MJW RnD

Composite Materials for Transportation and Biomedical Applications. 3D printing.

Michal J. WOZNIAK

Michal J. WOZNIAK PhD Eng

MJW RnD

Current positions

- CEO & Owner, MJW RnD Co. Warsaw, Poland – consulting in materials science
- R&D Manager, MIRO Group Co. Kwidzyn, Poland – automotive transportation
- Partner, MaterialsCare Co. Warsaw, Poland – 3D printing, biomedical solutions

Former positions

- R&D Manager & CTO, 45stages Co. Warsaw, Poland
- Vice President, MaterialsCare Co. Warsaw, Poland
- Researcher, PI & Project Manager, Warsaw University of Technology, Poland
- Visiting Researcher, National Institute for Environmental Studies (NIES), Tsukuba
- Postdoc Researcher, National Institute for Materials Science (NIMS), Tsukuba
- Junior Researcher, National Institute for Materials Science (NIMS), Tsukuba
- PhD Student, Warsaw University of Technology, Poland

Poland

Poland

MJW RnD

2019

日本ポーランド国交樹立100周年

Poland

Coat of arms

Flag

MJW RnD

Republic of Poland

Population: 38.43 million

Area: 312 696 km^2

Capital city: Warsaw

Currency: Polish Złoty (PLN)

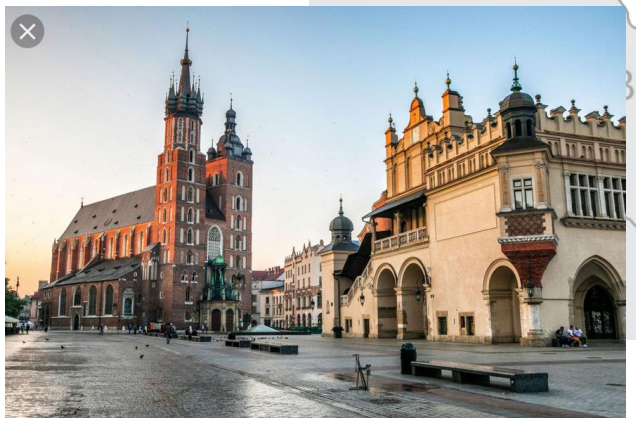
Gross domestic product: +5.1%

Membership:

- European Union (EU)
- NATO

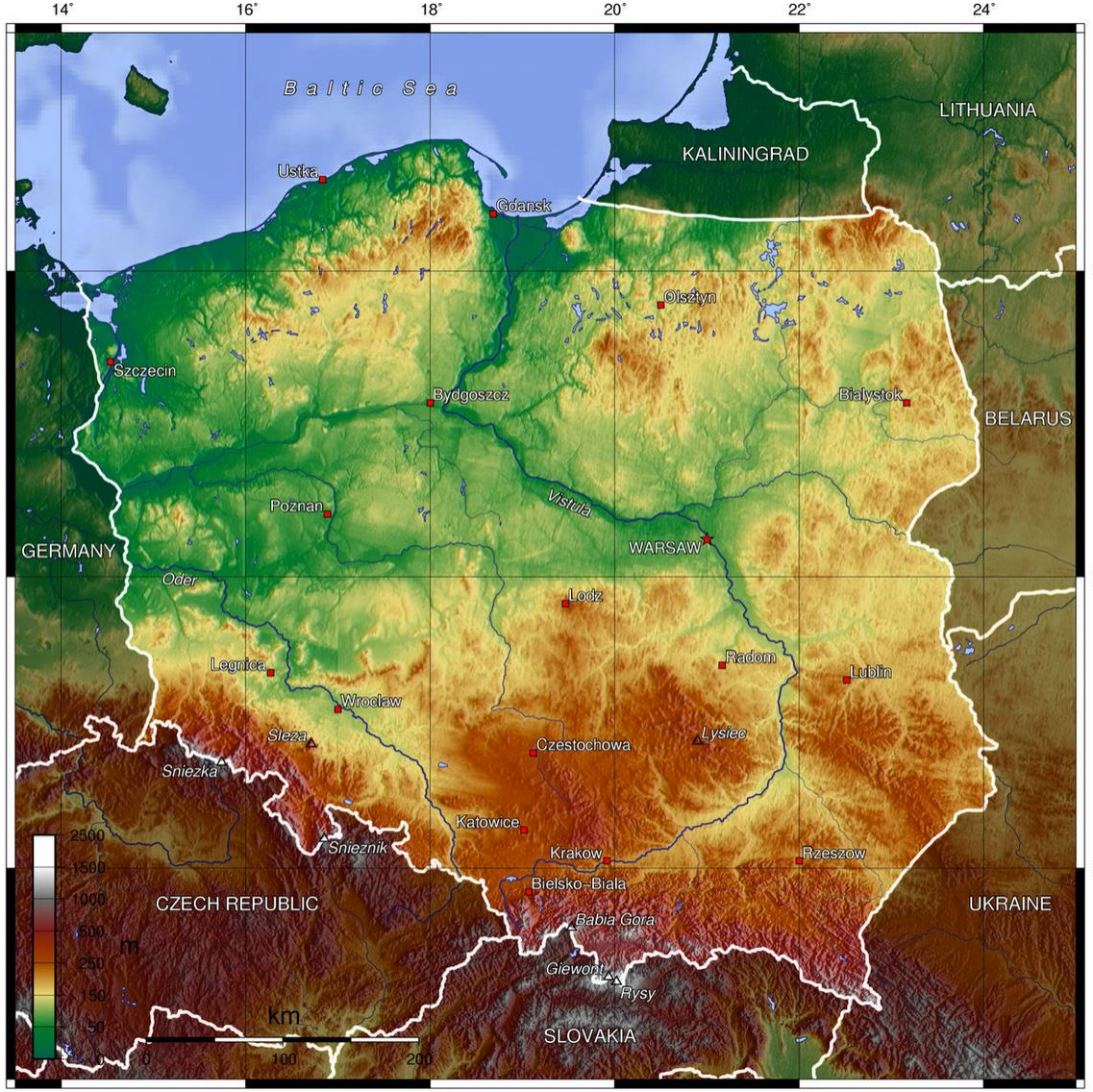
Poland

MJW RnD



Poland

MJW RnD



Poland

MJW RnD

Grey Wolf

Brown Bear

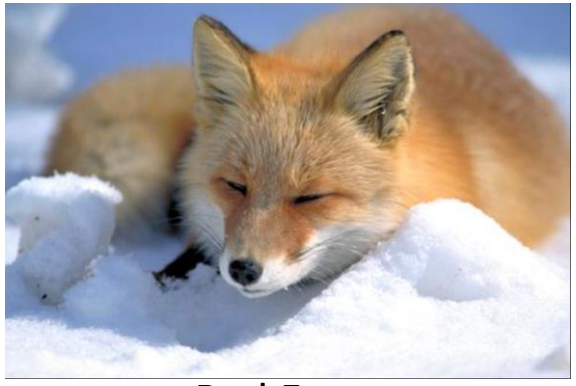
Raccoon

European Bison (Żubr)

Wild Boar

Eurasian lynx

Moose



Red Fox

White Stork

Poland

MJW RnD

Pierogi (dumplings
Polish Gioza)

Żurek (wheat flour soured soup)

Szarlotka (apple cake)

Beetroot Duck

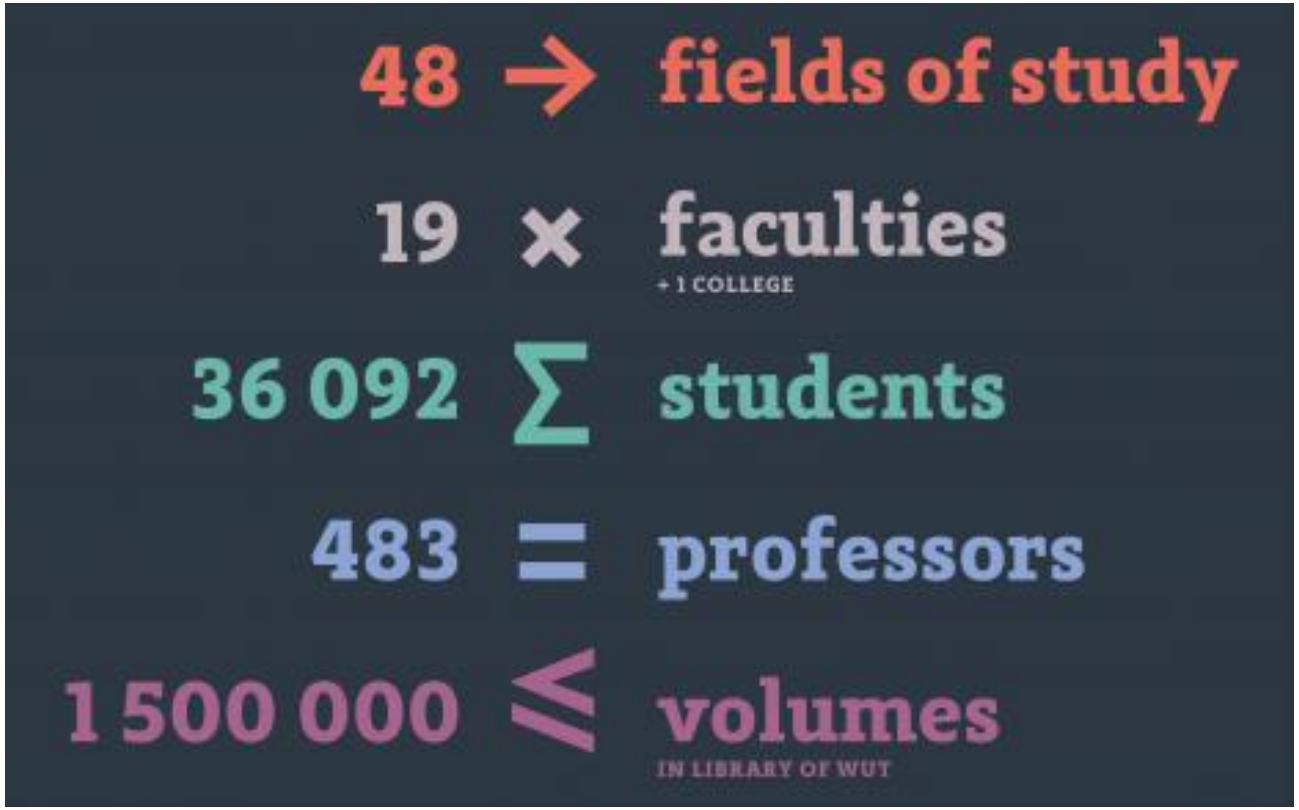
Sernik (cheesecake)

