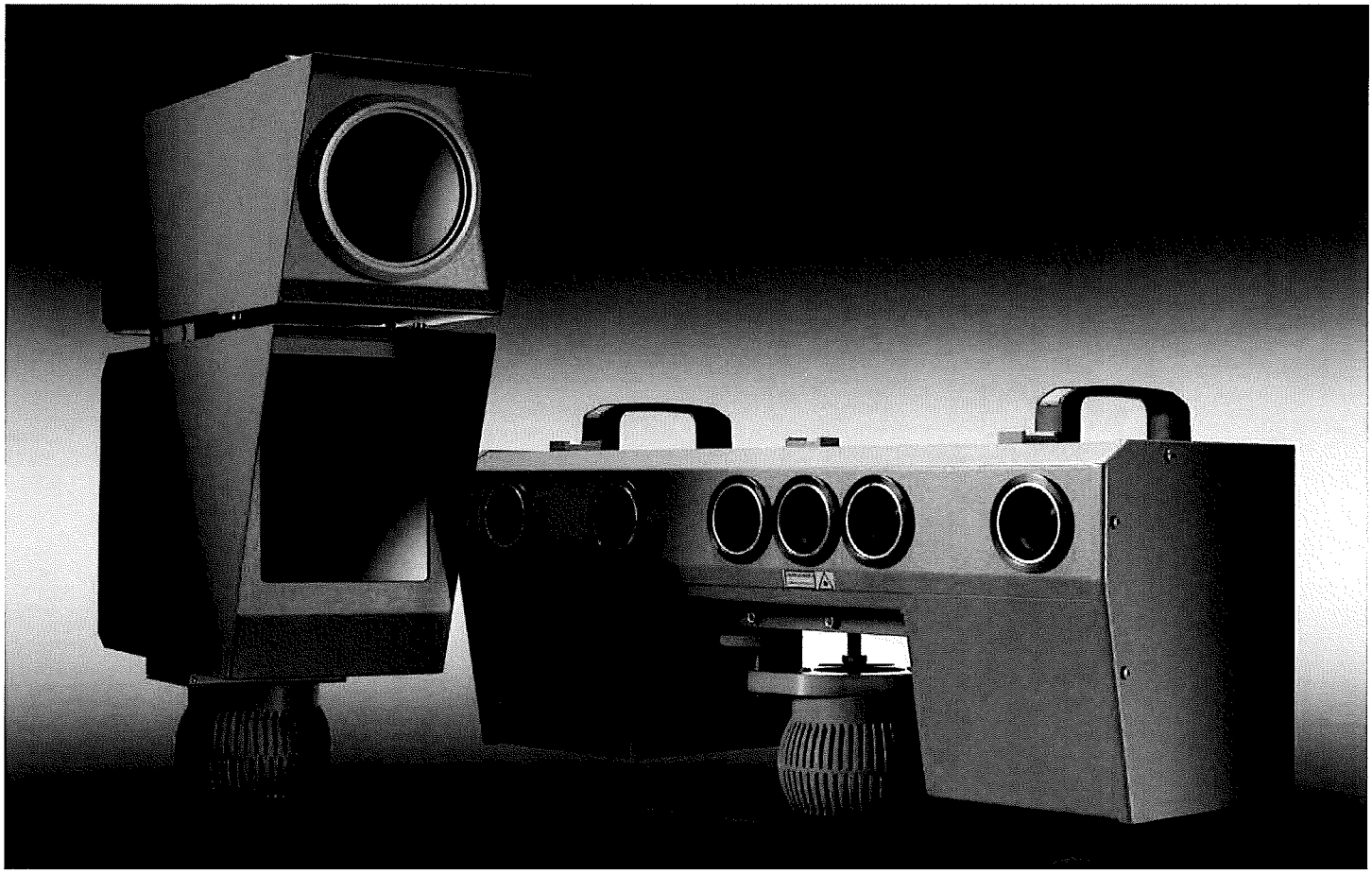
- Calibrated systems deliver maximum accuracy
- Guaranteed compliance with operating and certification requirements for toll-by-weight and direct enforcement
- Overall WIM performance is optimized

Warranty extension

With an optional extension of the standard warranty period, Kistler WIM products are replaced quickly and free of charge in case of defects – for many extra years of troublefree operation.

Benefits of a warranty extension:

- Security and long-term troublefree operation of WIM systems
- Minimized risk of system downtime due to faulty products
- Defective products are replaced free of charge throughout the warranty period



Mobile measurement solutions from Kistler help to increase traffic safety in many different application areas.

Accurate speed measurement with optical technology

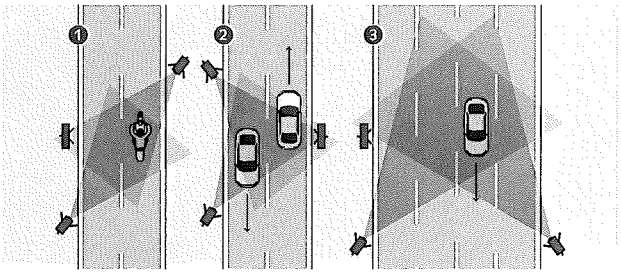
All around the world, speeding is one of the most common causes of road accidents – and it also presents a major challenge for police forces and local authorities. Certified eso measuring solutions from Kistler are the key to high-precision mobile or stationary speed enforcement – a critical factor in improving safety on our roads.

Downtown, on the open highway or even on a mountain pass: versatile complete systems from eso perform high-precision speed checks in virtually any environment. This measurement solution combines unique optical measuring technology with reliable driver and registration plate identification. Traffic violations are detected quickly and efficiently thanks to the short 50 cm measurement base – a tremendous advantage on interurban roads, highways and bends.

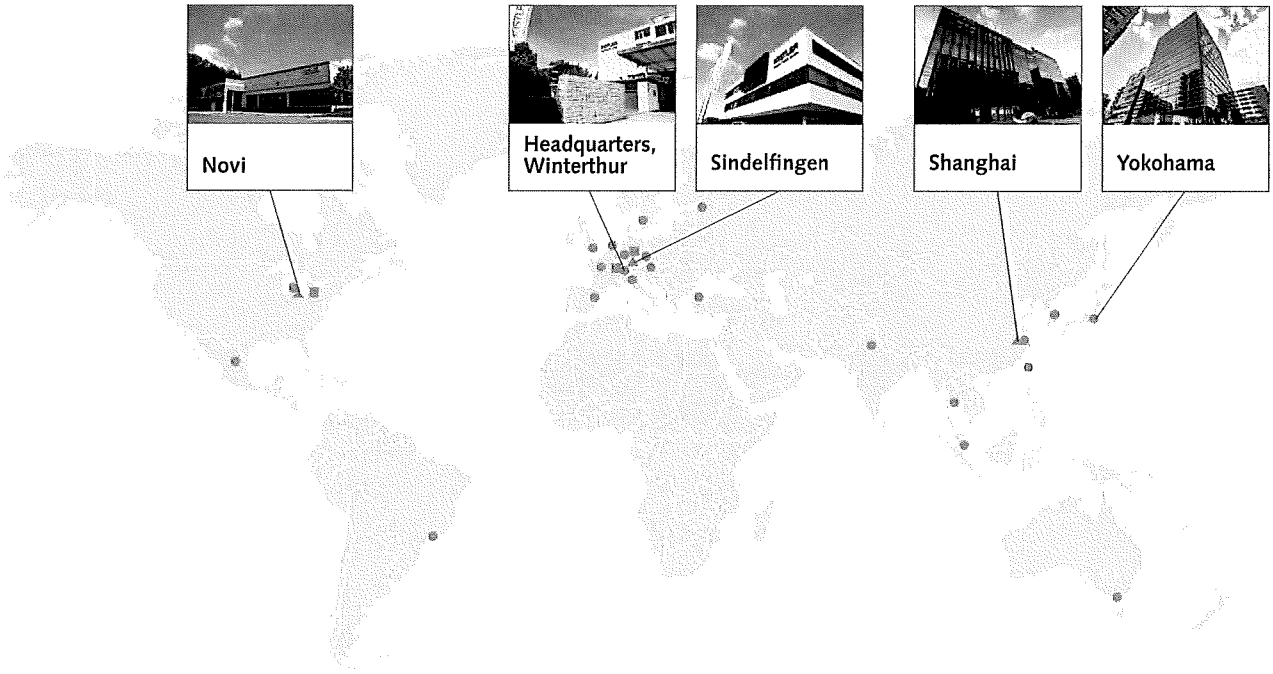
Unrestricted automatic measurement
One single instrument can measure the speed of vehicles in all classes (including motorcycles), in both traffic directions and across multiple lanes. A user-friendly software application supports evaluation and legal validation of the measured data. If needed, the mobile system can be converted into a stationary measurement solution at any time with minimal outlay.

Advantages of mobile speed enforcement:

- Universal, complete system for legally valid speed enforcement data
- Monitoring of different traffic directions with just one measuring instrument
- Precise measurements with high hit rates – regardless of vehicle class, speed or road condition, even on multiple-lane roads and bends
- Unique, easy-to-operate certified optical measurement technology
- Measurements in real time – even when traffic is heavy



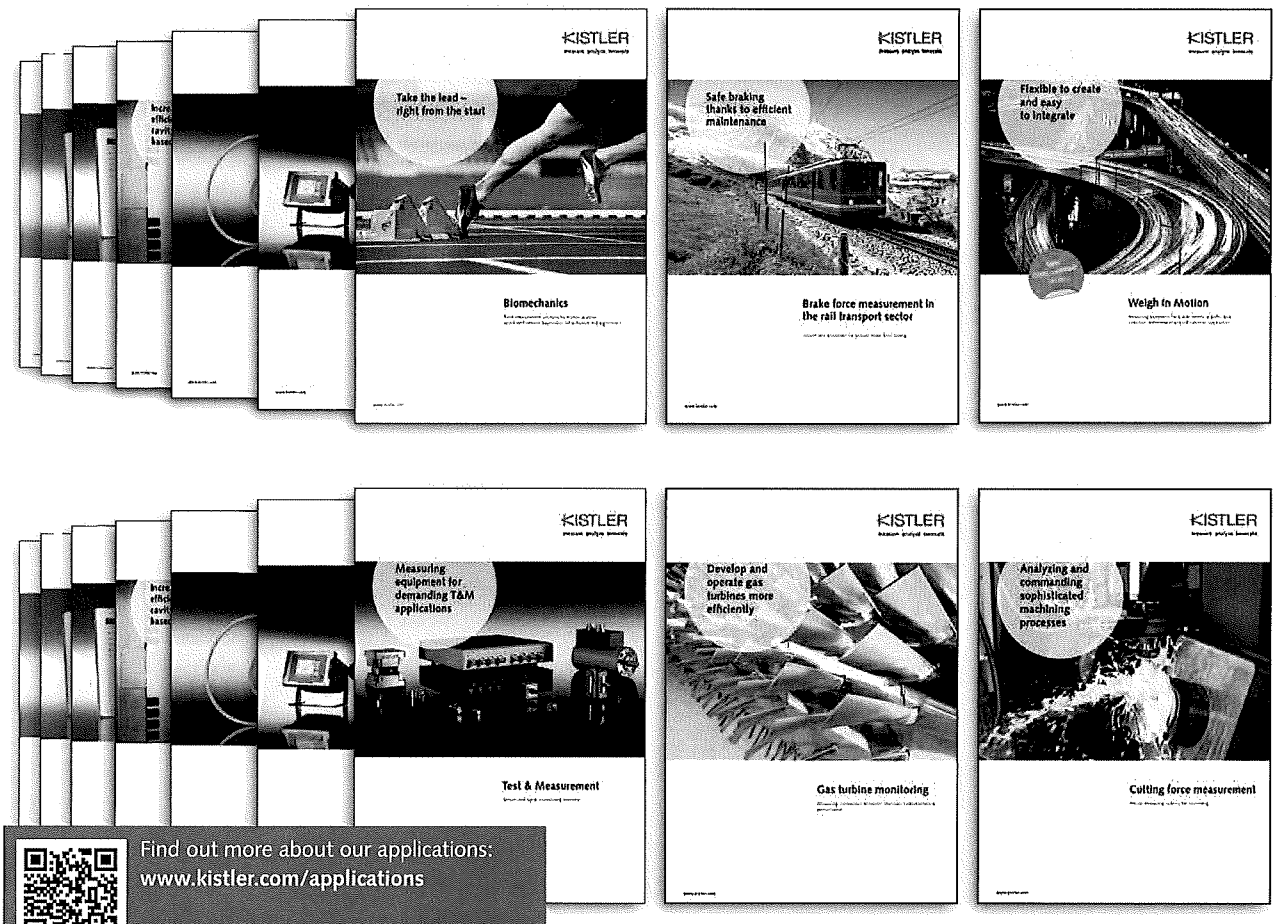
1. Motorcycles: license plate and driver are photographed
2. Drivers of vehicles traveling in both directions are photographed
3. High-quality, sharply focused driver photos on up to four lanes in one direction



- Sales Center
- Tech Center
- Production Center

At our customers' service across the globe

Thanks to Kistler's global sales and service network, we are always close to our customers. Some 2,200 employees at more than 60 locations are dedicated to the development of new measurement solutions, and they offer customized on-site support for individual applications.



