

# Welcome to the “The Challenges of Structural Health Monitoring (SHM)” Webinar

The presentation will begin at 04:00 PM Central European Time |  
09:00 AM Central Time | 10:00 AM Eastern Time

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PUBLIC

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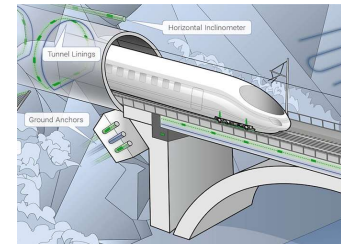
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# Dietmar Maicz

- Monitoring (and Railway) Specialist at HBK
- Master level degree in Engineering and Economics
- 20 years of experience, >15 years in test and measurement
- E-Mail: [dietmar.maicz@hbkworld.com](mailto:dietmar.maicz@hbkworld.com)



# Typical reasons for Structural Health Monitoring (SHM)

## Improving standard maintenance and inspection by condition-based maintenance

- Detecting damage in early stage, enabling proactive response
- Optimizing maintenance process
- Extension of major overhaul cycle
- **Lower costs, higher availability**



## Fatigue monitoring, lifetime prediction

- Boost lifetime and safety
- Optimize design and support cost effective solutions
- Continuous observation and data (for new projects)
- **Better insights, better product development**

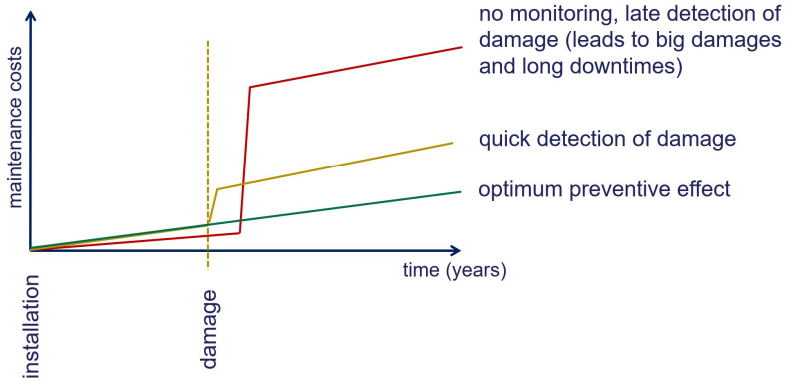
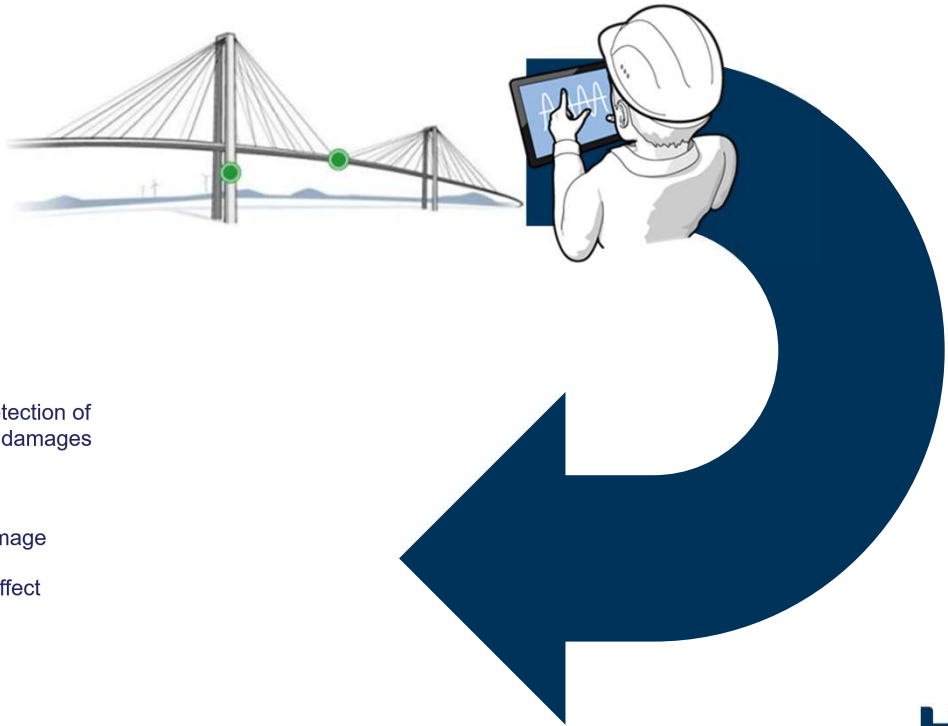
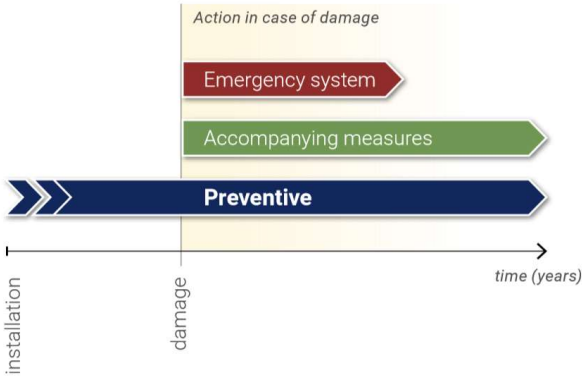


## Identification of critical situation

- Immediate reaction
- **Safe lives, avoid breakdown**



# Gaining Real Insight into a Structure's Health



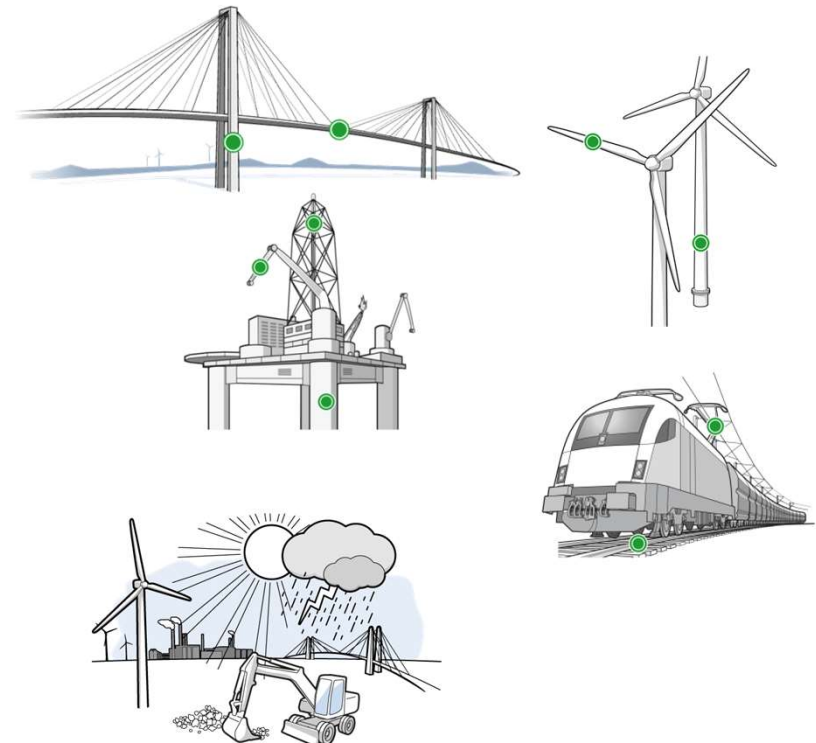
# Challenges

## Prerequisites for trustworthy forecasts/decisions

- reliable data
- high signal quality
- long term stability and durability
- data integrity (time synchronized data)
- extraction of the essential information needed for
  - immediate reactions
  - maintenance decisions
  - the prediction of lifetimes

