

AFD40(2) Monthly Web Meeting – BAST Session

BAST member of MLS UserGroup

-

**Research update, data handling
and new measurement system**

Bastian Wacker

Design and Structure of Pavements

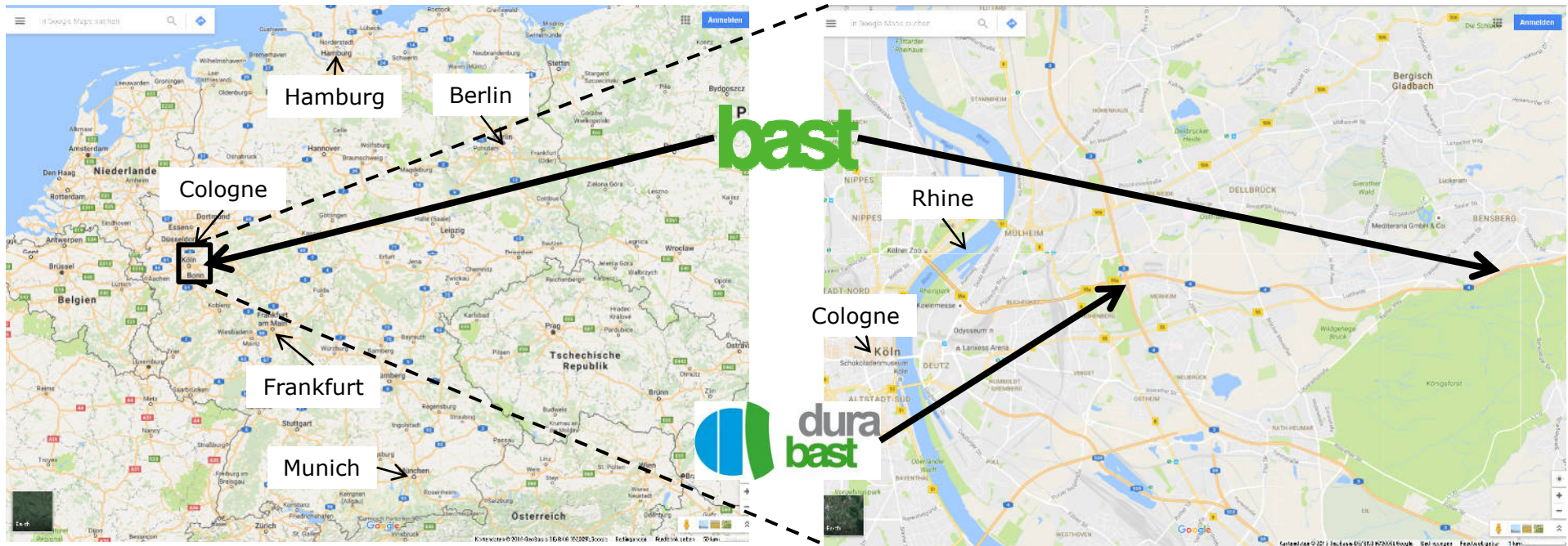
Federal Highway Research Institute
Bundesanstalt für Straßenwesen

Introduction

- **Name:** Bastian Wacker
- **Education:** civil engineer
(Dipl.-Ing, Master of Engineering)
- at BAST since 02/2013
 - **Section:**
Design and Structure of Pavements
 - **Research activities:**
accelerated pavement testing, structure analysis and technical research supervision



Introduction



Introduction

- Testing facilities at BAST
 - Indoor asphalt pavement test track
 - Indoor concrete pavement test track
 - Test hall for different research studies



- duraBAST → from march 2017
 - demonstration
 - investigation (**U**ntersuchung)
 - reference
 - area of **BAST**



Introduction

- Loading with Bogie - including loading wheels
 - Wheel load 40 to 75 kN (8,99-16,86 kip)
 - chosen standard operation with 50 kN (11,24 kip) (equivalent 10 to-Axle)
- Completion of loading wheels
 - dual or single
- Testing length
 - 3,50 m (11,48 Foot US)
- Speed
 - up to 22 km/h (13,67 mph)
= **6000 passes/h**