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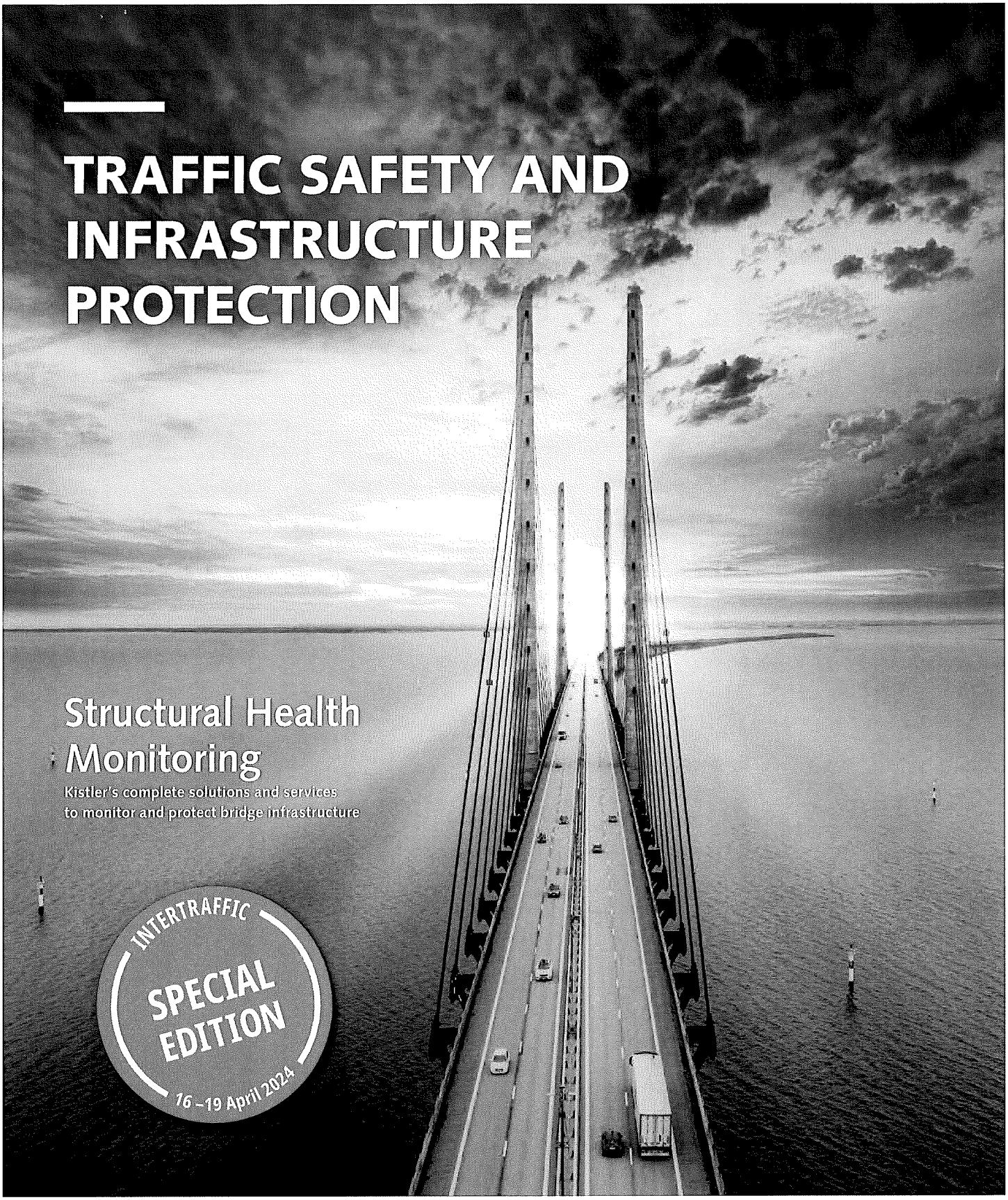
KISTLER
measure. analyze. innovate.



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Content

Protecting sensitive infrastructure with Structural Health Monitoring (SHM)

Bridges are backbones of the economy in every country in the world. These key elements of the traffic infrastructure usually consist of steel, cast iron and prestressed concrete – and nowadays, many of them are aging. It is very difficult to determine a bridge's stability merely by inspecting the structure from the outside. But thanks to Structural Health Monitoring (SHM), operators now have solutions to identify degradations of a bridge's structural integrity at an early stage – so they can take proactive and efficient steps to address these critical issues.

A bridge's structural integrity degrades naturally over time due to fatigue, cracking and corrosion. Also, increased traffic loads and harsher weather conditions place additional burdens on bridge structures. Critical structural deficiencies are present in an extremely high number of bridges built over 50 years ago as they approach (or even reach) the end of their service lives – but the same issues also affect many newer bridges that are not properly maintained. Drastic measures such as closing a bridge or imposing heavy limitations on traffic must be avoided at all costs. This is why maintaining bridges to extend their service lifetimes and ensure their safety is an overriding priority for all operators. There are limits to what regular inspections and assumption-based structural models can achieve – and this is precisely where sensor-based bridge monitoring (SHM) comes into play.

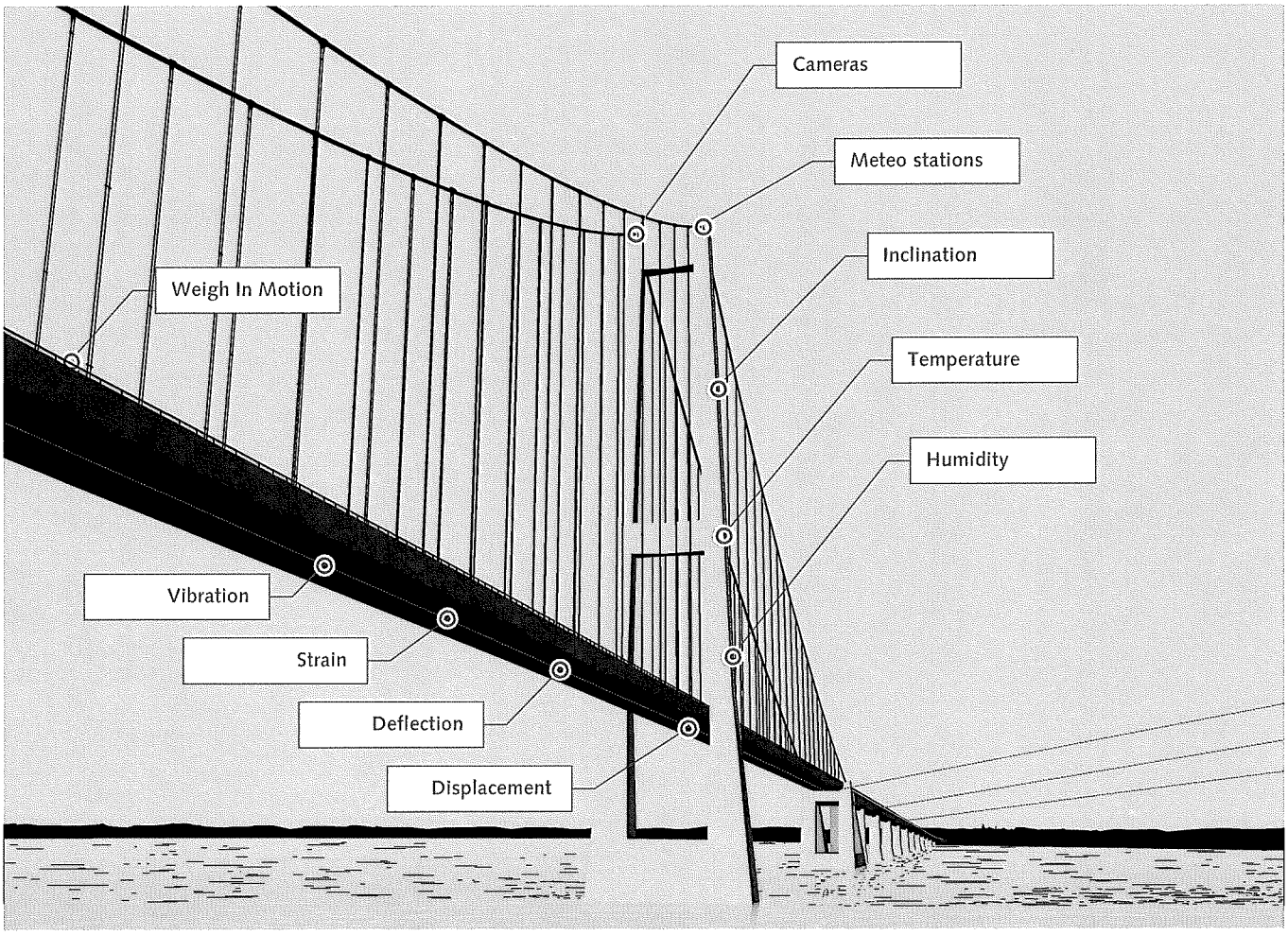
Find out more about SHM applications:

Sensor-based Structural Health Monitoring: the key to enhanced bridge safety

As an operator, you can gain unique advantages by opting for continuous sensor-based bridge monitoring to complement your conventional field inspections. SHM solutions deliver automatic monitoring on a 24/7 basis, with continuous measurements to track real bridge performance and traffic loading – so you can identify even the smallest variations as soon as they occur. Issues and faults are detected well before they can lead to more serious damage. You are kept continuously informed by relevant data supplied at regular intervals, and you are notified immediately whenever the monitoring systems automatically generate specific alarms.

SHM enhances bridge safety by delivering these key benefits:

- Condition ranking based on effective structural response
- Extension of remaining bridge service life (bridge lifespan)
- Damage detection at an early stage (lower maintenance and repair costs)
- Detection of structural deficiencies that are not visible during inspections
- Condition-based maintenance
- Continuous monitoring of real structural behavior
- 24/7 condition assessment to eliminate information shortfall between regular inspections



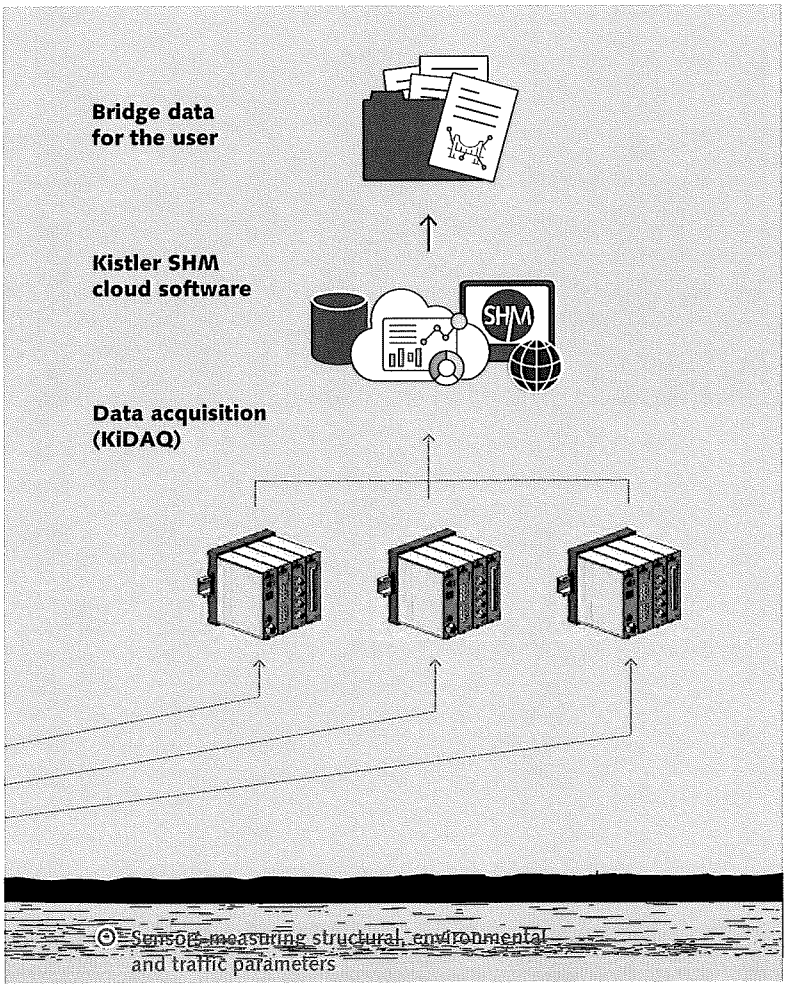
The easy way to monitor and protect your infrastructure: solutions by Kistler – from sensor to data

Backed by over 50 years of measurement technology experience, Kistler supplies fully customized monitoring solutions for bridges of all types – solutions that ensure seamless availability of highly reliable bridge structural data.

