



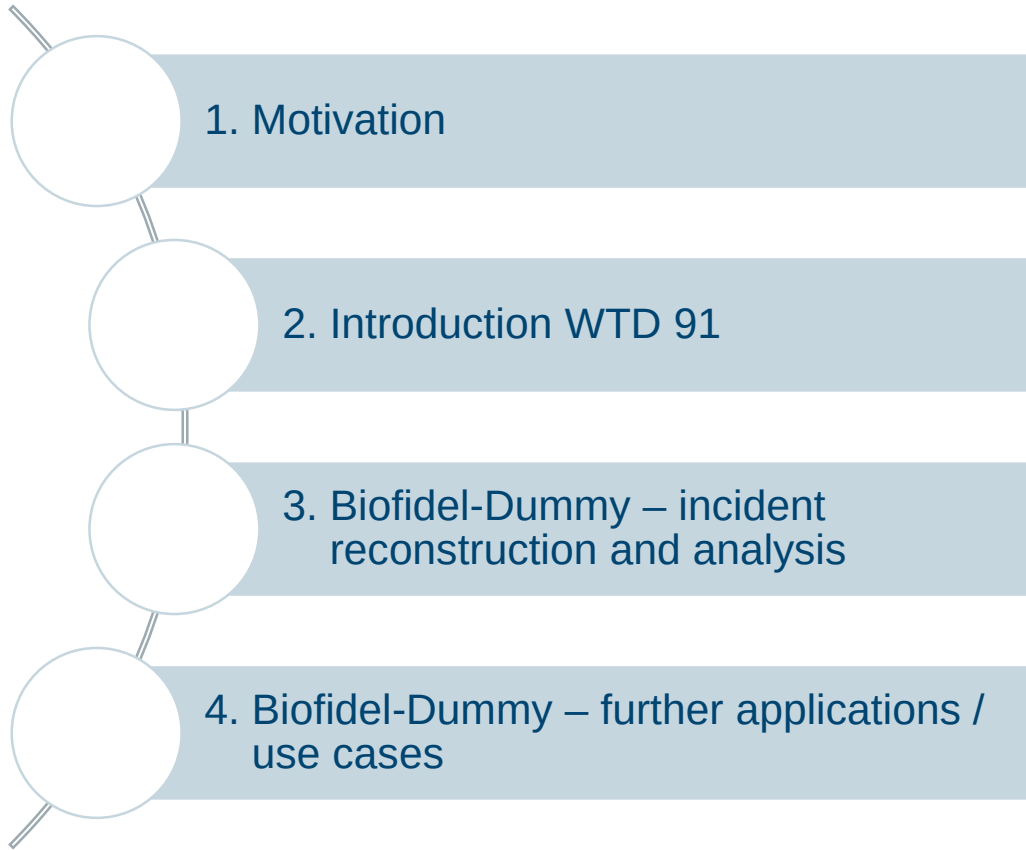
BLAST IMPACT SZENARIOS - INCIDENT RECONSTRUCTION AND ANALYSIS BY USING THE BIOFIDEL-DUMMY

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DUMMY. CRASHTEST. KONFERENZ. 2021, Münster