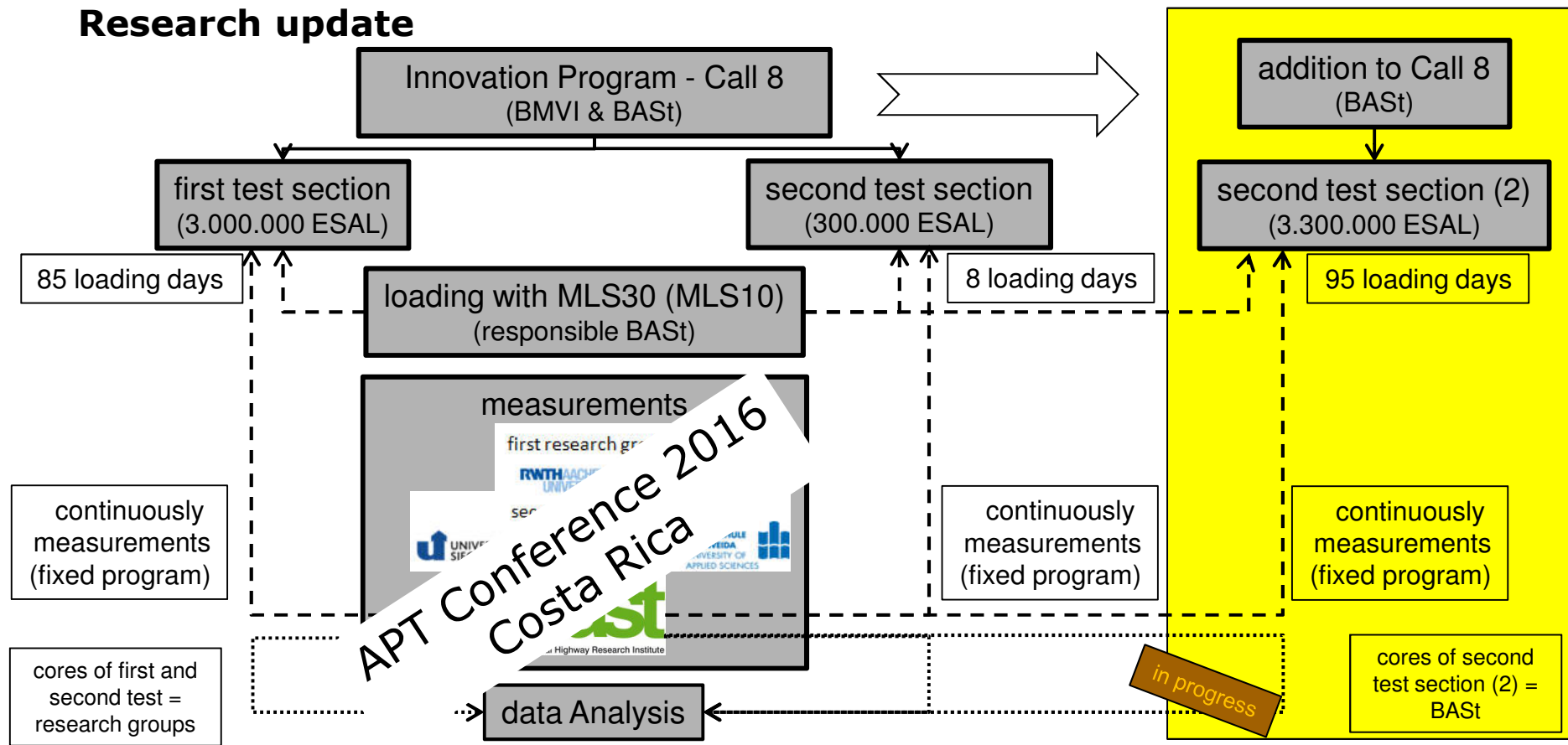


© Pavetesting – MLS66

Agenda

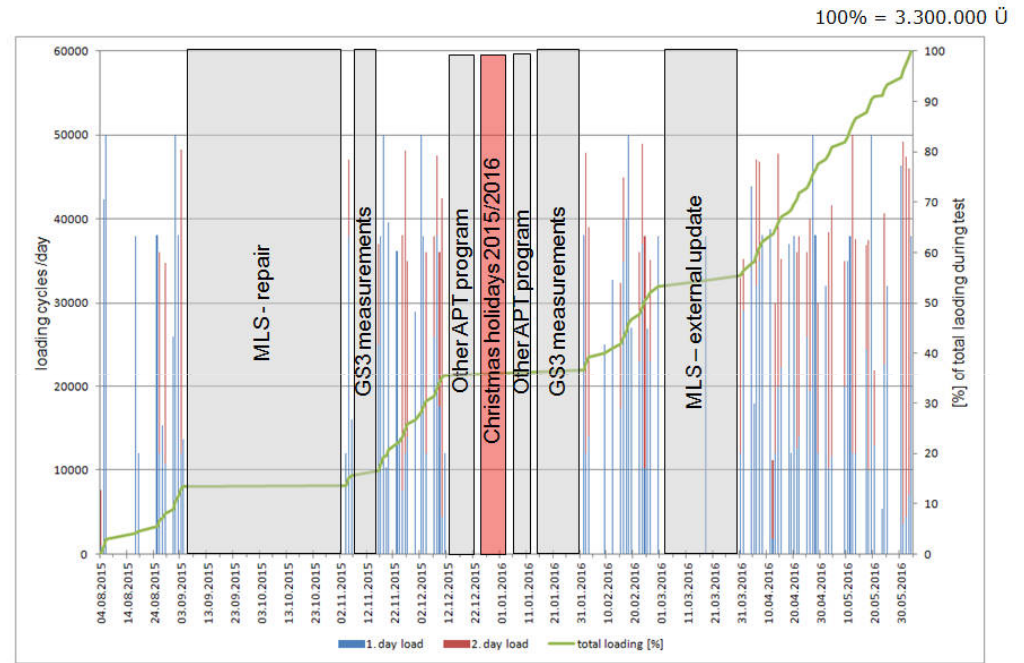
- Research update (approx. 10min.)
- Future data handling (approx. 20min)
 - Outdoor test facility duraBAST
- New measurement system on MLS30 (approx. 15min)
- Time for discussion and questions (approx. 10min)

Research update



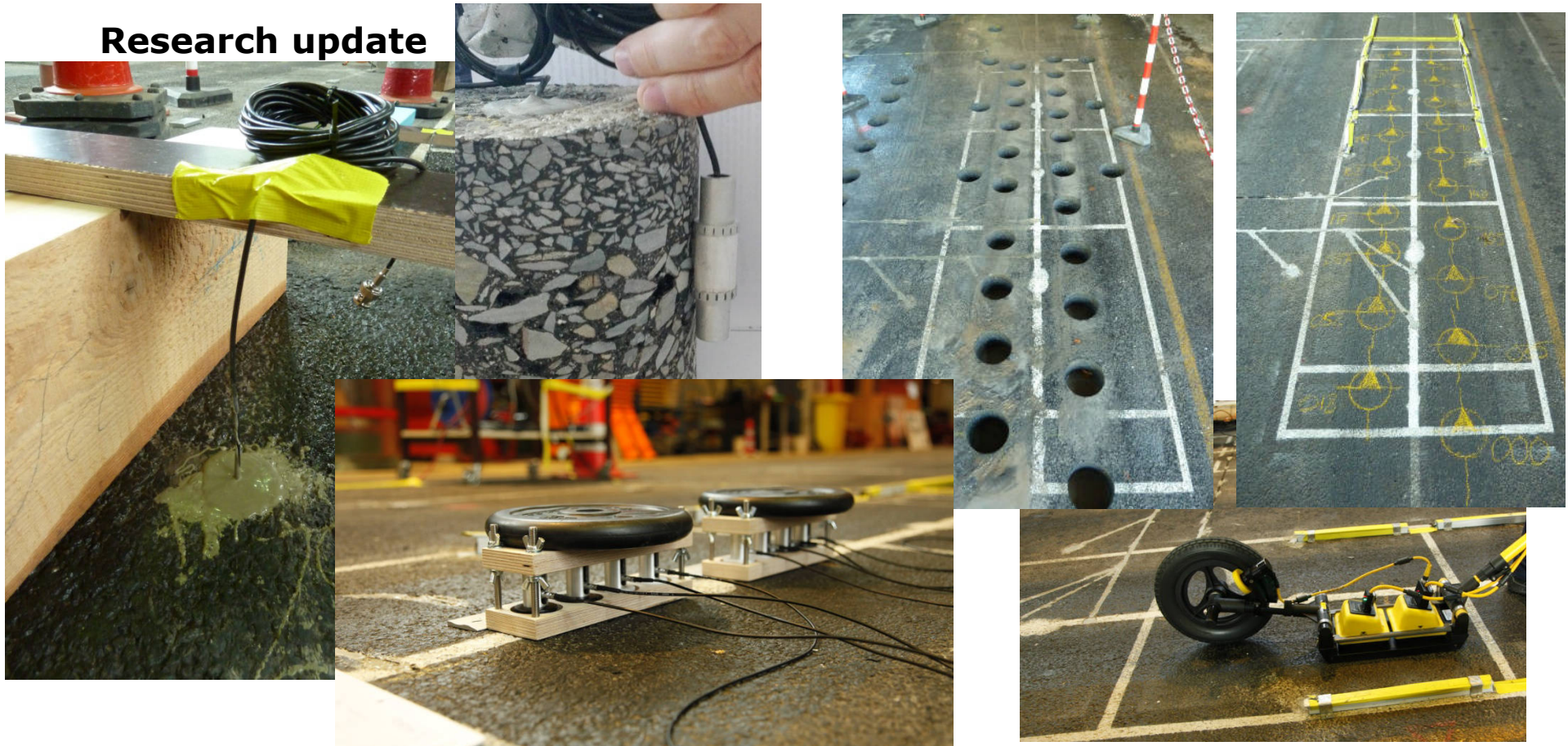
Research update

- Focus on non-destructive test methods
 - embedded ultrasonic sensors
 - mobile ultrasonic sensors
 - GPR systems in combination with ultrasonic sensors
 - measurement system with twelve geophones
 - Shaker in combination with acceleration sensors

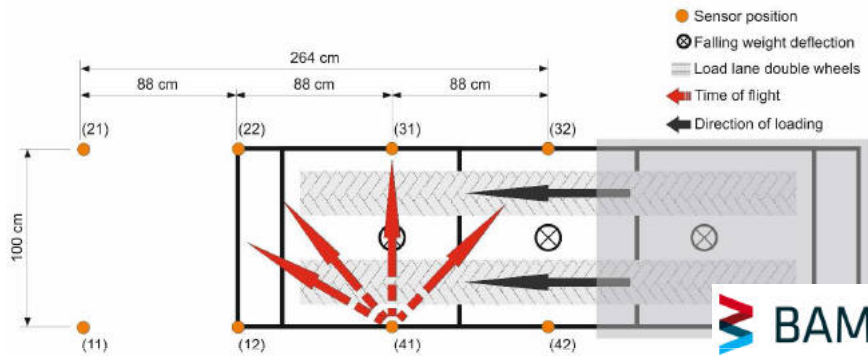


BAM	
MÜLLER-BBM	Feb. 10 th -11 th 2016, 1,35Mio ESAL
RWTH AACHEN UNIVERSITY	second test section Call 8 April 12 th 2016, 2,14Mio ESAL
AFD	second test section Call 8 June 28 th 2016, 3,30Mio ESAL

Research update



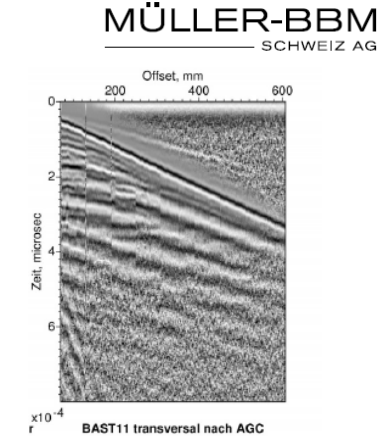
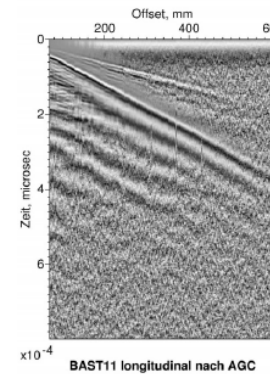
Research update



