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PRECISE SENSOR NETWORKS FOR MONITORING TASKS IN ENGINEERING GEODESY

Workshop *Geosensor Networks*, LUH, 20.02.2008

- Tasks
- Sensors
- Concepts
- Examples
- Conclusions

Tasks of Engineering Geodesy

„Technical surveying of all kinds with an adequate quality“

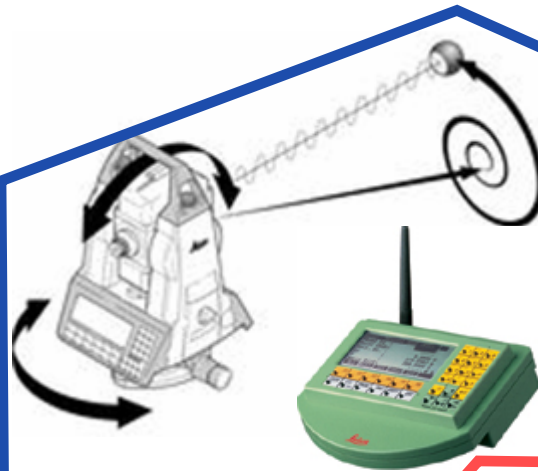
In concrete terms:

- Capture of spatial objects such as buildings, plants, ...
 - Observation and documentation
- Supply of positions and orientations
 - Stake-out, alignment and control
- Detection of (geometrical) changes
 - Geodetic monitoring

Pool of sensors and sensor systems



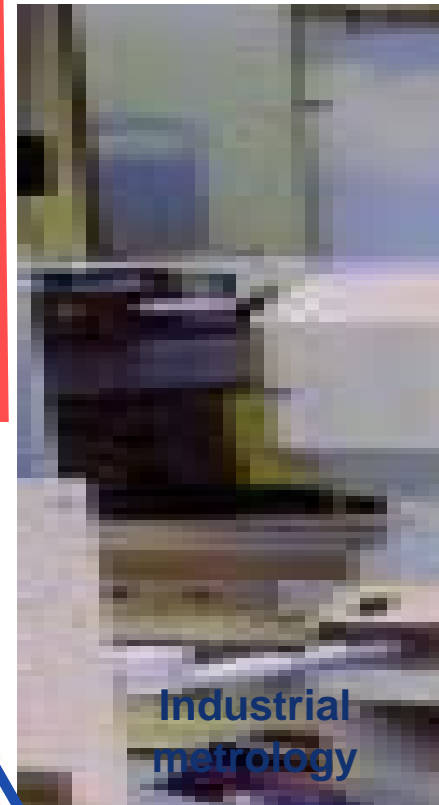
GPS



Tachymetry



Levelling



Industrial metrology

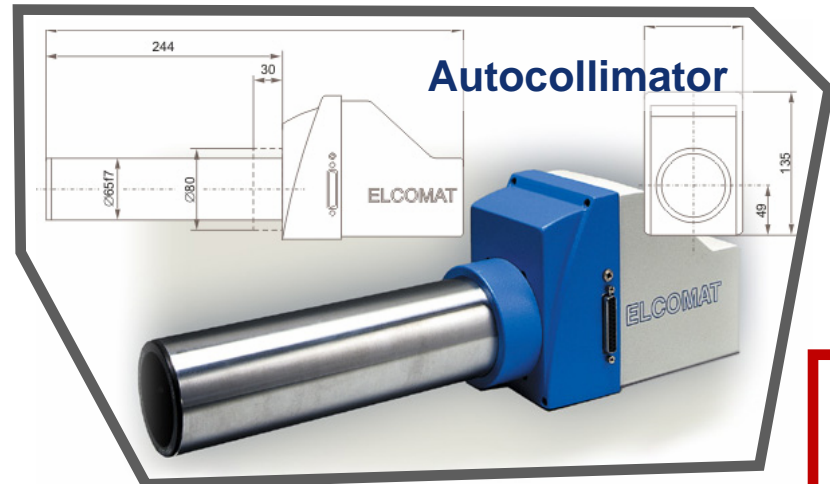
Pool of sensors and sensor systems



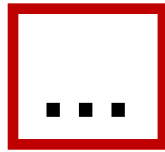
Terrestrial Laserscanners



Inclinometers



Autocollimator



Purpose

Determination of geometric states and state changes

Characteristics

- Variety of sensors

Individual properties concerning use, interpretation, ..., such as dimensionality, redundancy, complementarity, uncertainty

