



Robustness of SN02 prototype test results

**2nd Meeting of Informal Group GTR9 Phase 2
Osaka, March 28th and 29th 2012**

Oliver Zander

Bundesanstalt für Straßenwesen

Bundesanstalt für Straßenwesen

(Federal Highway Research Institute)

Background



- **At the 1st meeting of the Informal Group GTR9 Phase 2 a report related to the long term durability of the FlexPLI was given by OICA (Doc GTR9-1-04)**
- **Despite the reported damages, more than 300 tests have been carried out with prototype SN02, apparently without significant effects on the test results.**
- **BAST committed to presenting more details in terms of the robustness of test results at the subsequent meeting of this Informal Group.**
- **Basis of the comparative study carried out at BAST were results of inverse certification tests with Flex-GTR prototype SN02 that were performed during a time period of approx. three years.**
- **During this time period, except the replacement of the string potentiometers in January 2010, neither major exchange of parts nor calibration of particular sensors was undertaken.**

Results



- In total, 20 inverse certification tests with SN02 have been carried out at BAST
- Test period: January 2009 – November 2011
- Three different honeycomb materials used according to Draft GTR
- Test result overview:

Date	TA1	TA2	TA3	TA4	ACL	PCL	MCL
19.01.2009	262,7	251,3	194,9	114,5	10,8	5,5	19,0
20.01.2009	254,0	241,2	188,4	108,9	10,0	5,3	20,1
20.01.2009	256,1	240,9	185,1	110,5	10,7	5,4	20,2
19.11.2009	250,0	238,6	185,5	103,6	9,3	5,0	19,7
19.11.2009	248,5	237,5	185,5	102,4	9,1	4,8	19,5
20.11.2009	251,5	241,0	188,3	103,1	9,1	4,8	19,7
18.11.2009	257,5	241,0	190,9	107,3	8,6	5,2	19,1
18.11.2009	256,2	238,5	189,0	107,3	8,8	5,1	19,0
18.11.2009	255,6	241,5	189,5	106,1	8,6	5,2	19,2
18.11.2009	255,3	240,1	190,2	108,3	9,1	5,4	19,2
18.11.2009	258,0	241,0	191,9	110,9	9,4	5,3	19,0
18.11.2009	259,3	243,7	193,0	110,6	9,5	5,3	19,1
11.03.2010	254,1	243,7	189,2	102,6	9,7	5,2	19,9
29.11.2010	258,5	228,4	185,1	99,7	10,2	5,1	20,0
21.03.2011	271,8	240,9	193,5	98,1	9,5	5,5	18,9
31.05.2011	261,0	236,7	191,9	100,1	9,8	5,0	19,8
30.06.2011	260,3	233,0	187,1	98,8	9,3	5,0	19,3
29.07.2011	259,3	233,9	186,5	98,6	9,9	5,1	19,6
02.09.2011	262,6	236,2	188,9	95,6	10,7	4,9	19,3
08.11.2011	258,3	224,9	181,1	91,0	10,2	5,3	19,6

Inverse corridors:

fail

pass

Repeatability of test results



- Tibia A1, A2, A3 and MCL with good repeatability (CV < 3%)
- Tibia A4 with minor issues, but repeatability acceptable (CV < 7%)
- As usual, some scatter in ACL/PCL results; however, both acceptable