BUNDESWEHR



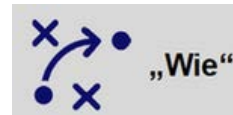
1. MOTIVATION



Weißbuch der Bundesregierung
Strategisch,
politische Vorgaben

Konzeption der Bundeswehr
Strategisch,
konzeptionelle Vorgaben

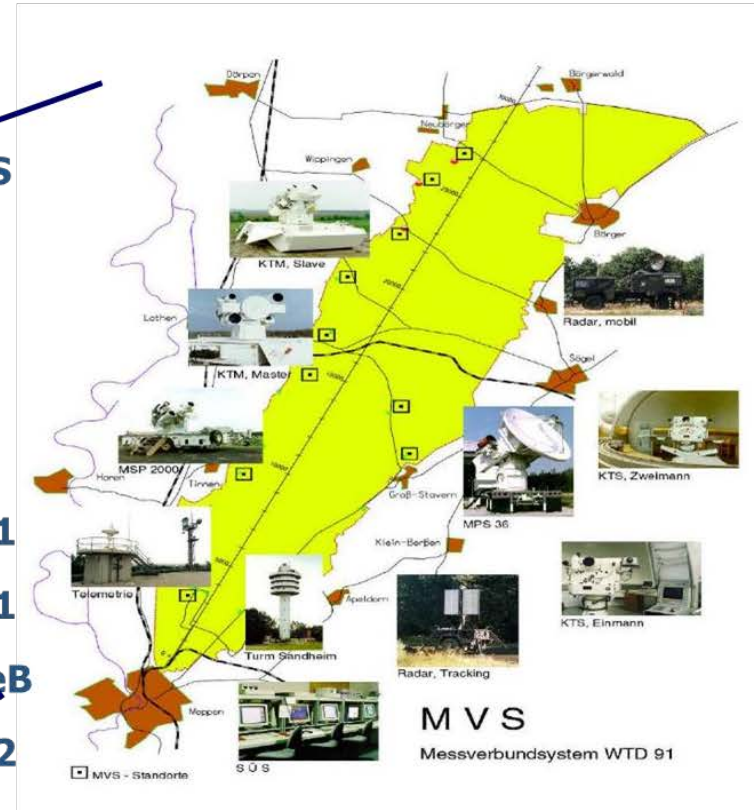
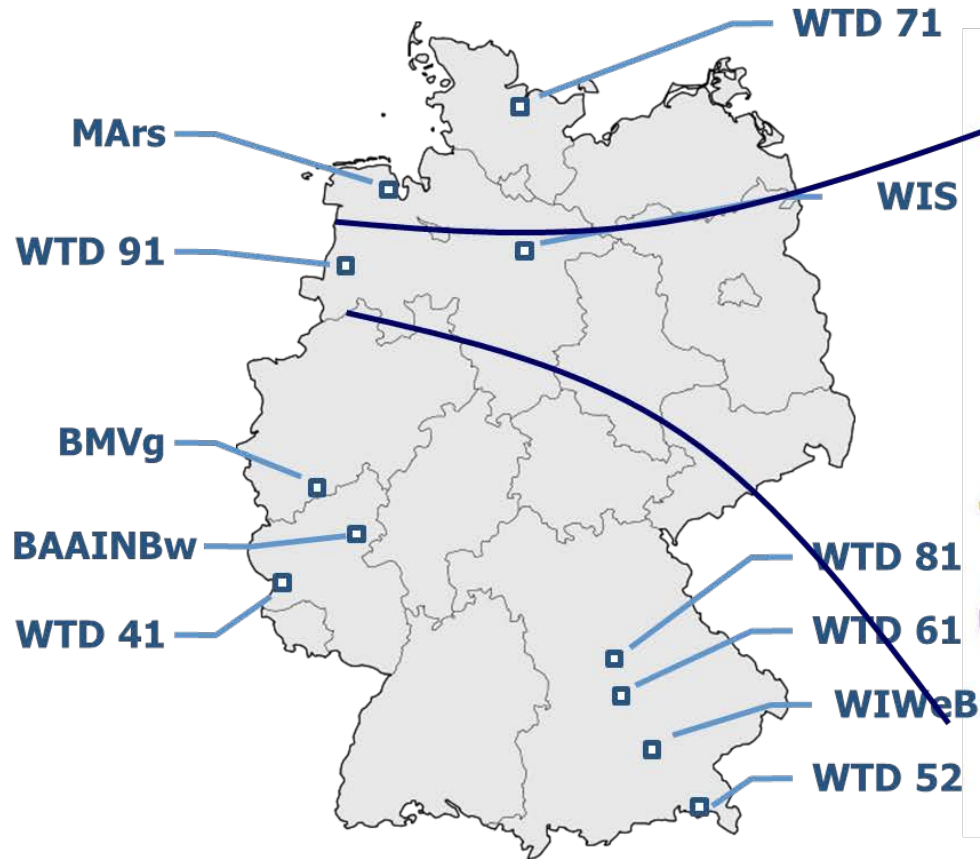
Fähigkeitsprofil der Bw
Handlungs-
und Leistungsvermögen



„Überlebensfähigkeit und Schutz unseres Personals.....sind essenziell für die Aufgabenwahrnehmung. Zugleich sind sie Ausdruck der Verantwortung für die der Bundeswehr anvertrauten Menschen.“

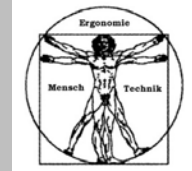
Weissbuch zur Sicherheitspolitik und zur Zukunft der Bundeswehr, 13.07.2016, S. 102

2. INTRODUCTION WTD 91

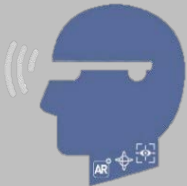


WTD 91 – 450

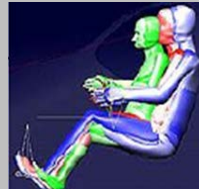
Schutz und Umfeld des Soldaten,
Mensch und Technik (Human Factors)



AR, VR, MR



Ergonomics



Occupant
Safety



Personal
Protection
Equipment



Incident
reconstruction
and
analysis



Threats



Systems



3. INCIDENT

- Two Infantrymen were involved in real-live shooting with anti-tank weapon „Panzerfaust 3“. One Infantryman moved behind the weapon at the time of chargeignition and was hit by the exhausts of the anti-tank-weapon.
-
-
-
- WTD 91 was tasked for incident reconstruction and analysis.