- Observation properties

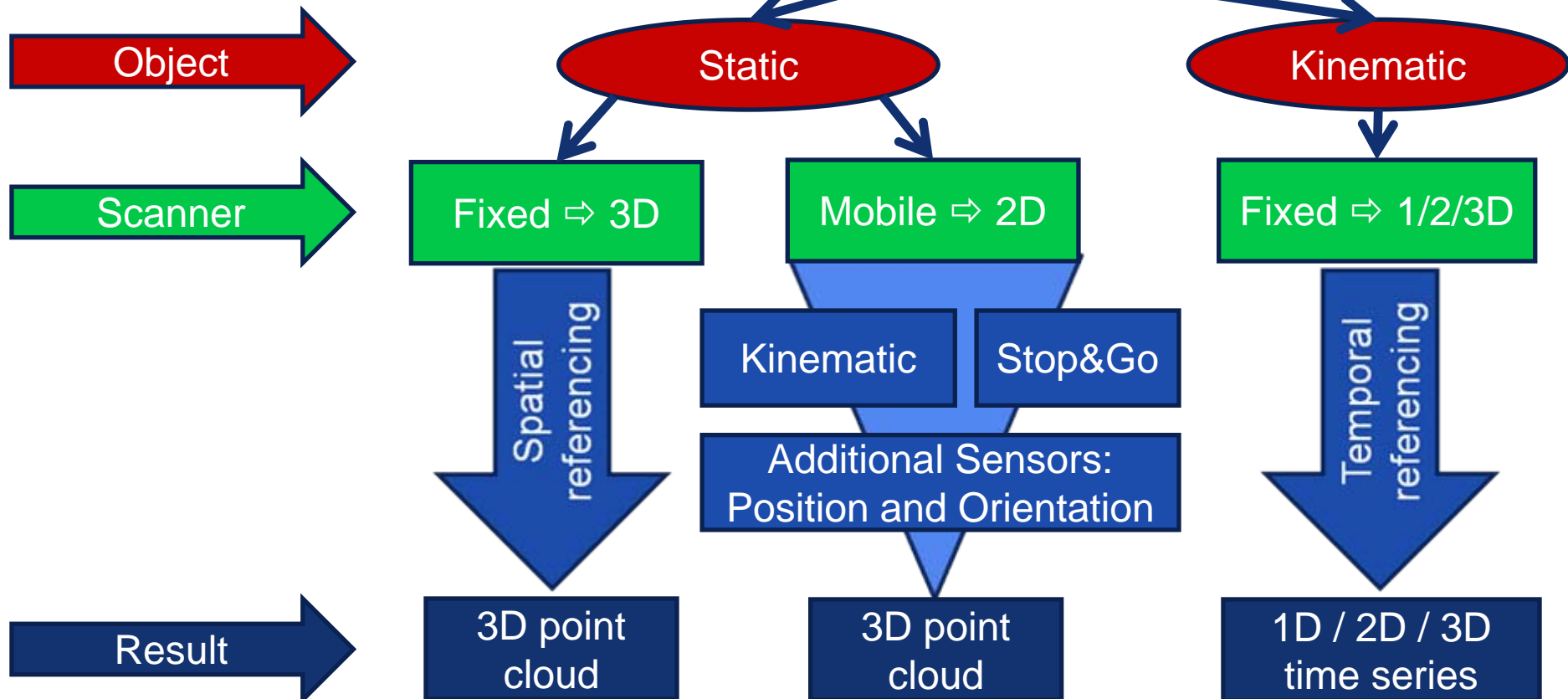
Episodical, periodical, or continuous capture
Automated or manual capture

- Supply of particular data

Observables and derived quantities, meta information

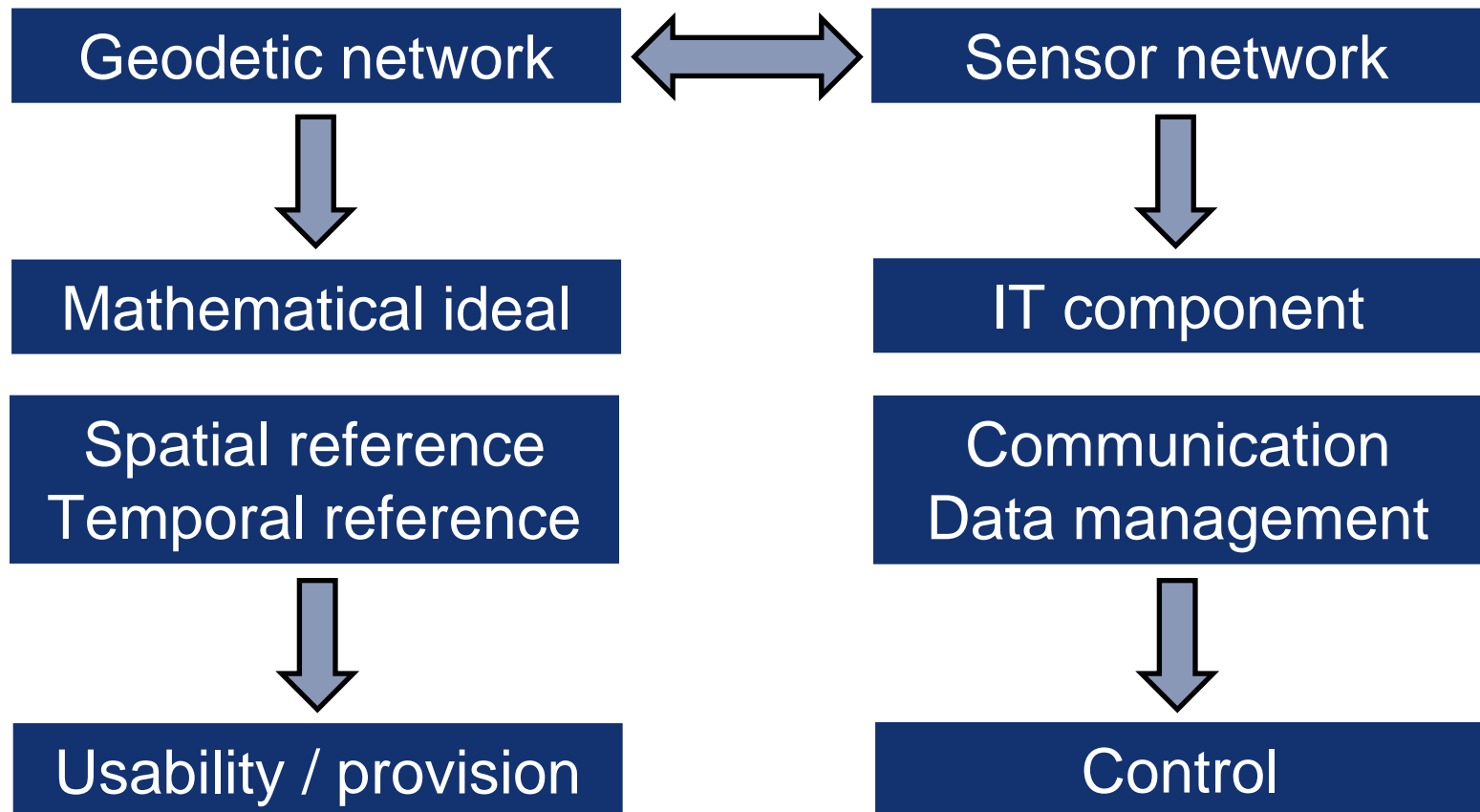
Benefit through integration of sensor data