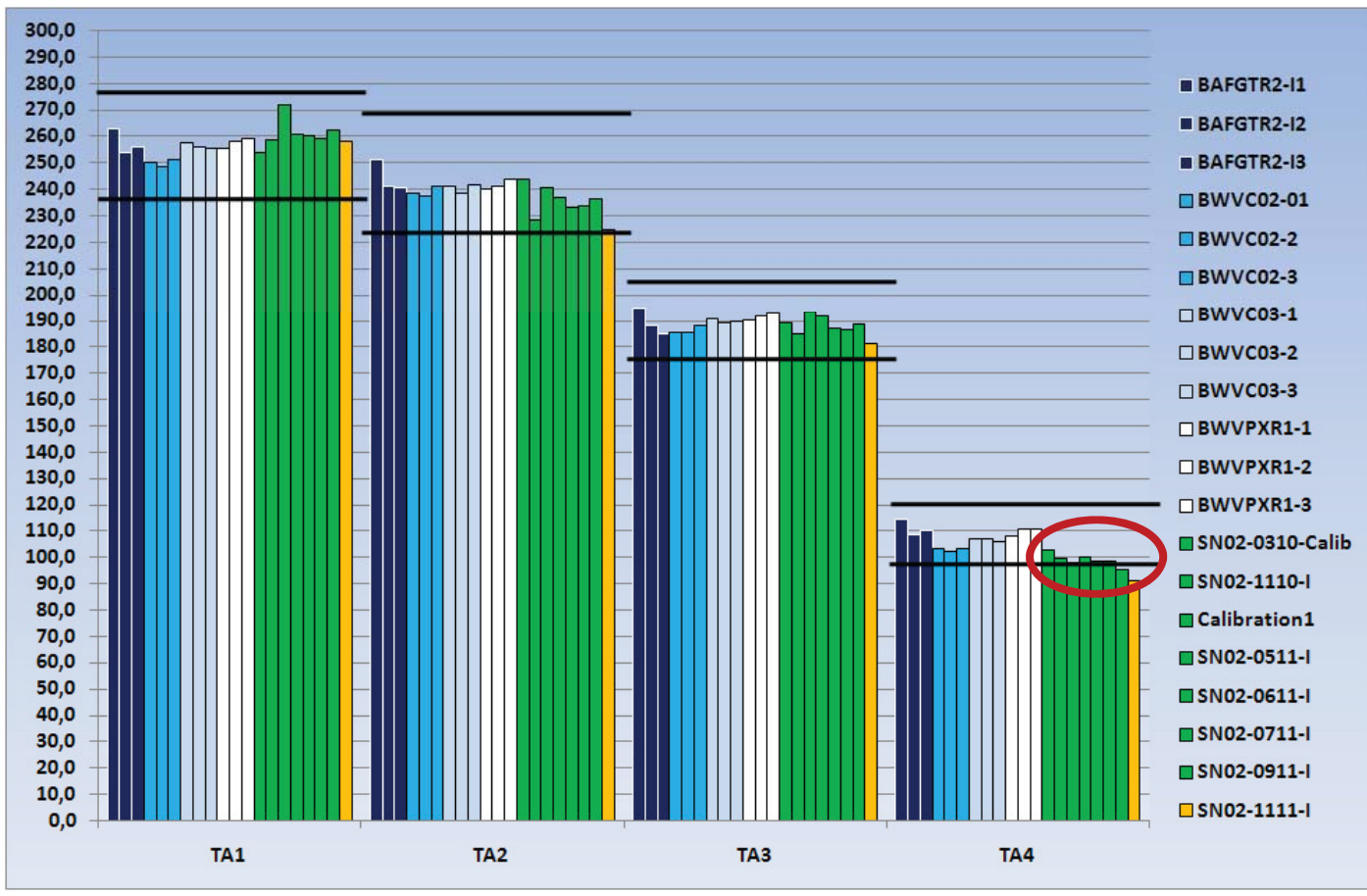
	TA1	TA2	TA3	TA4	ACL	PCL	MCL
Mean Value	257,53	238,70	188,78	103,90	9,62	5,17	19,46
Standard Deviation	5,10	5,69	3,40	5,99	0,67	0,21	0,40
Coefficient of Variation [%]	1,98	2,38	1,80	5,77	6,96	4,06	2,08
Maximum	271,80	251,30	194,90	114,50	10,80	5,50	20,20
Dev. from MV [%]	5,54	5,28	3,24	10,20	12,32	6,40	3,80
Minimum	248,50	224,90	181,10	91,00	8,60	4,80	18,90
Dev. from MV [%]	3,51	5,78	4,07	12,42	10,56	7,14	2,88
max. Dev. from MW	14,27	13,80	7,68	12,90	1,19	0,37	0,74
max. Dev. from MV [%]	5,54	5,78	4,07	12,42	12,32	7,14	3,80
Range	23,30	26,40	13,80	23,50	2,20	0,70	1,30



Certification corridors - Tibia



- Almost all tibia results within inverse certification corridors
- Issues with tibia A4: after string pot exchange and during the last two tests
- However, noticeable decrease of tibia results after disassembly and reassembly at BAsT/BGS undertaken for the OICA study (Doc GTR9-1-04)