Warsaw University of Technology

Warsaw University of Technology

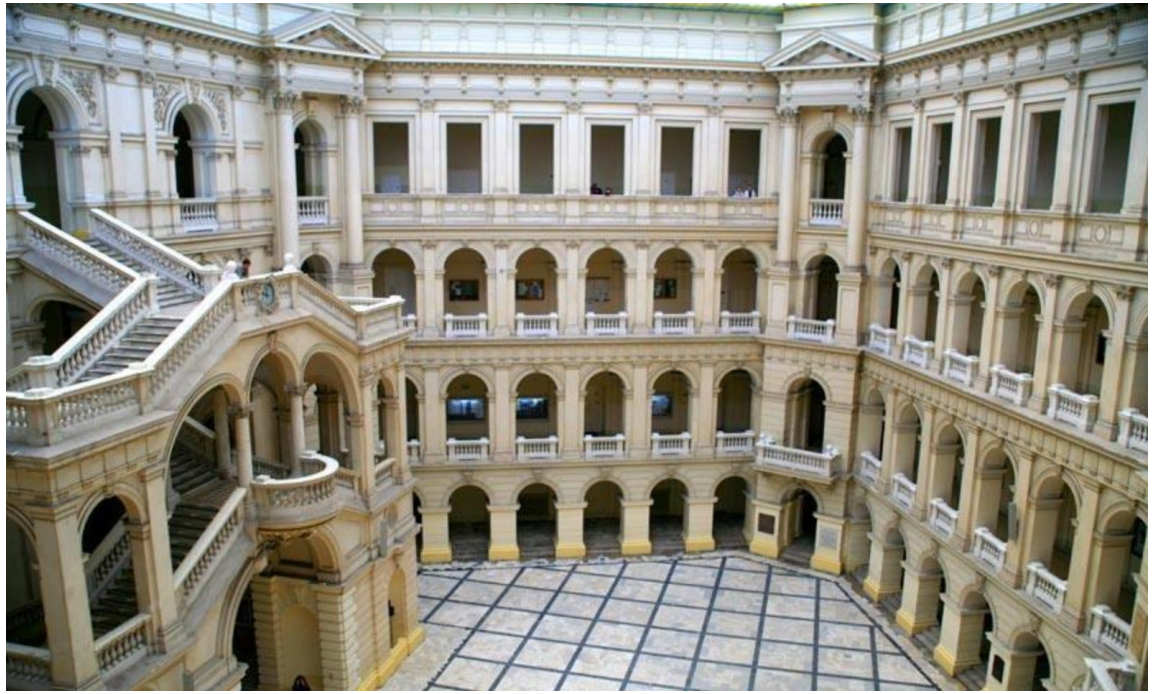
MJW RnD

Warsaw University of Technology (WUT) founded 1826
Best technical university in Poland, 3rd in general ranking



Warsaw University of Technology

MJW RnD



Main Building of WUT

Warsaw University of Technology

明治大学
MEIJI UNIVERSITY

MEMORANDUM OF UNDERSTANDING

BETWEEN

WARSAW UNIVERSITY OF TECHNOLOGY, Faculty of Chemistry

AND

MEIJI UNIVERSITY, School of Science and Technology

2018

3D Printing


BioCloner 3D
The first Polish biomedical 3D printer dedicated for biodegradable implants
3D bio-printing
45 stages

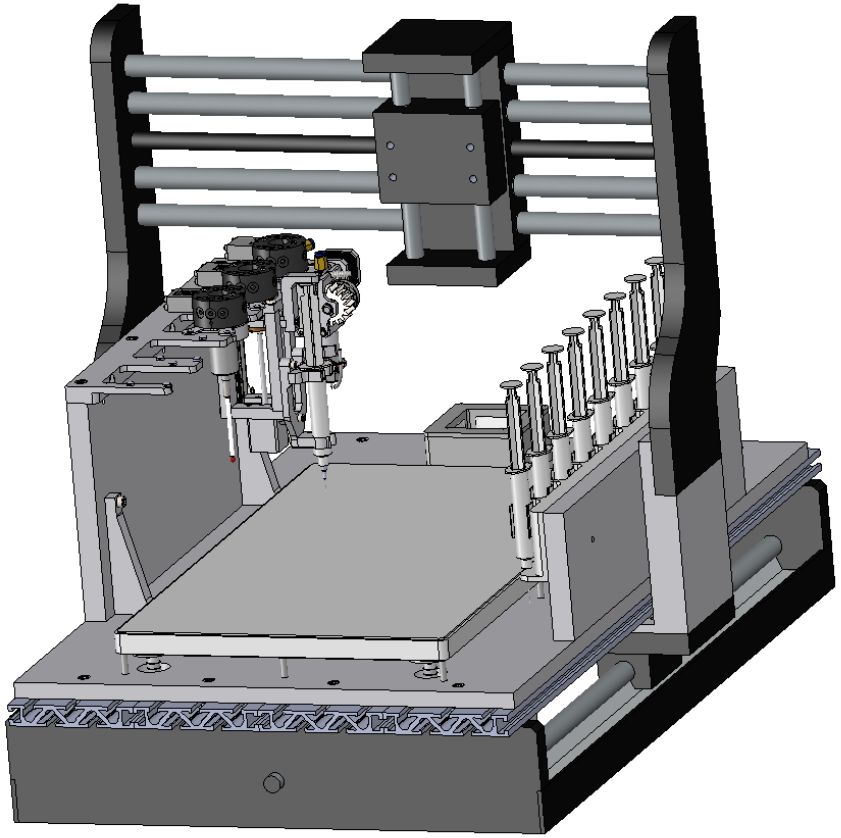
BioCloner 3D

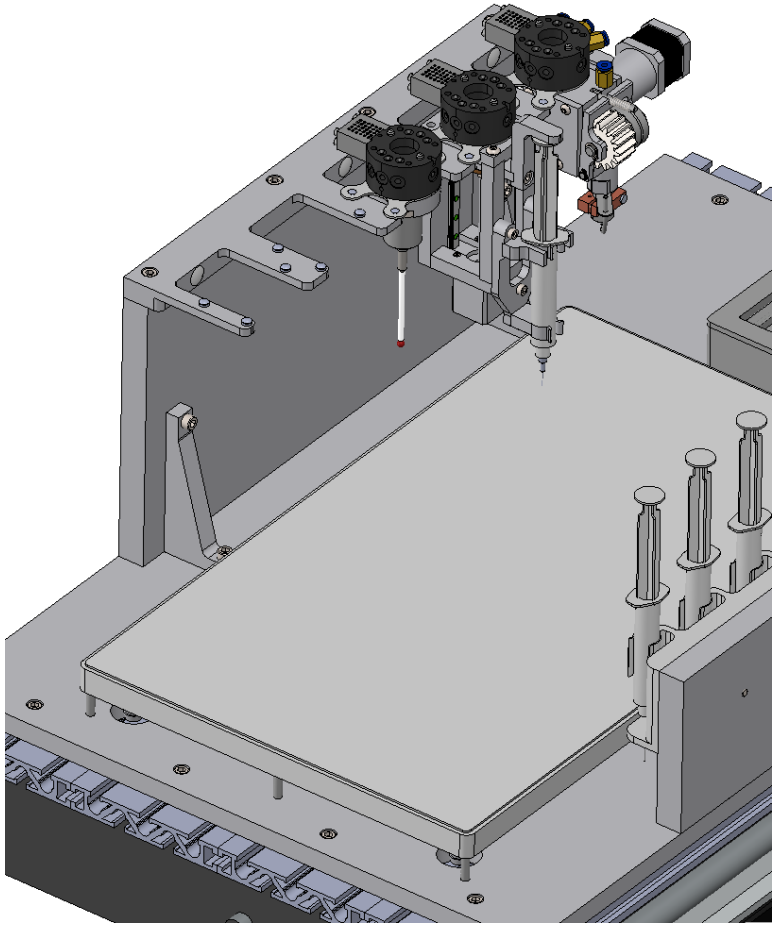
- The project BioCloner 3D covers the design and construction of the 3D bio printer that is able to produce scaffold for reconstruction of almost every part of our body.
- BioCloner 3D is designed for printing biodegradable implants (BioScaffolds).
- Implants (BioScaffolds) are manufactured from biodegradable materials (e.g.: PCL, PLA) that can be used to regenerate natural bone or cartilage defects.
- BioCloner 3D is biomedical printer currently under development. Will be available on market in 2 years from now.

Bio4med©

45 stages

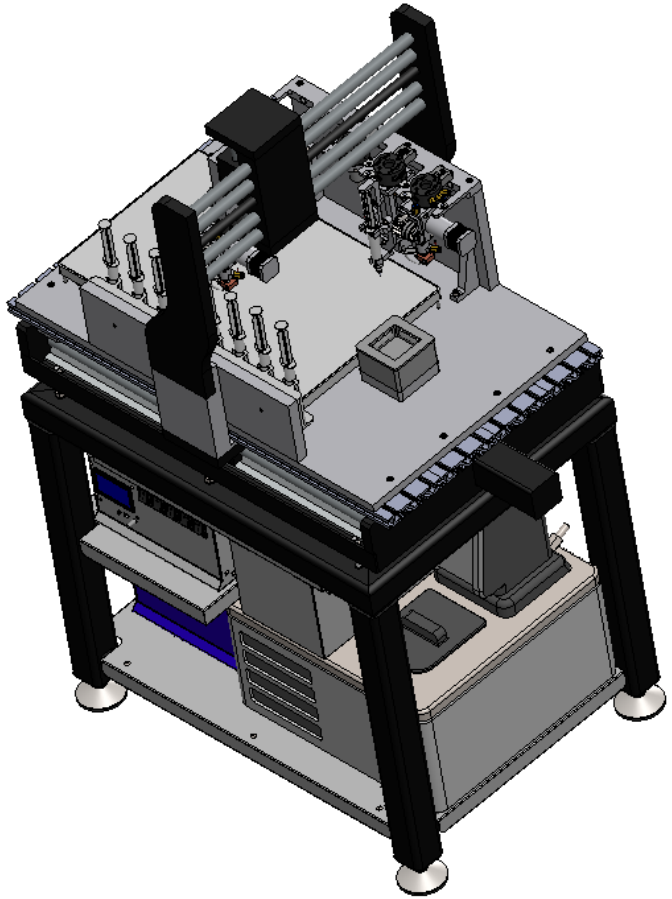
BioCloner 3D

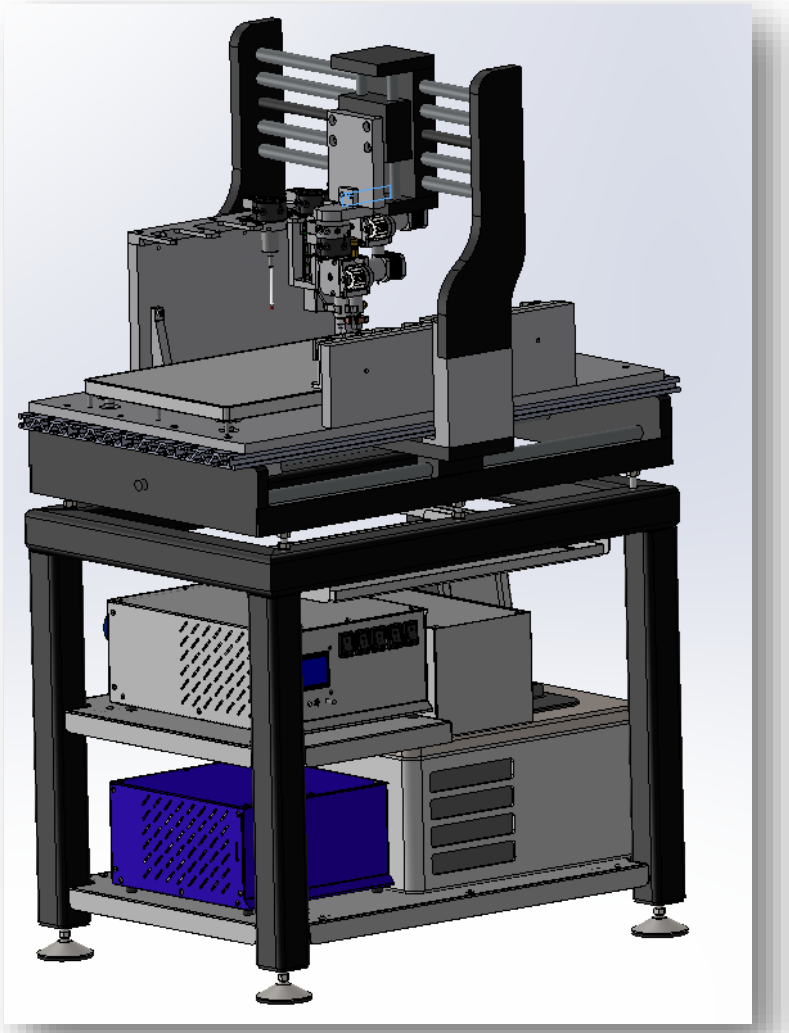




Gantry carrying frame with printing head components, parking system and hydrogel storage compartment.