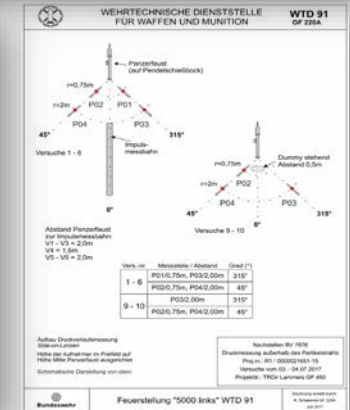
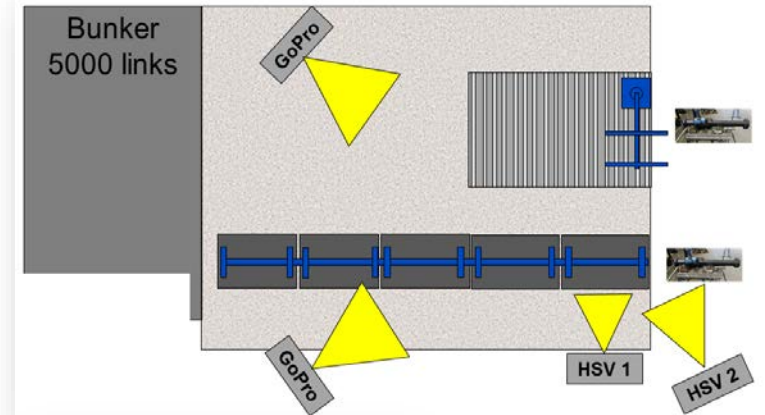


3. PANZERFAUST 3



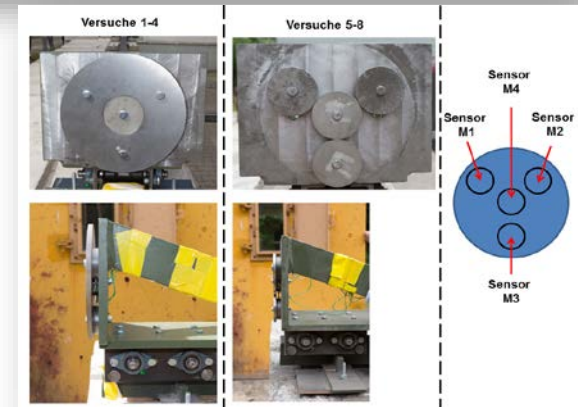
3. INCIDENT RECONSTRUCTION –TEST SET-UP

- Shooting tests with PzF 3
 - set-up 1: sled
 - set-up 2: Biofidel-Dummy
 - set-up 3: torso-surogate
 - Measurements
 - pressure
 - temperature
 - force
 - HSV
- set-up 4: numerical simulations



3. INCIDENT RECONSTRUCTION –TEST SET-UP 1 (SLED)

test	test object (m = ca. 120 kg)	distance [mm]
#1	Force gauges / sled	2000
#2	Force gauges / sled	2000
#3	Force gauges / sled	2000
#4	Force gauges / sled	1500
#5	Force gauges / sled / PPE	2000
#6	Force gauges / sled	2000
#7	Force gauges / sled / PPE	500
#8	Force gauges / sled	500