Kistler can supply a fully customized solution for any monitoring application. Our flexible components meet proven standards, and they combine technological reliability with expandability. Efficient integration guarantees the most reliable solution, delivered to you from one single source. Our solution architecture comprises a sensor layer, a data acquisition layer and, on top, a cloud software platform that acts as the user interface – with a range of functionalities such as data storage and processing, data visualization, notifications and reporting.

Kistler's own team of measurement technology specialists and structural engineering experts will support you, the user, with all the expertise you need to define and design your optimal monitoring application. What's more: our service engineers can be present on site to install and commission your solution.

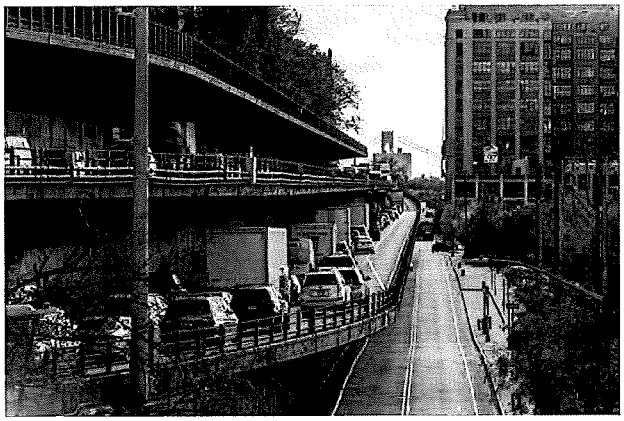
Kistler's complete solution delivers automatic 24/7 monitoring of your structures. All measured parameters are collected continuously and stored securely in our SHM cloud software.



Benefits

- **Modular and customizable solution** for monitoring of any bridge structure
- **Complete solution** comprising software platform, data acquisition, and sensors
- Measures all **parameters related to structure, environment, and traffic**
- **Unmatched accuracy for dynamic measurements**
- High reliability of data – **complete solution from one single source**
- Compliant with **bridge monitoring guidelines** and **latest research insights**
- Measurement technology experts and structural engineers **ready to advise the customer**
- **Local service engineers** standing by to support deployments

You are able to identify even the smallest structural variations as soon as they occur. Issues and faults are detected well before they can lead to more serious damage. You are kept continuously informed by relevant data supplied at regular intervals, and you are notified immediately whenever the monitoring systems automatically generate specific alarms.

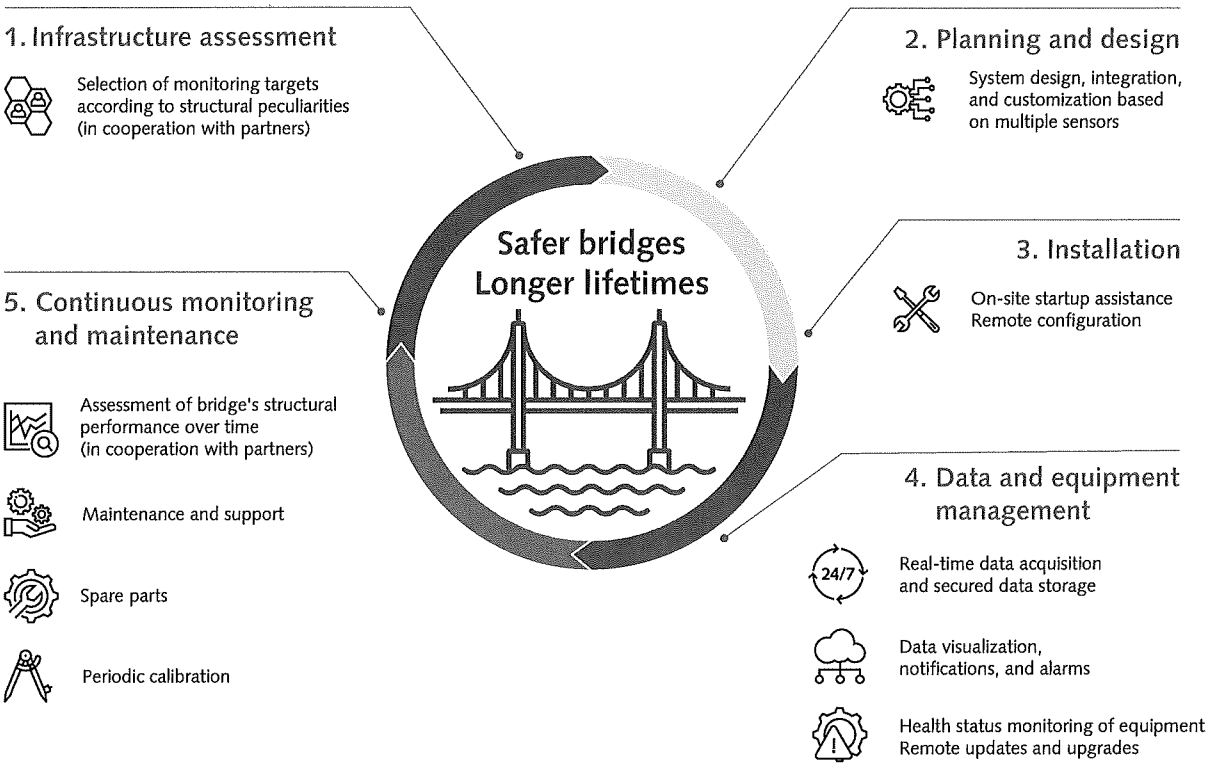


Our complete solution measures the key parameters related to the bridge structure, the environment and traffic. Specifically, these include:

Structural parameters
- Vibrations and oscillations
- Cracking (acoustic emissions)
- Strain and stresses
- Movement (displacement and tilt)
- Deflection

Environmental parameters:
- Wind
- Temperature
- Humidity

Traffic parameters:
- Traffic density on bridge
- Traffic loading on bridge
- Vehicle weights (gross vehicle and axle load)
- Vehicle distances
- Vehicle speeds



Kistler supports users with services throughout all project phases

Kistler provides a wide range of services that ensure optimal support for users in all phases of the project, and throughout the entire operation and service lifespan of our complete solution. Kistler offers you flexibility: you can source the services you require according to your specific project, your requirements, and your own expertise.

Thanks to Kistler's worldwide network of experts, you benefit from consulting and support throughout all phases of your project. Our range of services includes:

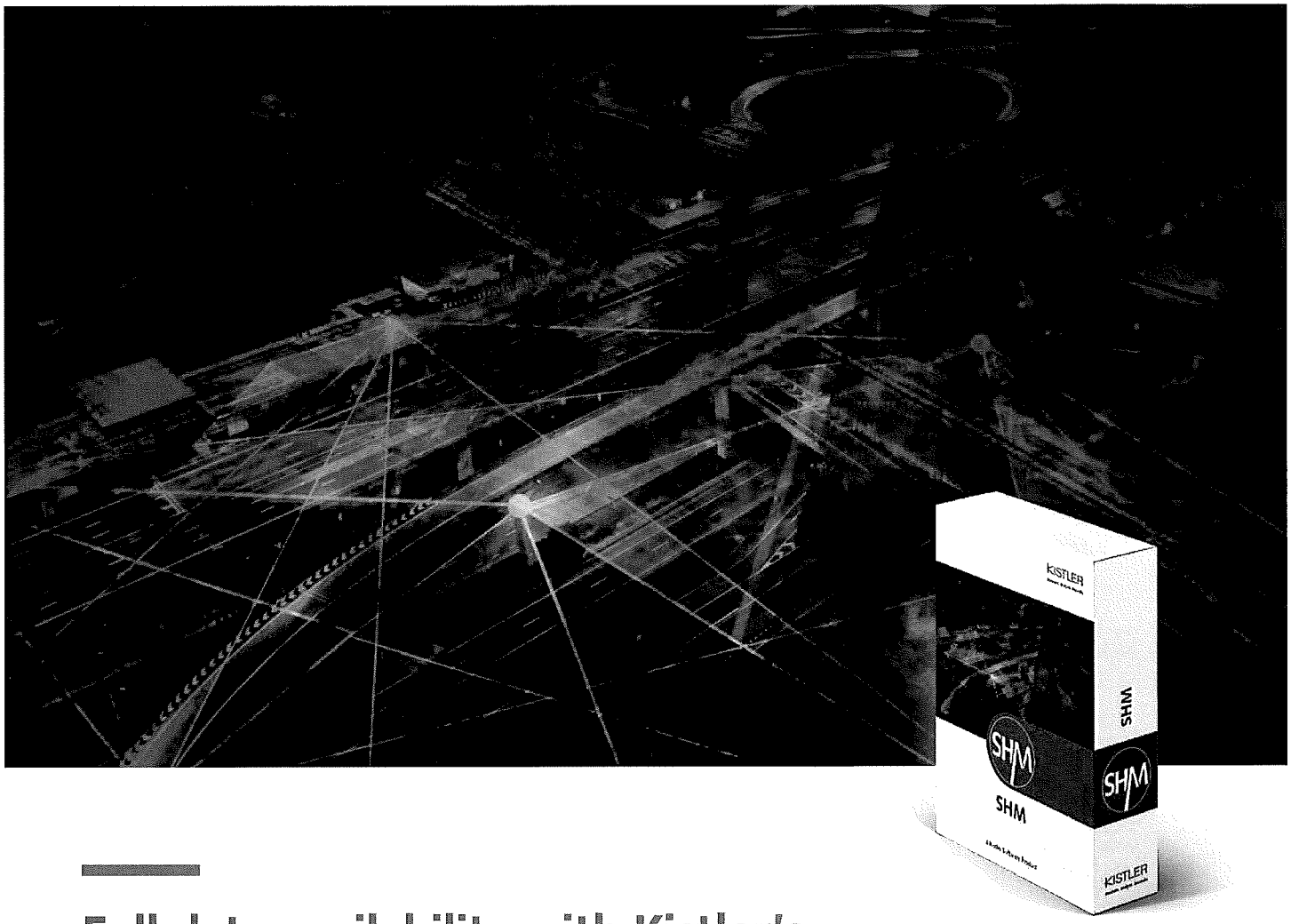
- **Infrastructure assessment**
  The process starts with collecting customer requirements and defining project scopes. The monitoring targets are defined according to the structural peculiarities and criticalities, which are derived from an initial assessment of the infrastructure.

- **Planning and design**
  Our team will design and integrate a monitoring system based on multiple sensors (for both static and dynamic monitoring). The result: a system that meets the unique requirements of each bridge, so you can count on accurate and reliable data collection for comprehensive structural analysis.

- **Installation**
  Kistler's team is present on site to give you startup assistance that ensures a smooth and efficient installation process. Our technicians are there to guide you through the setup, calibration and commissioning phases – so you can be sure your monitoring system will be up and running in next to no time.