BioCloner 3D





Gantry carrying frame with additional base for the control and power modules

BioCloner 3D comparison with the competition

			Features						
			Material			Printer parameters			
Company	3D printer	Country	hydrogel + cell + growth factors + drugs	thermoplastic polymer in granular form	thermoplastic polymer in form of fialment	system of mixing of 2 materials inside the printer	environmental chamber	needle autopositioning	UV lamp
Bioprinting Solutions	*Fabion*	Russia	+	–	–	–	–	–	–
EnvisionTEC's	*Bioplotter Manufacturer Series*	Germany	+	+	–	–	–	+	–
Sys&Eng	*Bioscaffolder*	Germany	+	+	–	–	–	–	–
GeSim	*Bioscaffolder 2.1*	Germany	+	+	–	–	–	+	+
RegenHU	*3DDiscovery - Biofactory*	Switzerland	+	+	–	–	–	–	–
Ourobotic	*Revolution*	UK	+	–	–	–	+	+	–
3Dynamic System	*Alpha & Omega*	UK	+	–	–	–	–	–	–
Bio3D's SYN	*E–plorer*	Singapore	+	–	–	–	–	–	–
BioBot	*BioBot1*	USA	+	–	–	–	–	–	+
CELLINK	*Inkredible*	USA	+	–	–	–	+	–	–
Organovo	*NovoGen MM*	USA	+	–	–	–	+	+	–
Advanced Solutions	*BioAssemblyBot*	USA	+	–	–	–	–	–	–
n3Dbio	*Bioassembler*	USA	+	–	–	–	+	+	–
Aspect Biosystem	*Lab–on–a–printer*	Canada	+	–	–	–	–	–	–
45stages	*BioCloner 3D*	POLAND	+	+	+	+	+	+	+

Bio4med©

45 stages

BioCloner 3D comparison with the competition

			Features						
			Printer parameters						
Company	3D printer	Country	process monitoring cameras	material monitoring and refilling during printing system	separated heating zones	controlled fiber output diameter	modular work table	monitoring and automatic reporting of process parameters changes	easy installation of the needle
Bioprinting Solutions	***Fabion***	Russia	–	–	–	–	–	–	–
EnvisionTEC's	***Bioplotter Manufacturer Series***	Germany	–	–	–	–	–	–	–
Sys&Eng	***Bioscaffolder***	Germany	–	–	–	–	–	–	–
GeSim	***Bioscaffolder 2.1***	Germany	+	–	–	–	–	–	–
RegenHU	***3DDiscovery - Biofactory***	Switzerland	–	–	–	–	–	–	–
Ourobotic	***Revolution***	UK	+	–	–	–	–	–	–
3Dynamic System	***Alpha & Omega***	UK	+	–	–	–	–	–	–
Bio3D's SYN	***E–plorer***	Singapore	–	–	–	–	–	–	–
BioBot	***BioBot1***	USA	–	–	–	–	–	–	–
CELLINK	***Inkredible***	USA	–	–	–	–	–	–	–
Organovo	***NovoGen MM***	USA	–	–	–	–	–	–	–
Advanced Solutions	***BioAssemblyBot***	USA	+	–	–	–	–	–	–
n3Dbio	***Bioassembler***	USA	–	–	–	–	–	–	–
Aspect Biosystem	***Lab–on–a–printer***	Canada	–	–	–	–	–	–	–
45stages	***BioCloner 3D***	**POLAND**	+	+	+	+	+	+	+

Bio4med©

45 stages

3D Printing

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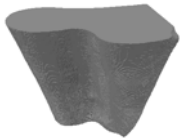
Biomedical Materials + 3D Printing

MJW RnD

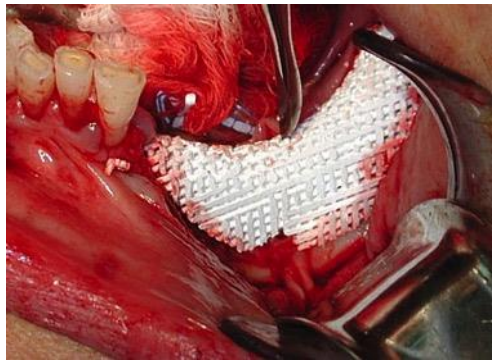
Medical imaging



Model 3D

Bio 3D Printing

Implant
(BioScaffold)



Implantation

Regeneration

Personalized
tissue engineering
regenerative medicine

MATERIALS CARE

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BioScaffold – Biodegradable Implant

PROBLEM

The body is not able to regenerate large tissue defects (critical defects) of bone or cartilage.

Such losses can result from: cancer or traffic accidents.

SOLUTION

Biological 3D printed scaffold based on biodegradable polymers or composites. Implanted in the critical defect. Implant dissolves gradually and the natural tissues: bone or cartilage take it place.

MATERIALS CARE

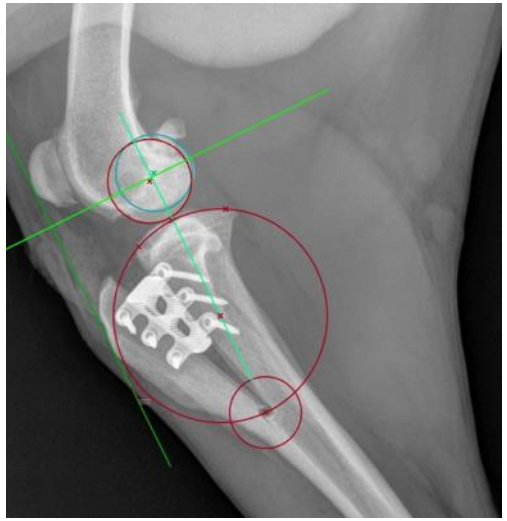
BioScaffold-Application

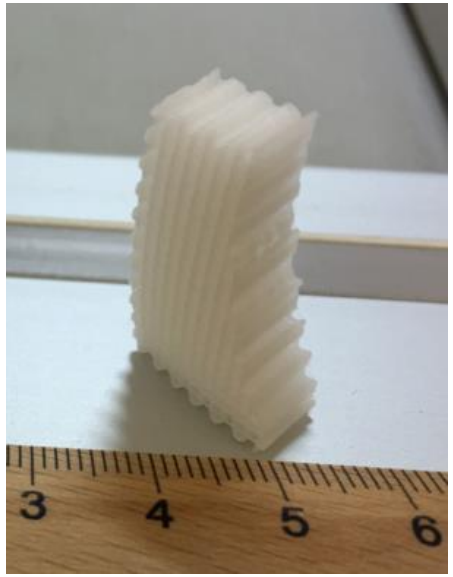
BioScaffolds are used to regeneration even a large bone or tissue defects cartilage defects – so call critical defects, which can not be regenerated by body itself.

BioScaffolds can be used in veterinary and human orthopedics.

TTA / TPLO Biodegradable 3D printed implants

- TTA - Tibial Tuberosity Advancement
- TPLO - Tibial Plateau Leveling Osteotomy



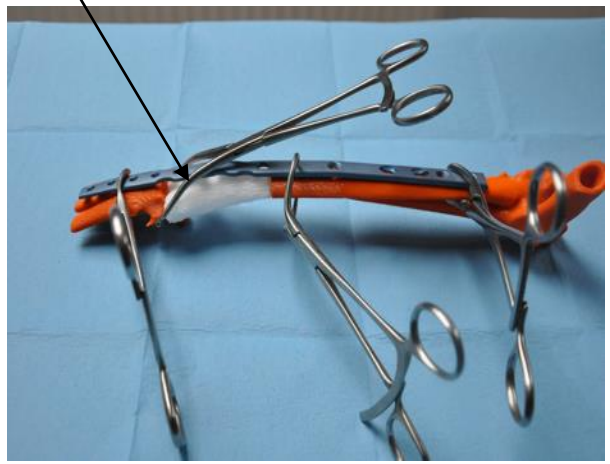


MATERIALS CARE


BioScaffold
Case Study
Veterinary
Implants
MATERIALS CARE

Personalized regenerative medicine: case study - veterinary

3D printed personalized BioScaffold



The aim was to reconstruct a radius bone loss after cancer treatment in 8 years old dog. Reconstruction done with BioScaffold.

MATERIALS CARE

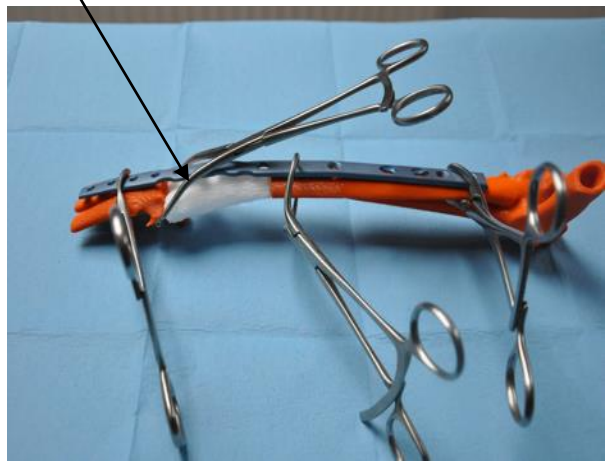
Personalized regenerative medicine: case study - veterinary

Dog before surgery. Radiographs of the affected limb revealed proliferative changes and lysis of the radial metaphysical cortex with an irregular periosteal reaction in the distal radius.

Limb-sparing surgery was offered because the owner refused limb amputation. In this study a 10 cm of radius bone region was removed and the defect was reconstructed with the BioScaffold.

Personalized regenerative medicine: case study - veterinary

3D printed personalized BioScaffold



The aim was to reconstruct a radius bone loss after cancer treatment in 8 years old dog. Reconstruction done with BioScaffold.

MATERIALS CARE

Personalized regenerative medicine: case study - veterinary

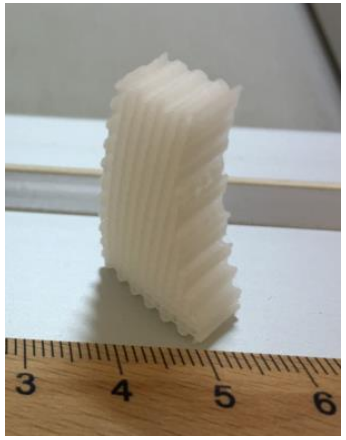
Dog after surgery. After scaffold implantation a significant improvement of the dog movement have been obtained. Every month implanted scaffold using radiographs was evaluated.