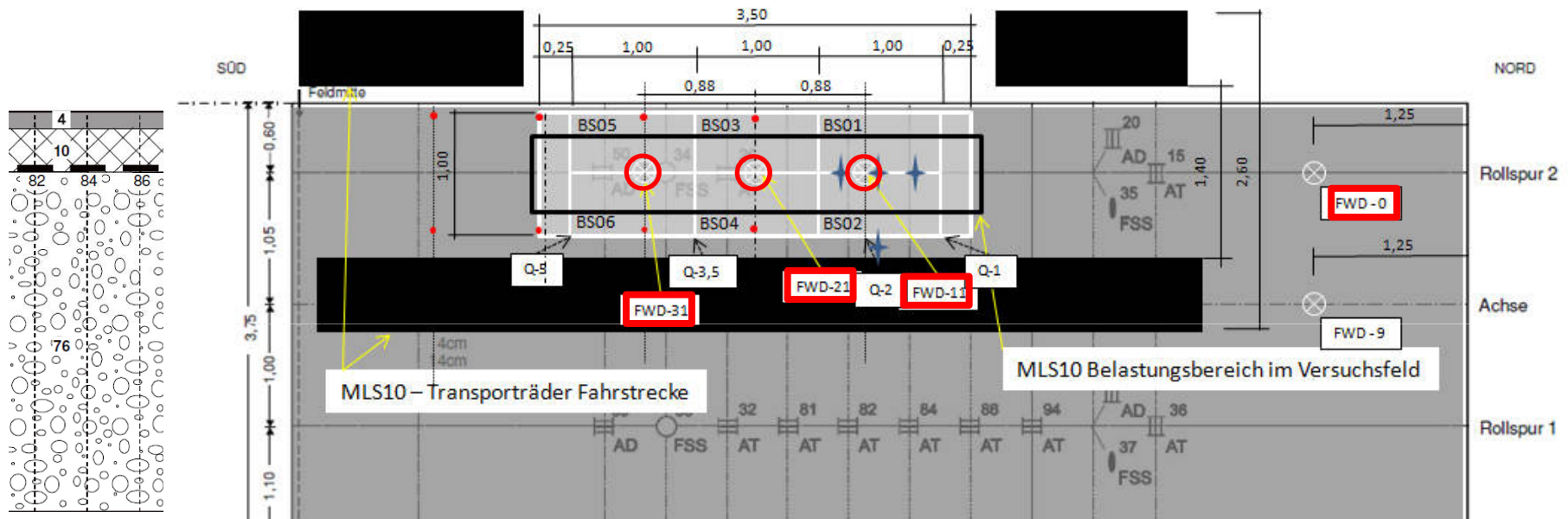
21.02.2017 Workshop; Embedded sensors – Modellstraße BAST (Bergisch Gladbach)

- embedded ultrasonic sensors
 - evaluation of big data
 - temperature changes (even small) have a huge influence on test results
 - research still needed to evaluate asphalt properties

- mobile ultrasonic sensors
 - operation takes time
 - evaluation process takes time
 - big experiences necessary to operate and to evaluate measurements



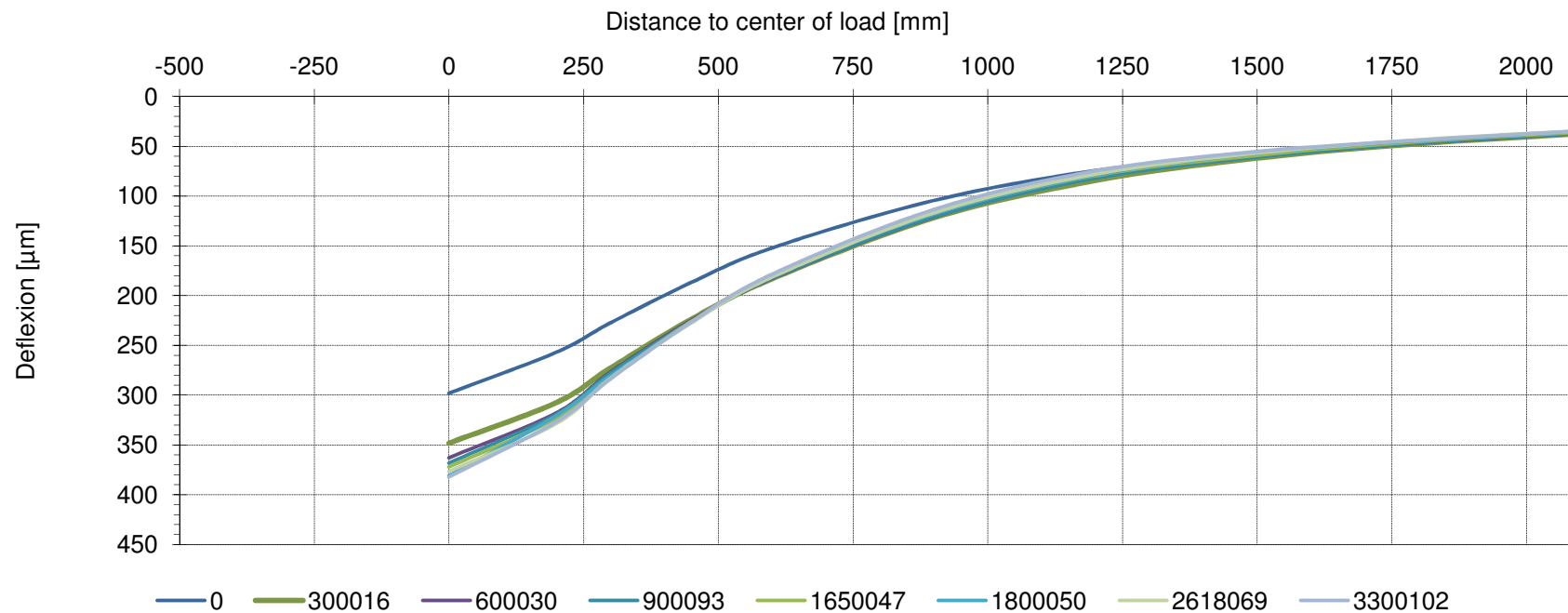
Research update



- backcalculation of FWD results
 - not very common in Germany
 - in combination with GPR the potential and acceptance of backcalculation raises
- reference point very important for correction
 - no change of bearing capacity
 - temperature correction on 20°C

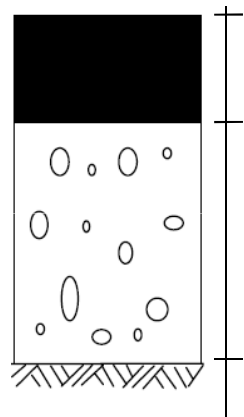
Research update

- deflection basin of one measurement point
 - correction to 20°C (68°F) and reference point



Research update

unloaded
0 loading cycles



12.250 MPa

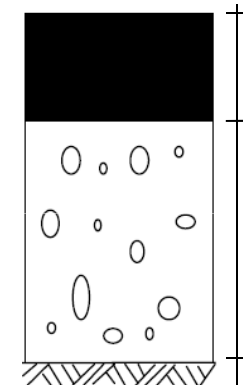
150 MPa

177 MPa

Goodness of fit: 97,5%

	Loading cycles	0,3 Mio.	0,6 Mio.	...	1,8 Mio.	...
Asphalt [MPa]		12.500	11.750	...	10.250	...
SoB [MPa]		100	100	...	100	...
UG [MPa]		170	170	...	181	...

loaded
3,3 Mio. loading cycles



9.250 MPa

100 MPa

181 MPa

Goodness of fit: 97,8%

GOF [%] 97,2 98,0 ... 96,9 ...

parameter back calculation

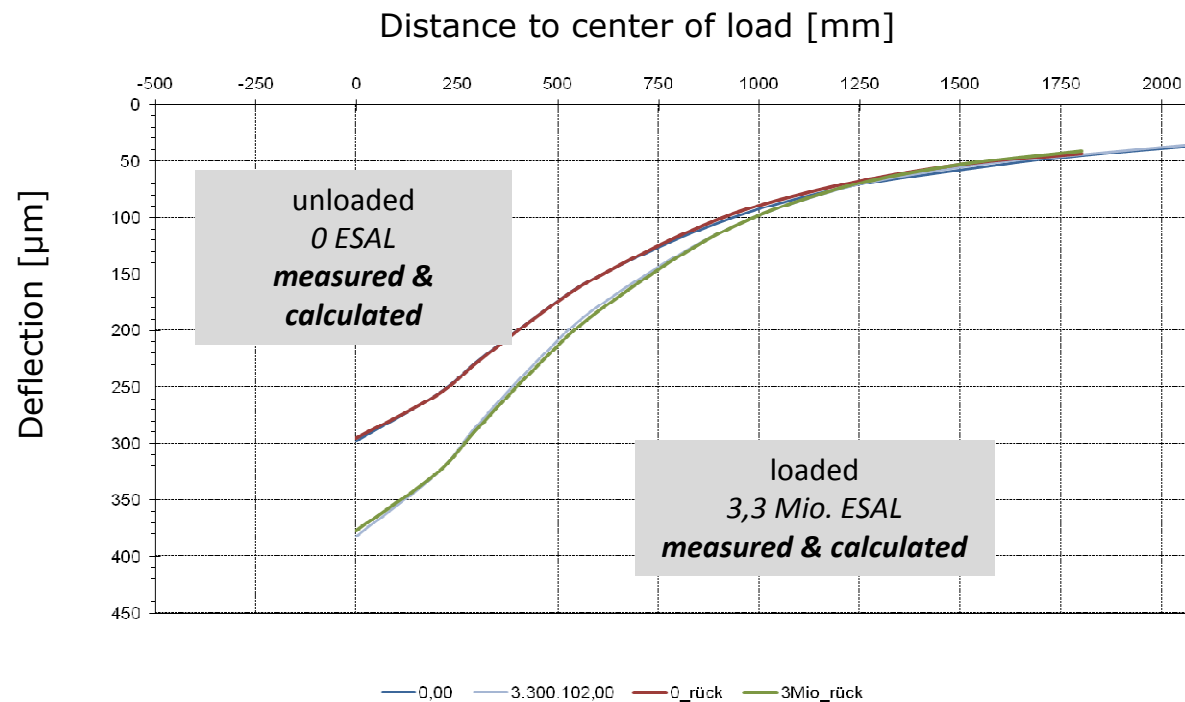
Asphalt: between 5.000 and 14.000 MPa increment 250 MPa

SoB: between 50 and 400 MPa increment 25 MPa

UG: direct derivation $d_{1.800}$ (dynamic module)!