- **Data and equipment management**
  Also included in our solution: services to guarantee fully functional real-time data acquisition with secured storage. You benefit from customizable notifications and alarms that give you timely insights into the bridge's structural health. Plus: continuous monitoring of overall functionality (covering all systems and all sensor channels), so any malfunctions are reported automatically. And it's easy to implement updates and upgrades remotely.

- **Continuous monitoring and maintenance**
  We collaborate with our partners to provide continuous monitoring of your bridge's structural performance. To ensure the longevity and accuracy of the entire monitoring system, we provide maintenance and support services including a remote support hotline, spare parts service with on-site support for repairs and replacements, and periodic calibration.



Full data availability with Kistler's SHM cloud software platform

Our SHM software is a comprehensive cloud-based platform that enables multiple functions: distributed data acquisition, storage, structuring, visualization, indexing, and analysis.

Kistler's SHM software offers you a wide range of functionalities to ensure data availability at all times and from any sensor channel. Users can remotely configure all the measuring equipment installed on the bridge (sensors and systems). Sensor data streams are captured and stored securely, and visualization of relevant data can be tailored to your individual needs. As a user of our SHM software, you can continuously monitor key parameters related to your bridge's structure, traffic, and environment; you can also configure specific notifications or alarms to match your requirements. User-specific algorithm can be implemented in the same platform to ensure seamless data processing. Our platform can integrate data originating from sources of any type – not only from Kistler's KiDAQ units, but also from any third-party systems. As an added advantage, the platform comes equipped with API interfaces for data transfer to higher operator-side data management systems. You benefit from usage-based pricing and scalable architecture so you can enjoy the full modularity and scalability of this platform. The SHM cloud-based software also leverages edge computing technology, with an on-site computer to manage and process huge amounts of data in real time. This feature enables our SHM solution to maintain the same performance, no matter whether your data is sourced from just a few sensors or several thousand: long-term data storage is guaranteed, and you can perform complex data processing operations and calculations in real time.

Summary of main SHM software functionalities:

Measurement data storage and visualization

- All measured data is buffered on the edge PC to guarantee full data availability – but only the data relevant to you is uploaded to the cloud.
- The data is aggregated 24/7 and visualized on an intuitive cloud dashboard – which you can adapt to your project's specific requirements.
- You are aware of all critical events thanks to the highest sampling rate, with triggering based on events or alerts; back-in-time-triggering is also available in case you missed something.

Notifications

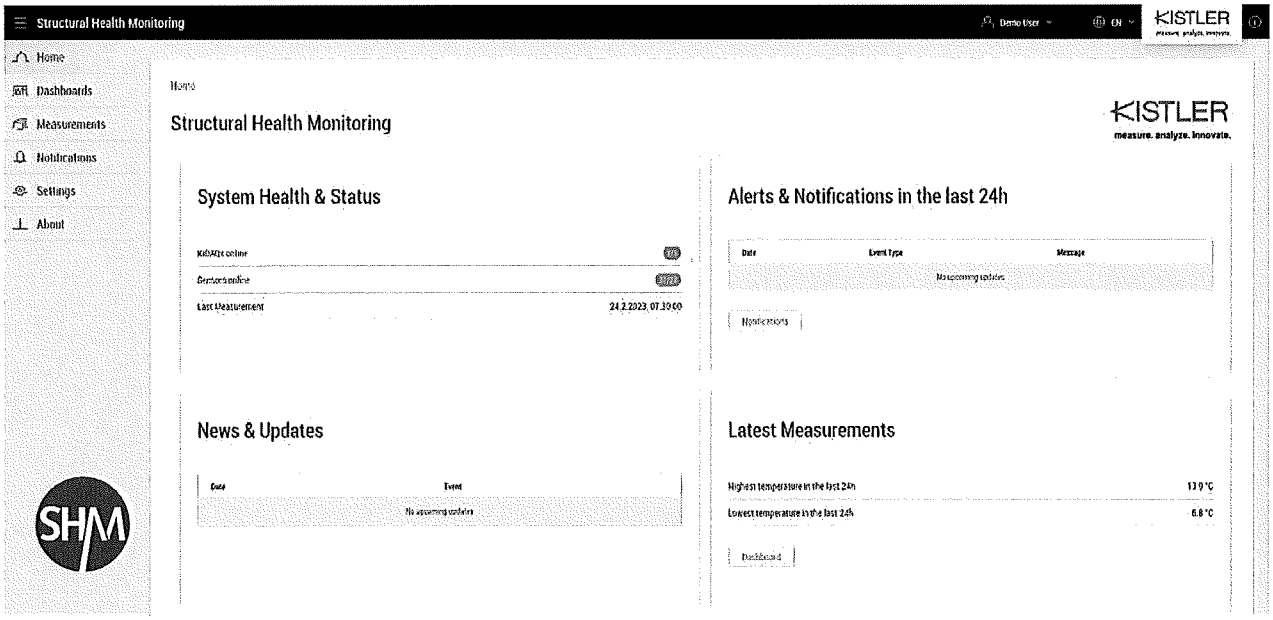
- You are notified whenever an event occurs on your structure; with filtering, you can restrict notifications to events that are relevant to you – and you can be informed at any time, wherever you are.
- Notifications and events can be defined on the basis of sensor values and system status, and also for calculated channels.

Settings and configuration

- The system is fully configurable from the cloud, with 100% remote control for all your data acquisition, edge computers, and other devices.
- We provide you with regular SW updates for all our devices – these can be applied remotely to ensure your system is always up to date and secure.

Health status monitoring

- All our sensors and devices are continuously monitored for abnormal behavior.
- Defects and anomalies are identified and flagged so you can easily locate them on the bridge.
- You can exclude flagged data from any further analysis to prevent incorrect conclusions.



Homepage of Kistler's SHM software platform with overview of main functionalities

Customer algorithm runtime

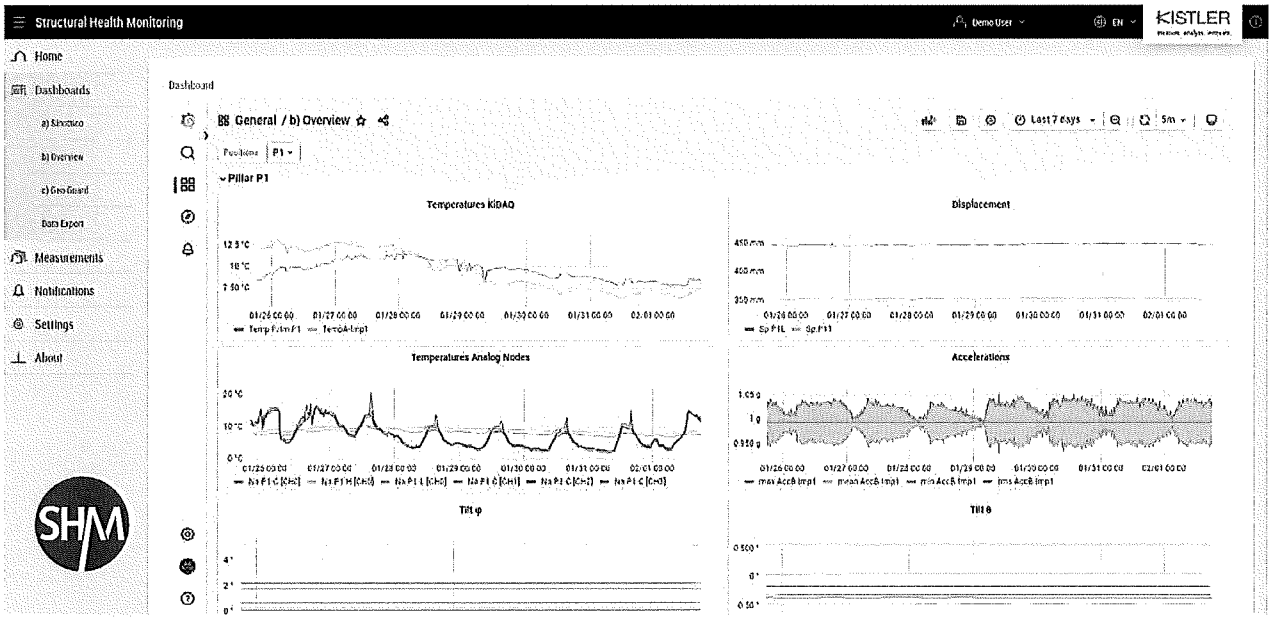
- Our solution includes an interface to run your own algorithm both on our real-time data and on the aggregated data.

Access rights and security

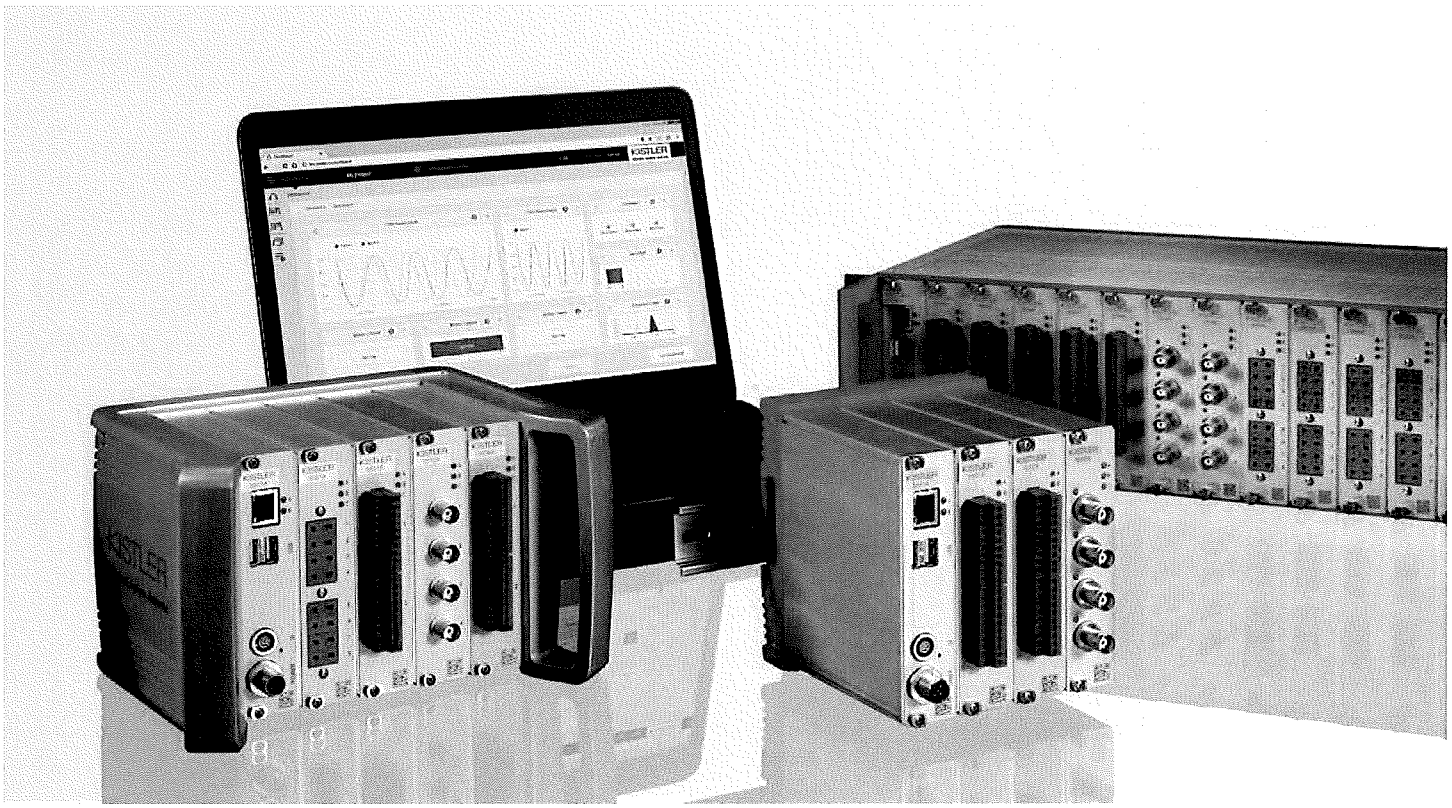
- The web-based interface allows remote access to the bridge and its data from any location.
- Our granular OAuth 2.0-based access management system gives you full control over who can access your system, and at which depth.
- We continuously update the cloud SW – so you can rest assured your data will always stay secure and accessible.