3. INCIDENT RECONSTRUCTION –TEST SET-UP 1 (SLED) RESULTS

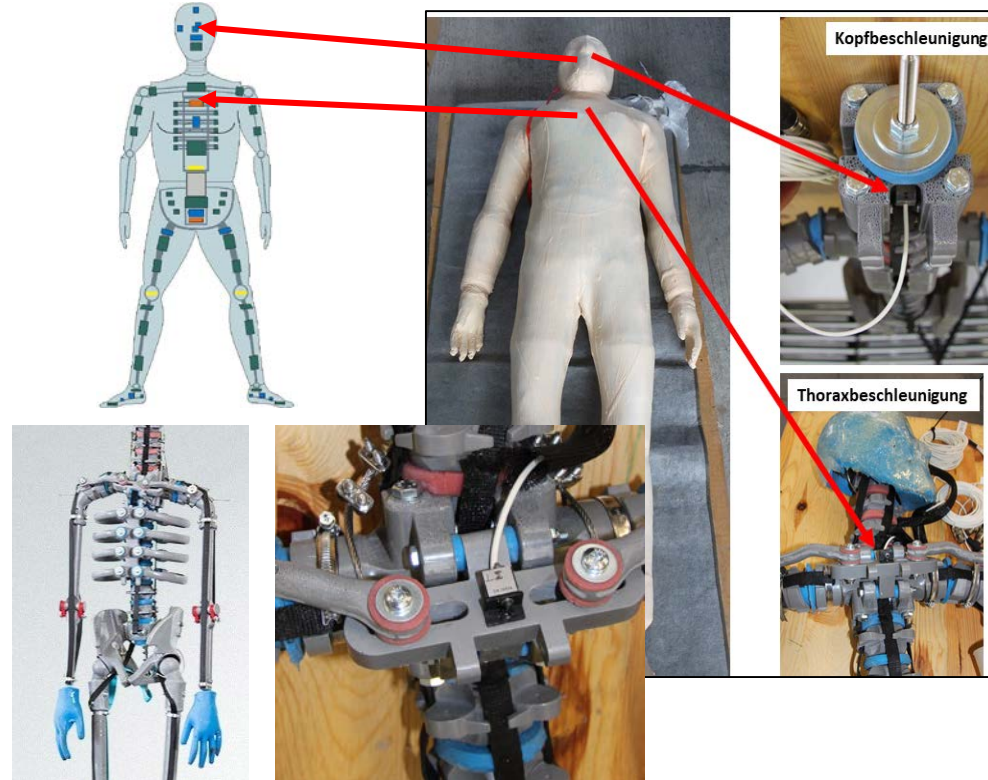
- sledmass = ca. 120 kg
 - $F_{\text{max}} \geq X \text{ kN @ } 1,5 \text{ m}$
 - $F_{\text{total}} \geq X \text{ kN @ } 1,5 \text{ m}$
 - Plastic deformations of steel plate ($t = 12 \text{ mm}$)
- $a_{\text{max}} = X \text{ g @ } 1,5 \text{ m}$
- $a_{\text{max}} = X \text{ g @ } 0,5 \text{ m (with vest)}$
- $a_{\text{max}} = X \text{ g @ } 0,5 \text{ m (w/o vest)}$
- -> increase of acc (use of vest)



3. INCIDENT RECONSTRUCTION –TEST SET-UP 1 (SLED) RESULTS

Dummy-Type: Biofideldummy CTS 2017 (pre PRIMUS breakable)

- height: 1,75 m / 50. percentile, male
- mass: 77,8 kg
- bones: epoxy resin
- soft parts: silicone / acryle
- tendons and ligaments: polypropylen
- skin: Chloropren-rubber / latex
- head: 3-axis accelerometer ENDEVCO
- thorax: 3-axis accelerometer ENDEVCO



3. INCIDENT RECONSTRUCTION –TEST SET-UP 2 (BIOFIDEL-DUMMY)



- Test #9 dress code
 - Underwear
 - Combat dress
 - Combat boots
 - Ballistic helmet



- Test #10 dress code
 - #9
 - bullet proof vest

3. INCIDENT RECONSTRUCTION –TEST SET-UP 2 (BIOFIDEL-DUMMY) RESULT #9 (W/O VEST)



- Severe damages to the dummy
- Under Right scapula 30 cm (diameter) orifice
- thrown distance = ca. 5 m (dummy)
- $a_{\text{max_head}} > X g$
- $a_{\text{max_thorax}} > X g$



High-Speed-Video

3. INCIDENT RECONSTRUCTION –TEST SET-UP 2 (BIOFIDEL-DUMMY) RESULT #10 (WITH VEST)



- Severe damages to the dummy and the vest, spread radius 10m
- Under Right scapula 30 cm (diameter) orifice
- thrown distance = ca. X m (dummy)
- $a_{\text{max_head}} > X \text{ g}$
- $a_{\text{max_thorax}} = X \text{ g}$



High-Speed- Video

3. INCIDENT RECONSTRUCTION –TEST SET-UP 2 (BIOFIDEL-DUMMY) RESULT

#9 (w/o vest)



#10 (with vest)



3. INCIDENT RECONSTRUCTION –TEST SET-UP 2 (BIOFIDEL-DUMMY) RESULT

#9 (w/o vest)



Schutzkriterium	Einheit	High PL	Low PL	Meßwert	Kriterien erfüllt
					H L
Kopf:					
HIC15 Wert	[1]	250			
Kopf A_res (peak)	[g]	80			
A3ms Kopf	[g]	72			
			CFC1000; Meßwertzeitbe		
Brustkorb:					
Brustkorb 3ms-Wert	[g]	60			
			CFC180; Meßwertzeit		
Brustkorb 7ms-Wert	[g]	40			
			range=561.2		

#10 (with vest)