## Typical constrains

- Size of the structure, long distances
- Harsh environmental conditions
- remote location, slow data connectivity
- data transfer
- data management and storage (data lake)





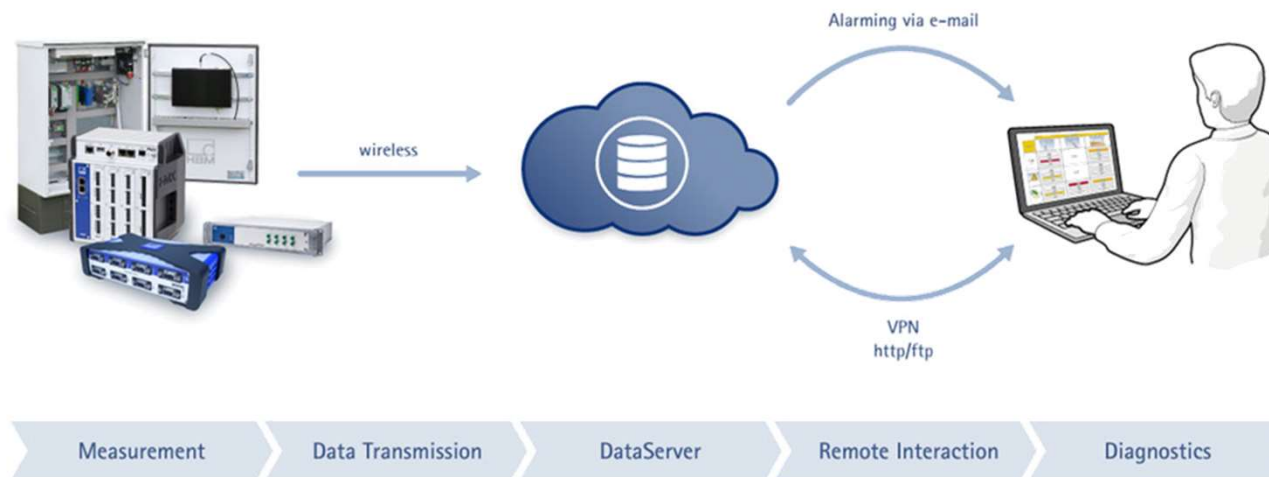
# Overall solution concept





# Ideal solution?

- There is no ideal/standard solution
  - Every SHM needs a **case by case analysis**
- ➔ **reason for HBK modular approach**