Main benefits of our SHM software

- Open solution – **fully customizable** to meet each project's requirements
- **Data you can trust** – professional system architecture combined with advanced functions to ensure the highest standard of data quality
- **Data availability guaranteed at any time** – including local buffering to allow 'back-in-time triggering'
- State-of-the-art **data security**
- **Remote configuration** and **updates**
- **Open interface** – so customers can run their own structural analysis



Dashboard of Kistler's SHM software with visualization of selected live data channels (e.g. temperature, acceleration, displacement), customizable to individual needs



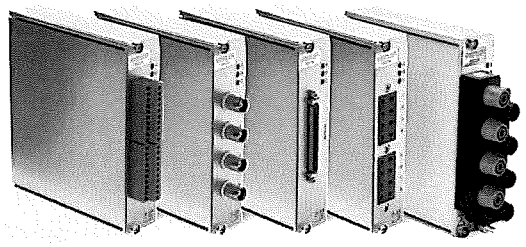
The KiDAQ data acquisition system – make your signals available digitally

Kistler offers KiDAQ – a unique integrated data acquisition system, highly modular and easily customizable to monitor any type of bridge with any type of sensor technology.

KiDAQ ensures comprehensive networking of sensors, and delivers high data quality thanks to high resolution, high sampling rates and precise data synchronization. Our KiDAQ data acquisition system features a modular design that gives you the flexibility to expand your solution as you wish. KiDAQ offers a wide choice of measurement modules covering over 20 different measurands and sensor interfaces (such as voltage, current, resistance, temperature, strain gauges, and many more). These modules are available in different housing variants to ensure maximum flexibility. The KiDAQ system also includes distributed measurement technology. Multiple KiDAQ units can be deployed and daisy-chained along the bridge to build a highly reliable distributed system, so installation becomes much easier.

You benefit from our measurement technology expertise throughout the entire measuring chain – from the sensors and signal conditioning all the way through to the software

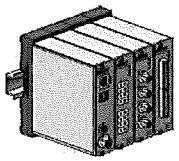
- Highly reliable and precise digitalization of sensor data with no loss of information
- Most versatile and modular hardware concept
- Up to 19 measurement modules available for vast range of sensors (static and dynamic mode)
- Expandable as distributed systems (daisy chaining)
- Precise time synchronization with PTP
- Quick and easy remote configuration



A wide range of different measurement modules (up to 19) ensures full flexibility and modularity to interface with any type of sensor output.

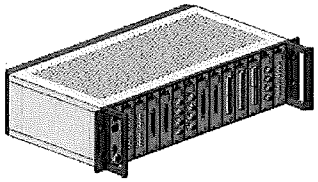
KiDAQ housing options

KiDAQ DIN Rail



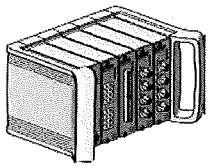
- Simple standardized mounting on DIN rail
- You can combine any number of measurement modules (from the list below)

KiDAQ Rack



- Standard 19" housing for simple mounting in roadside cabinet
- Up to 13 measurement modules can be selected individually (from the list below)

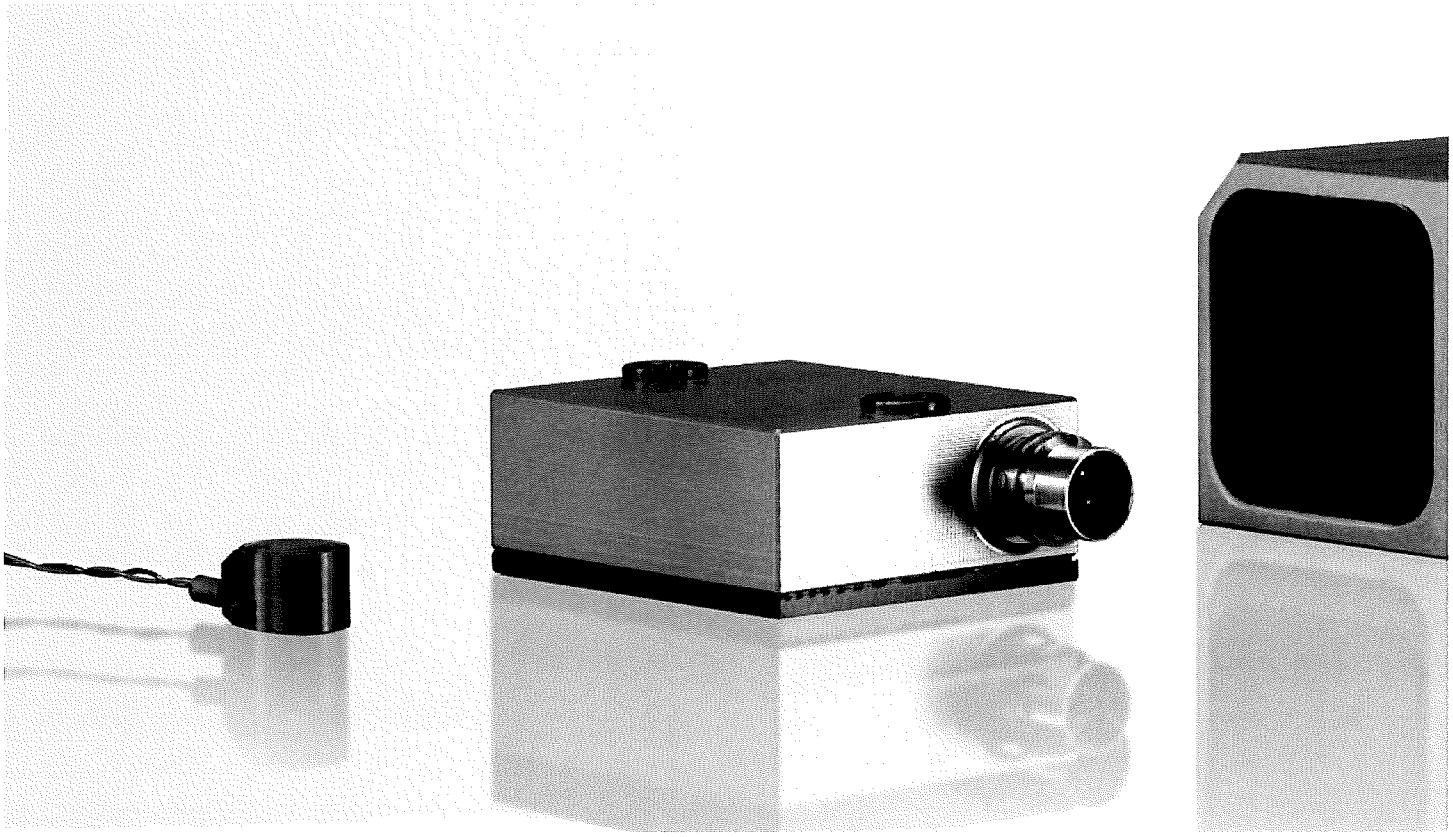
KiDAQ Portable



- Compact, robust housing for stationary and mobile measurements
- Up to 13 measurement modules can be selected individually (from the list below)
- Battery operation possible

KiDAQ measurement modules overview

Measurement module type	5501A	5502A	5505A	5506A	5507A	5509A	5512A	5514A	5517A	5518A	5521A	5522A	5525A	5526A	5528A	5529A	5531A	5534A	5535A
Analog input channels	2	4	8	8	8	4	4	8	8	2	8	4	4	4	4	4	-	-	-
Digital input channels	2	-	2	2	-	-	-	-	-	4	-	-	-	-	-	-	4	8	6
Sampling rate per channel (S/s)	100 k	20 k	20 k	20 k	20 k	100 k	100 k	20 k	20 k	20 k	100	10	20 k	100 k	100 k	100 k			
Analog signals: Voltage	■	■	■ < 10 V	■ < 60 V	■		■	■			■ < 80 mV								
Analog signals: Voltage (isolated 1.2 kV)														■	■	■			
Analog signals: Voltage (range up to 1.2 kV)															■	■			
Analog signals: Current	■	■	■		■									■	■				
Analog signals: Resistance	■	■										■							
Analog signals: Potentiometer	■	■																	
Analog signals: Pt100, Pt1000 (RTD)	■	■										■							
Analog signals: Thermocouples	■	■									■								
Analog signals: Thermocouples (isolated 1.2 kV)													■						
Analog signals: Strain gauges	■	■							■	■									
Analog signals: Inductive full and half bridges										■									
Analog signals: LVDT (displacement)										■									
Analog signals: Piezoelectric sensors						■													
Analog signals: IEPE sensors (Piezotron)	■						■												
Analog signals: MEMS capacitive sensors (K-Beam)								■											
Analog signals: Piezoresistive pressure transmitters (PRT)					■														
Digital signals: Frequency																	■	■	■
Digital signals: Pulse width																	■	■	■
Digital signals: Counter signal																	■	■	■
Digital signals: Time																	■	■	■
Digital signals: Status	■		■	■						■							■	■	■
Digital signals: TEDS	■						■												



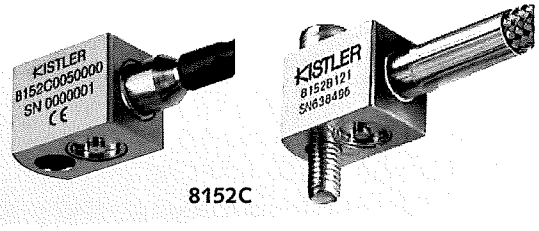
Sensors – your monitoring system's nerve cells

Sensors from Kistler capture a vast range of physical parameters such as acceleration, acoustic emissions, strains, stresses, loads, and many more. Our measurement experts select the right sensor for your specific measuring task and if necessary, we add sensors from qualified third-party suppliers to enhance your system. Kistler sensors meet the highest quality standards and deliver measurements with maximum precision – so you can rest assured there will be no errors due to noise, thermal drift or any other factors.

Acoustic emission sensors

Acoustic emission (AE) sensors offer a unique method of monitoring fatigue and cracking in bridge steel structures and stay cables.

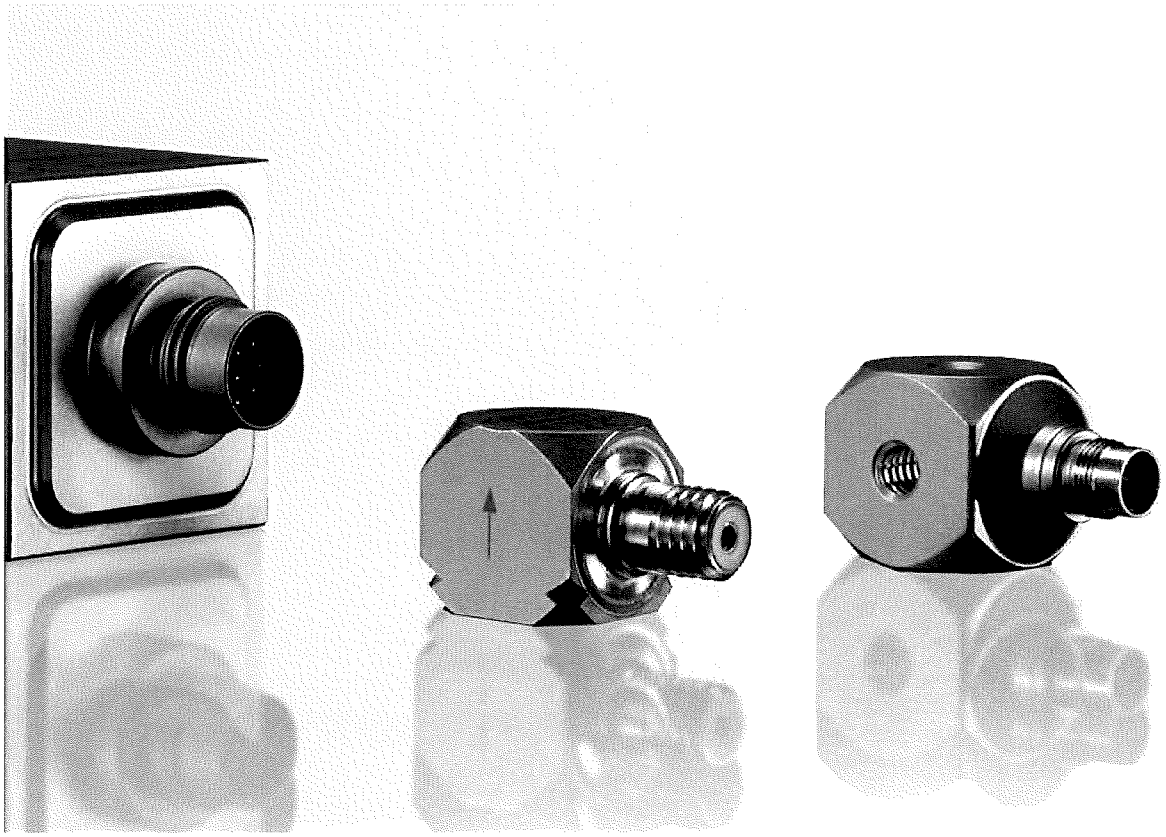
When cracking takes place, material waves with frequencies of up to 1,000 Hz are released: these can be captured by Kistler's high-end acoustic emission sensors. Cracking can be identified in the initial stage before it can propagate and cause more extensive damage.