after string pot replacement

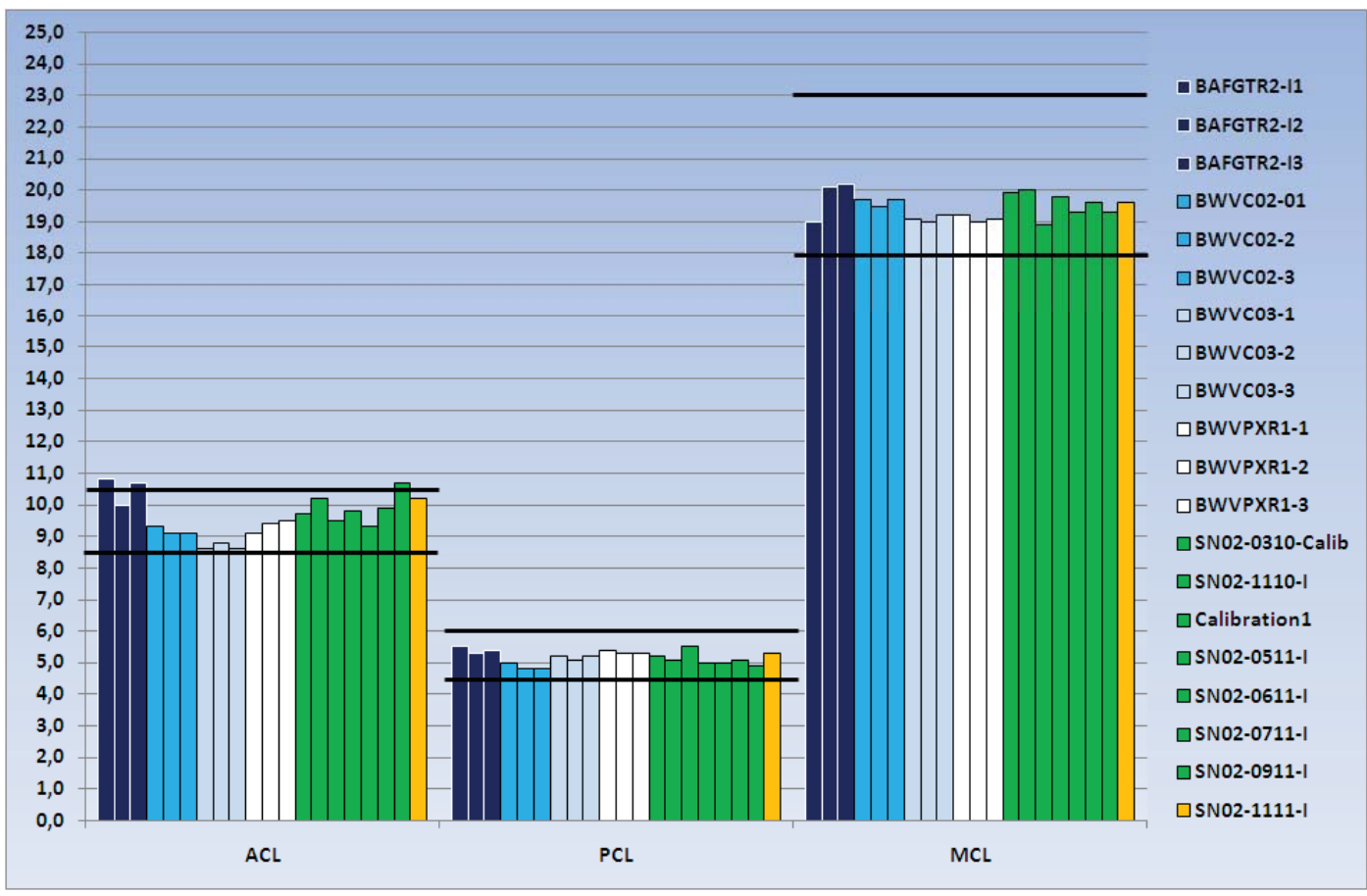
after reassembly



Certification corridors - Ligaments



- All MCL and PCL results within inverse certification corridors
- Few issues only with ACL during the course of the test series
- No noticeable influence of the string pot replacement and the impactor disassembly and reassembly at BAST/BGS on test results