# Standard approach – useful for most projects

## Amplifier



universal



rugged



fibre optical

- Logging
- Intelligent triggering
- Preprocessing / Edge computing



- ftp/sftp
- cloud connect

## processing



Reports

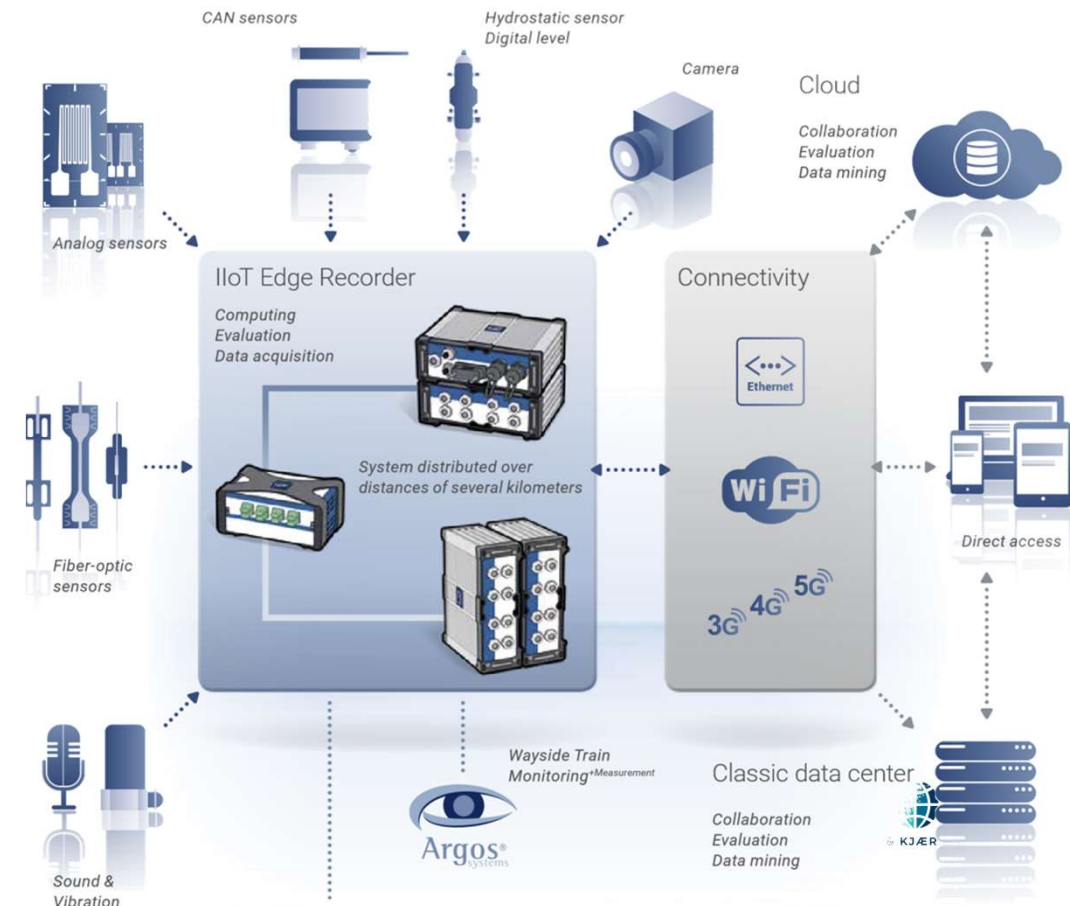
HBM push notification

Alert via E-Mail



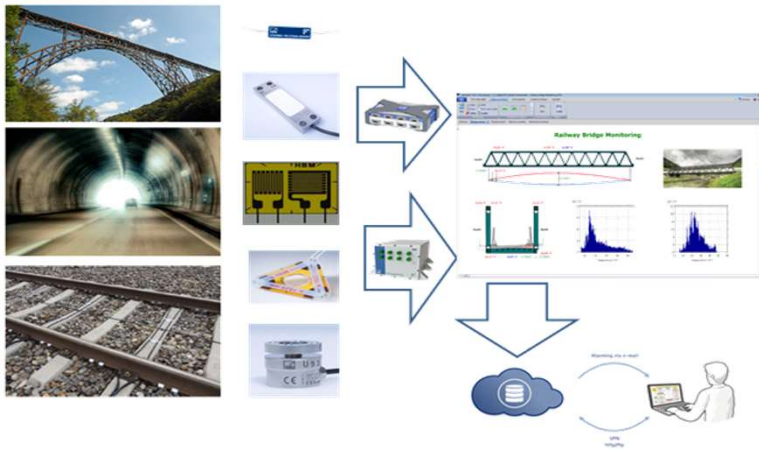
# Wide sensor range, distributed over distances

- Wide range of physical and digital inputs
- hybride fibre optic sensor system
- Ultra-robust (vibration, shock) according to MIL-STD202G
- Extended temperature range: -40...+80 °C, dew-point resistant
- Dust- and water-proof with ingress protection grade IP65 and IP67
- Fire protection rating according to DIN EN 45545-1:2013
- Reliable design offering 10,000 plug cycles
- Distributed system, Time-synchronized data



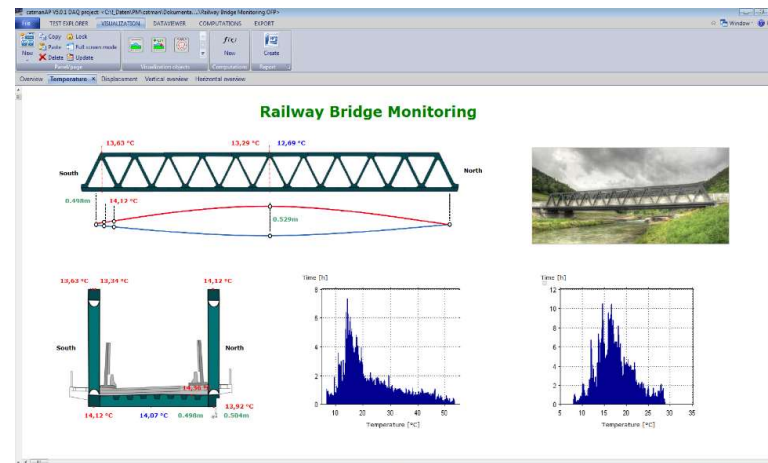
# HBK solution set

- Components (sensors, DAQ – QuantumX, PMX, FS22 software – Catman, nCode, Reliasoft)
- Cabinet equipped with components incl. startup and software (modular set)
- Custom solution incl. cloud, on-site sensor installation and service



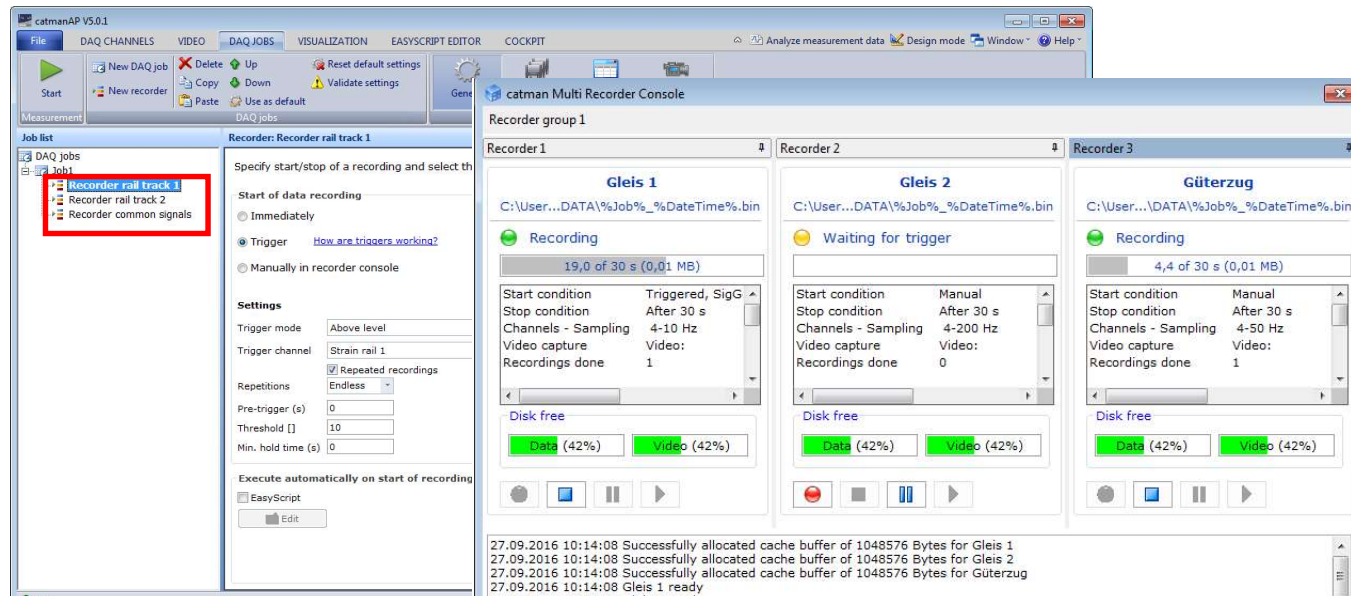
# Out-of the box: Data logger functionality for Monitoring

- Take long-term measurements over several days, weeks and months
- Easy setup of hybrid systems (electrical and fibre optic sensors mixed)
- Carry out parallel data acquisition jobs using a single data recorder (individual files, triggers)
- Data classification - Rainflow, FromTo, etc - direct in Logger
- Save data locally or automatically transfer data to FTP servers or the cloud
- Implement automated actions and alerts such as smart phone push messages or/and E-Mails triggered by defined events
- Integration of weatherstation signals
- Live data visualization in the Web using Microsoft Power BI
- Event and status logging



# Parallel Recording - Define several recorders within one DAQ job

- Recorders are running **in parallel** (max 15)
  - Each recorder can have a individual **subset of channels** with **own sample rate**
  - **Separate** start/stop condition
  - Individual files per recorder
  - By default recorders are repeated endless



# Statistic journal for parallel long term measurement

- Statistic journal can be used to do long term DAQ **in parallel to** triggered measurement
  - Use Case: “load events” (crossing train, heavy vehicle, storm) all inputs are acquired with high sample rates (triggered) in parallel to constant time recordings (7 hours / 365 days) for slow moving structure
- Saves Min, Max, Mean in separate bin file
- Works independent from DAQ trigger (optional)
- Wide range of update interval (sample rate): 5s .. 24h
- Configure time interval for file creation
- Available in DAQ job settings