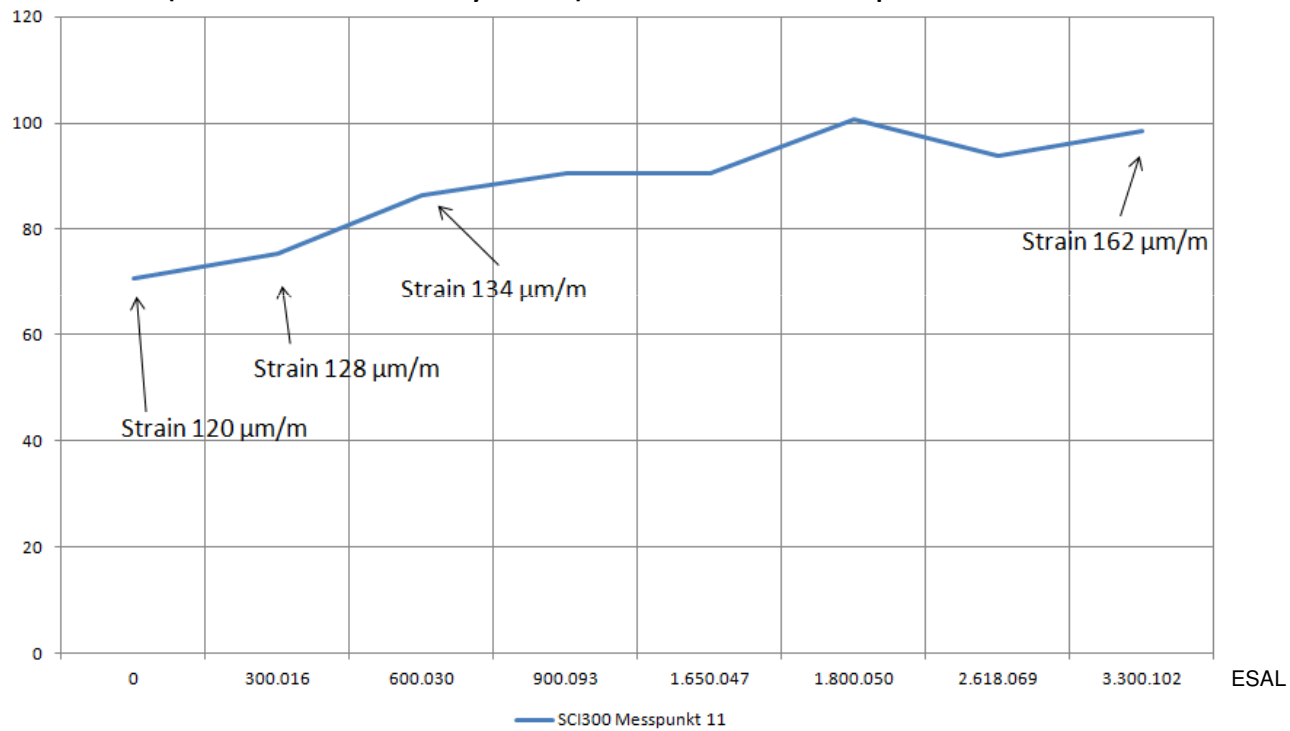
Research update

- results of measured (calibrated) and calculated deflection basins



Research update

- Calculated strain (back calculated system) on bottom of asphalt



Research update

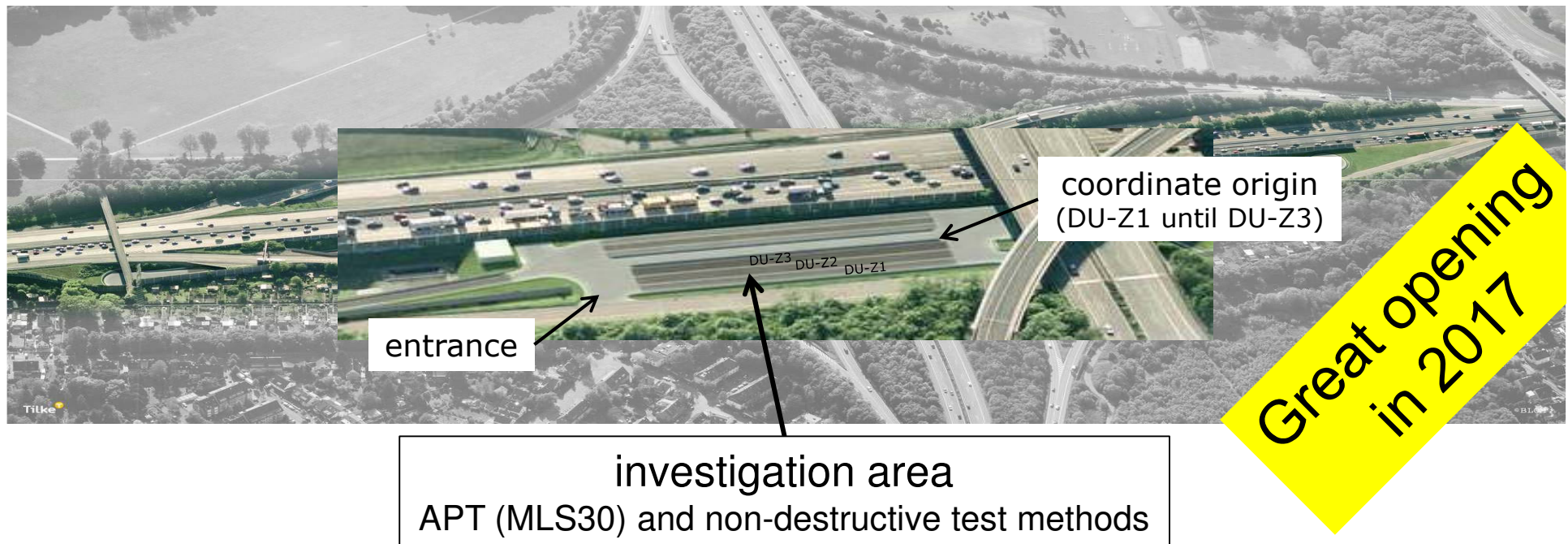
- next steps
 - evaluation of core results
 - stiffness and fatigue
 - use the data to residual service life
 - combine the results out of non-destructive test methods
 - find solutions to take the temperature into account (ultrasonic sensors)

Agenda

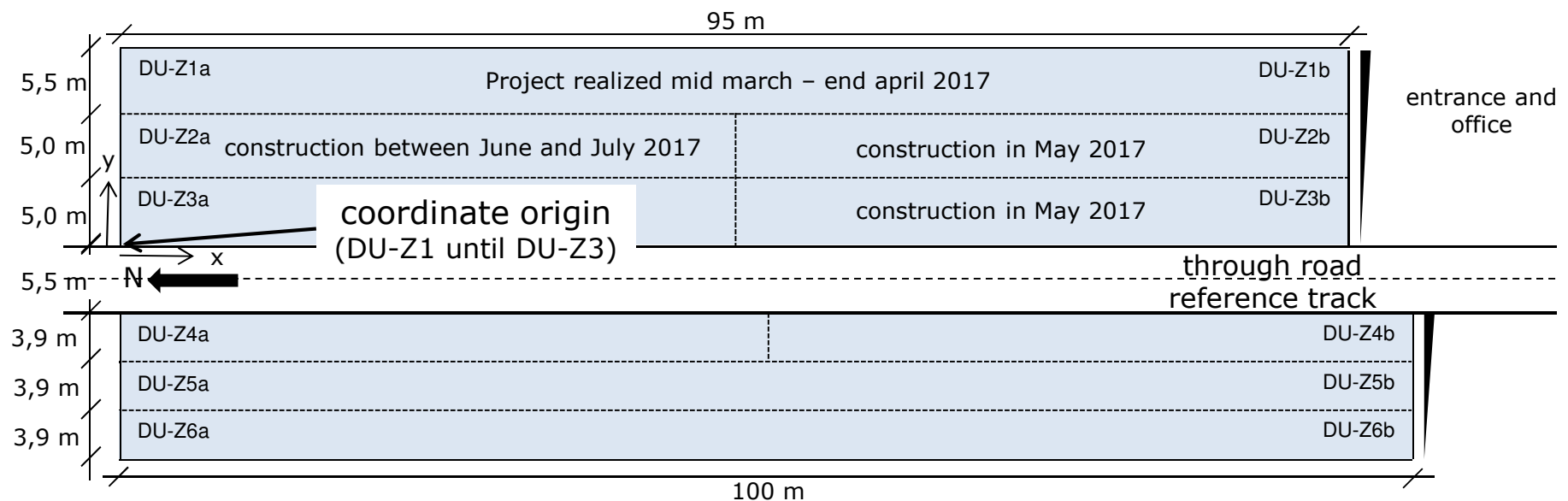
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Future data handling

duraBAST – outdoor test area
demonstration, investigation (**U**ntersuchung), reference area