Observation strategies: Example TLS



(according to Staiger und Wunderlich, zfv 2/2007)

Integration of sensors



Integration methods

- Sensor-based integration

- Sensor fusion \Rightarrow Multi-sensor systems
- Forced centring \Rightarrow Local ties

- Object-based integration

- Homologous points \Rightarrow Markers, unique object points
- Identical features \Rightarrow Unique object parts

- Integration based on similarity relations

- Spatial similarity
 - Temporal similarity
- } Object-induced correlations

Integration results

- Parameter time series

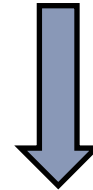
- 1D / 2D / 3D
- Points / lines / surfaces / volumes
- Synchronized
- Spatially referenced

- Uncertainty measures

- Modelling
- Propagation



Prediction and filtering



State-space filtering,
multivariate statistics,
soft-computing,

...

A multi-sensor monitoring network



Rethel Vertical Lift Bridge
Hamburg

Technical data

Year of construction:	1934
Material:	Steel
Length of the lift section	74 m
Width of the lift section:	15 m
Height of the towers:	62 m
No. of ship passings:	300 / month

System analysis ⇒ Causal model

- Relevant influences

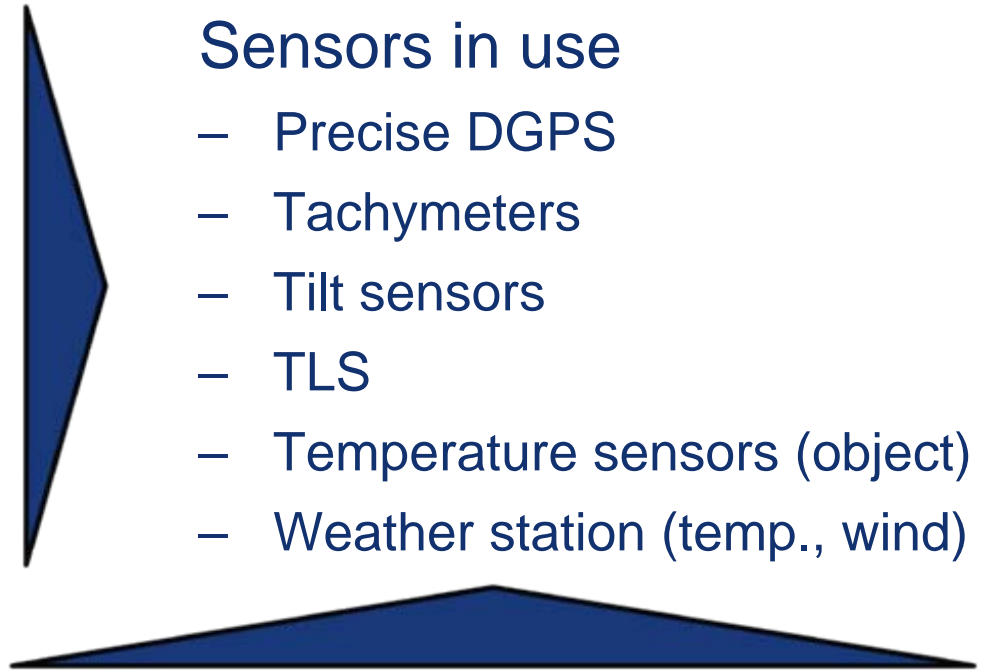
- Tide
- Wind
- Temperature
- Traffic load
- Bridge lifting