After 3 months of implantation of BioScaffold, we observed that sufficient tissue formation can be induced in segmental bone defect.

3D printed biodegradable implants

PROBLEM

Metallic implant: often the need for revision surgery, high risk of metalosis, weakening of the bone tissue around the implant and difficulties in medical imaging (NMRI, microCT)



TTA / TPLO

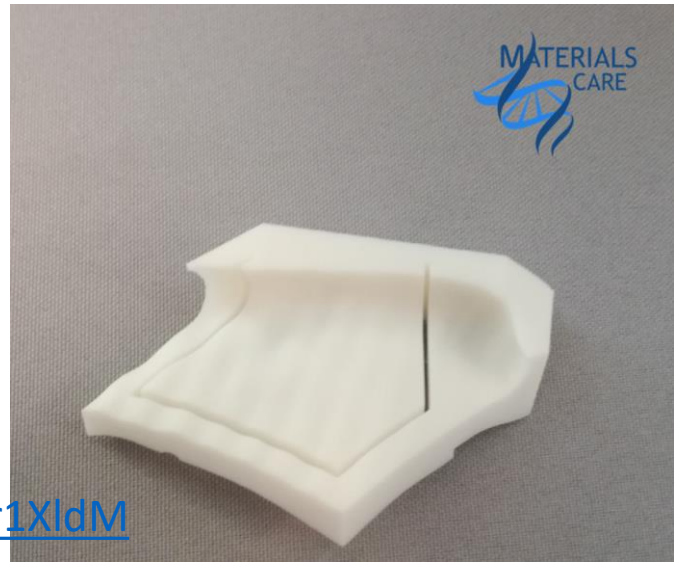
BioScaffold

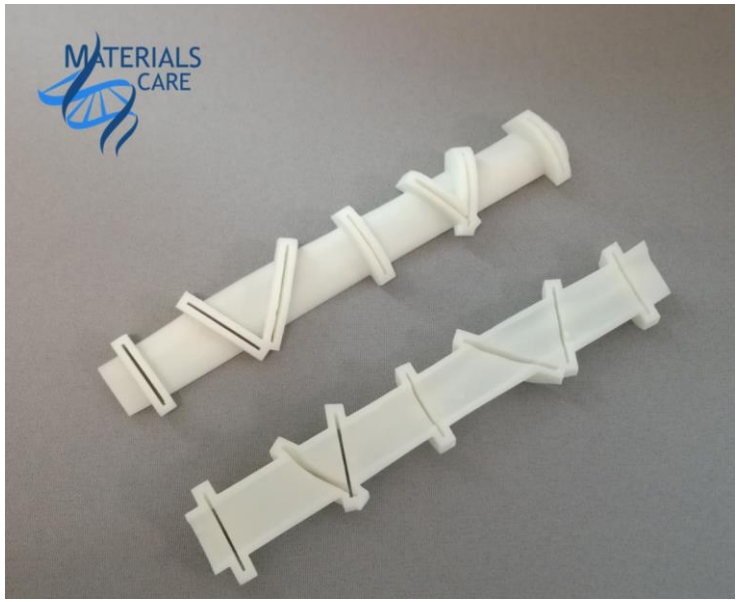
SOLUTION

Biodegradable 3D printed implants eliminate the problems encountered when to use metallic implants, such as allergic reactions, local inflammatory reactions, loosening of the implants

MATERIALS CARE

https://youtu.be/Hwxqkr1XldM





MATERIALS
CARE

Materials for Transportation

Materials for Transportation

MJW RnD

Fiat Ducato, soft shell.
Most popular cargo van in EU.

Materials for Transportation

MJW RnD

Problem # 1

Overload cargo tracks, vans. Serious problem in EU.

Materials for Transportation

MJW RnD

Problem #2

Thievery from cargo tracks, vans. Serious problem in EU.

Materials for Transportation

MJW RnD

Solution

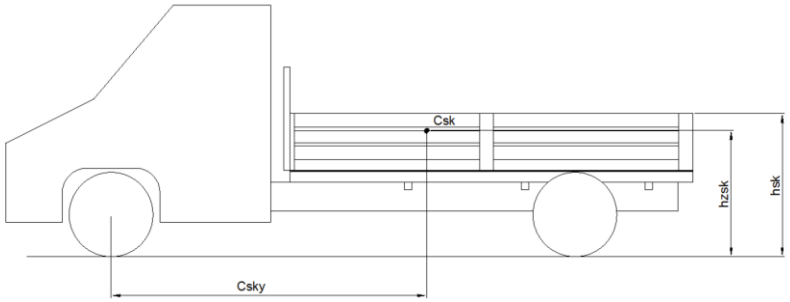
light weight

thievery resistant

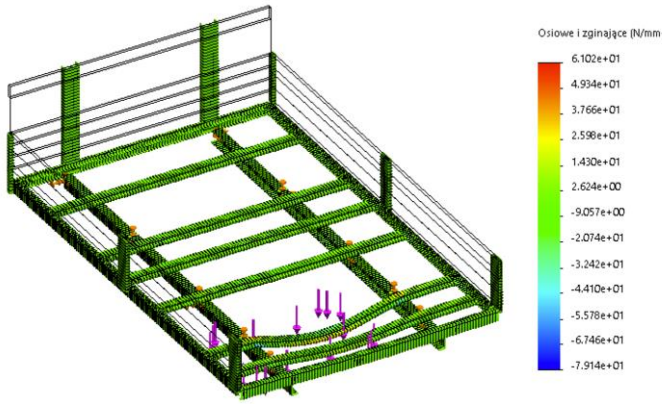
cargo track, van

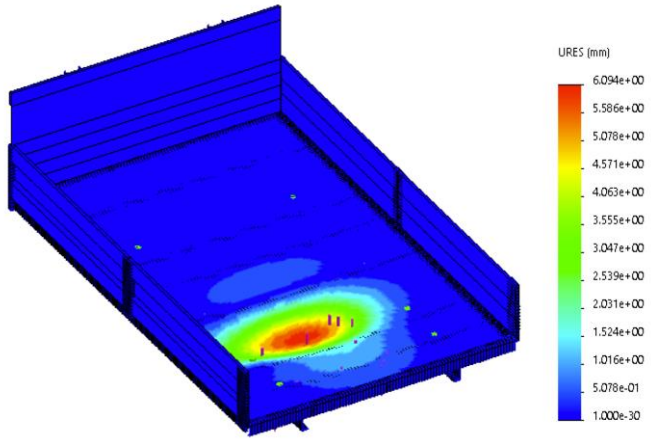
Materials for Transportation

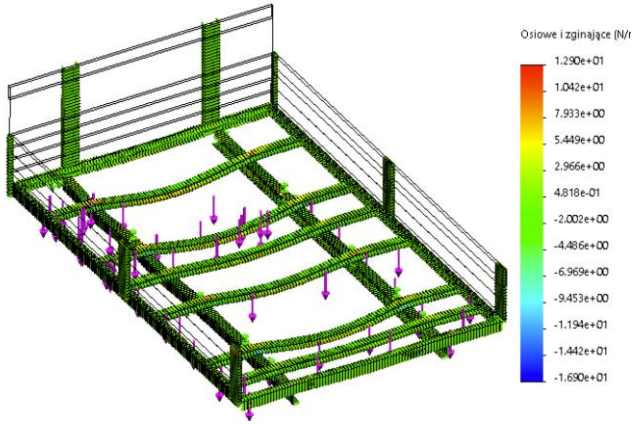
MJW RnD

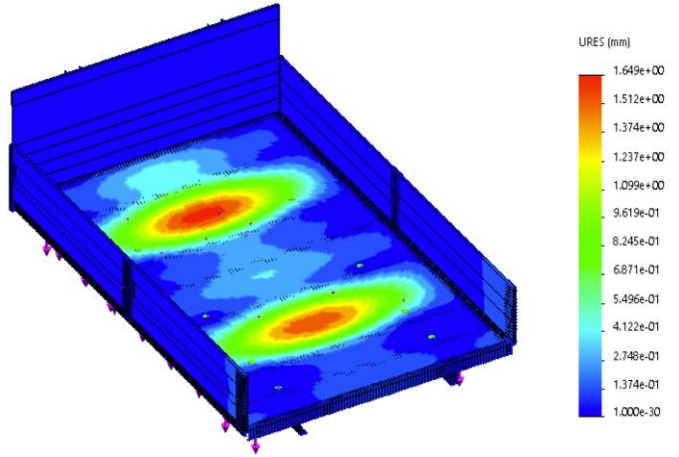


Standard euro palet





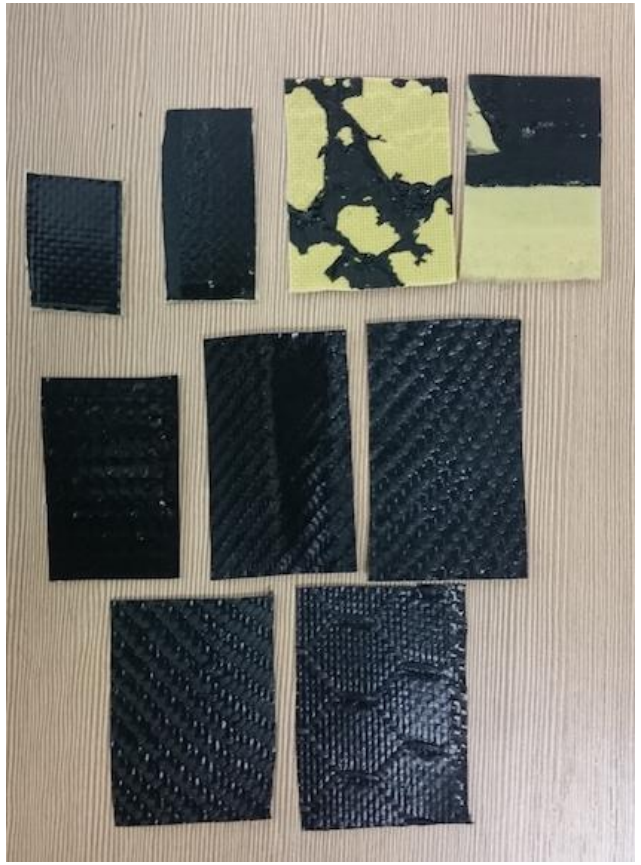




Computer modelling, van loaded by 1 and 2 euro pallet

Materials for Transportation

MJW RnD



Shear Thickening Fluid (STF)

Shields and protectors based on
non newtonian fluids
thickened by shear

FluidShields

45 stages

Shear Thickening Fluid (STF)

Fluid Shields are shields based on non newtonian shear thickening fluid (STF). STF are also known as dilatant fluids are liquids or solutions whose viscosity increases with the increasing shear rate. They are made by mixing ceramic powder and a dispersing agent together. STF have the ability to dissipate energy.