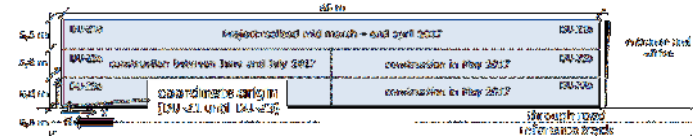
Future data handling



- for example:
 - DU-Z2a = demonstration and investigation (DU) – central area (Z) no. 2 north part (a)

Future data handling

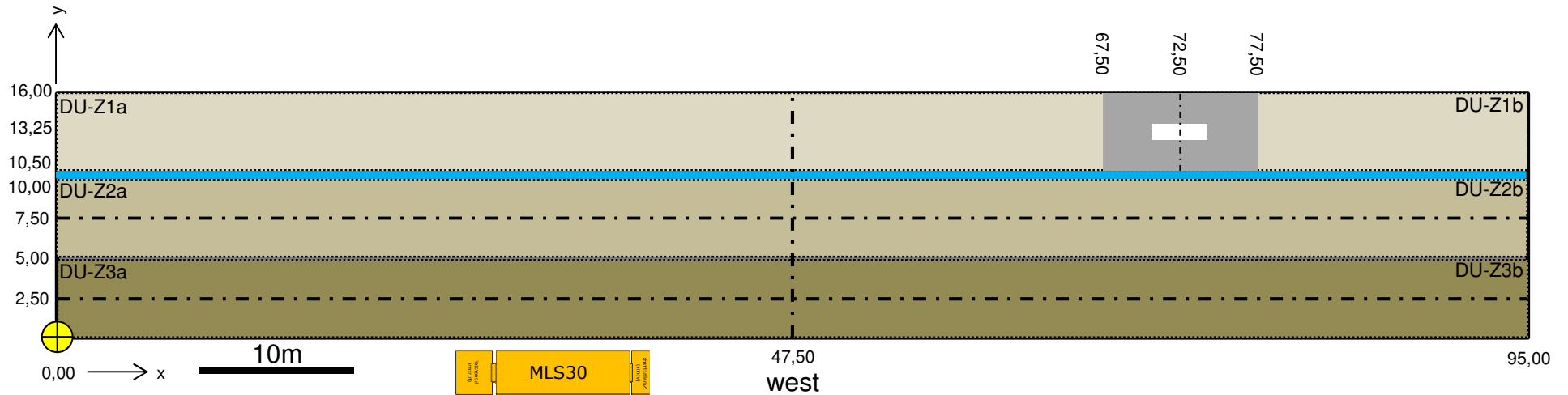
east



Construction & Loading direction

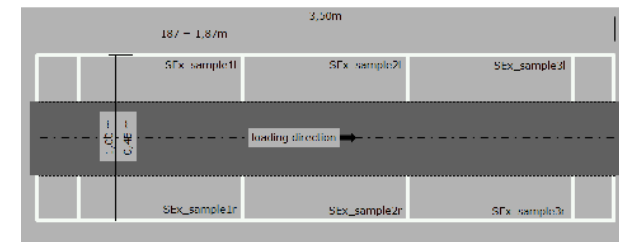
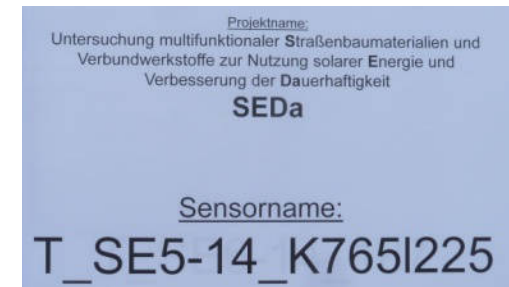
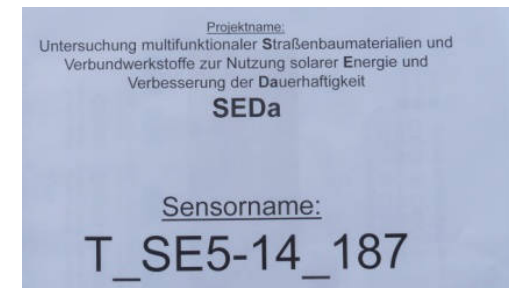


Test Section
DU-Z1_SE5-2017



Future data handling

- Relevant information embedded in sensor name
 - type of sensor (T, C, S, M)
 - loading or investigation section (SEDa = SE1-SE6)
 - depth [cm]
 - position
 - `_K765` = coordinate system 76,5m
 - `_187` = 1,87 [m] loading area
 - deviating from axis
 - no information behind position = axis of test section (SEDa = y-coordinate 13,25)
 - “l” or “r” in loading direction (SEDa = north to south)
 - `l225` = 2,25 [m] left of axis (SEDa = y-coordinate 15,50)



Future data handling

Legende:

AC T	=	Asphalt concrete Base Layer (Tragschicht)
b	=	loaded area (belasteter Bereich)
C	=	Compressive stress
FSS	=	frost protection layer (Frostschuttschicht)
Ref	=	Referenzpunkt
S	=	Strain
SMA	=	Spitlmastixasphalt
T	=	temperature
test section	=	H9 / H7 / DU-Z / DU-N / EX
ToB	=	base layer (Tragschicht ohne Bindemittel)
unb	=	unloaded area (unbelasteter Bereich)
SE	=	SEda

wacker:
H9 = Halle 9 BAST
H7 = Halle 7 BAST
DU-Z = Untersuchungsfläche
DU-N = Untersuchungsfläche
EX = Externe Fläche

wacker:
_K = Angabe Koordinate _K114 = 11,4m

wacker:
bleibt leer wenn kein Versatz zur Belastungsachse vorhanden ist
S= Süd / A= Asphalt / N= Nord