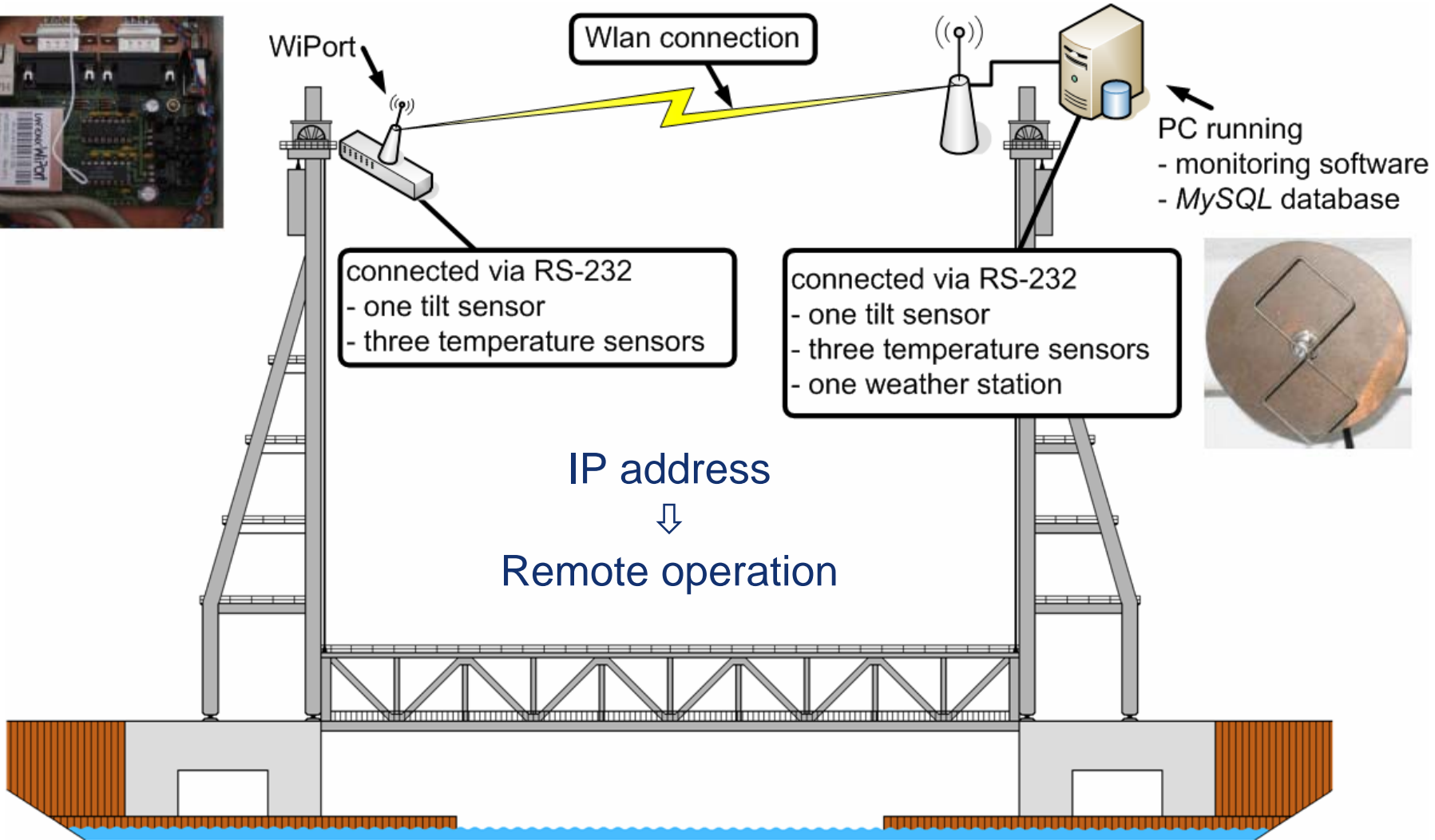
- Sensors in use

- Precise DGPS
- Tachymeters
- Tilt sensors
- TLS
- Temperature sensors (object)
- Weather station (temp., wind)

- Observable effects

- Inclination and torsion of the towers
- Absolute position and height changes, respectively
- Bending of the bridge





Network configuration and communication design

User interface

Projektseminar Ingenieurgeodäsie

Datei Sensor Daten Fenster ComSchnittstelle ?

MySQL

MySQL Datenbank füllen alle Min

Beim letzten Update hinzugefügte Datenzeilen:

TemperaturBox: vP_Temp

Anzeige der Messwerte

Sensor 1	Sensor 2	Sensor 3	Sensor 4	Sensor 5	Sensor 6	Sensor 7	Sensor 8
29,2	-99,9	-99,9	-99,9	-99,9	-99,9	-99,9	-99,9
Sensor 9	Sensor 10	Sensor 11	Sensor 12	Sensor 13	Sensor 14	Sensor 15	Sensor 16
-99,9	-99,9	-99,9	-99,9	-99,9	-99,9	-99,9	-99,9

Festlegen des Abtastintervalls

Messwert abspeichern: Sek

Libelle Schaevitz: vP_Libelle

Anzeige des Messwertes

Messwert

Festlegen des Abtastintervalls

Messwert abspeichern: Sek

Datentabelle

vP_Temp

Datum	Zeit	Sensor_1	Sensor_2	Sensor_3
02.07.2006	16:45:13	29	-99,9	-99,9
02.07.2006	16:45:18	29	-99,9	-99,9
02.07.2006	16:45:23	29	-99,9	-99,9
02.07.2006	16:45:28	29	-99,9	-99,9
02.07.2006	16:45:33	29	-99,9	-99,9
02.07.2006	16:45:38	29,2	-99,9	-99,9
02.07.2006	16:45:43	30,9	-99,9	-99,9

ComSchnittstelle

Einrichtung der COM-Schnittstelle

COM-Port:

Baudrate:

Parität:

Datenbits:

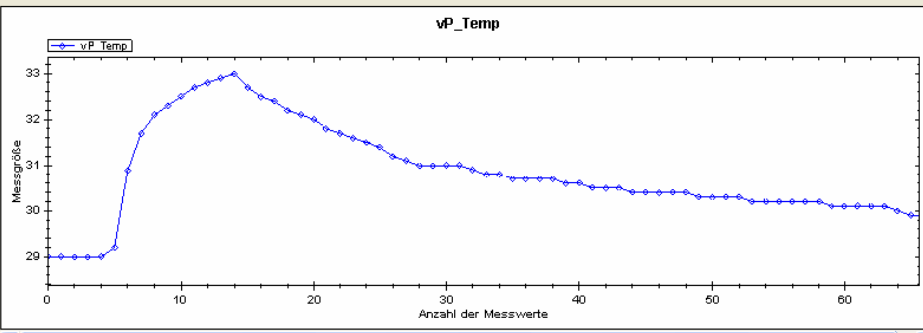
Stoppsbits:

Timeout [ms]:

COM6 (2400 8-N-1)

Grafikmanager

vP_Temp



Messgröße

Anzahl der Messwerte

Example A

Database: MySQL
(Web-browser access)

192.168.81.33 / localhost / projekt_suite / | phpMyAdmin 2.7.0-pl1 - Mozilla Firefox

http://192.168.81.33/phpmyadmin/index.php?lang=de-iso-8859-1&server=18

Server: localhost | Datenbank: projekt_suite

Tabella	Aktion	Einträge	Typ	Kollation	Größe	Überhang
<input type="checkbox"/> hubvorgaenge		232	MyISAM	latin1_general_d	10,4 KB	-
<input type="checkbox"/> nordturm_schaevitz		9.981		---	unknown	-
<input type="checkbox"/> nordturm_temperatur		4.062		---	unknown	-
<input type="checkbox"/> nord_schaevitz		9.981	MyISAM	latin1_general_d	187,0 KB	-
<input type="checkbox"/> nord_temperatur		99.159	MyISAM	latin1_general_d	8,1 MB	-
<input type="checkbox"/> nord_temperatur_neu		4.062	MyISAM	latin1_general_d	225,4 KB	-
<input type="checkbox"/> pegel_harburg		2.448	MyISAM	latin1_general_d	98,9 KB	-
<input type="checkbox"/> pegel_stpauli		2.448	MyISAM	latin1_general_d	98,9 KB	-
<input type="checkbox"/> suedturm_schaevitz		9.153		---	unknown	-
<input type="checkbox"/> suedturm_temperatur		4.014		---	unknown	-
<input type="checkbox"/> suedturm_wetterstation		4.042		---	unknown	-
<input type="checkbox"/> sued_schaevitz		9.153	MyISAM	latin1_general_d	177,9 KB	-
<input type="checkbox"/> sued_temperatur		4.014	MyISAM	latin1_general_d	639,0 KB	149 Bytes
<input type="checkbox"/> sued_wetterstation		4.042	MyISAM	latin1_general_d	669,6 KB	-
14 Tabellen	Gesamt	99.129	MyISAM	latin1_general_ci	10,1 MB	149 Bytes

Alle auswählen / Auswahl entfernen / Tabellen m. Überhang ausk.

Druckansicht | Strukturverzeichnis

Neue Tabelle in Datenbank projekt_suite erstellen

Name: Anzahl der Felder:

Fertig

Example A



Topic of special interest

Short-term deformations due to traffic load

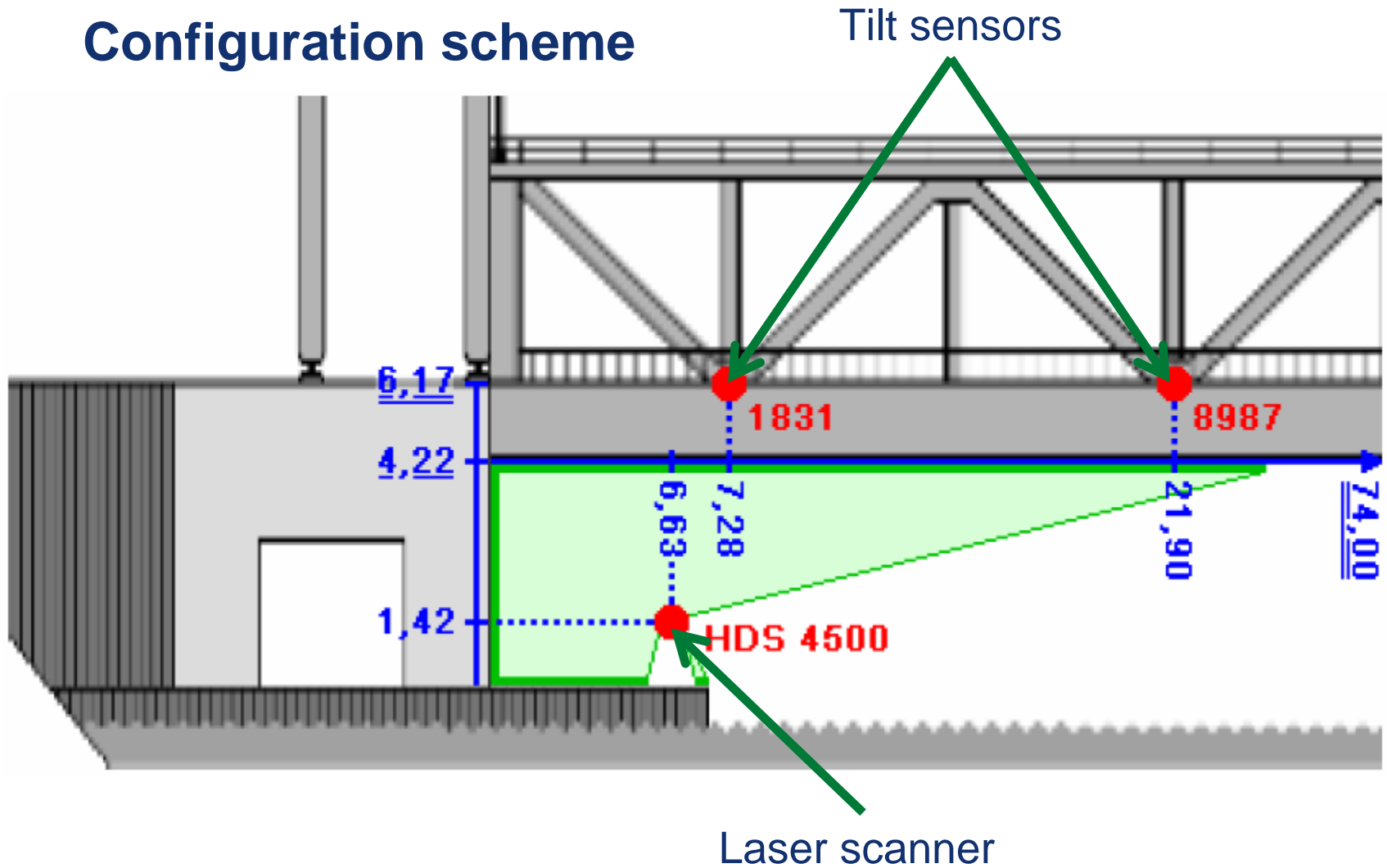
Basic idea

Repeated static TLS as kinematic procedure
(1D / 2D / 3D) → k-TLS

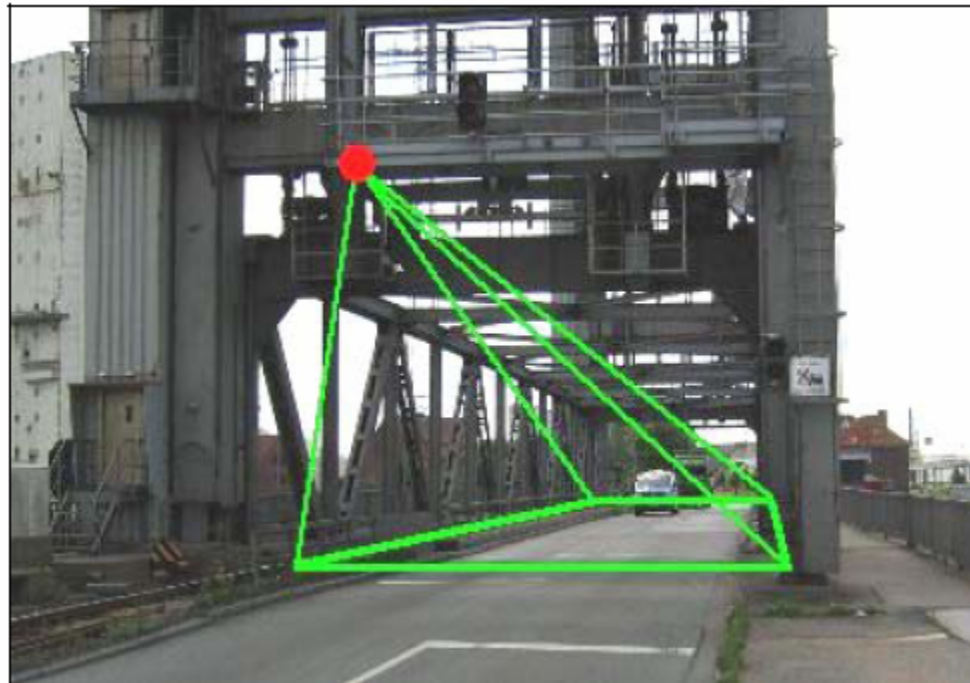
Configuration

- 2D k-TLS (vertical profile mode) beneath the bridge
- Tilt sensors on bridge above the laser scanner
- *Synchronization* of k-TLS and tilt sensors
- Traffic load capture from video sequences