8152C

Features and benefits

- Can identify cracking/fatigue at an early stage
- Non-destructive testing
- Frequency range of up to 1,000 Hz
- Single-axis and triaxial
- Thermally stable, can measure at temperatures of up to 165°C



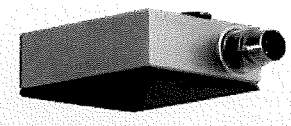
Accelerometers

When studying and monitoring large structures such as bridges, dynamic response is a key element for assessing structural behavior. These bridge structures move very little, and they move slowly. To capture these movements precisely, the sensors must meet very demanding requirements as regards accuracy, thermal stability and low noise so that users can draw the right conclusions about structural health.

As the recognized expert in dynamic measurement technology, Kistler can provide best-in class accelerometers to measure acceleration and vibration. These sensors from our K-Beam family are designed to measure with high accuracy in the very low frequency band, with no temperature errors (high thermal stability) and with an almost zero level of noise density.

When measuring other structures in a bridge (such as stay cables), higher frequency ranges are of interest – and Kistler's acceleration portfolio also includes products that can meet this requirement.

From the extensive range of Kistler accelerometers, we make sure that the most suitable product is selected to meet each customer's requirements.



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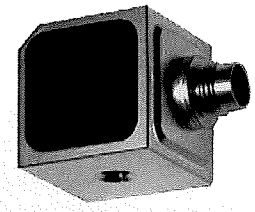

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Features and benefits

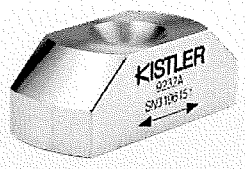
- Best-in class accelerometers from the K-Beam family
- Highest accuracy to monitor structural changes precisely over time
- No thermal drift (highest thermal stability)
- No signal distortion – lowest noise density
- Single-axis and triaxial
- Miniature design

Surface strain sensors

Piezoelectric sensors from Kistler can be used for high-resolution measurements of the strains acting on a structure. Surface strain sensors are simply attached to the structure with a mounting screw. These strain sensors are suitable for measuring dynamic and quasistatic strains; they have a very high measuring sensitivity, and thus they can detect smallest deformations of the structure.

Features and benefits

- Durable, no creep
- Simple to install
- Very high measuring sensitivity



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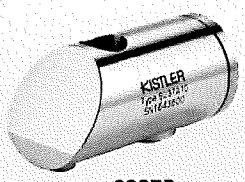

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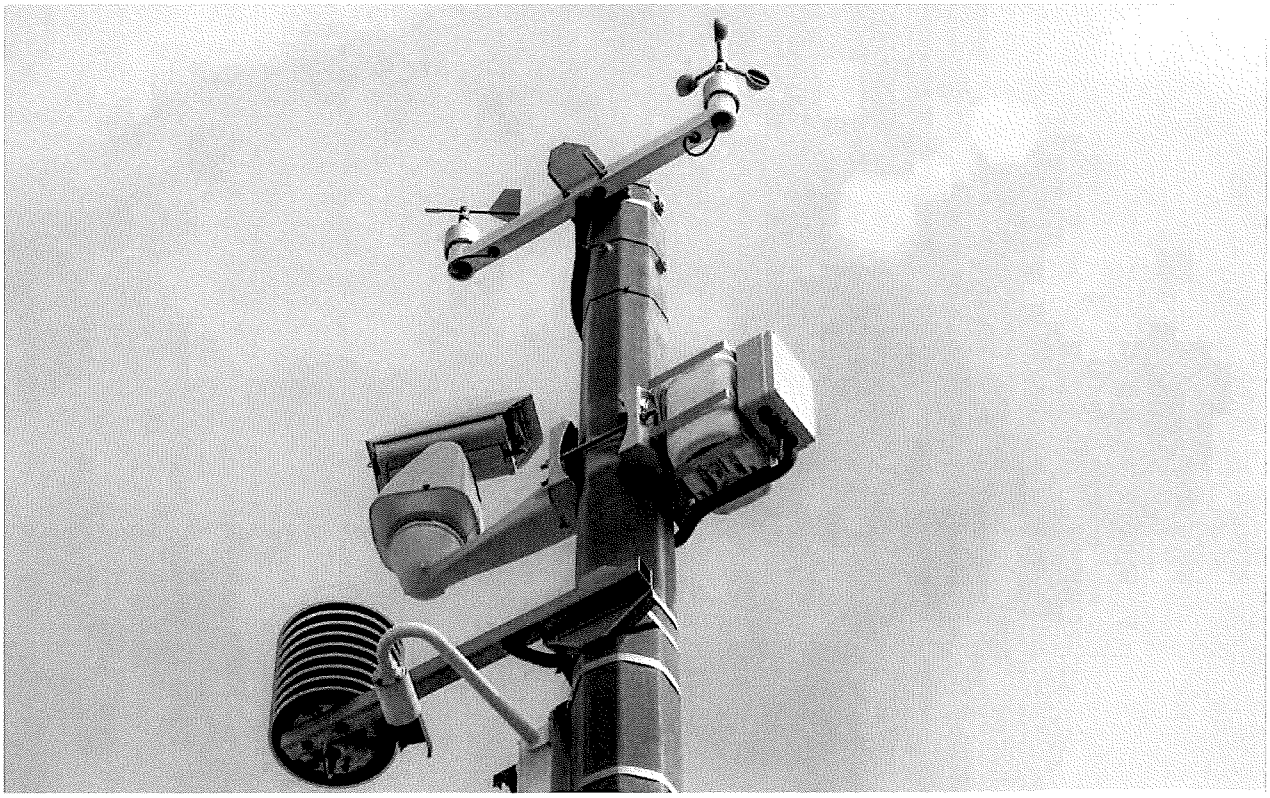
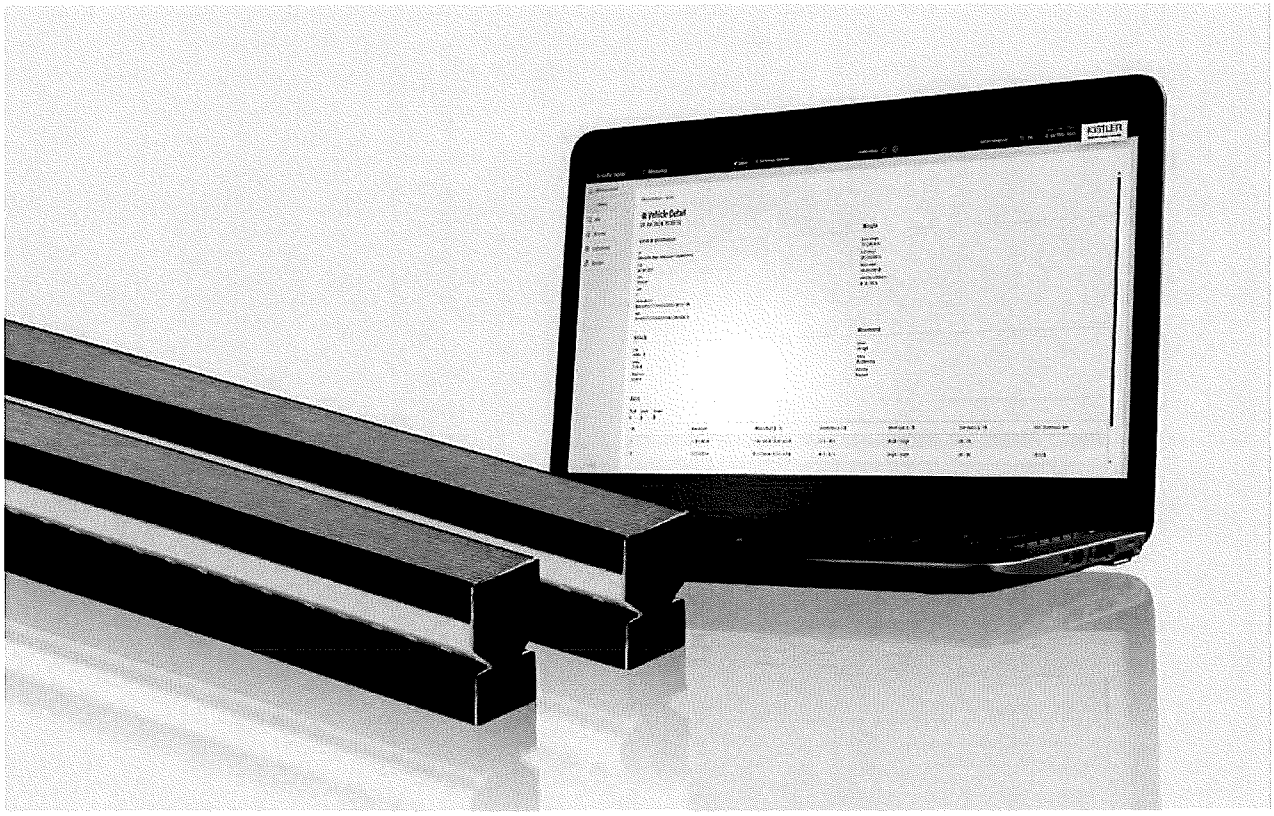
Flexible integration of third-party sensors and subsystems

Kistler monitoring solutions are designed to allow integration of sensors and systems from qualified third-party suppliers, including:

- Temperature and humidity sensors
- Weather stations
- Inclinometers
- Displacement sensors
- Others



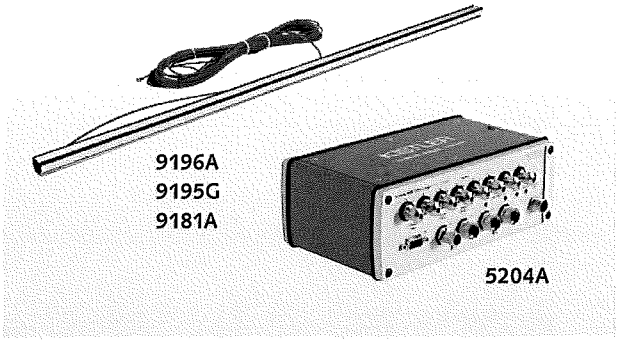
Automatic weather station, with a weather monitoring system and video cameras for observation