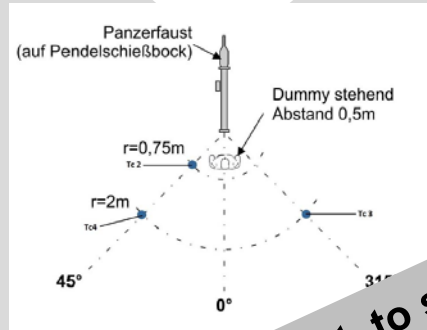


Schutzkriterium	Einheit	High PL	Low PL	Meßwert	Kriterien erfüllt	
					H	L
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			CFC1000; Meßwertzeitbere			
Brustkorb:						
Brustkorb 3ms-Wert	[g]	60				
			CFC180; Meßwertzeit			
Brustkorb 7ms-Wert	[g]	40				
			range=21.6			

3. INCIDENT RECONSTRUCTION –TEST SET-UP 2 (BIOFIDEL-DUMMY) RESULT

#9 (w/o vest)

#10 (with vest)

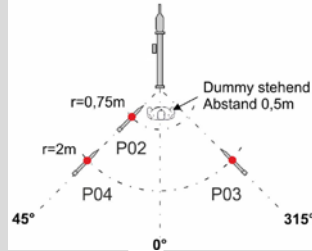


temperatur uncritical w.r.t. to skin burns

3. INCIDENT RECONSTRUCTION –TEST SET-UP 2 (BIOFIDEL-DUMMY) RESULT

#9 (w/o vest)

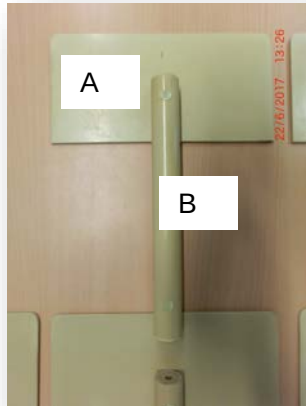
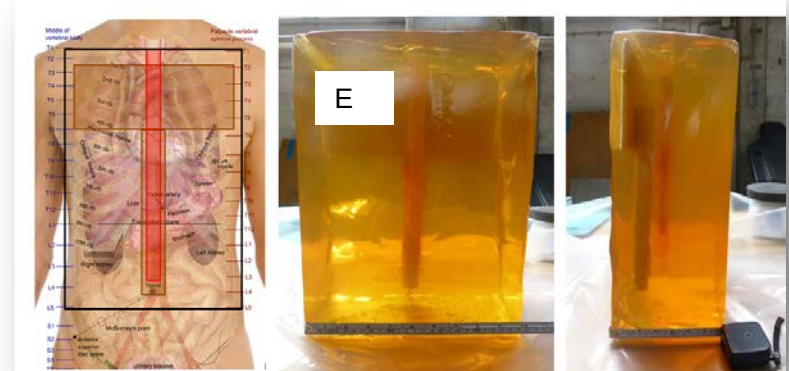
#10 (with vest)



pressure uncritical w.r.t. non-auditory effects,
 $p_{max_1ms} < \text{Lung-damage-threshold (bowen-curves)}$

3. INCIDENT RECONSTRUCTION –TEST SET-UP 3 (TORSO-SURROGAT)

- surrogate (A): Synbone plane bone (shoulder)
- surrogate (B): Synbone long bone (spine)
- surrogate (C): aorta from pig (aorta)
- surrogate (D): gelatine block 36,5 x 26,5 x 20 cm (tissue)
- surrogate (E): foil (skin)



3. INCIDENT RECONSTRUCTION –TEST SET-UP 3 (TORSO-SURROGAT)



- with vest



- w/o vest



test	test object	distance [mm]
#11	gelatine block with vest	3000
#12	gelatine block with vest	3000
#13	gelatine block w/o vest	3000
#14	gelatine block with vest	1500
#15	gelatine block w/o vest	1500
#16	gelatine block with vest	500

3. INCIDENT RECONSTRUCTION –TEST SET-UP 3 (TORSO-SURROGAT) RESULTS

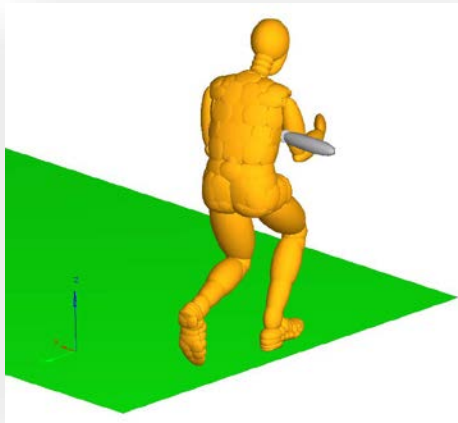
- @ 3 m with vest
 - no severe damages
 - $a_{\max} = X \text{ g}$
- @ 3m w/o vest
 - tissue penetration of plume
 - $a_{\max} = X \text{ g}$
- -> increase of acc (use of vest)
 - @ 1.5 m with vest
 - Severe damages to tissue / gelatine
 - Multiple fractures of bones
 - Bones partly separated from tissue
 - @ 1.5 m w/o vest
 - destruction of gelatine block

results after impact (surrogat with vest)