Configuration scheme



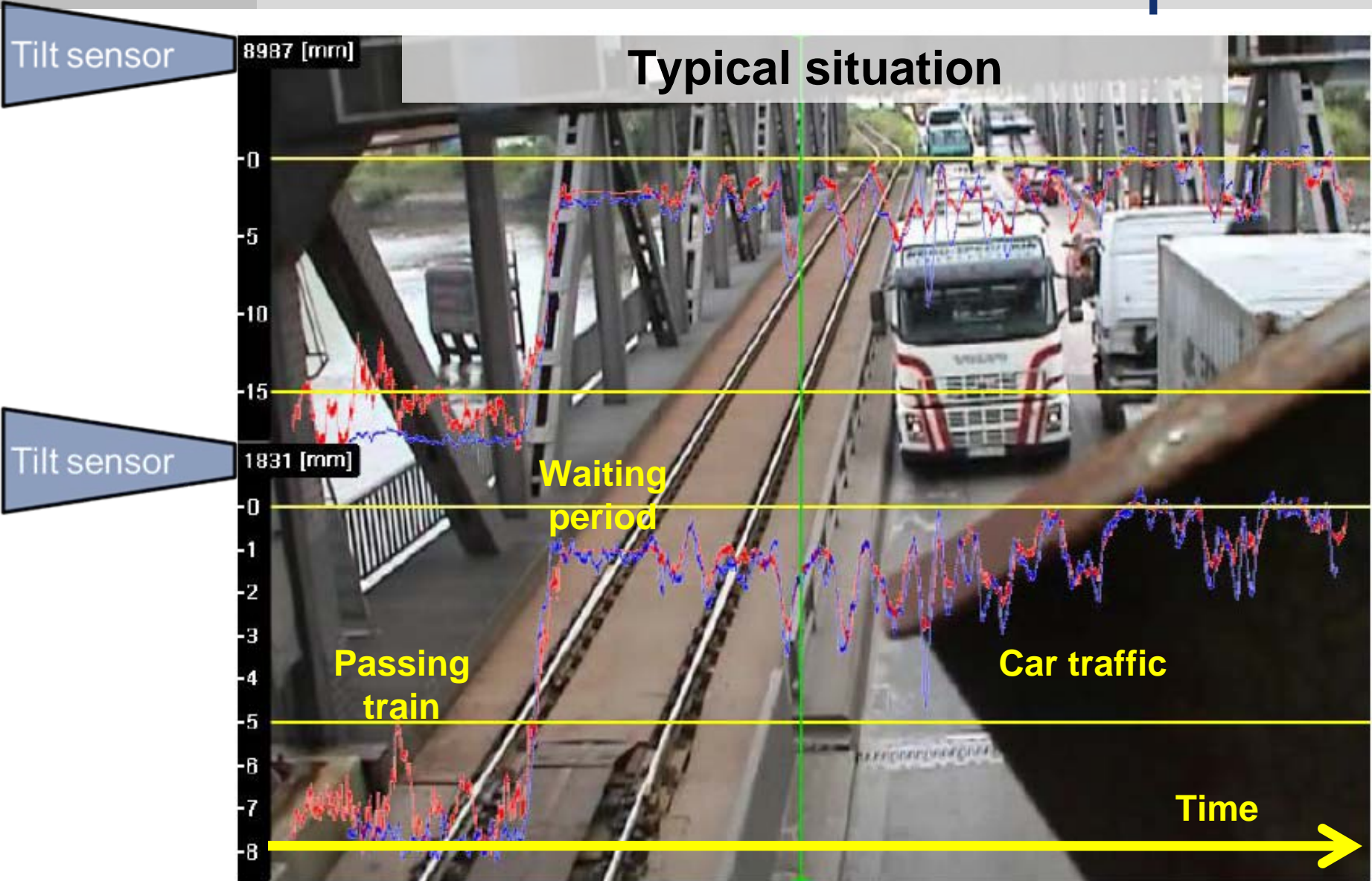
Traffic load capture



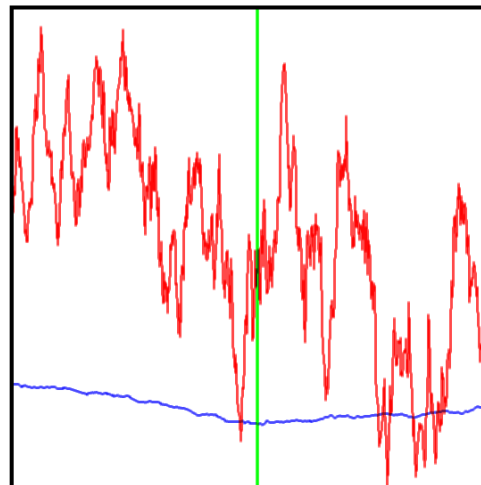
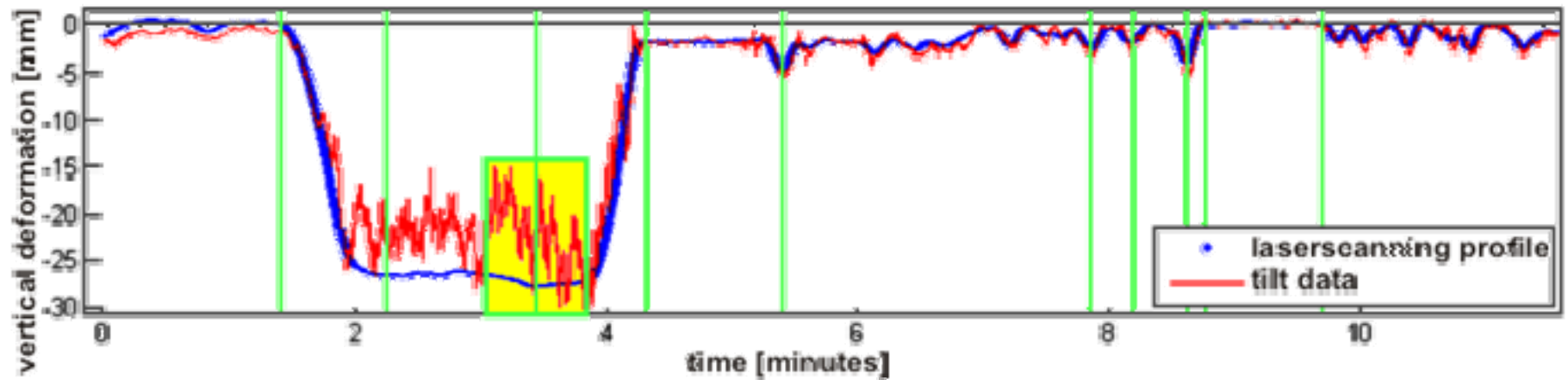
Position and orientation of the video camera