STF absorbs the energy of impact. STF can be used in sports protectors, armored vehicles, body armors (bullet proof jackets), shock absorbers - earthquake proof structures. Fluid Shields is technology which is currently going to be introduced into market.

smartfluid® 45 stages®

Shear Thickening Fluid (STF)

STF demonstration

Shear Thickening Fluid (STF)

Shock Absorbers
(Earthquake Proof Structures)

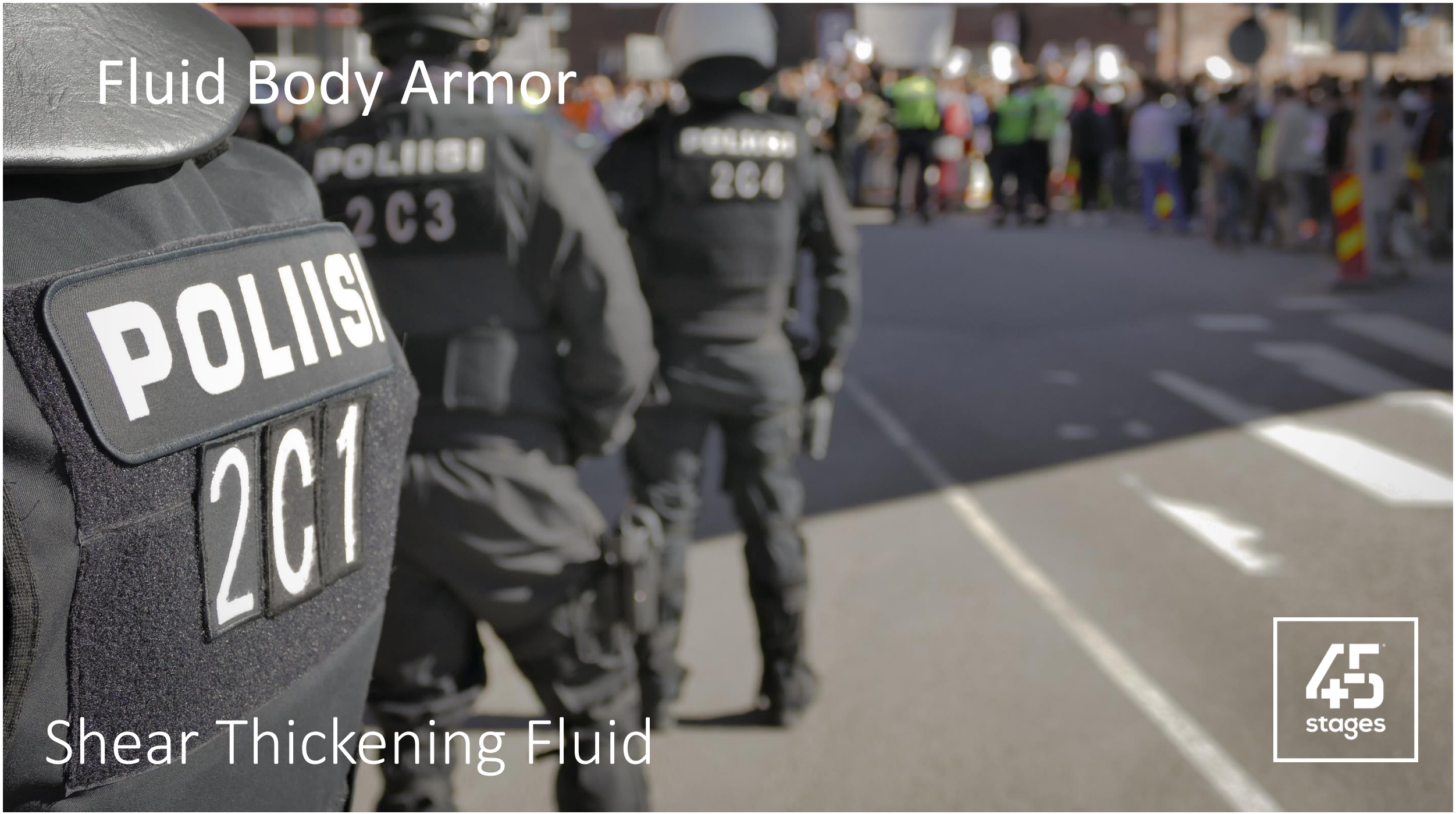
Armoured Vehicles
Body Armours

Sports Protectors

smartfluid®

45 stages®

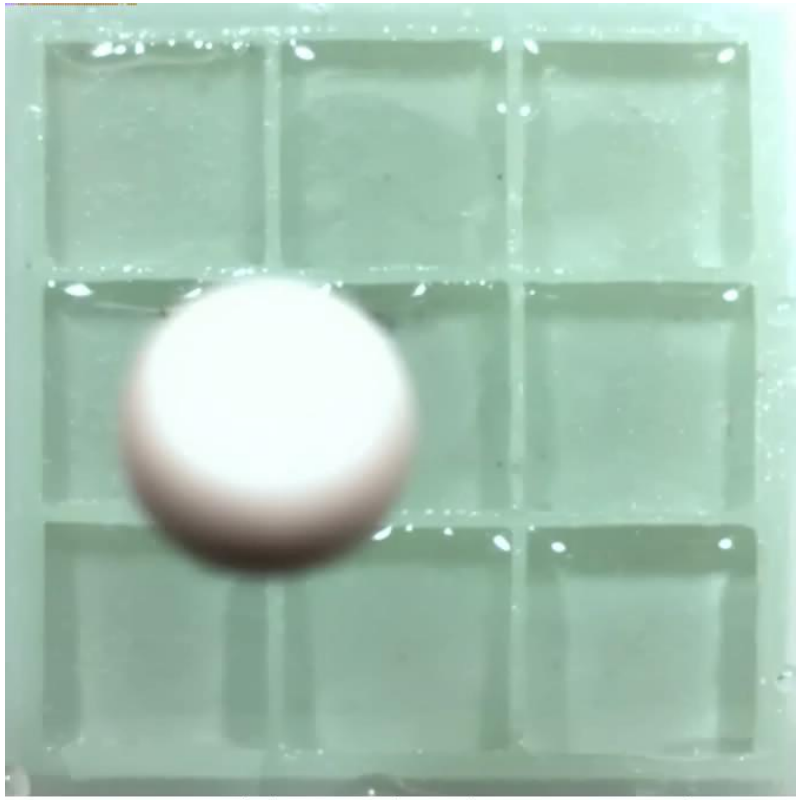
Fluid Body Armor

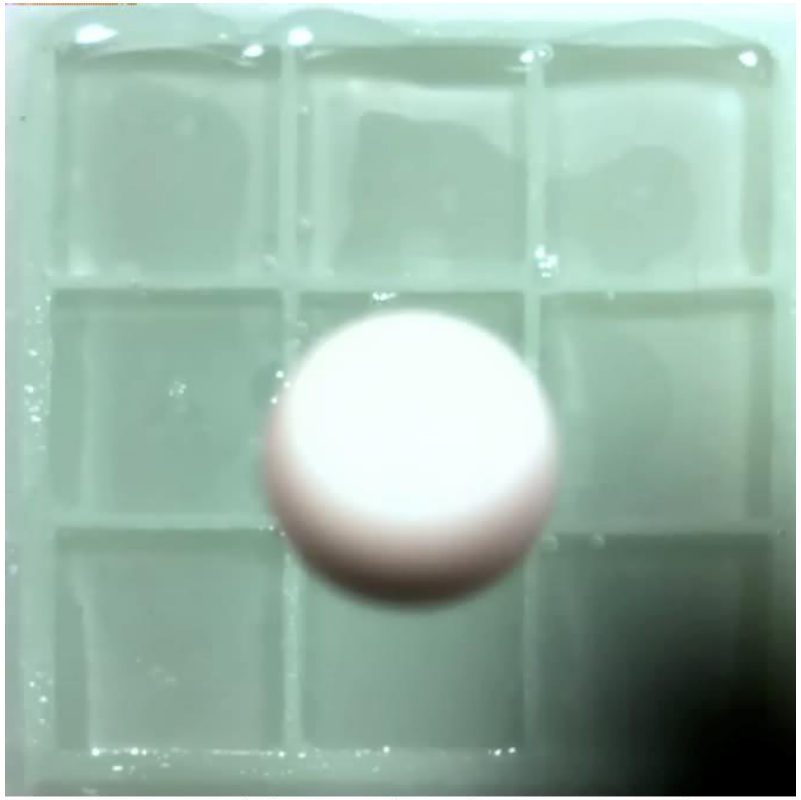


Shear Thickening Fluid

45 stages

Ability to dissipate energy





Ceramic ball, weight 56 g. Water (left) vs Shear Thickening Fluid (right)

smartfluid® 45 stages®

STF polymeric materials

Textiles and elastomers:

Polyurethane sponge
Polyester sponge
Aramid fabrics
PET fiber fabric
Cordura

Filling

Reduce mass of the system
increase energy absorption
increase flexibility

Impregnating or using as a separate layer

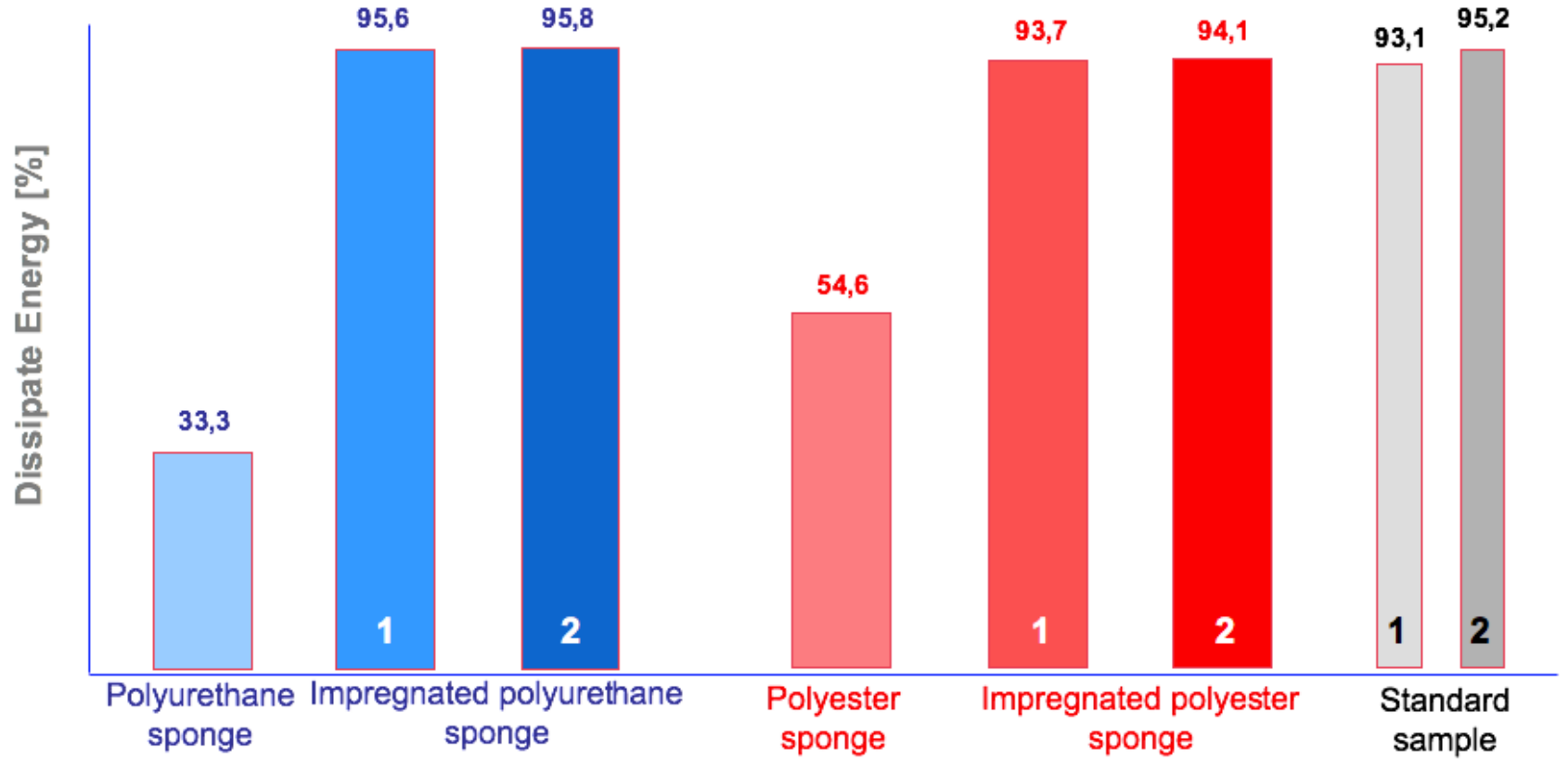
Weldable, can be easily quilted

high-strength, typical material used for backpacks

high-strength
typical ballistic materials used for protection of human body

Absorption test – the ability to dissipate energy

Influence of impregnation polymeric porous materials



smartfluid

45 stages

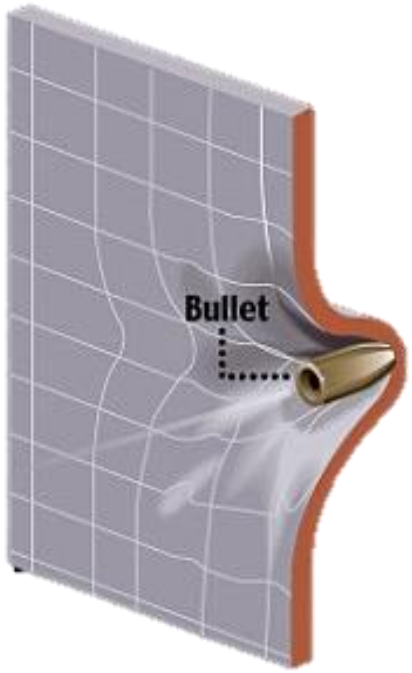
STF: Ballistic Resistance

31 layers of Kevlar

Concentration of forces at one point

Dent on 4 cm

Large deformation causing injuries: bridge rupture, myocardial infarction, spleen injuries



10 layers of fabric mixed with layers of STF fluid

A significant reduction in weight and stiffness of the vests

The distribution of forces over a larger area

Dent up to 2 cm

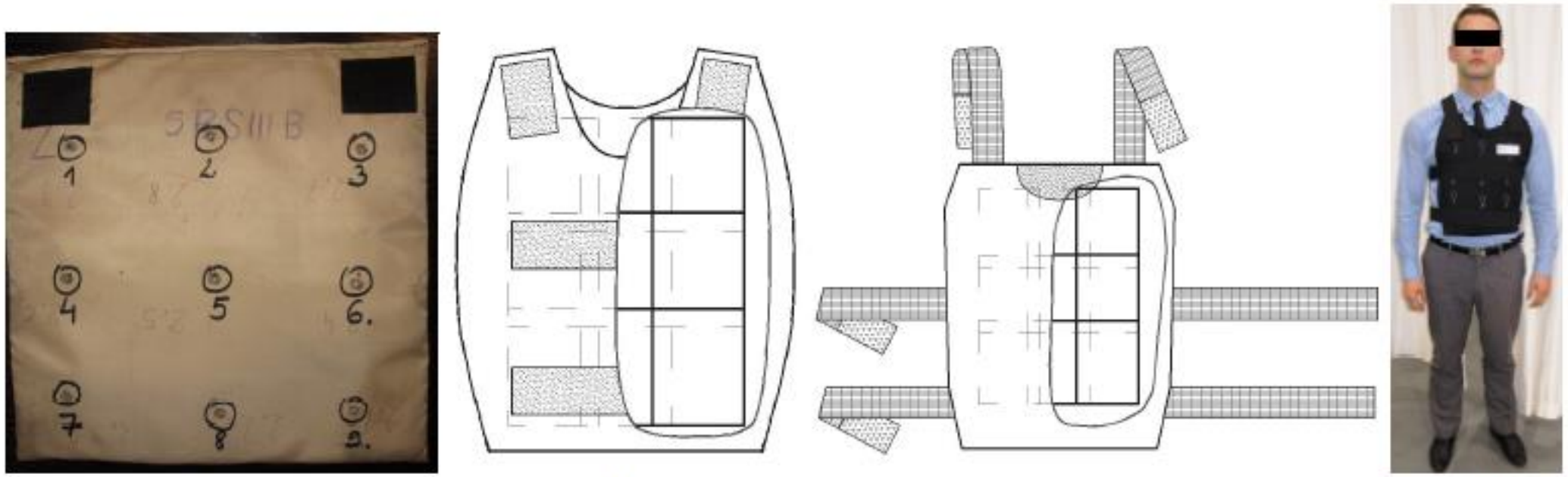
Protects against internal injuries

smartfluid® 45 stages®

STF: Flexible Bulletproof Vest

Fluid armor – flexible bulletproof vest

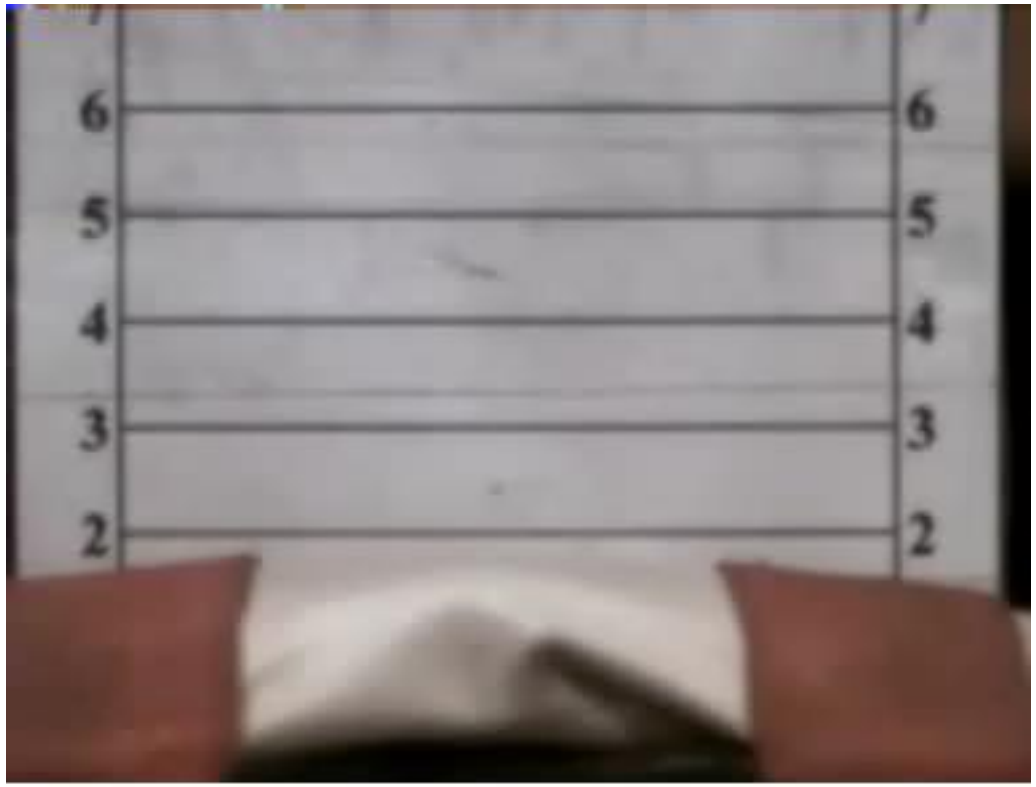
STF: Flexible Bulletproof Vest



Body armor: a - insert with the modules containing STF after ballistic tests; b – draft of bulletproof vest - front, b - draft of bulletproof vest - back, c - smart armor vest.

STF: Ballistic Resistance FMJ Parabellum 9 mm

Kevlar



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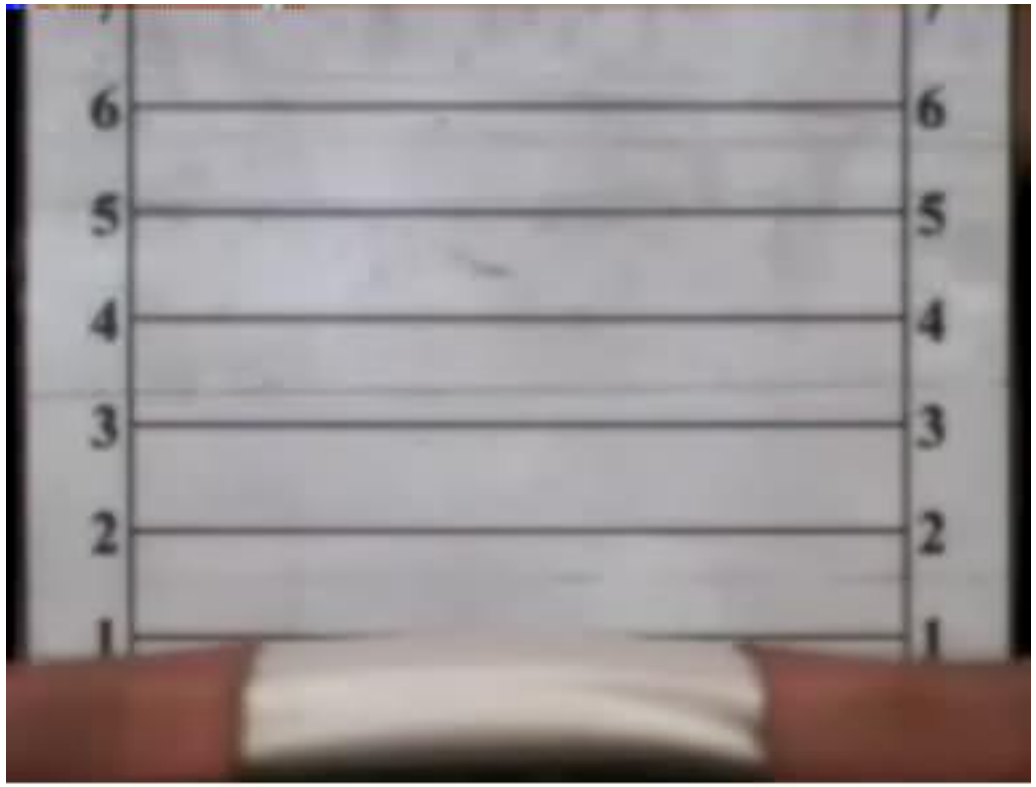
STF: Ballistic Resistance FMJ Parabellum 9 mm