after reassembly

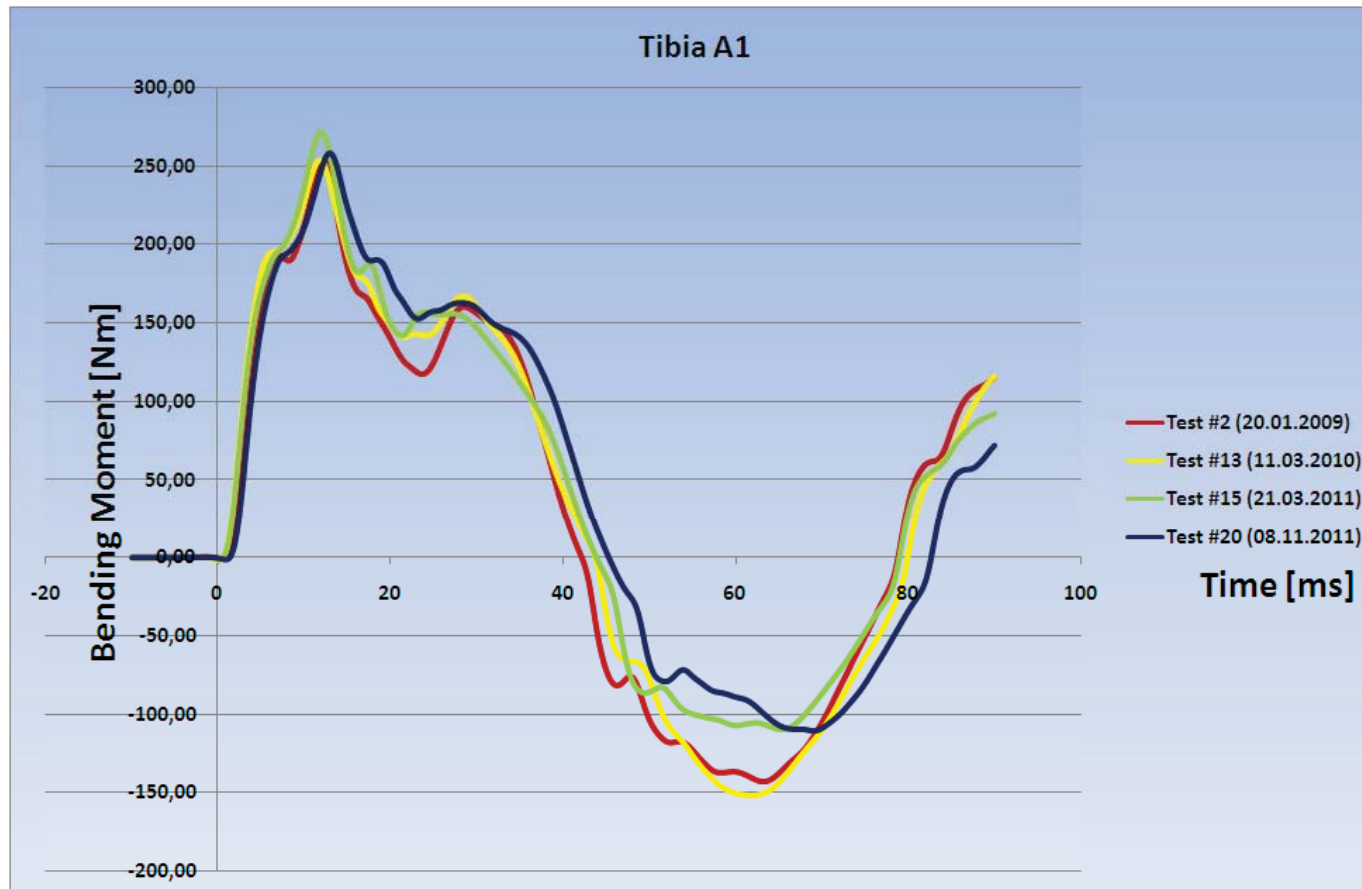
Time history curves



- Comparison of time history curves

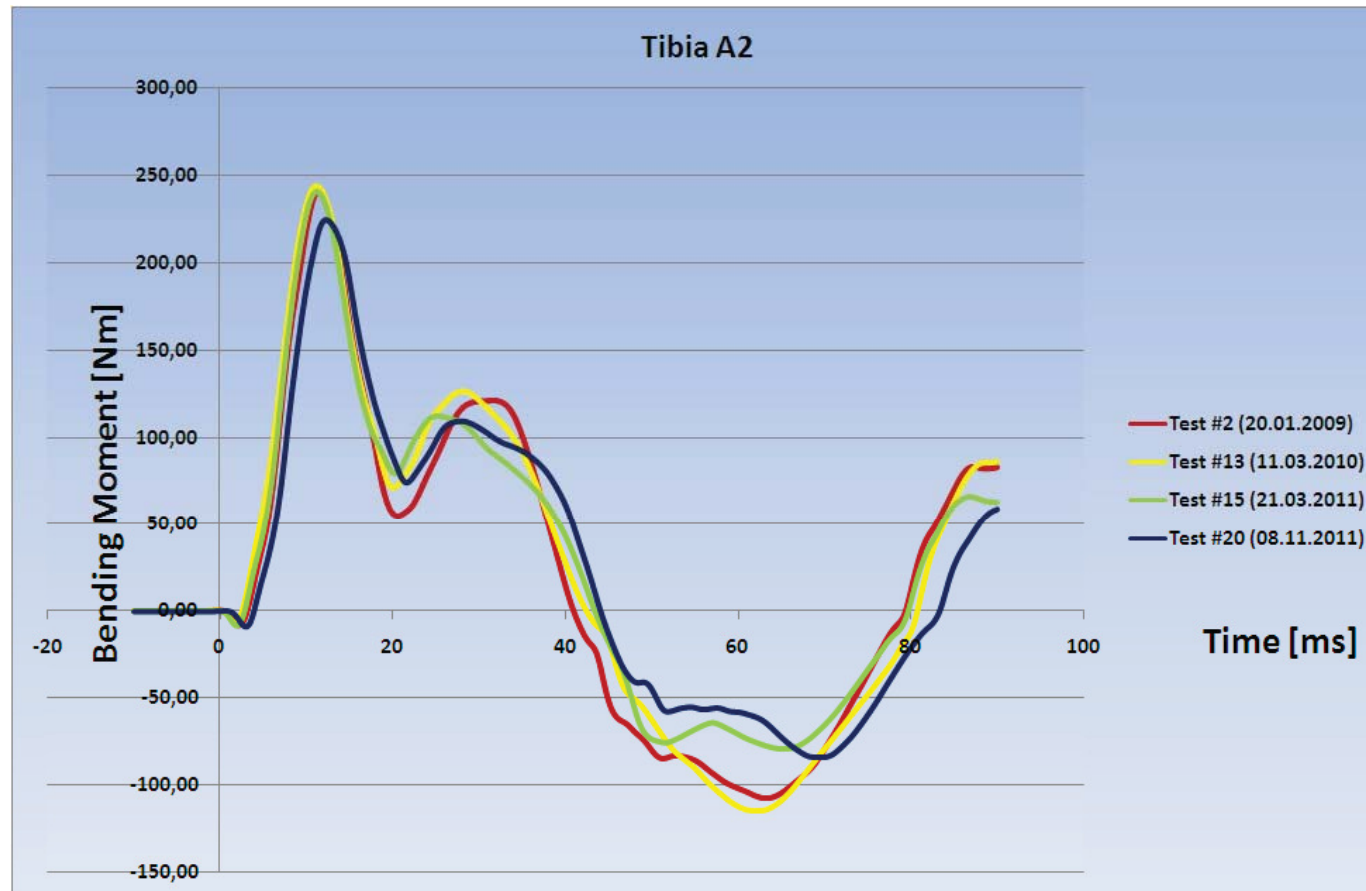
	Date	TA1	TA2	TA3	TA4	ACL	PCL	MCL
Test #2 →	19.01.2009	262,7	251,3	194,9	114,5	10,8	5,5	19,0
	20.01.2009	254,0	241,2	188,4	108,9	10,0	5,3	20,1
	20.01.2009	256,1	240,9	185,1	110,5	10,7	5,4	20,2
	19.11.2009	250,0	238,6	185,5	103,6	9,3	5,0	19,7
	19.11.2009	248,5	237,5	185,5	102,4	9,1	4,8	19,5
	20.11.2009	251,5	241,0	188,3	103,1	9,1	4,8	19,7
	18.11.2009	257,5	241,0	190,9	107,3	8,6	5,2	19,1
	18.11.2009	256,2	238,5	189,0	107,3	8,8	5,1	19,0
	18.11.2009	255,6	241,5	189,5	106,1	8,6	5,2	19,2
	18.11.2009	255,3	240,1	190,2	108,3	9,1	5,4	19,2
	18.11.2009	258,0	241,0	191,9	110,9	9,4	5,3	19,0
Test #13 →	18.11.2009	259,3	243,7	193,0	110,6	9,5	5,3	19,1
	11.03.2010	254,1	243,7	189,2	102,6	9,7	5,2	19,9
	29.11.2010	258,5	228,4	185,1	99,7	10,2	5,1	20,0
Test #15 →	21.03.2011	271,8	240,9	193,5	98,1	9,5	5,5	18,9
	31.05.2011	261,0	236,7	191,9	100,1	9,8	5,0	19,8
	30.06.2011	260,3	233,0	187,1	98,8	9,3	5,0	19,3
	29.07.2011	259,3	233,9	186,5	98,6	9,9	5,1	19,6
	02.09.2011	262,6	236,2	188,9	95,6	10,7	4,9	19,3
Test #20 →	08.11.2011	258,3	224,9	181,1	91,0	10,2	5,3	19,6