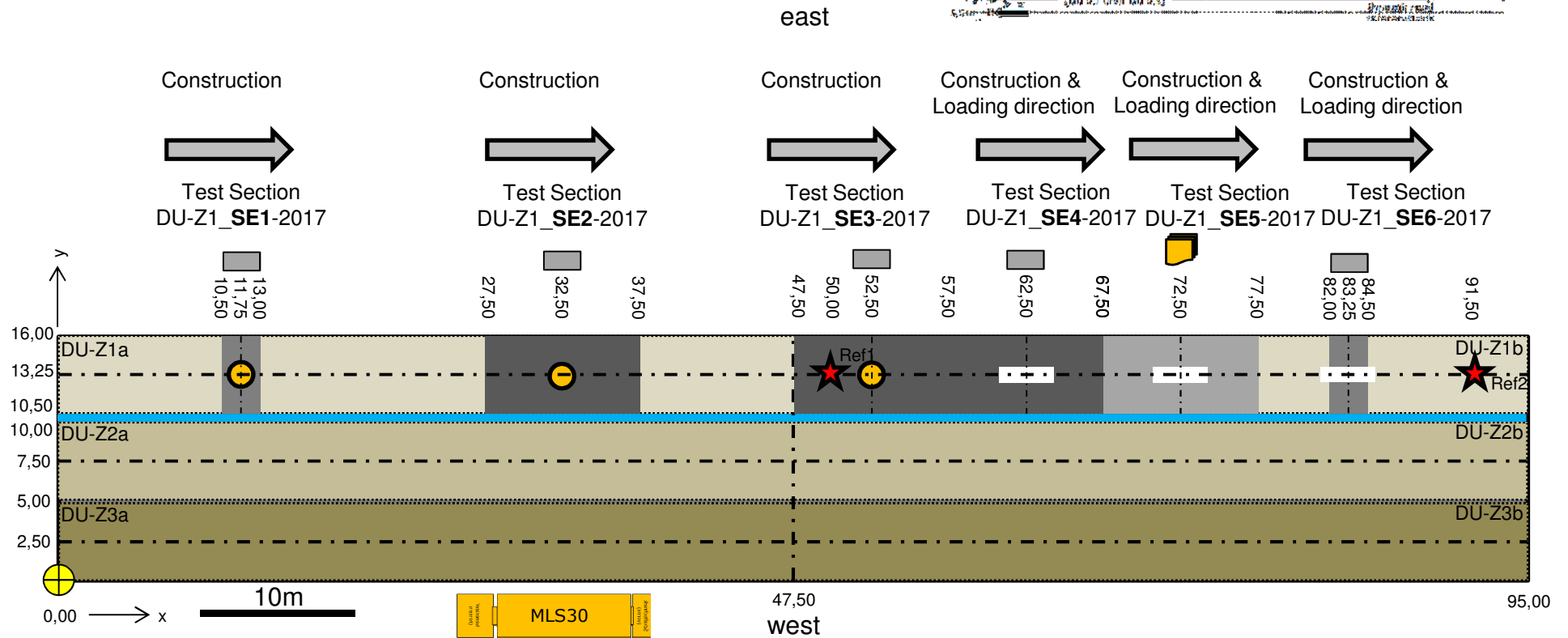
Sensorbezeichnung

test section	Sensortyp	Project	_ts	depth [cm]	_A zu Start	r/l zur Achse	komplette Bez.	Sensor ID	Status
DU-Z1_SE5-2017	T	SE	5	-02	K765		T_SE5-02_K765	BB6CF0	eingebaut
DU-Z1_SE5-2017	T	SE	5	-02	K765	l225	T_SE5-02_K765l225	BB2703	eingebaut
DU-Z1_SE5-2017	T	SE	5	-00	K765		T_SE5-00_K765		beschafft jetzt
DU-Z1_SE5-2017	T	SE	5	-00	K765	l225	T_SE5-00_K765l225		beschafft jetzt
DU-Z1_SE5-2017	C	SE	5	-40	075		C_SE5-40_075	1725142	eingebaut
DU-Z1_SE5-2017	C	SE	5	-40	175		C_SE5-40_175	1725140	eingebaut
DU-Z1_SE5-2017	C	SE	5	-40	275		C_SE5-40_275	17251	eingebaut
DU-Z1_SE5-2017	S	SE	5	-22	050		S_SE5-22_050	324	eingebaut
DU-Z1_SE5-2017	S	SE	5	-22	125		S_SE5-22_125	318	eingebaut
DU-Z1_SE5-2017	S	SE	5	-22	175		S_SE5-22_175	317	eingebaut
DU-Z1_SE5-2017	S	SE	5	-22	225		S_SE5-22_225	315	eingebaut
DU-Z1_SE5-2017	S	SE	5	-06	300		S_SE5-06_300		kalibriert
DU-Z1_SE5-2017	T	SE	5	-40	187		T_SE5-40_187	BB1C02	eingebaut
DU-Z1_SE5-2017	T	SE	5	-22	187		T_SE5-22_187	BAE736	eingebaut
DU-Z1_SE5-2017	T	SE	5	-14	187		T_SE5-14_187	BC4A88	eingebaut
DU-Z1_SE5-2017	T	SE	5	-06	187		T_SE5-06_187	HT28	eingebaut
DU-Z1_SE5-2017	T	SE	5	-02	187		T_SE5-02_187	BB6F64	eingebaut
DU-Z1_SE5-2017	T	SE	5	-02	187	l30	T_SE5-02_187l30	BC2AB7	eingebaut
DU-Z1_SE5-2017	T	SE	5	-00	187		T_SE5-00_187		beschafft jetzt Kali
DU-Z1_SE5-2017	T	SE	5	-00	187	l30	T_SE5-00_187l30		beschafft jetzt Kali

Projektnamen:
Untersuchung multifunktionaler Straßenbaumaterialien und Verbundwerkstoffe zur Nutzung solarer Energie und Verbesserung der Dauerhaftigkeit
SEda

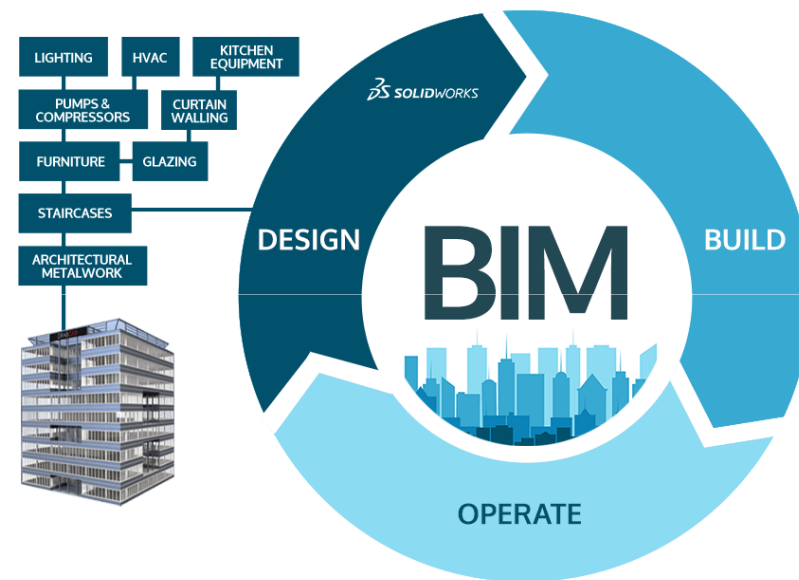
Sensornamen:
S_SE5-22_050

Future data handling



Future data handling

- duraBAST will be a dynamic research area
 - We have to know everything!
 - position (3D)
 - type of installation
 - ...
 - for example:
 - rebuild a constructed test section
 - build up on a constructed test section



<https://www.innova-systems.co.uk/solidworks-architectural-construction-industry-bim/>

Different persons at BAST are working on this topic

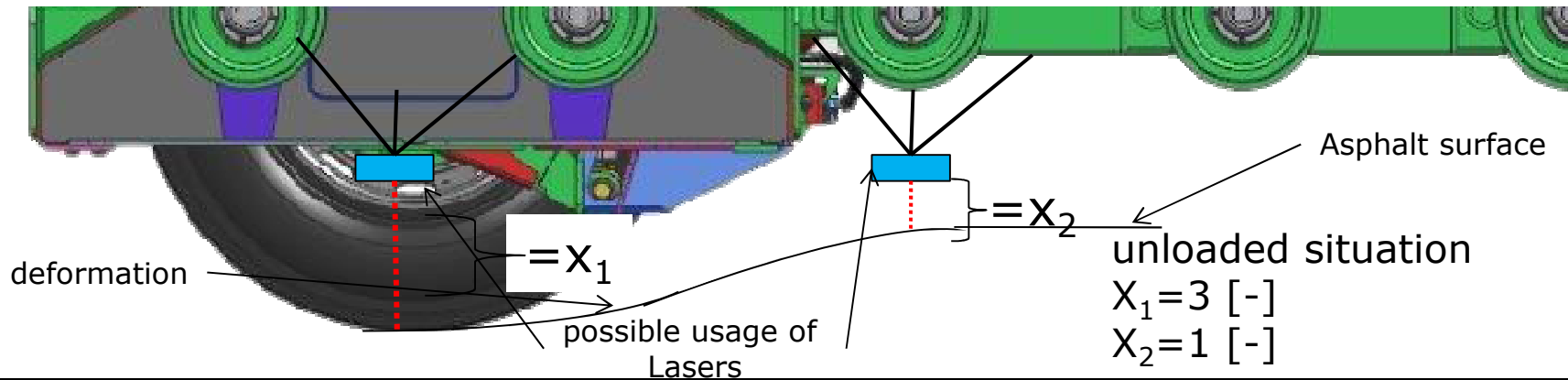
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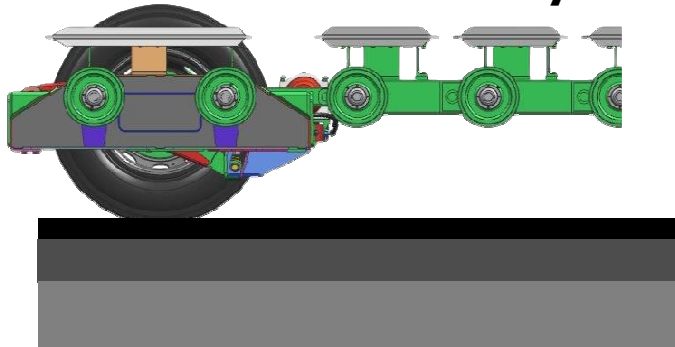
New measurement system on MLS30