STF + Kevlar



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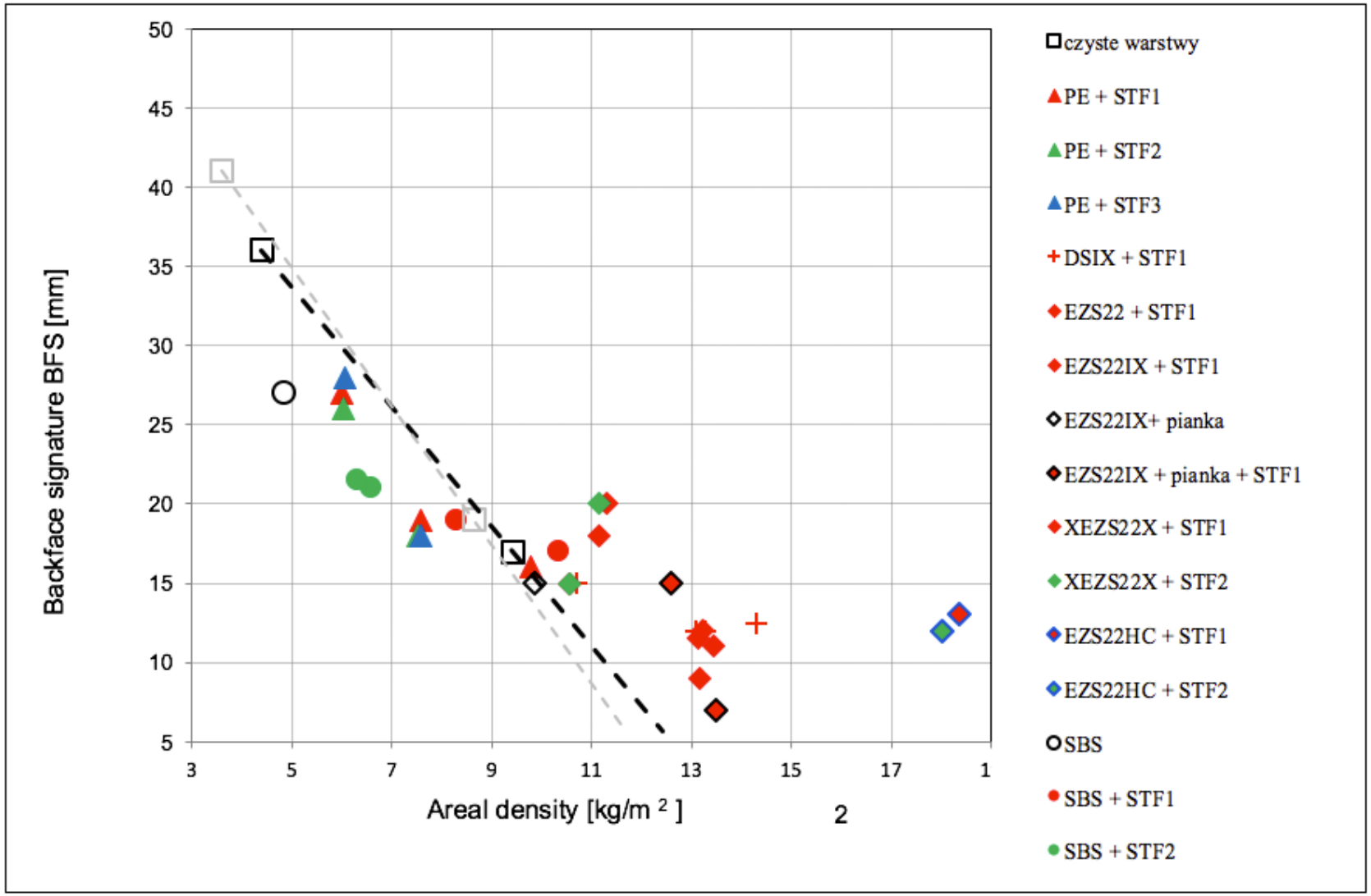
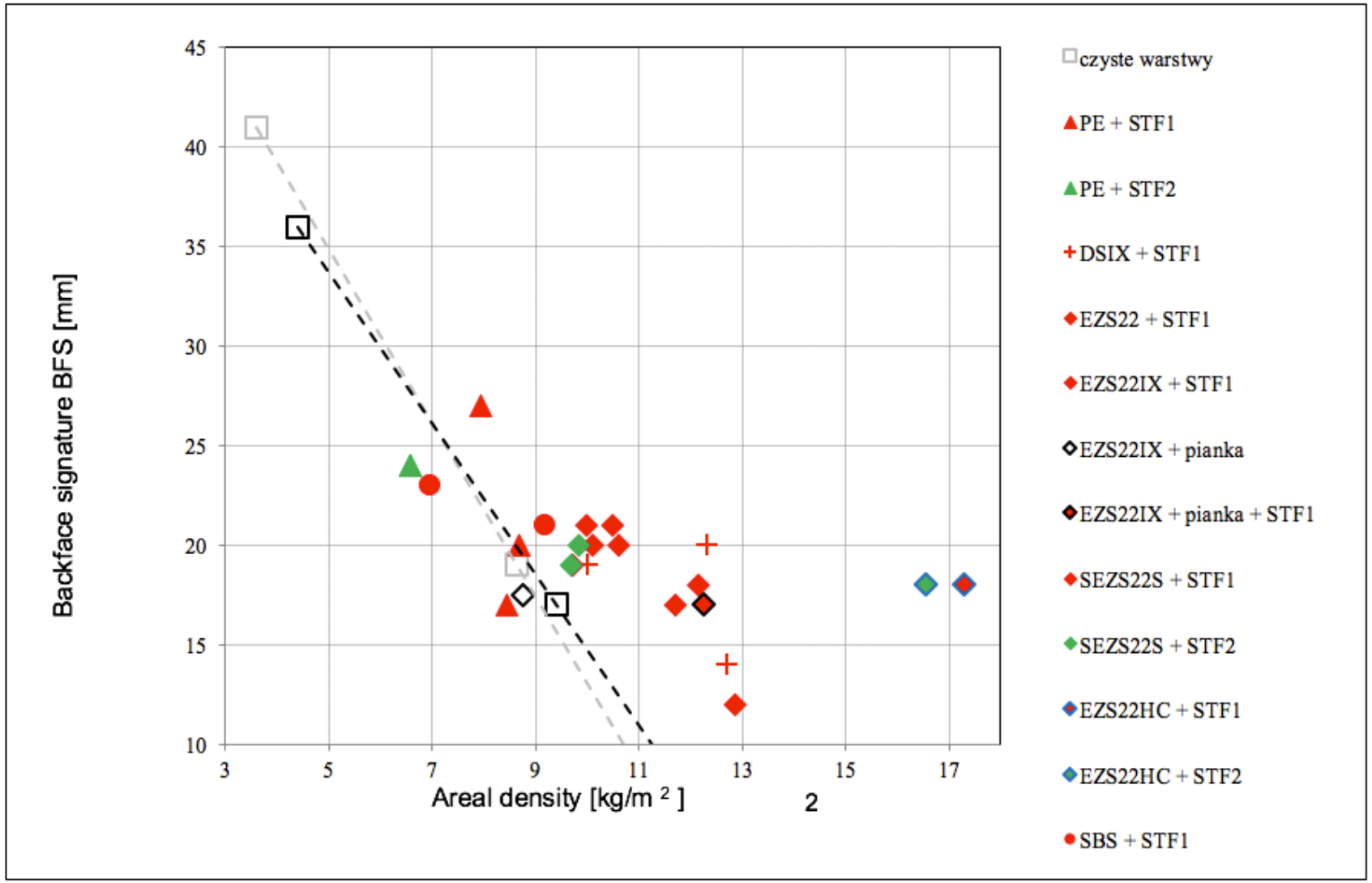
STF: Ballistic Resistance FMJ Parabellum 9 mm



Construct based on Kevlar XP S307 – 11 layers Kevlar XP S307 / Pocket + STF / 2 layers Kevlar XP S307

smartfluid 45 stages

STF: Ballistic Resistance FMJ Parabellum 9 mm



Construct based on Dyneema SB71 – 13 layers Dyneema SB71 / pocket + STF / 3 layers Dyneema SB71

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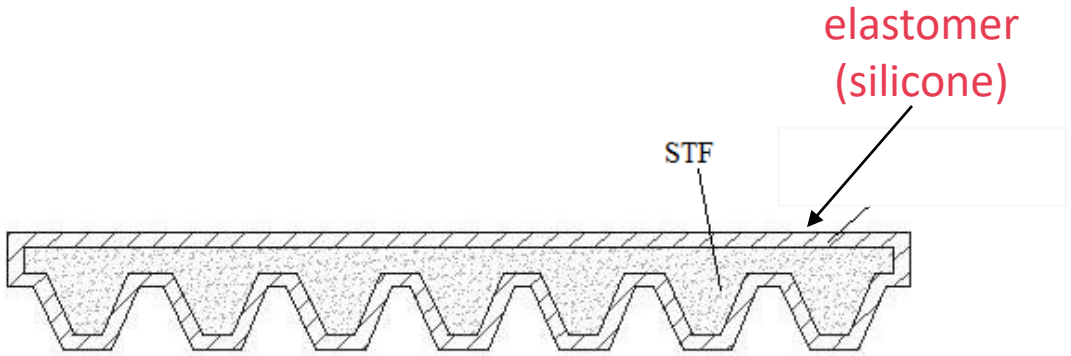
STF: Ballistic Resistance FMJ Parabellum 9 mm

Sample and base after the tests: a - ballistic plasticine, b - cover for the insert, c - Kevlar® layers in front of the cover with modules containing STF, d - cover with modules containing STF, e - Kevlar ® layers behind the cover with modules containing STF.

STF: Ballistic Resistance FMJ Parabellum 9 mm



Bulletproof vest with STF anti-trauma elastomeric pad

STF: Ballistic Resistance FMJ Parabellum 9 mm

Present bullets traces after using a normal bulletproof vest (on the left side of block) and with STF anti-trauma elastomeric pad for bulletproof vest (on the right side of block) on a ballistic plasticine block.