Time history curves – Tibia A1



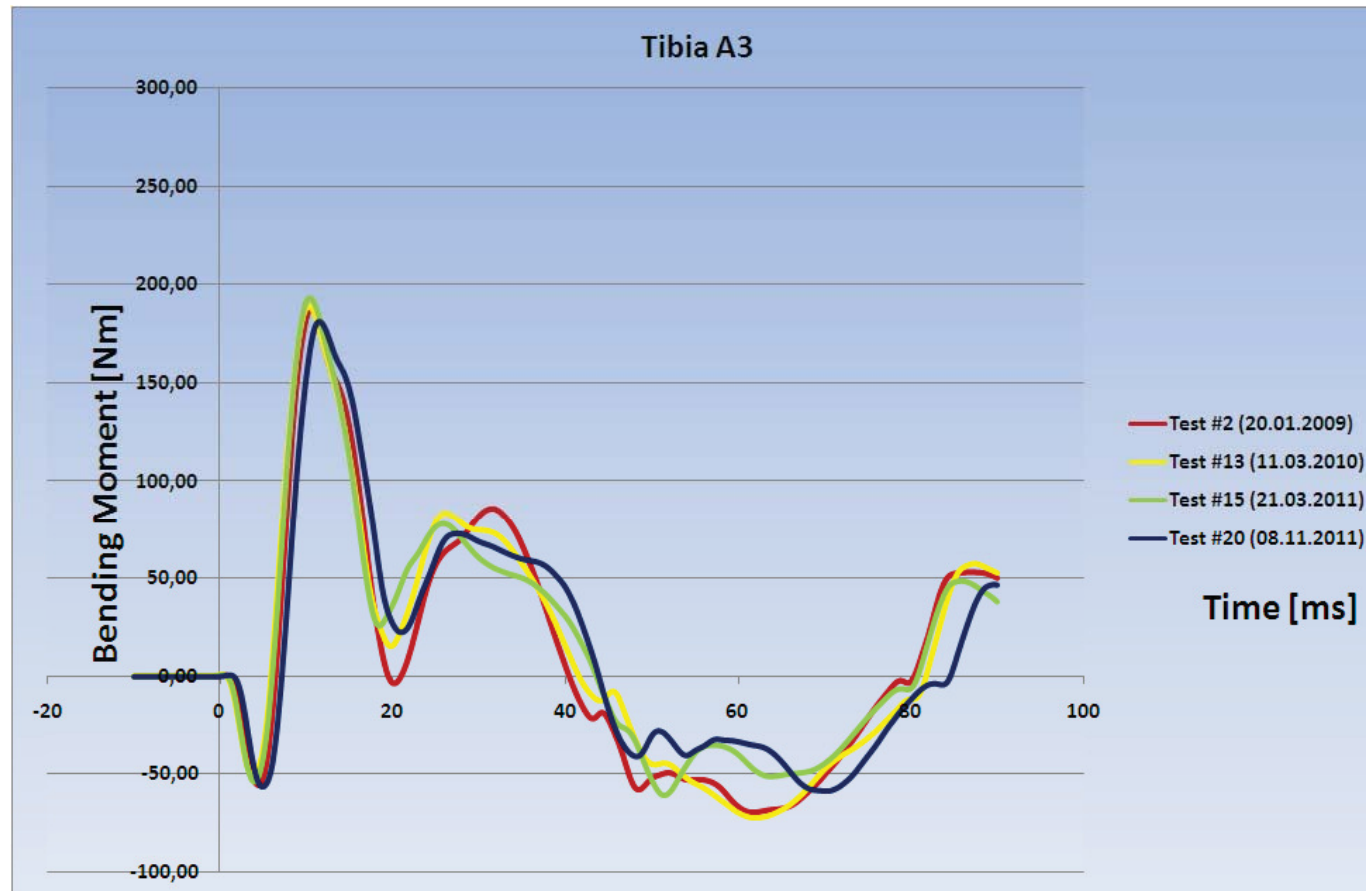
High repeatability during the impact phase
Test #2 with highest decay after first peak