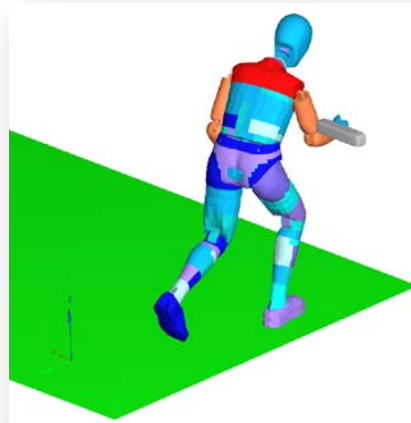
3. INCIDENT RECONSTRUCTION –TEST SET-UP 4 (NUMERICAL SIMULATION)

- MADYMO models



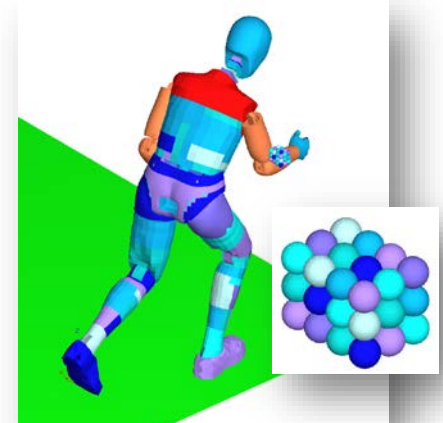
Model A

ATD: H3 (MB)
Impactor: rigid body (MB)



Model B

ATD: motor cycle dummy (FE)
Impactor: rigid body (FE)