KiTraffic Digital, the unique Weigh In Motion solution

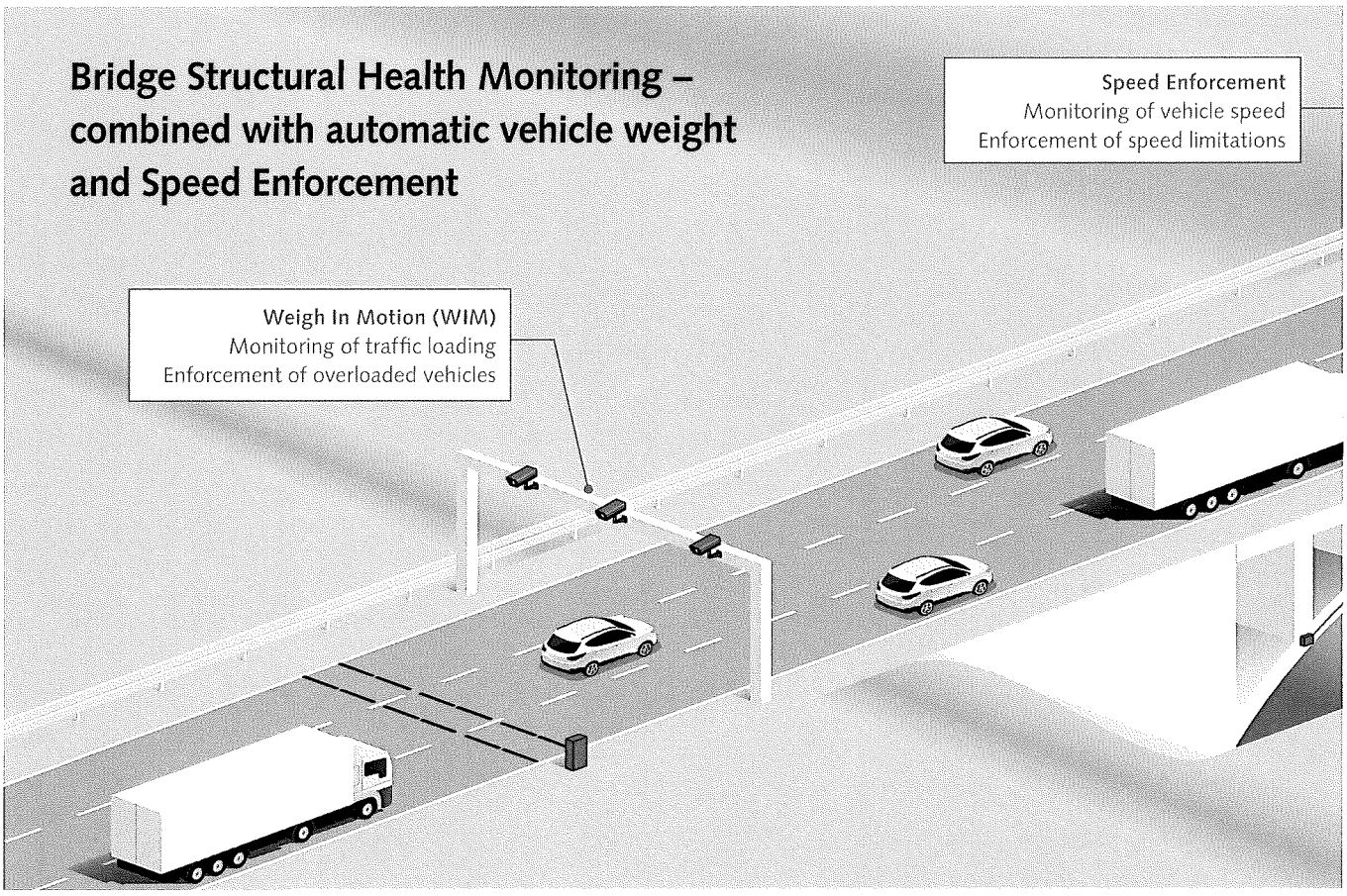
Traffic sensors and Weigh In Motion

When monitoring bridges and performing structural analysis, consistent information on the real traffic loads passing over the bridge is essential. Traffic loads have a direct impact on bridge fatigue, so real traffic load analysis is an important factor when calculating a bridge's remaining service life. Kistler's Weigh In Motion (WIM) systems monitor traffic on a 24/7 basis to provide users with relevant information on traffic loading: data is supplied on traffic volumes, vehicle weights and axle loads, vehicle distances, vehicle classes, and many more parameters. The core elements of these WIM systems are our unique Lineas quartz WIM sensors (installed in the road pavement) and the WIM Data Logger, which collects the traffic data.



Features and benefits

- Essential traffic load information for structural analysis
- 24/7 traffic monitoring
- Accurate weighing of vehicles moving at any speed
- Unique quartz technology for highly reliable vehicle weighing
- Easy to install and operate
- Certified to the OIML R134 standard
- Compliant with COST-323 and ASTM E1318-09 standards

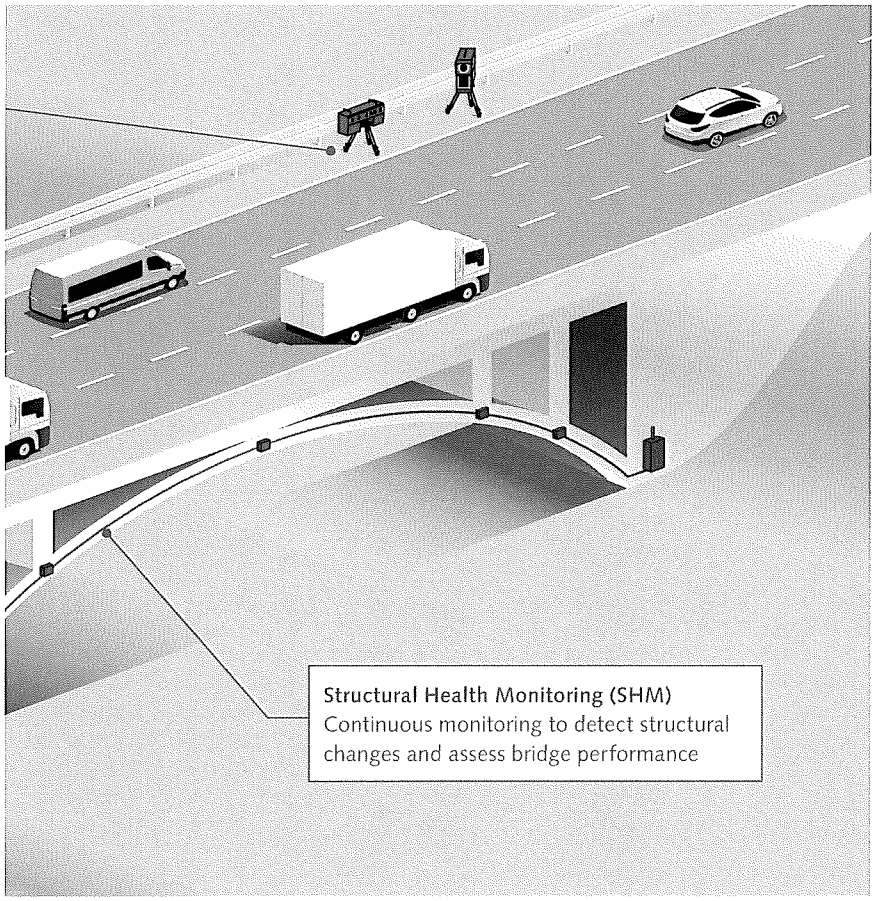


Kistler's holistic solution to ensure traffic safety and protect infrastructure

Bridge structures have limited service lifetimes – and they face growing challenges due to natural aging as well as major increases in traffic density and loading. Holistic solutions from Kistler take account of all relevant parameters to ensure effective protection for infrastructure. At the same time as monitoring the bridge's structure, our technology measures all vehicles passing over it on a 24/7 basis – so any vehicle violating the legal limits for gross vehicle weight, axle weight and speed can be identified and then prosecuted.

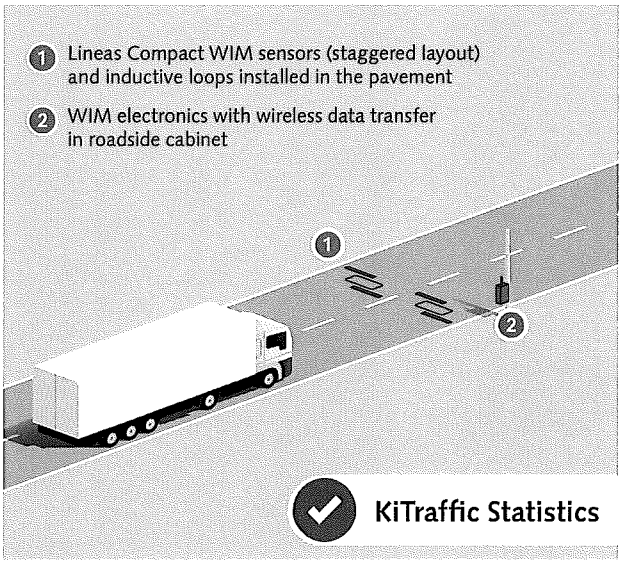
Traffic loads have a direct impact on bridge fatigue – so it follows that analysis of real traffic loading plays a critical part in assessing a bridge's fatigue and its remaining lifetime. When monitoring bridges and performing structural analysis, consistent information on real traffic loads and travel speeds is essential. Compliance with legal loading and speed limits is a key factor in ensuring traffic safety and the health of a bridge structure. Traffic load and speed limits are often imposed on bridges with structural deficiencies. A WIM system makes it easy to identify overloaded vehicles so violators can either be automatically fined, stopped and made to unload, or rerouted to an alternative itinerary: all these measures ensure highly effective protection for the bridge infrastructure.

Generally, when performing infrastructure assessment, dynamic weighing (WIM) enables comprehensive categorization of real traffic patterns, which serve as reference models and have better accuracy than the models from the guidelines. In addition, when dynamic weighing is conducted from the extrados, together with acceleration measurements also made there, it provides important information about the deformations occurring at different points in the bridge. Thus, the integration of local and global bridge measurements is very valuable additional information for assessing the structural integrity of the artifact, especially in the context of processing large amounts of data.

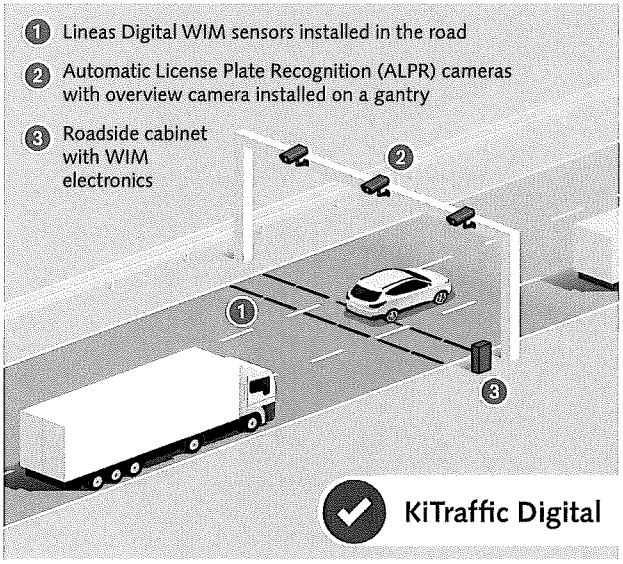


Benefits

- Your single-source supplier for holistic solutions that combine bridge structural monitoring with traffic law enforcement
- Improved assessment of bridge fatigue and remaining lifetime based on real traffic loading information
- Effective protection of bridges – overloaded vehicles are detected and prosecuted or rerouted
- Simple and effective enforcement of speed limits



WIM system for traffic loading analysis



WIM system for automatic weight enforcement

Weigh In Motion (WIM)

Users of Weigh In Motion (WIM) systems benefit from 24/7 traffic monitoring with automatic collection of key traffic parameters. Kistler's WIM systems are available with various degrees of precision, at prices to match each user's requirements: our portfolio ranges from simple WIM sites to collect statistics and analyze traffic loading (such as the KiTraffic Statistics system) to highly complex solutions for automatic weight enforcement (such as the KiTraffic Digital system).

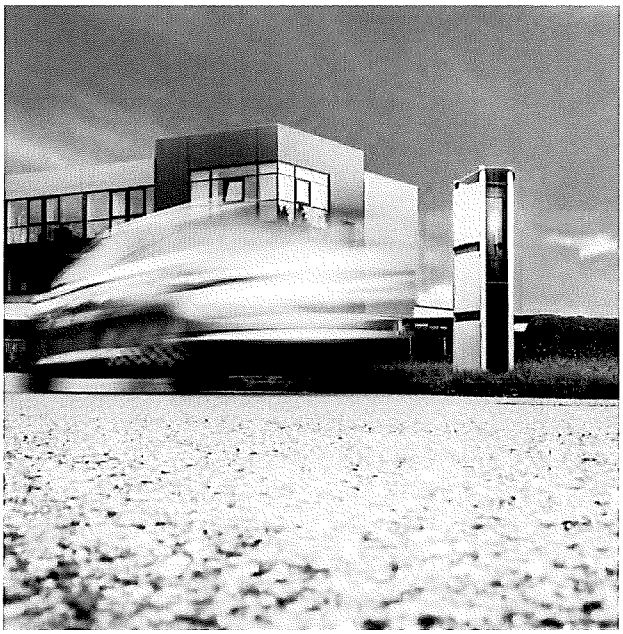
Backed by more than 25 years of experience and with over 80,000 Lineas sensors installed in more than 50 countries, Kistler is your partner of choice for the most advanced technology and the highest level of expertise in WIM applications.