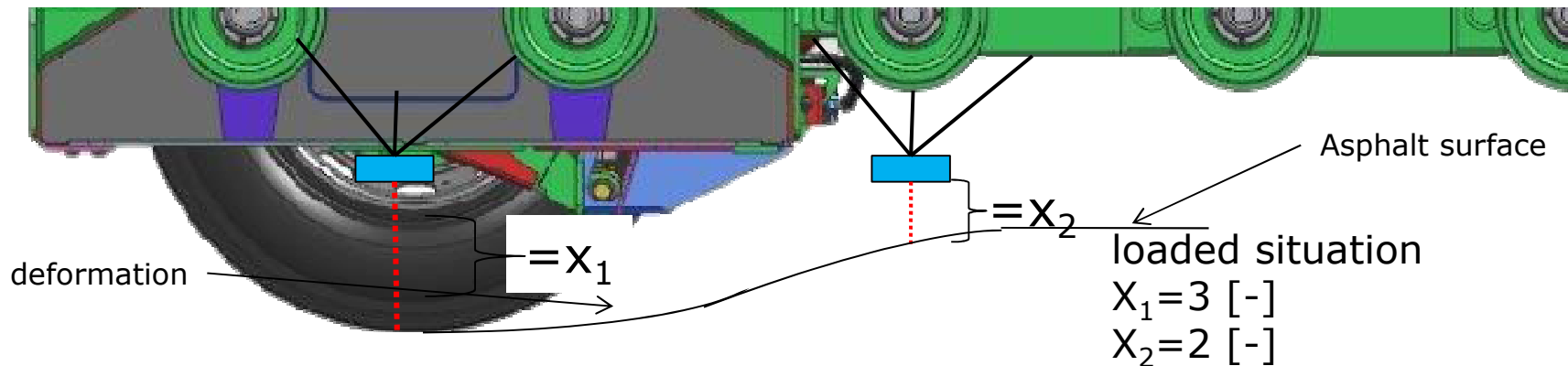
Inflated – not to scale



New measurement system on MLS30

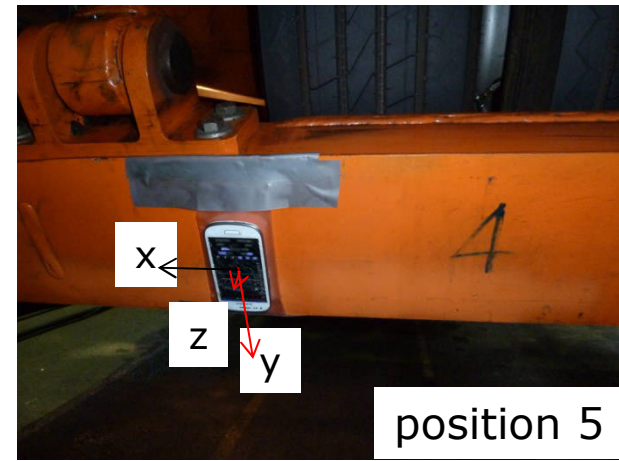
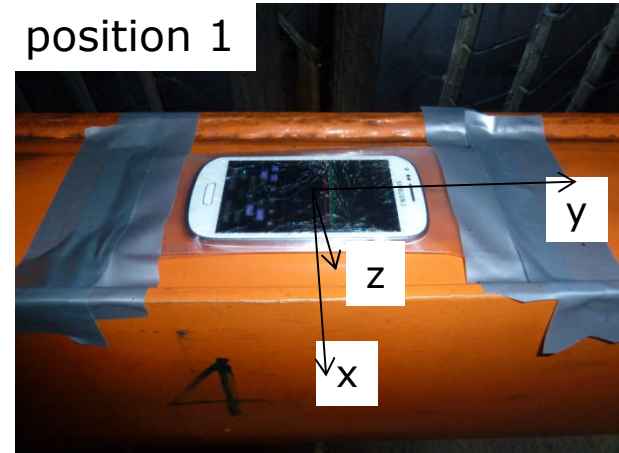
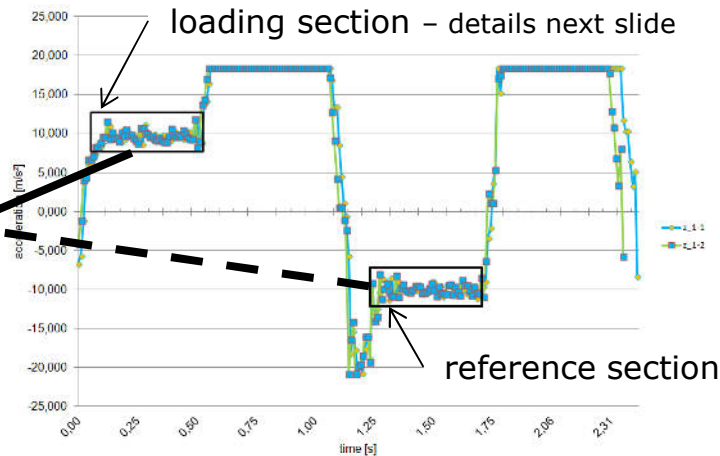
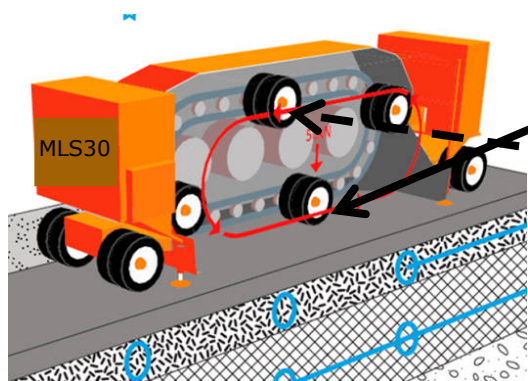


Inflated – not to scale



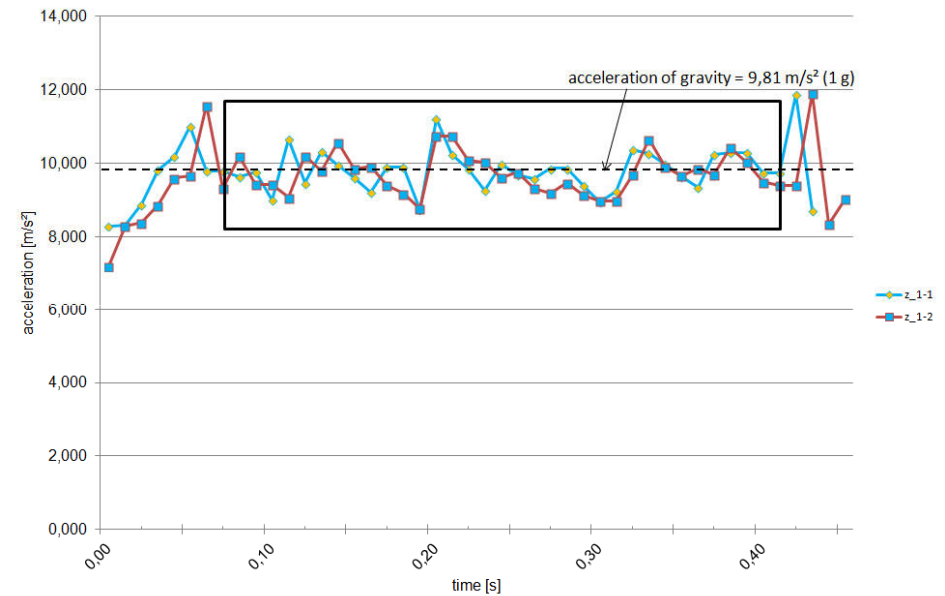
New measurement system on MLS30

- Acceleration measurements on Bogie frame
 - position 1: Phone on top of Bogie frame z down
 - position 2: Phone in front of Bogie frame x down
 - ~~position 3: Phone in the back of Bogie frame~~ not realized
 - position 4: Phone underneath Bogie frame z down
 - position 5: Phone in front of Bogie frame y down



New measurement system on MLS30

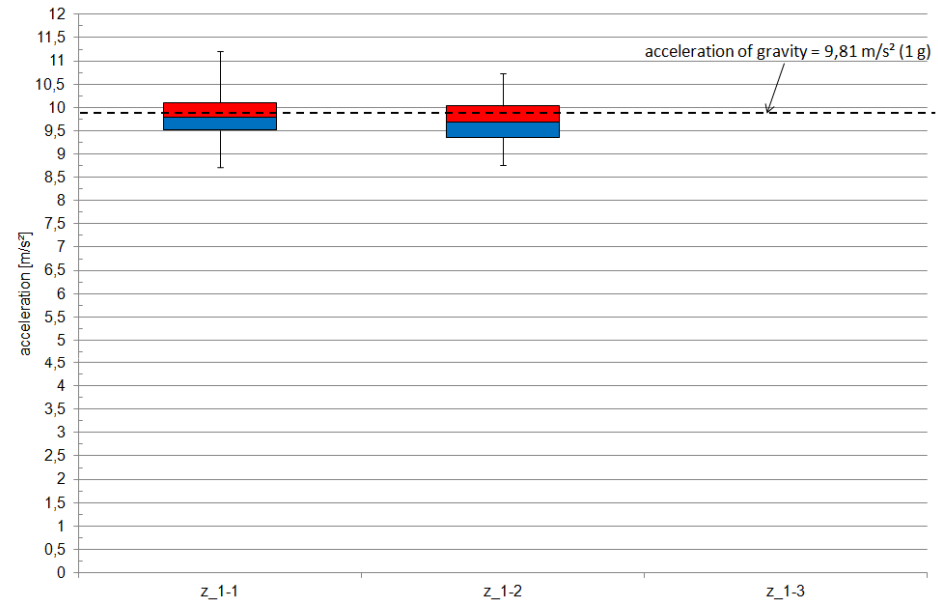
- Loading section (pos. 1)
 - measurement time (rectangle)
 - 0,34 s (0,07 – 0,41 s)
 - MLS30 speed
 - 6.000 mm/s
 - suitable measurement length
 - 2.000 mm