Create statistic journal [More information about statistic journal](#)

Update interval  Also active during waiting for trigger

Backup

---

# Enhanced workflow for fibre optical interrogator

- Assign strain and temperature sensors just by Drag&Drop  
 → Physical value will directly be displayed on regular channel;  
 No need of extra computation channel
- Fine tune sensor settings via usual Sensor Adaptation dialog (e.g. the reference center wavelength for a FS63)
- FS sensors like FS62 (strain), FS63 (temperature) and FS65 (acceleration) HBM sensor database

The image displays a software interface for configuring DAQ channels and sensor settings. The main window shows a table of channels with their respective readings and sensor functions. A 'Configure fiber optical sensor' dialog box is open, showing settings for an 'Optical Fiber-Bragg-Grid temperature sensor'. A 'Composite Temperature Sensor CALIBRATION SHEET' is also visible, providing technical information and a graph.

**Configure DAQ channels** Devices: 1 hardware channels: 4

Channel name	Reading	Sample rate/Filter	Sensor/Function	Zero value
FS22DI_1 [10.0.0.150]				
NTP_TIME	1452184117,3788 (▶▶)	50 Hz / Filter: Off	Optical fiber sensor	
DIAG_SEQ_NUMBER	0000,0000 ▶▶	50 Hz / Filter: Off	Optical fiber sensor	
Oven temperature	439,5 °C ▶▶	50 Hz / Filter: Off	FS63 Composite Temperature Sensor	
Strain	-0,1 µm/m ▶▶	50 Hz / Filter: Off	FS62 Weldable Strain Sensor	

**Configure fiber optical sensor**

Channel: Oven temperature

Optical Fiber-Bragg-Grid temperature sensor

FS63 temperature sensor Determination of temperature

-0,7000 S2

33,9000 S1

30,0000 S0 (reference temperature in °C)

1515,0000 Base wavelength composite sensor in nm (see data)

Update in sensor database

Create new sensor

**Optical sensors**

Search: fs

- No sensor
- FS62 Weldable Strain Sensor
- FS63 Composite Temperature Sensor
- FS65 Accelerometer
- Optical strain sensor
- Optical temperature sensor

**Composite Temperature Sensor CALIBRATION SHEET**

General Information

Type: FS63 - Composite Temperature Sensor Indoor Ø 3 mm cable FC/APC

Part Number: K-FS63-17-1-322

Serial Number: 040 840 810 204-H

FS63 Name ID: T.15.12.040

Technical Information

Legend: T: Temperature (°C), W: Wavelength (nm), S: Sensitivity (°C/nm), S<sub>0</sub>: Reference Temperature (°C)

Temperature (°C) vs Wavelength (nm) graph:  $y = -0,717 \cdot x + 33,9$

Certification

Reference Temperature (°C)	Calibration Tolerance (°C)	Maximum Error
0, 25, 40	0,5	0,20



# Integration weather stations



- Acquire wind speed, barometric pressure, air temperature, humidity, rainfall and hail
- Tested with model Vaisala WXT520



catmanAP V3.6.1

MESSKANÄLE VIDEO MESSIOPS VISUALISIERUNG DATAVIEWER SENSORDATENBANK AUTOSEQUENZ-EDITOR EASYSRIPT-EDITOR COCKPIT

Umbenennen Messwert Live-Anzeige Kanal

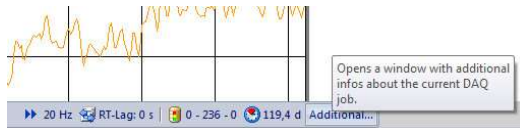
Langsam Standard Schnell Einrichten TEDI Sensor mV/V Anpassen Bearbeiten Ausführen Erzeugen Nullstellen Berechnungskanäle

GW 1 AUS GW 2 AUS GW 3 AUS Grenzwerte und Ereignisse

Messkanäle einrichten Geräte: 2 Hardwarekanäle: 15 [Live-Anzeige aktiv]

Kanalname	Messwert	Messrate/Filter	Sensor/Funktion
<b>AAAbelHeiko [MX410] [UUID=9E50015DB] [Sync-Slave] [172.19.190.22]</b>			
Time 1 - Schnelle Messrate		Zeit aus Messrate	
Kalibrierkanal	Overflow	2400 Hz / BE 500 Hz (Auto)	DC Spannung
SigGen	Overflow	2400 Hz / BE 500 Hz (Auto)	DC Spannung
AAAbelHeiko_CH_3	Overflow	2400 Hz / BE 500 Hz (Auto)	DC Spannung
Goofy?	No signal	2400 Hz / BE 500 Hz (Auto)	DC Spannung
<b>VAISALA_Weather_Transmitter [COM5 19200/n/8/1]</b>			
Time 2 - Standardmessrate		Zeit aus Messrate	
VAISALA_Weather_Transmitter_WindDirection	191,0 °	50 Hz / NA	WIND_DIRECTION_AVG
VAISALA_Weather_Transmitter_WindSpeed	0,1000 m/s	50 Hz / NA	WIND_SPEED_AVG
VAISALA_Weather_Transmitter_BarPressure	1,010 bar	50 Hz / NA	BAROMETRIC_PRESSURE
VAISALA_Weather_Transmitter_AirTemp	25,90 °C	50 Hz / NA	AIR_TEMPERATURE
VAISALA_Weather_Transmitter_RelHumidity	45,90 %	50 Hz / NA	REL_HUMIDITY
VAISALA_Weather_Transmitter_RainAccu	0,00000 mm	50 Hz / NA	RAIN_ACCUMULATION
VAISALA_Weather_Transmitter_HailAccu	0,00000 hits/cm <sup>2</sup>	50 Hz / NA	HAIL_ACCUMULATION
VAISALA_Weather_Transmitter_RainIntensity	0,00000 mm/h	50 Hz / NA	RAIN_INTENSITY
VAISALA_Weather_Transmitter_HailIntensity	0,00000 ----	50 Hz / NA	HAIL_INTENSITY
VAISALA_Weather_Transmitter_RainPeakIntensity	0,00000 mm/h	50 Hz / NA	RAIN_PEAK_INTENSITY
VAISALA_Weather_Transmitter_HailPeakIntensity	0,00000 hits/cm <sup>2</sup>	50 Hz / NA	HAIL_PEAK_INTENSITY
<b>Berechnungskanäle</b>			

# System diagnostic



Job status: DAQ job: Job1

**DAQ process workload and disk space**

Process workload **15%**

Temp. storage **80% used**

Data saving **87% used**

Video **0% used**

General Events (6)

Status	
Storage mode	Storage: All
Data saving	Manual after measurement
▶▶ Default sample rate	300 Hz 75608 values
▶ Slow sample rate	Not used
▶▶▶ Fast sample rate	Not used
RT-Lag (real-time lag)	0 s
Max. sampling duration	5,7 d
Synchronization	Unsynchronized
Camera_1	N.A.
Camera_2	N.A.
Camera_3	N.A.
Camera_4	N.A.