Typical view of the video camera



Short-term deformations due to traffic load



Max. bending: 27.9 mm

Noise level: 0.1 mm

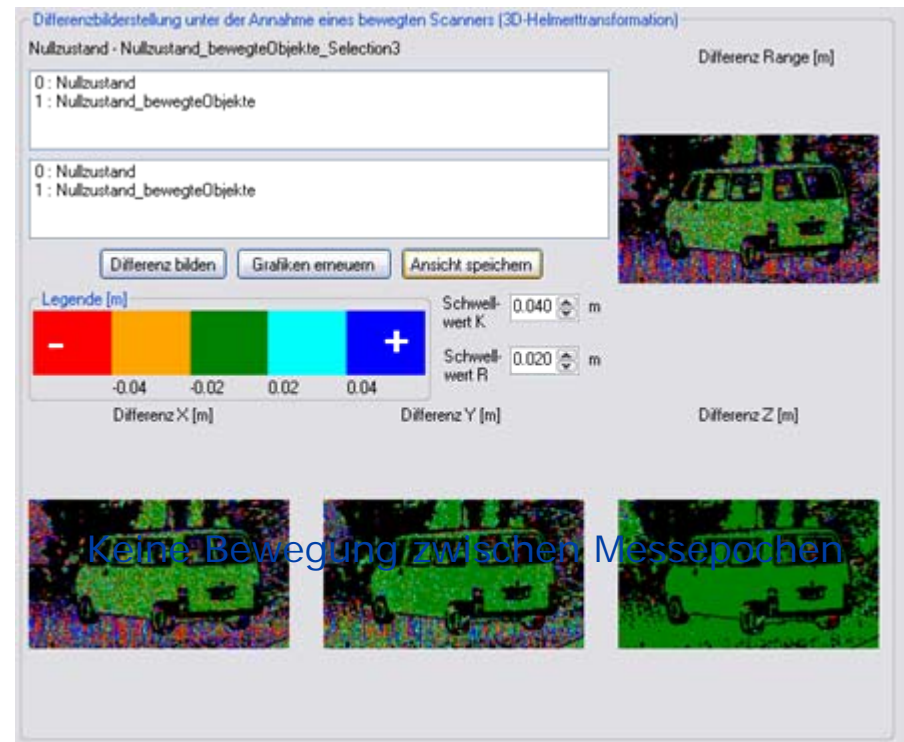
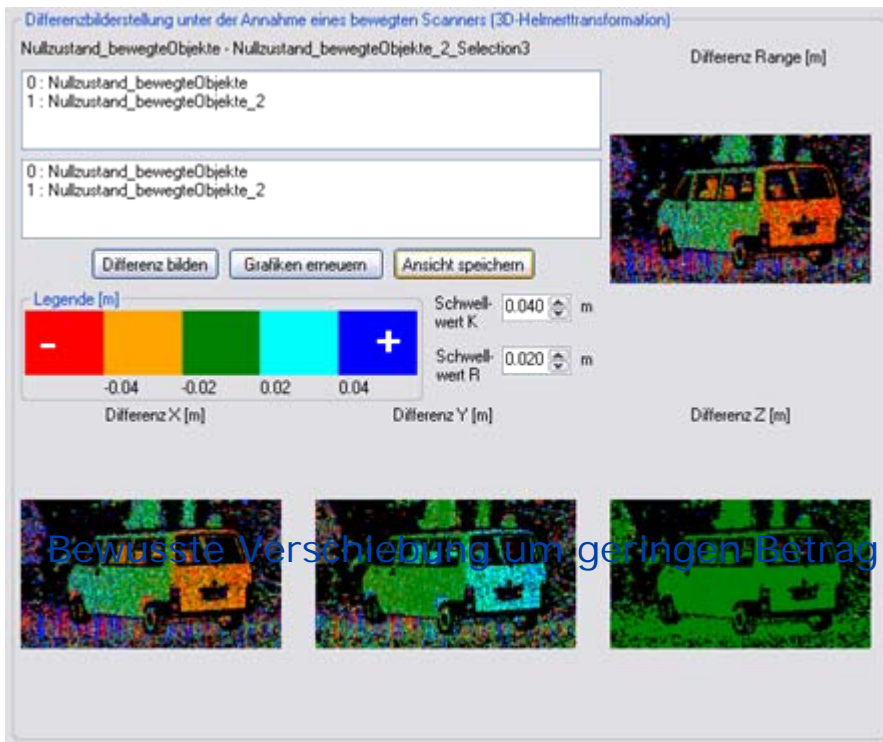
remote control of a terrestrial laser scanner

software system *re-mo Sys*

- data capture and control using a *Leica HDS 4500*
- modular implementation in *MS Visual C# 2005*
- **+ Automated change analysis based on differential scans**

• project based data management (XML)

Differential scans \Rightarrow Vehicle motion



Object motion of a few cm detected on distances up to 20 m

- Dedicated design
 - Individual sensor distribution
 - Capture of complementary and redundant data
 - Maximum sensitivity
- Technical requirements
 - Wireless communication
 - Free sensor interfaces
 - Efficient data streams
- Benefit
 - Flexibility in mounting
 - Real-time data capture and management
 - Remote control and alarm system