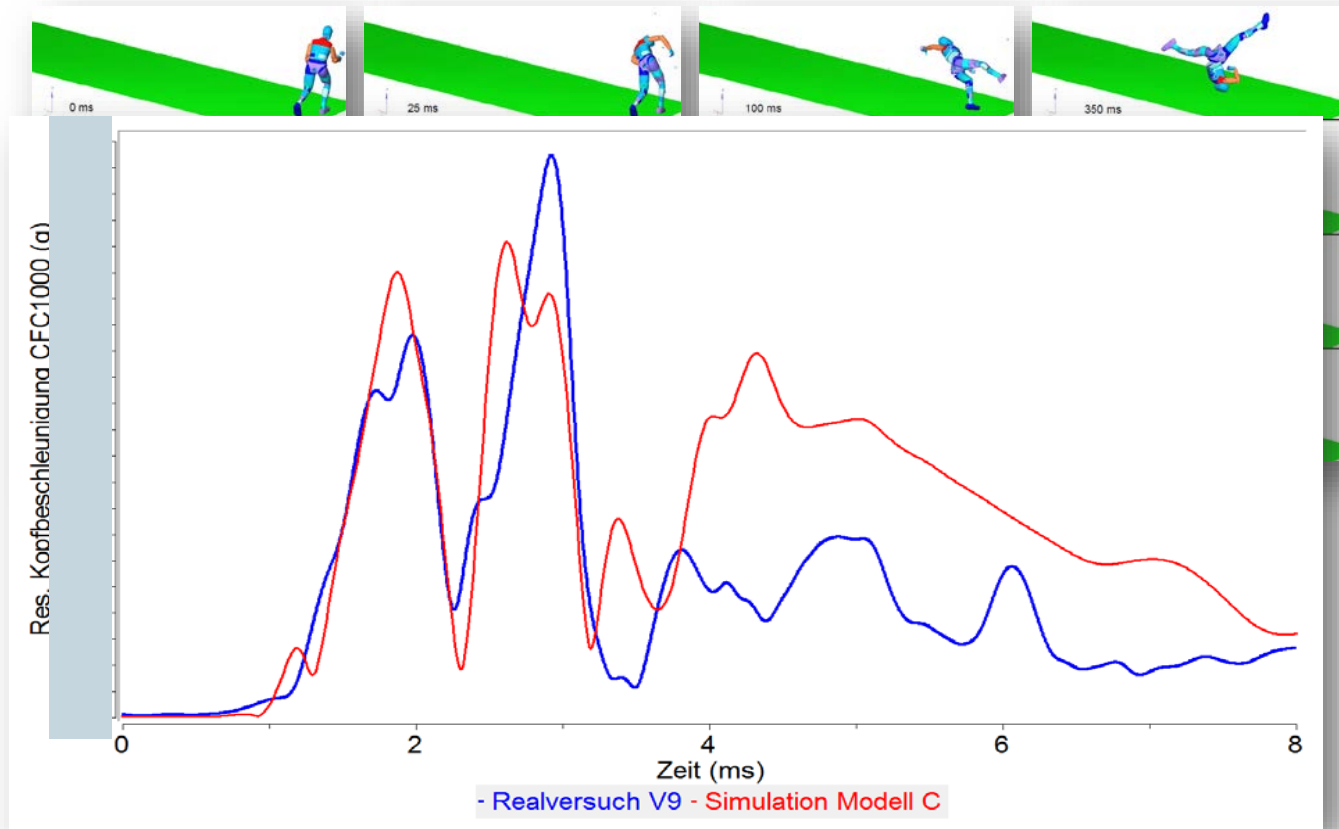
Model C

ATD: motor cycle dummy (FE)
Impactor: coarse particles (FE)

3. INCIDENT RECONSTRUCTION –TEST SET-UP 4 (NUMERICAL SIMULATION) RESULTS

- thrown distance = ca. X m
- $A_{\max_head} = X\ g$
- Rotating of upper body

-> very high
congruence w.r.t. to
#9 (biofidel dummy
w/o vest)



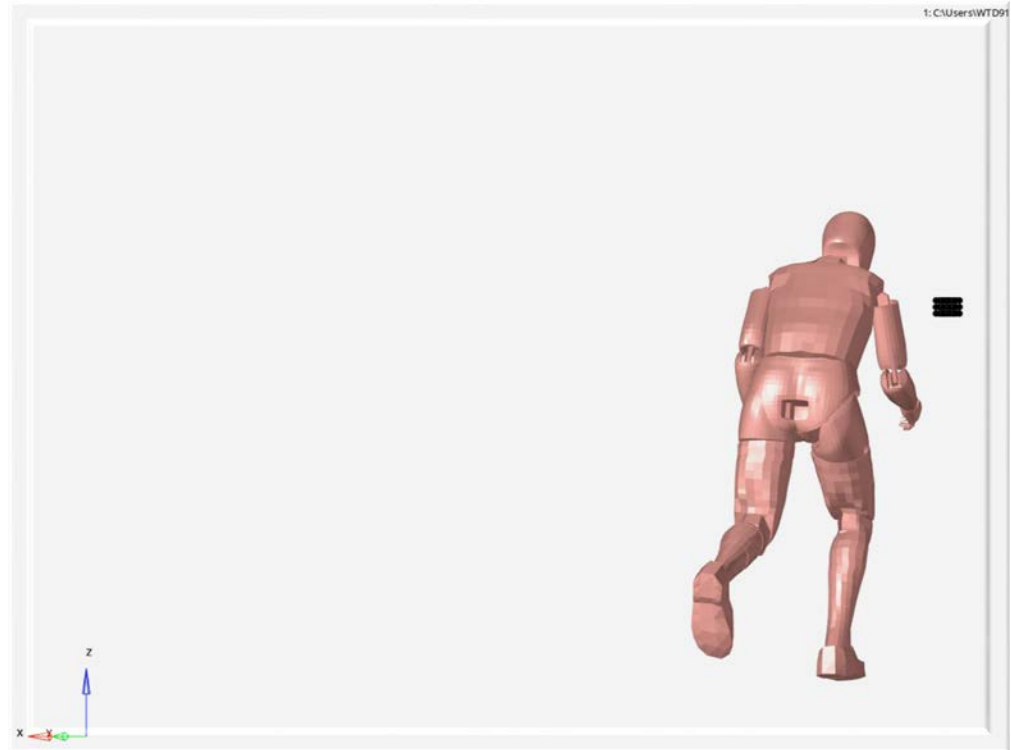
Comparison of the results of numerical simulation (model C) vs. Test #9 (biofidel-dummy w/o vest)

3. INCIDENT RECONSTRUCTION –TEST SET-UP 4 (NUMERICAL SIMULATION) RESULTS

Biofidel-Dummy (#9)