Job status: DAQ job: Job1

**DAQ process workload and disk space**

Process workload **12%**

Temp. storage **80% used**

Data saving **87% used**

Video **0% used**

General Events (6)

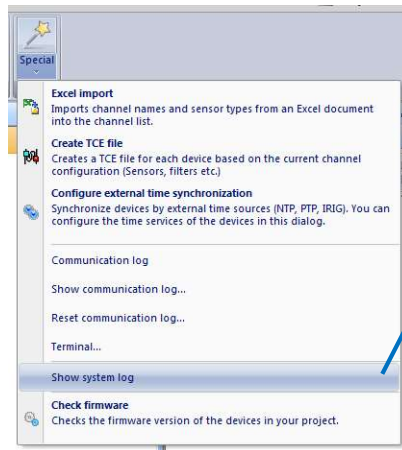
```

16.01.2015 14:12:28 DAQ job Job1 started
16.01.2015 14:13:49 DAQ job Job1 started
16.01.2015 14:14:22 DAQ job Job1 started
16.01.2015 14:25:52 DAQ job Job1 started
16.01.2015 14:29:20 Process workload over 80%
16.01.2015 14:29:38 Process workload fallen under 50%
    
```

Clear Delete Restore Clipboard

# Advanced logging capabilities

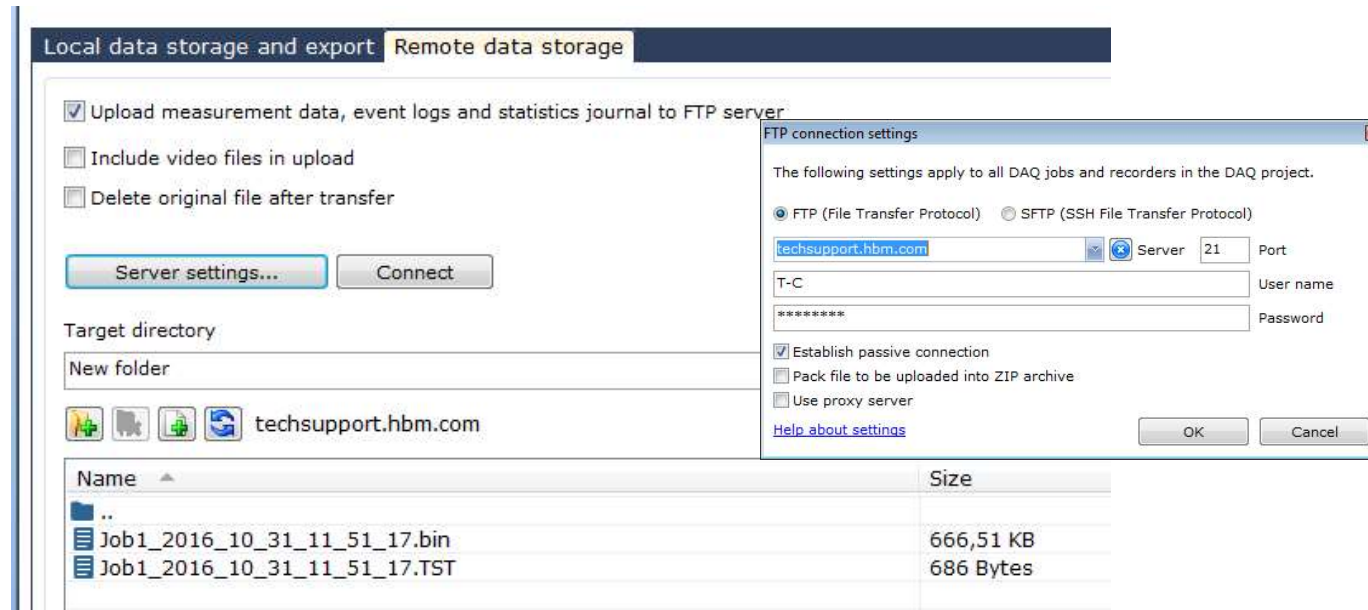
- Text format for better readability with 3<sup>rd</sup> party tools
- If log file exceeds 1MB a new file is created
- **All type of events** are logged
  - DAQ job events (trigger, start/stop DAQ)
  - User events if enabled in options (level crossing)
  - System events
  - Accessible over catman GUI (location in user directory)



```
11.08.2015 14:39:13 0,00 s DAQ job Job1 started
11.08.2015 14:39:19 6,00 s Displacement Alert (U9B 200N)
11.08.2015 14:39:20 7,00 s Start trigger fired
11.08.2015 14:39:27 14,00 s Displacement Alert (U9B 200N)
11.08.2015 14:39:29 16,00 s Displacement Alert (U9B 200N)
11.08.2015 14:39:29 16,00 s Displacement Alert (U9B 200N)
11.08.2015 14:39:38 25,00 s stop trigger fired
11.08.2015 14:39:38 25,00 s Filling post-trigger
```

# Integrated FTP/SFTP client for data transfer to a server

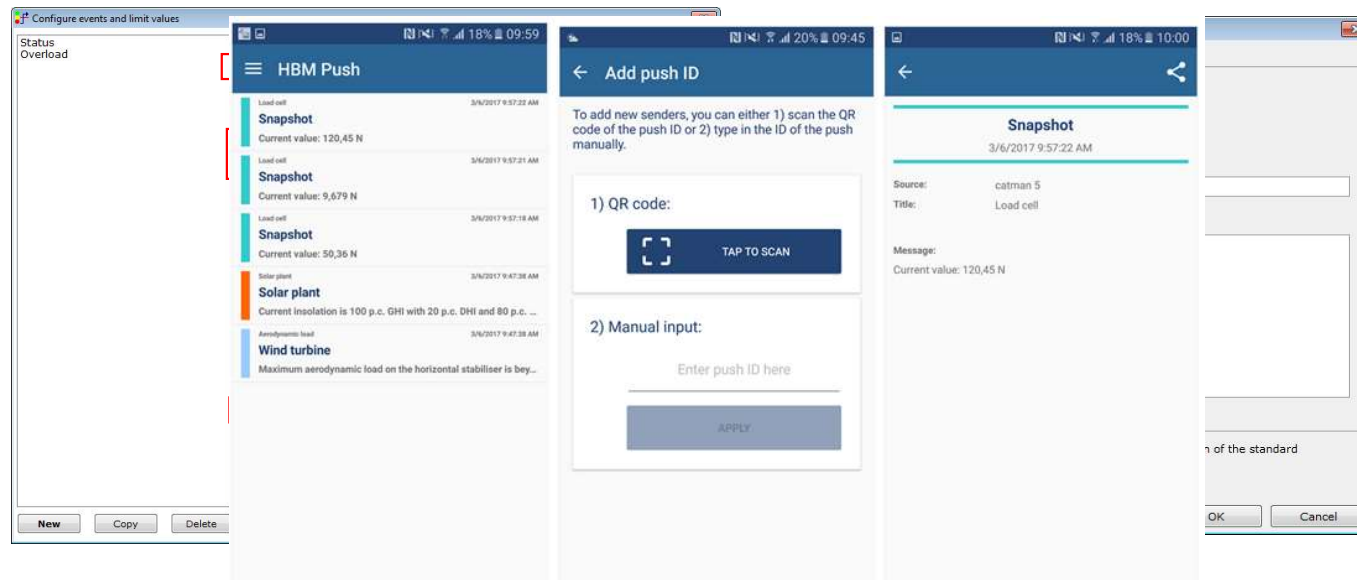
- Client configuration: rules for automatic data transfer; server address; user; password, etc.