Kistler's WIM system automatically records these traffic parameters:

- Vehicle class
- Vehicle weight (gross weight and axle loads)
- License plate and overview picture
- Driving direction and driving lane
- Vehicle dimensions (height, length, width) and axle spacing
- Vehicle distances, speeds and traffic volumes
- Wheel and tire information (single/double wheel, underinflated tires)

Advantages of Kistler's WIM systems

- Highly accurate and reliable thanks to unique quartz sensor technology
- Long service lifetimes thanks to robust design
- Highly reliable in all weather conditions
- Long-term stability (no aging), insensitive to temperature variations
- Quick and easy sensor installation in road pavement
- Global footprint with over 80,000 installations in more than 50 countries
- OIML-certified system for direct fining of overloaded trucks (no need for static weighing)



Kistler's Speed Enforcement system (stationary installation)

Speed Enforcement

With Speed Enforcement systems by Kistler, users can efficiently measure the speed of any passing vehicle and automatically fine vehicles that exceed the speed limit. Our versatile systems provide both the flexibility and the precision you need when performing speed checks: Kistler solutions are widely used not only on bridges but also on secondary roads, open highways and construction sites. These measurement solutions combine unique optical measurement technology with cameras for reliable driver and license plate. Traffic violations can be identified quickly and efficiently thanks to the system's unique measurement base of just 50 cm. One single instrument can measure the speed of any type of vehicle in both traffic directions and across multiple lanes. Our user-friendly software application supports downstream evaluation and legal validation of the measured data. The same system can be operated as a portable unit (for mobile enforcement) or converted into a stationary measurement solution by installing the protective cases on the roadside.

Advantages of Kistler's Speed Enforcement

- Universal system for legally valid Speed Enforcement data
- Just one instrument can monitor traffic traveling in different directions
- Precise measurements with high hit rates – regardless of vehicle type or speed, even on multiple-lane roads
- Unique, easy-to-operate certified optical measurement technology
- Can be operated as a mobile or stationary enforcement system

Putting monitoring solutions into practice – with Kistler

The Great Belt Bridge in Denmark, one of the world's longest suspension bridges, benefits from Structural Health Monitoring with measurement technology by Kistler.

Great Belt Bridge, Denmark

Since 1998, Kistler technology has been operating successfully on Denmark's Great Belt Bridge to measure the structure's sway in the wind and the natural frequency of its suspension cables. Two types of Kistler measurement systems were installed on the East Bridge section, which ranks as one of the world's longest suspension bridges: one system measures the natural frequency of the vertical suspension cables, and another (housed inside the main span) covers the main bridge structure.

Kistler's solution combines special low-frequency K-Beam accelerometers with low-pass filters to cover frequencies of 1 Hz inside the bridge and 10 Hz on the suspension cables. Mechanical dampers were added for the sensors integrated in the main span, and efficient signal conditioning was a key design focus. Changes in natural frequency and swaying behavior are monitored continuously, and the measurements provide key insights into the bridge's structural behavior – one important result was a modification of the bridge construction in the initial phase of the project.

> "The frequencies as well as the g-forces are very low here, so the main challenge was to isolate the signals from other vibrations such as those from vehicles crossing the bridge."
>
> Erik Nielsen, Sales Engineer at Kistler

The measuring systems (including accelerometers, filters and transmission) on the vertical suspension cables were installed in special boxes to ensure long-term robustness under harsh weather conditions.

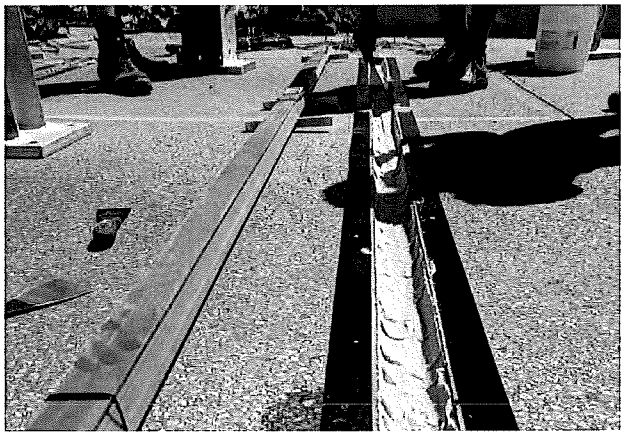
A view of the railway bridge in Austria previously damaged by heavy timber transportation – now protected thanks to the KiTraffic Statistics Weigh In Motion (WIM) system from Kistler

Road bridge over a railway line, Austria

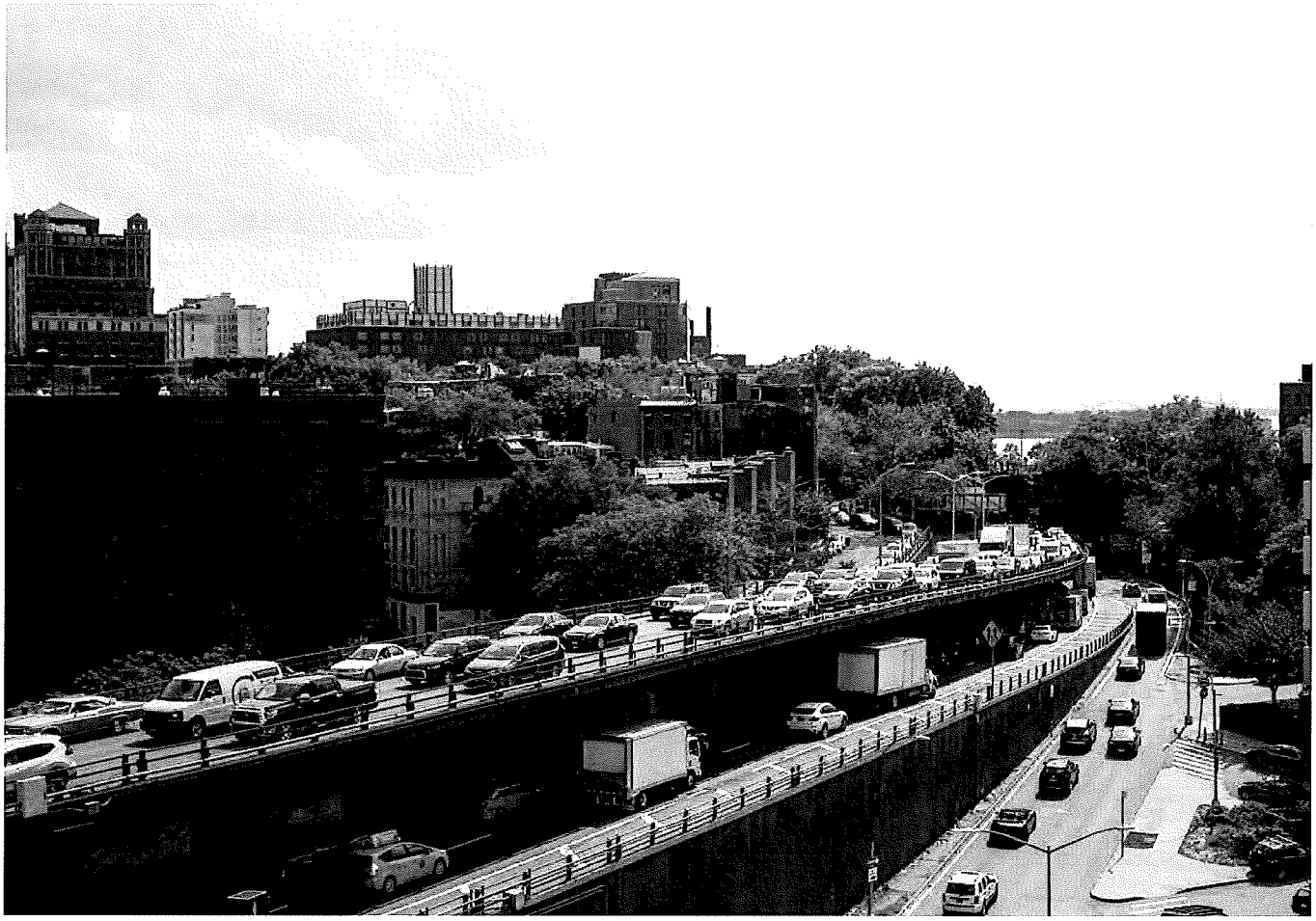
Strain, fatigue and aging can affect bridges of all sizes. This small bridge over a railway on the access road to a village in the heart of Austria is near a large sawmill, so trucks carrying heavy loads of timber cross it every day. The result: visible damage to the bridge, with several cracks in its supporting structure. To address the problem, Austrian Federal Railways (ÖBB) called in REVOTEC, the Vienna-based bridge monitoring specialist and system integrator. In January 2020, REVOTEC launched a project that soon identified an effective solution: Kistler's KiTraffic Statistics WIM system – and it was installed within just one day! Reliable overload detection and vehicle classification now prevent any further overloading of the bridge. Vehicles weighing over 44 tonnes are penalized, and changes in the bridge's condition can also be tracked more accurately.

"Automated bridge monitoring systems to measure supporting structures and axle loads are likely to become standard elements of the infrastructure, to allow real-time condition monitoring and predictive maintenance."

Michael Vospernig, one of REVOTEC's two founders



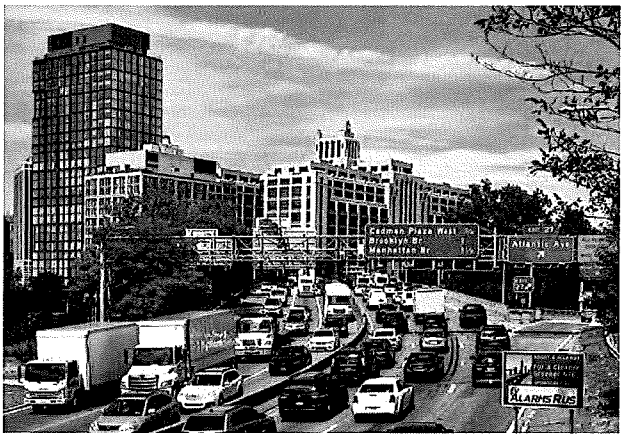
The Lineas sensors for the KiTraffic Statistics WIM system by Kistler are installed slightly below the road surface; they are coated with a special grouting compound to ensure long lifetimes.



Trucks carrying loads over the legal weight limit were causing stress on New York's Brooklyn-Queens Expressway.

Brooklyn-Queens Expressway, United States

Built over 70 years ago, the Brooklyn-Queens Expressway (BQE) in New York is a vital regional artery that connects Brooklyn with major access points to Manhattan, Queens and Staten Island. However, aging of the structure combined with an 11% increase in legal truck limits over the years prompted concerns about the BQE's safety – focused especially on the stretch known as the "Triple Cantilever". The New York City Department of Transportation (NYC DOT) responded by launching a project to quantify overweight truck traffic as the basis for an eventual direct enforcement solution. The DOT's traffic engineering partner C2SMART Center brought Kistler on board. During the pilot phase, the Weigh In Motion (WIM) system comprising Kistler Lineas quartz sensors and a Data Logger showed that 15% of the 25,000 trucks using the BQE each day were over the weight limit. In 2023, based on further high-accuracy data, the WIM site earned certification as the USA's first automated citation system for overweight vehicles. The result: one month after the WIM system went live, the daily number of overweight vehicles using the BQE was cut in half. This success opens the way for other U.S. states to protect aging infrastructure with automated direct enforcement technology.



Heavy traffic on the Brooklyn-Queens Expressway, looking north towards Brooklyn Bridge Park

"Kistler's technology and commitment to making the BQE direct enforcement initiative successful is second to none."

Hani Nassif, PhD, PE – Professor of Civil and Environmental Engineering at Rutgers University, Associate Director of C2SMART Center

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