Time history curves – Tibia A2



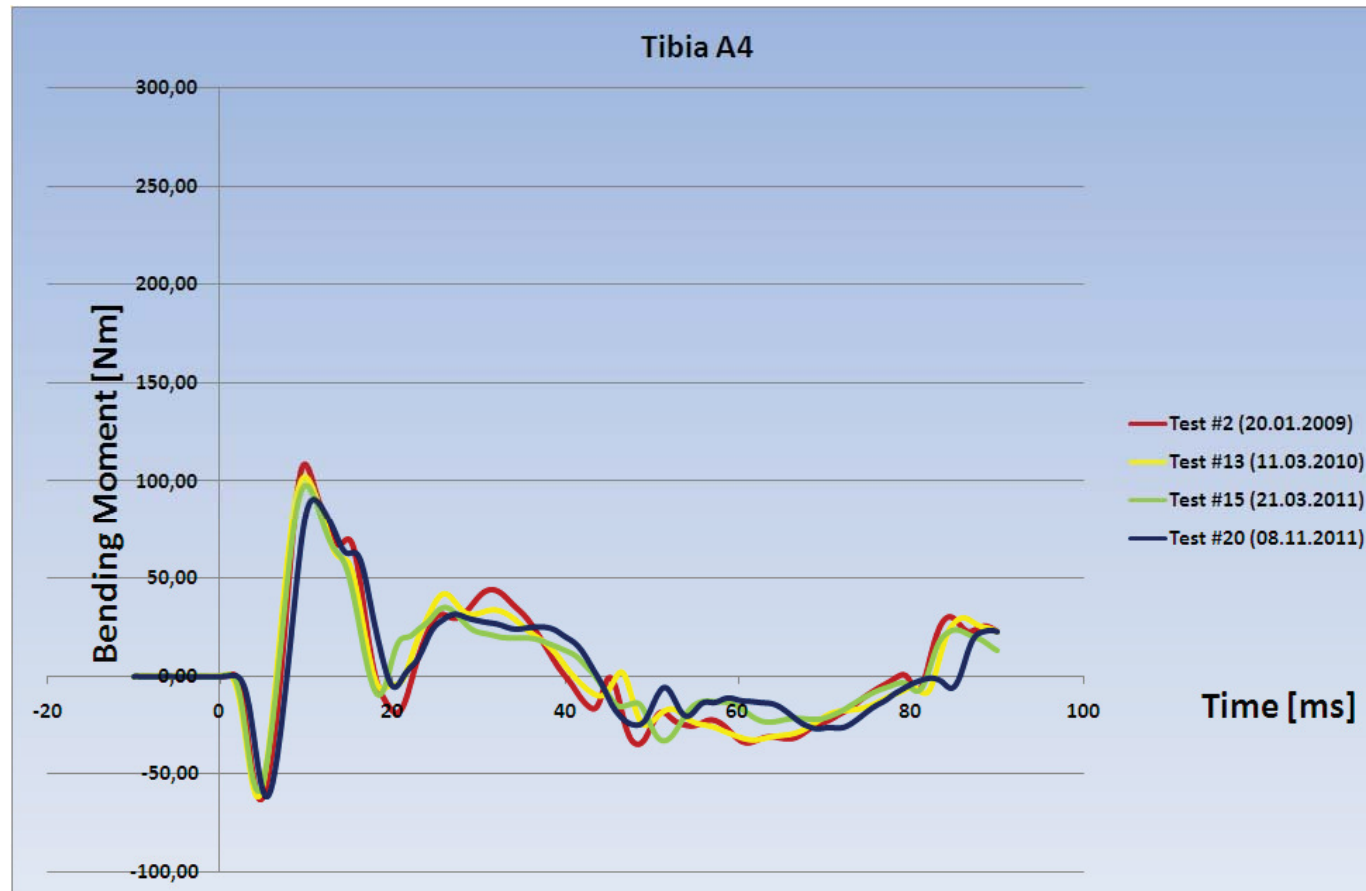
High repeatability during the impact phase
Test #2 with highest decay after first peak

Time history curves – Tibia A3



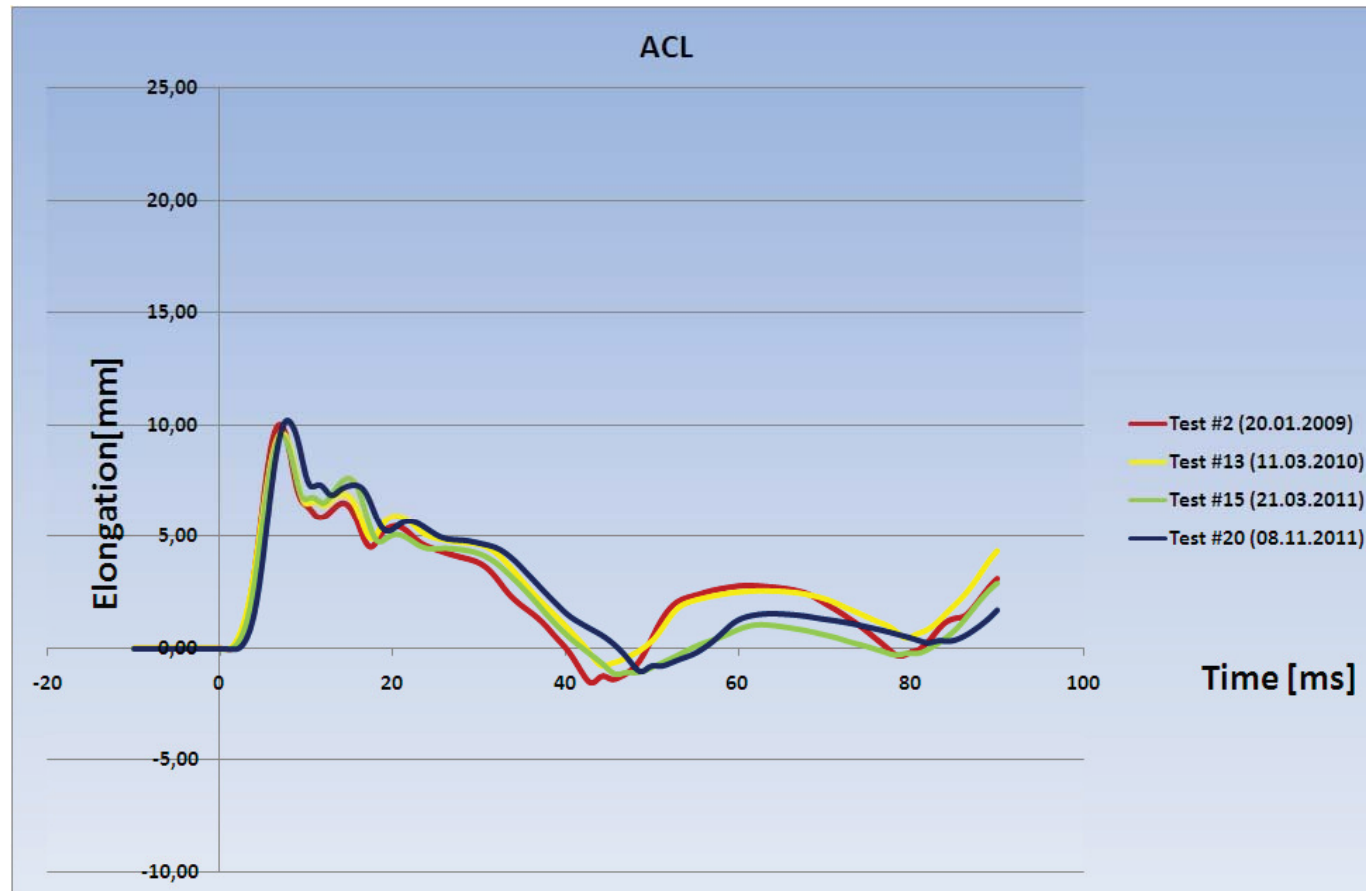
**High repeatability during the impact phase (primary impact)
Test #2 with highest decay after first peak**