# Push notifications to smart devices as reaction on a detected event/alarm

- Alarms, e.g. overload
- Warnings, e.g. battery low
- Diagnostics, e.g. system alive

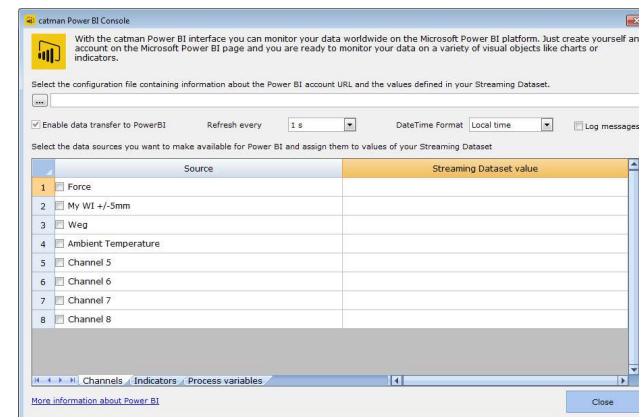
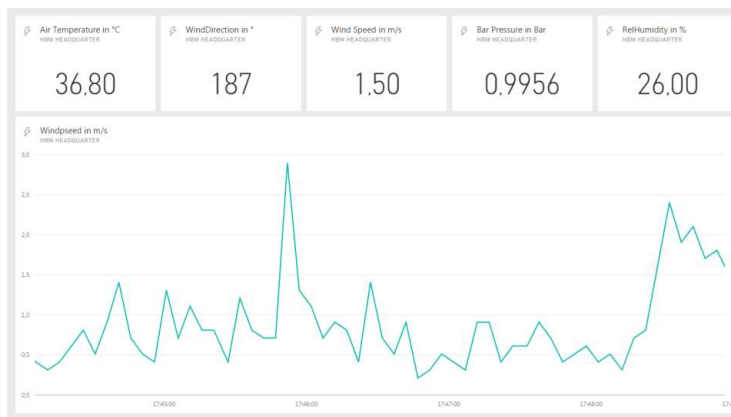
[Google Play Store](#)   [AppleStore](#)



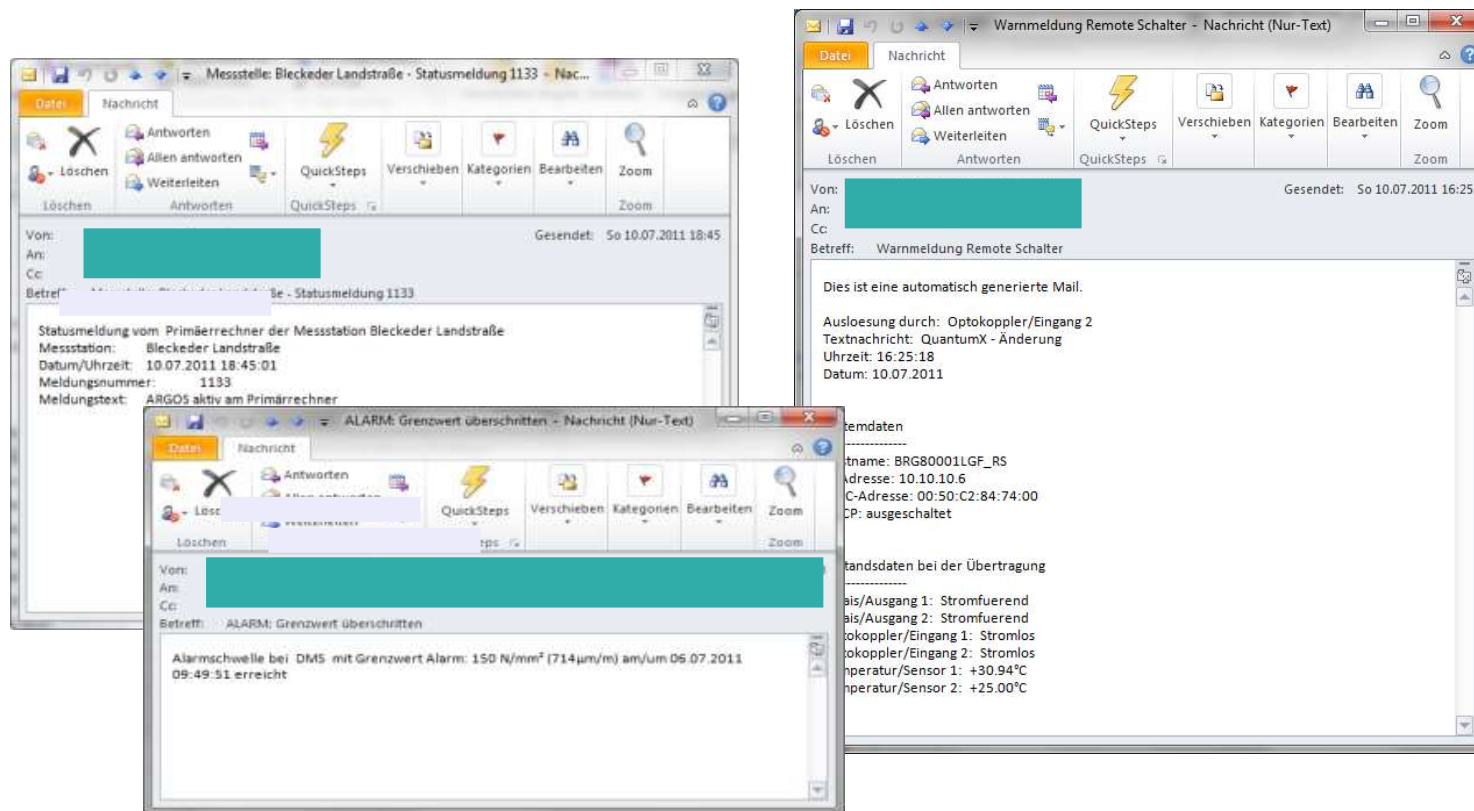
# Data streaming to Microsoft Power BI for visualization of data in the web