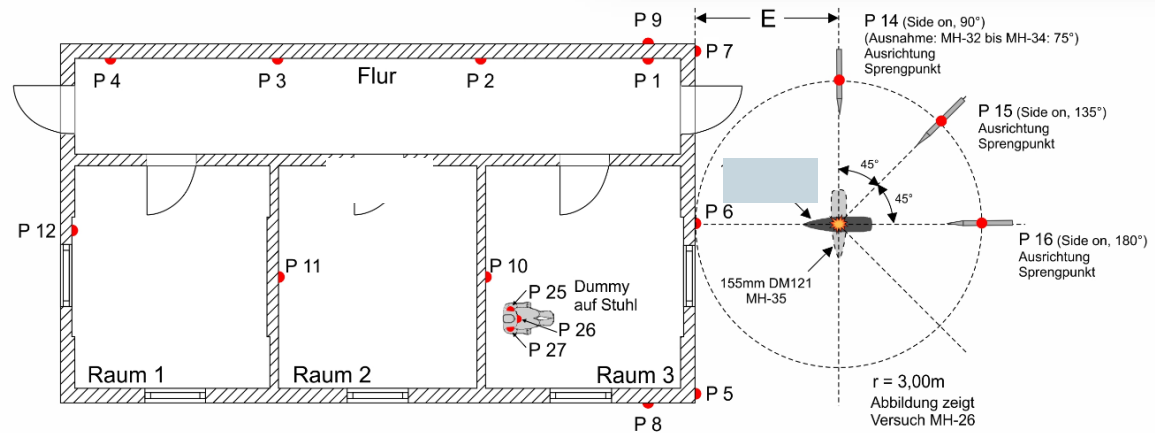


MADYMO-Simulation (model C)



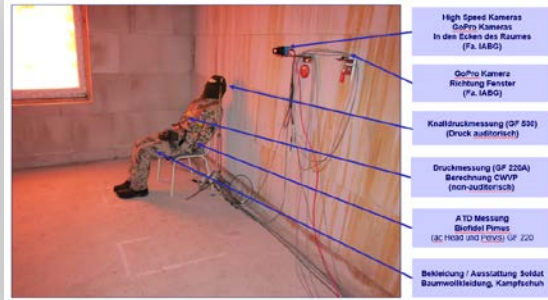
4. BIOFIDEL-DUMMY – FURTHER APPLICATIONS / USE CASE (2)

- Test with(in) infrastructure
- Impacts with artillery shells
- Evaluating the occupant loading by using biofidel-dummy



4. BIOFIDEL-DUMMY – FURTHER APPLICATIONS / USE CASE (2)

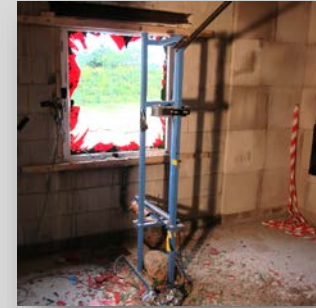
before test



ATD Typ:
CTS Biofidel Dummy
Modell 2 (vor Primus)
50th Percentile.

ATD Sensoren: 3 x 3
achsige
Beschleunigungen
9 Messkanäle
Kopf / Brust / Thorax

after test



4. BIOFIDEL-DUMMY – FURTHER APPLICATIONS / USE CASE (3 / 4 / 5 / 6)

EOD suits



occupant safety



medevac



low_impact

cabin crew e.g.

- frequency
- acceleration

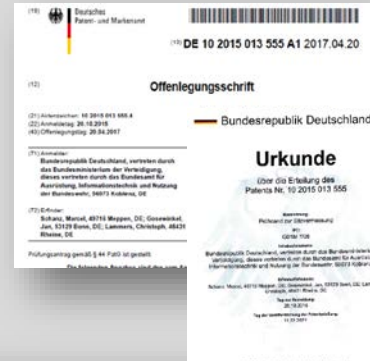
4. BIOFIDEL-DUMMY – FURTHER APPLICATIONS / USE CASE (3 / 4 / 5 / 6)

way ahead

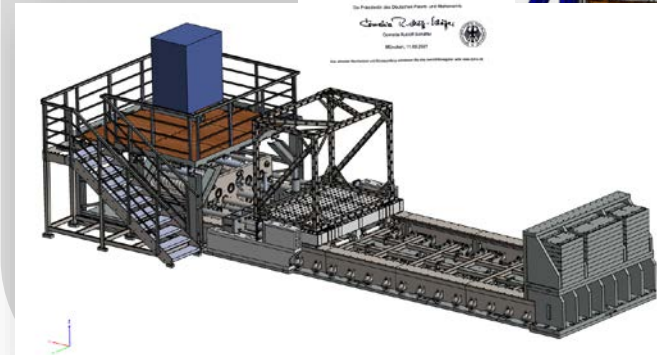
- comparison tests
 - Hybrid III
 - EUROSID II RE
 - THOR
 - WIAMAN
- Military environments / scenarios
- criteria
- standards

BIOFIDEL /
PRIMUS

means



Mine Blast Simulator (MBS)



IED Blast and Crash Simulator (IBaCS) (Fertigstellung 2022)

4. BIOFIDEL-DUMMY – FURTHER APPLICATIONS / USE CASE (7)



Mine Blast Simulator (MBS)

- Laboratory tests
 - w/o explosives
 - reproducibility
 - efficiency
 - parametric studies
- SRS (mine, IED)



scope

- seat systems
- restraint systems
- Vehicle interior
- [compatibility](#)
- [qualification](#)
- [Transfer function of occupant safety systems](#)