Time history curves – Tibia A4



High repeatability during the impact phase (primary impact)
Test #20 contributes to a higher scatter and thus a CV of 5,77 %
Test #2 with highest decay after first peak

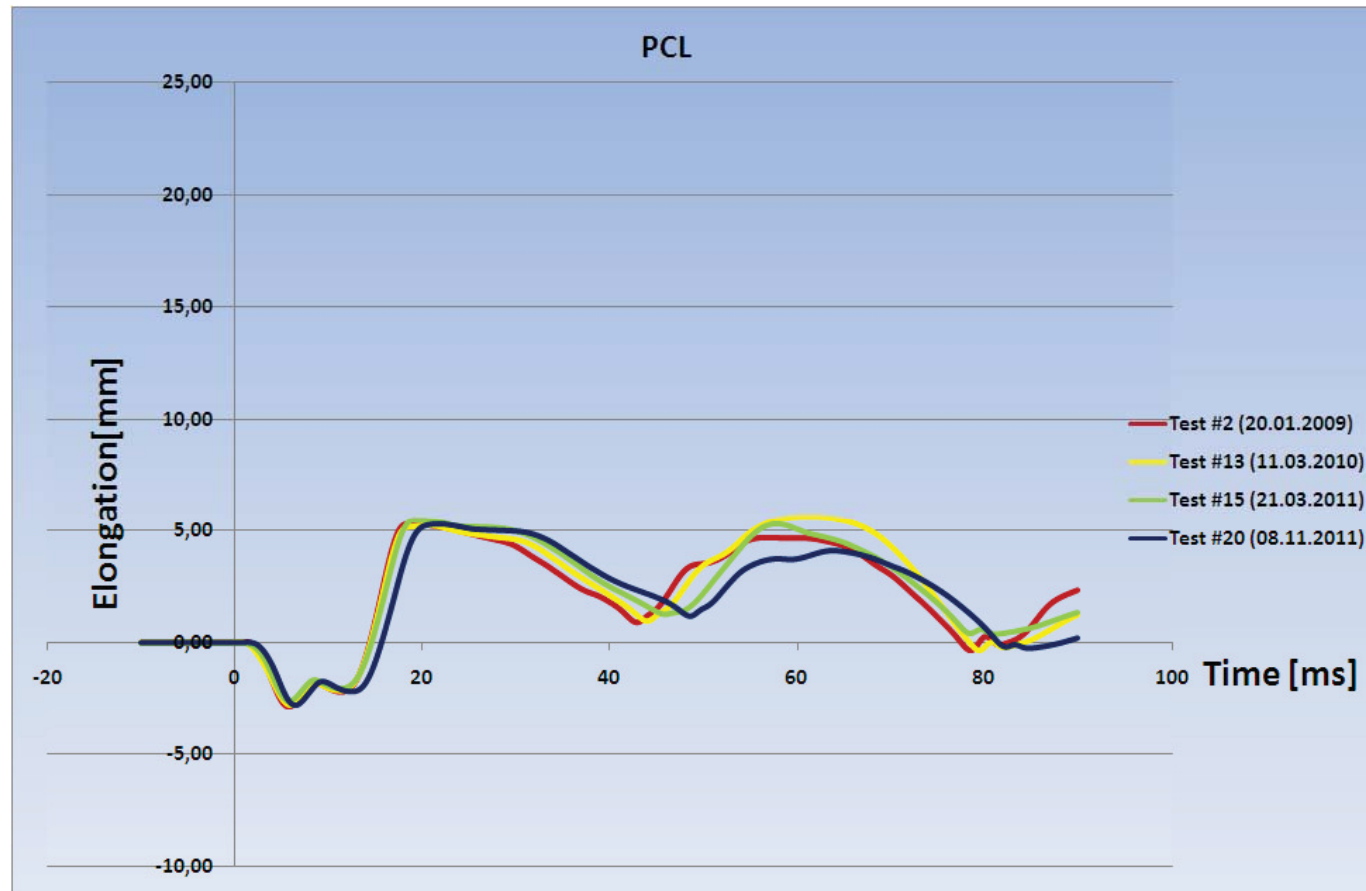
Time history curves – ACL



High repeatability during the impact phase

Test #20 with slightly different time history curve after the first peak

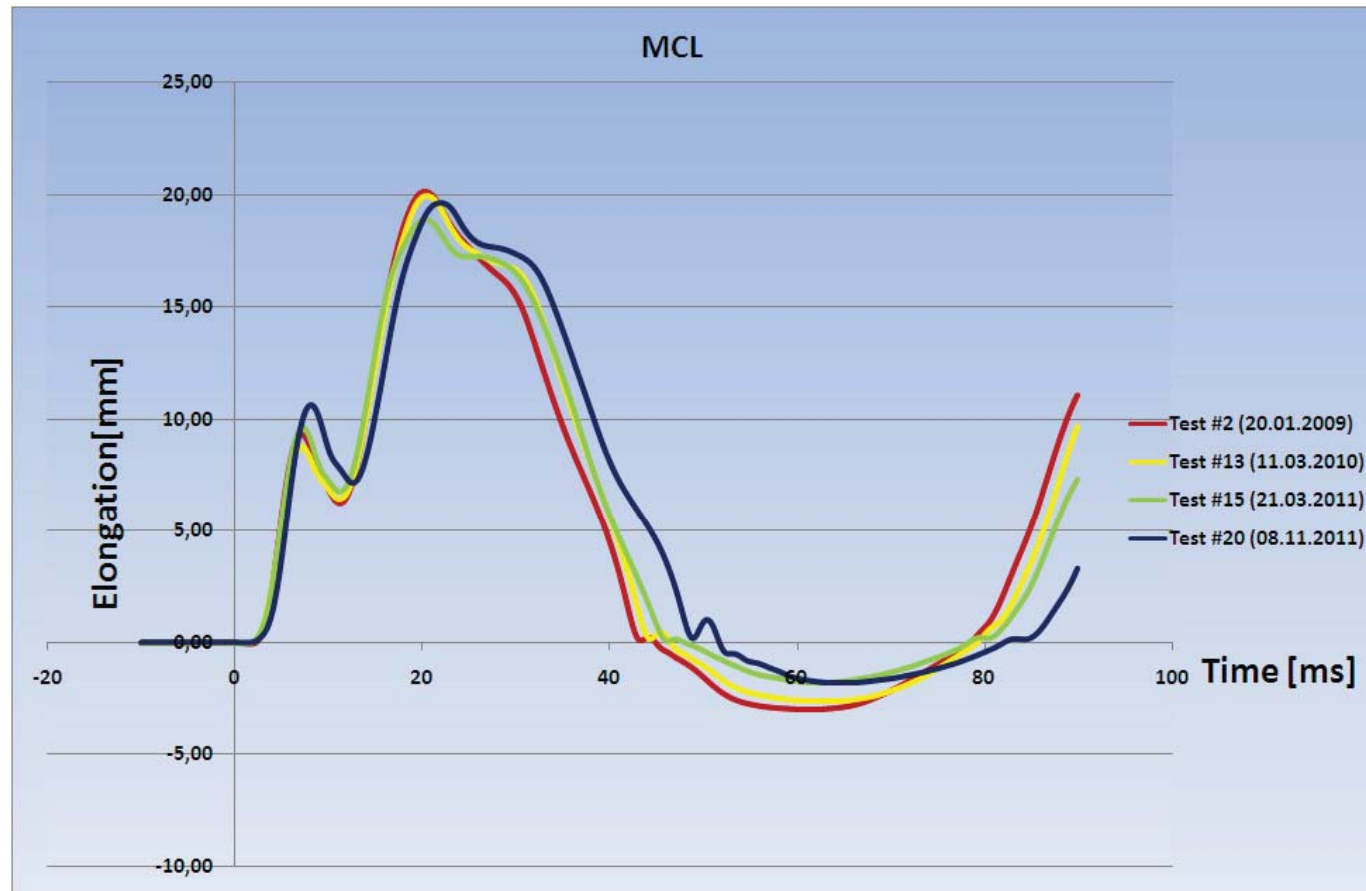
Time history curves – PCL



High repeatability during the impact phase

Test #20 with slightly different time history curve after the first peak

Time history curves – MCL



High repeatability during the impact phase
Test #20 with slightly different time history curve

Conclusions



- 20 inverse certification tests with SN02 carried out at BAST during approx. three years
 - Good repeatability of four (out of seven) segments at least during the impact phase
 - Repeatability of ACL/PCL results naturally lower than most of the other segments
 - Apparently no major influence of physical damages reported in Doc GTR9-1-04 on test results
 - After replacement of string potentiometers: decrease of tibia results
 - After disassembly and reassembly of the impactor: Decrease of tibia results and slightly different time history curves
 - From test #13 on: constant decrease of Tibia A4 results
 - Tibia A4 not meeting the corridor during the last two tests
- ➔ The damages reported by OICA apparently without significant effects on the test results.



Thank you !