Live data streaming with a lower sample rate (2 S/s maximum) of selected channels to Power BI dashboards (or generic Endpoint)


- Create Power BI dashboard (visualization) and data endpoints
- Save dashboard and endpoint configuration in text file
- Read text file in catman DAQ project and match catman signals to Power BI variables
- Share dashboard with dedicated users



# Emails on status change



# System status (custom solution)


Threshold Analyse Values Charts Locations
04/21/2015 - 04/29/2015 Go

## Status

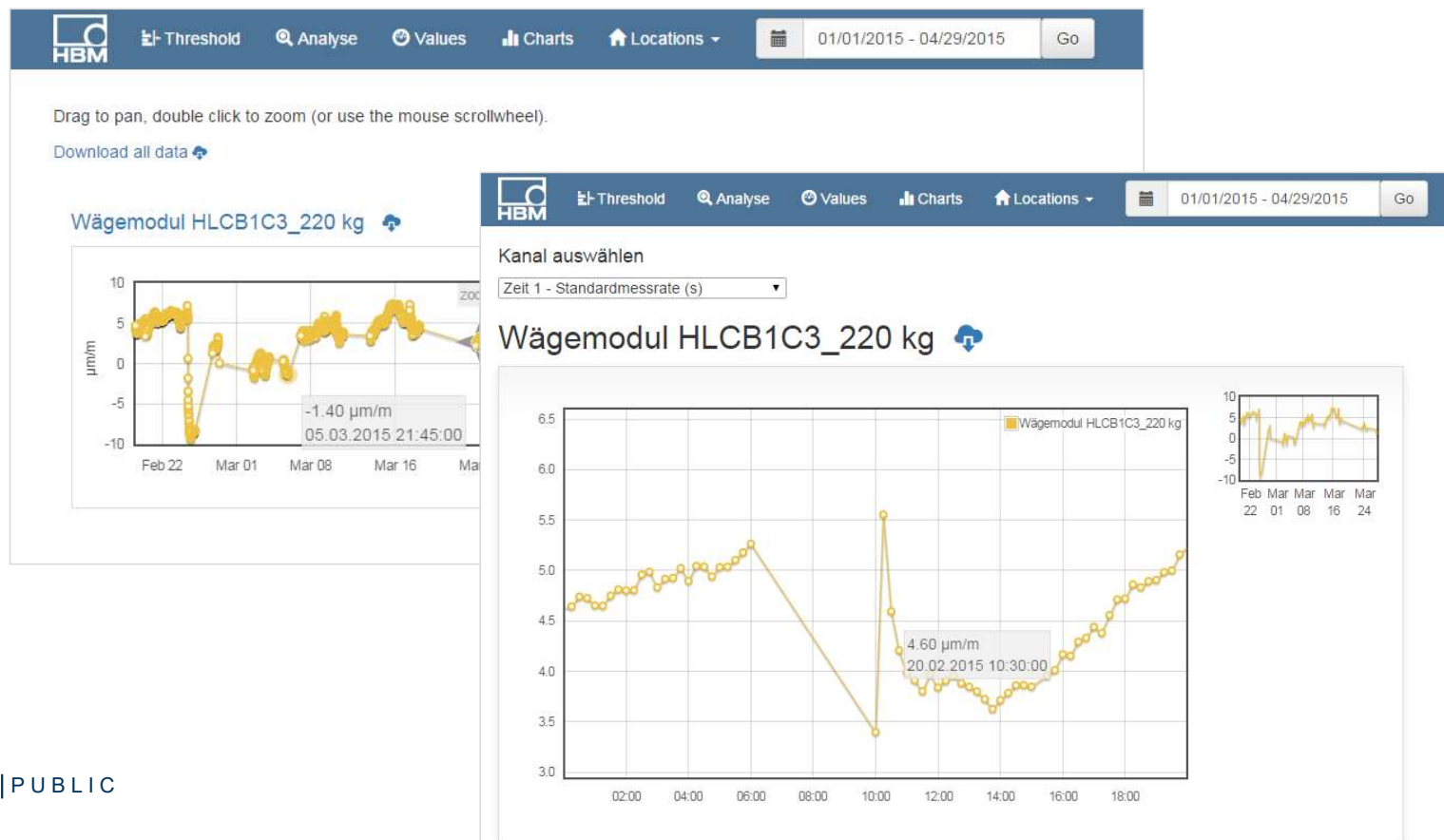
Location	Status	Online*	Last transfer**	System
QXdemo	unbekannt	02.04.2014 10:48:16	20140402 103550	C:/ 11% frei D:/ 12% frei
MSTBA_001GE	in Errichtung	02.04.2014 10:48:16	20140402 103550	C:/ 11% frei D:/ 12% frei

\* rot wenn älter als 25 Minuten  
 \*\* rot wenn älter als 60 Minuten



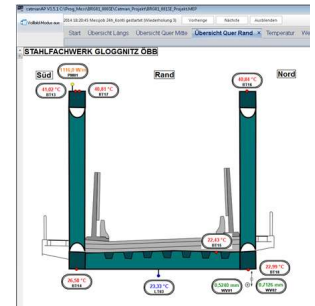
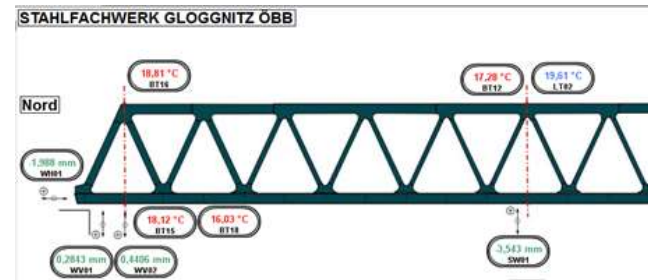