New measurement system on MLS30

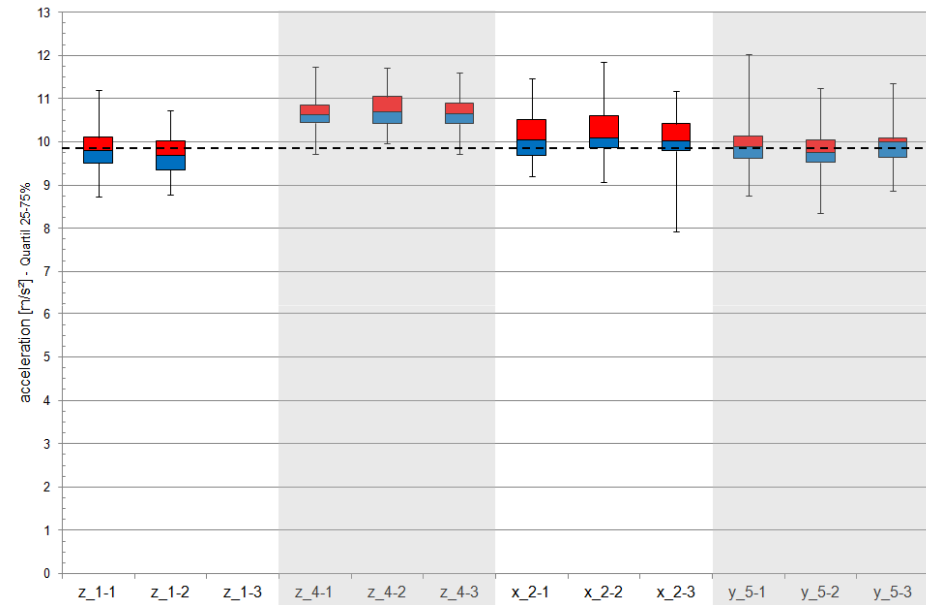
- only two measurements on position 1 can be analyzed
 - third measurement data are not transmitted
- 50% of measurement points (range)
 - $z_{1-1} = 0,59 \text{ m/s}^2$
 - $z_{1-2} = 0,67 \text{ m/s}^2$
 - $z_{1-3} = -$
- median
 - $z_{1-1} = 9,79 \text{ m/s}^2 \rightarrow 0,02 \text{ m/s}^2 \text{ diff. to } 9,81 \text{ m/s}^2$
 - $z_{1-2} = 9,69 \text{ m/s}^2 \rightarrow 0,12 \text{ m/s}^2 \text{ diff. to } 9,81 \text{ m/s}^2$
 - $z_{1-3} = -$

average
0,63 m/s²



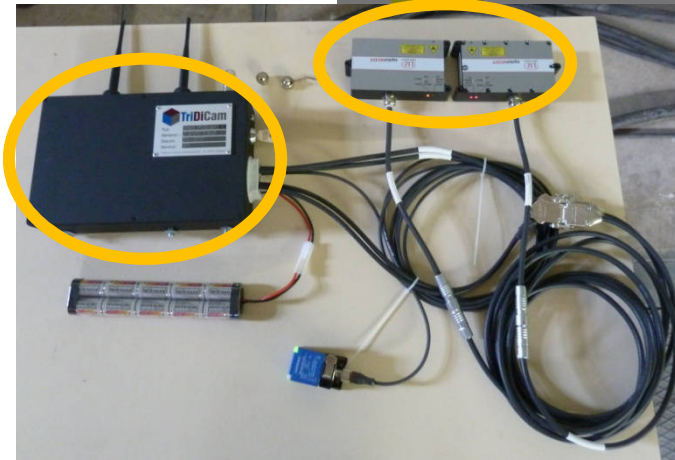
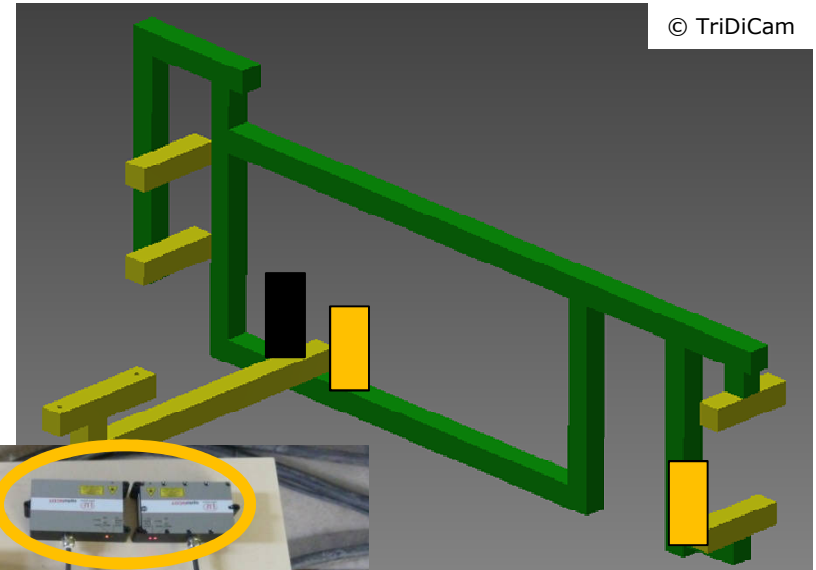
New measurement system on MLS30

- evaluation of all items
 - average range = 0,62 m/s²
for 50% of measurement points
 - z_1 = 0,63
 - z_4 = 0,50
 - x_2 = 0,74
 - y_5 = 0,49
 - median to acceleration of gravity
 - z_1 = 0,07
 - z_4 = 0,39
 - x_2 = 0,23
 - y_5 = 0,07



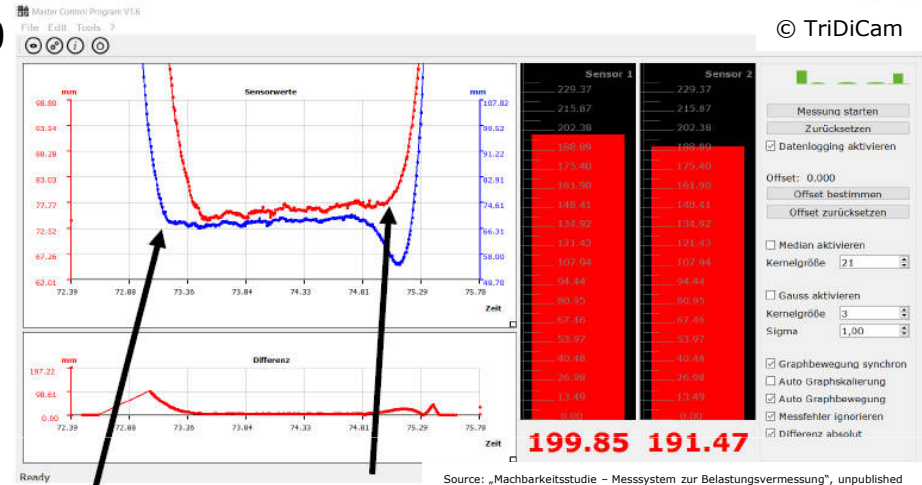
New measurement system on MLS30

- development of sensor mounting (feasibility study)
 - three mounting points
 - two sensors
 - one control unit

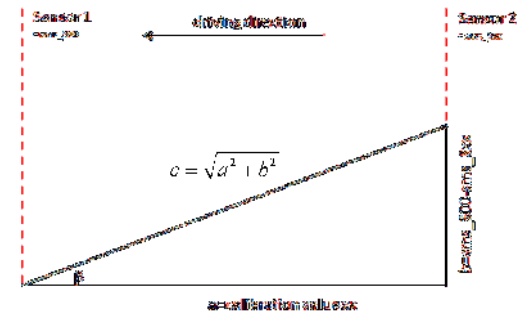


New measurement system on MLS30

- next steps
 - installation of measurement system until end of May 2017
 - test measurements June 2017
 - implementation into regular APT program
 - July, September, October 2017
 - evaluation until march 2018
 - search for the best parameter for test section assessment - e.q. angle
 - next webinar more detailed information about my PhD-project



back sensor (sensor 2) front sensor (sensor 1)



Thank you for your attention!



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