# Overview measured values

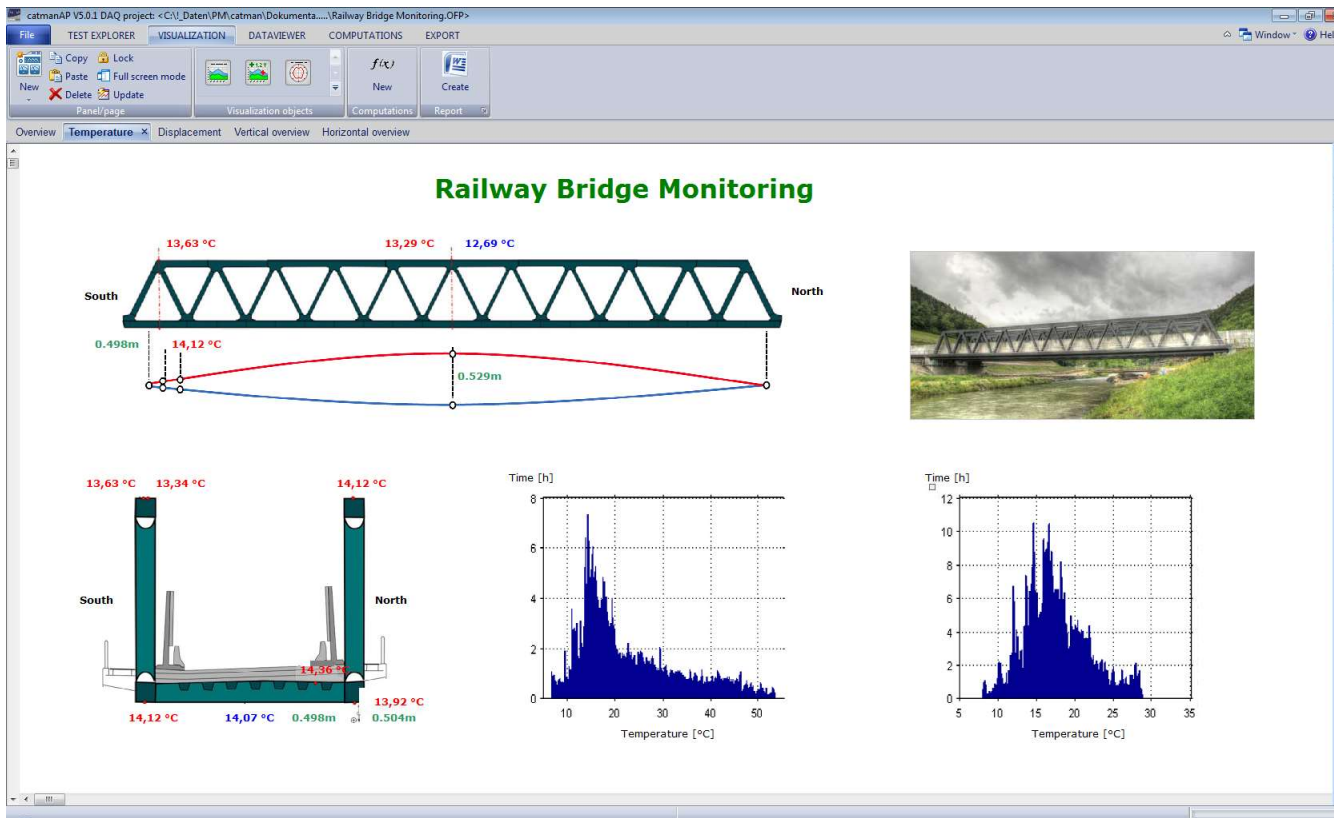


# Application example: Railway bridge Austria

- Digital Twin
- Monitoring of temperature influence on the steel construction
- Prove of calculations and assumptions
- 20x Temperature, 6 displacement, 1 pyranometer

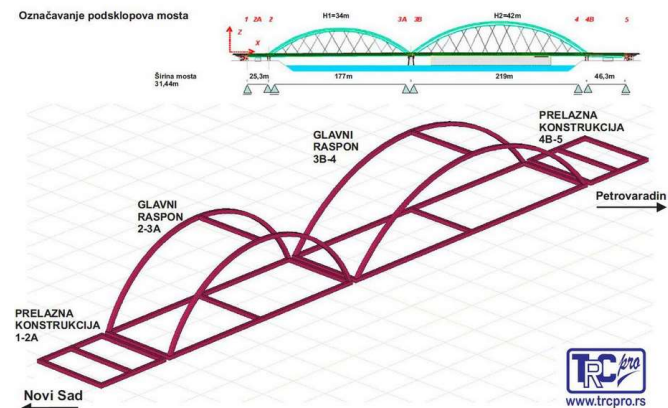


# Application example: Railway bridge Austria



# Application example: Zezelj Bridge in Serbia

- Bridge over the Danube River for railway, road traffic and pedestrians
- 2 railway tracks, 2 road traffic lanes, 2 bicycle and pedestrian lanes
- 472 sensors: 328 strain, 80 force, 12 displacement, 32 inclination, temperature
- 24 PMX synchronized over NTP
- Data storage concept: Transfer to data center (FTP) + local storage (USB + internal flash)



# HBM support and scope of supply

## Core Functions

Server Software

### HBK Products Offering

- ▲ Data visualization and search
- ▲ Automated analysis
- ▲ Web interface Linux & Windows Server / Cloud
- ▲ Notification / Reports

### HBK Services

- ▲ Setup and scale on-premise or cloud
- ▲ IT expertise
- ▲ Training analysis

Edge Software

- ▲ Scalable inputs
- ▲ Distributable / short sensor lines
- ▲ Electrical / optical technology
- ▲ Wide range of physical and digital inputs
- ▲ Time-synchronized data
- ▲ Live visualization
- ▲ Data preprocessing

- ▲ Setup and cabinet mounting
- ▲ Turn-key finishing
- ▲ Training setup and Edge recording
- ▲ Network integration

Electronics / DAQ

Sensors

- ▲ Strain, displacement, acceleration tilt, own and 3<sup>rd</sup> party sensors + camera, GNSS

- ▲ Expertise selecting the right sensor
- ▲ Field service support (on / offshore)
- ▲ Training sensor application

Monitoring Object

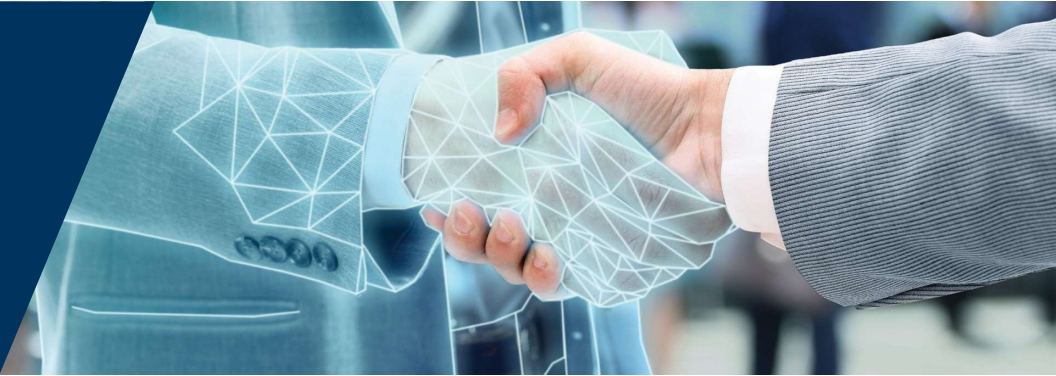
- ▲ bridge, tunnel, railway, wind energy incl. offshore, oil&gas, cranes, building

- ▲ **Domain expertise:** Civil engineering, railway, wind energy experts incl. offshore, oil&gas

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