STF: Ballistic Resistance FMJ Parabellum 9 mm

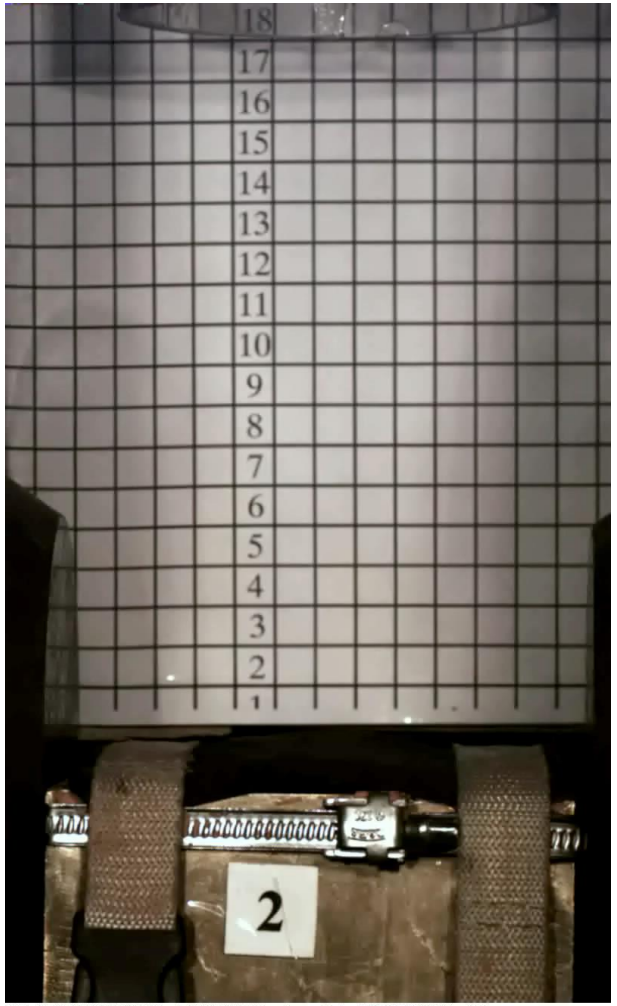
Ballistic Composite System CBS	Projectile Velocity [m/s]	Average Backface Signature Depth [mm]	CBS Mass [g]	Penetration [Yes/No]
Soft Ballistic Insert Behind Composite Ballistic Panel	725,9 ± 5,4	30,8 ± 2,1	2194,0 ± 10,0	No
Anti-trauma Elastomeric Pad Behind Composite Ballistic Panel	726,9 ± 3,1	12 ± 1,8	2123,8 ± 10,0	No

Bulletproof vest with STF anti-trauma elastomeric pad

smartfluid® 45 stages®

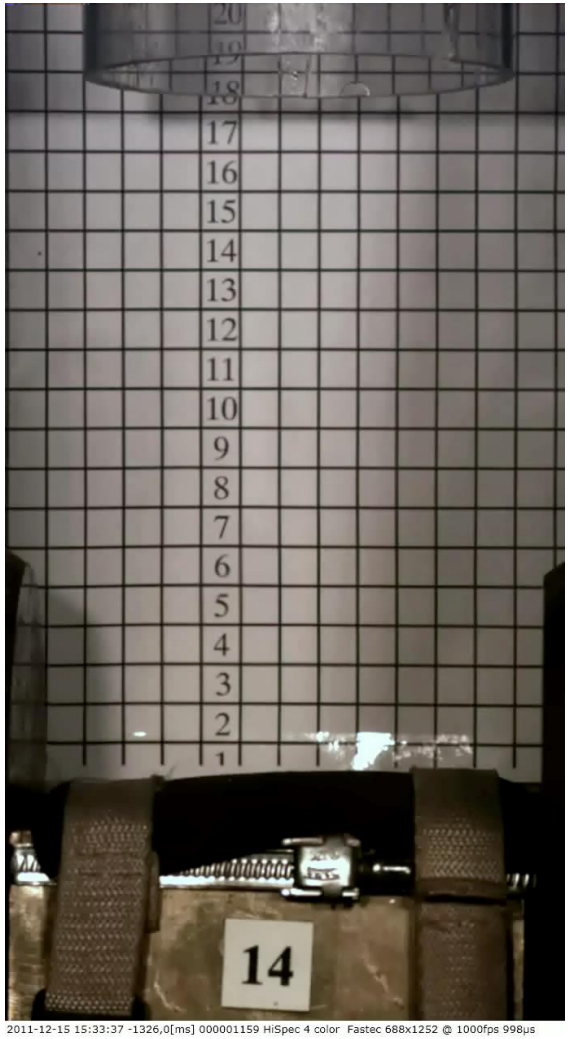
STF: Knife Free Fall Drop Impact Test

Kevlar



STF: Knife Free Fall Drop Impact Test

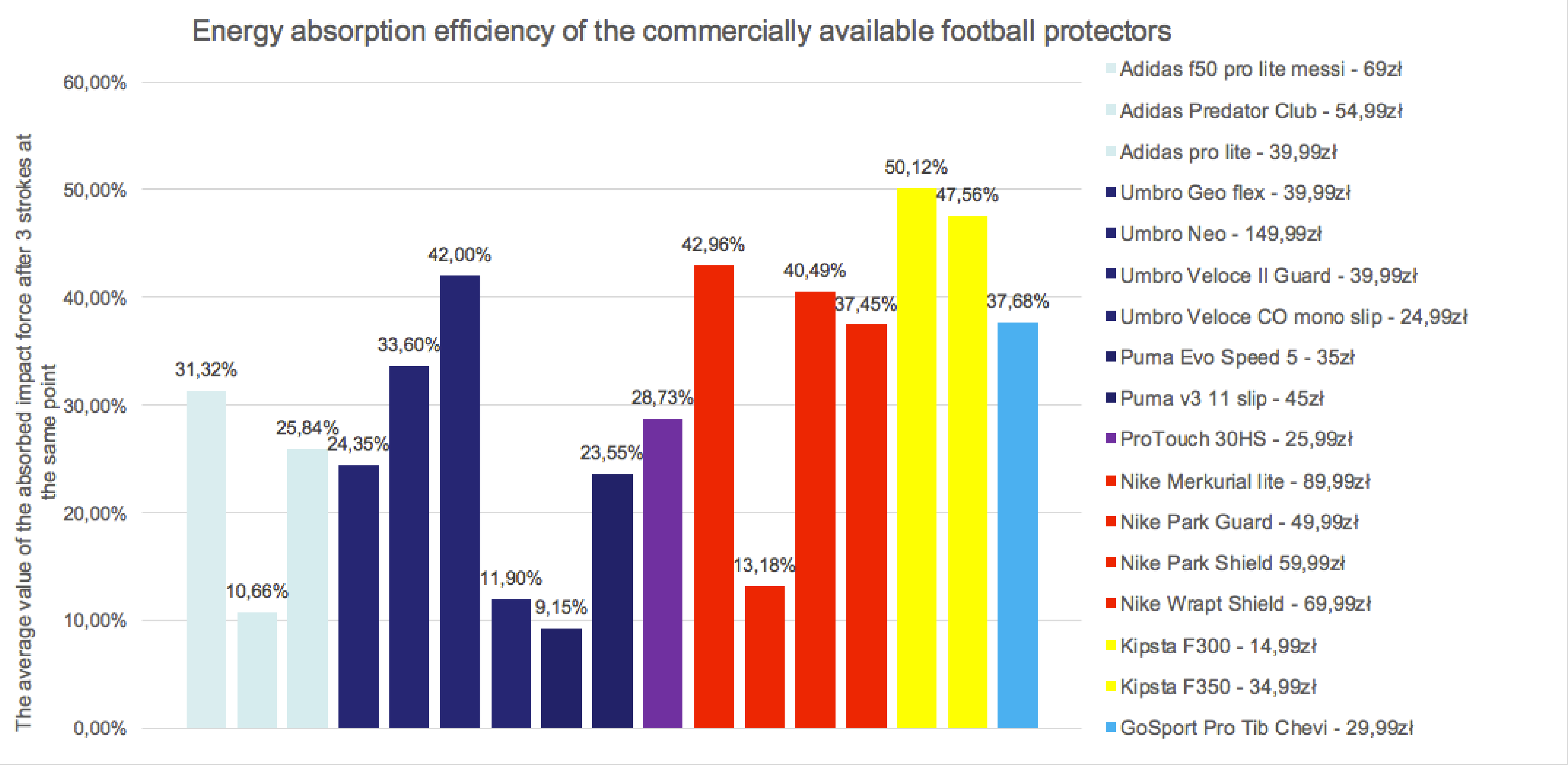
STF + Kevlar



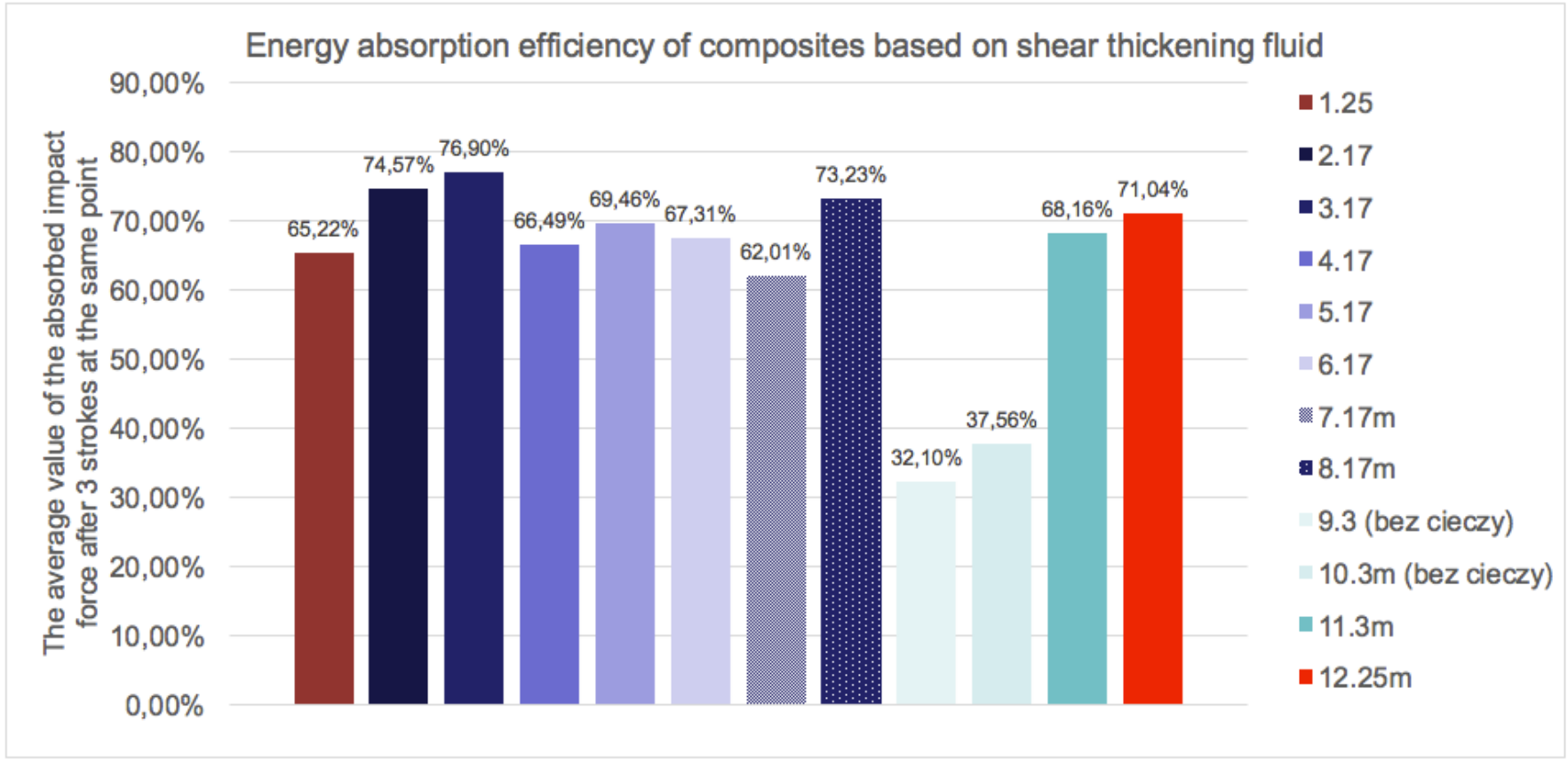
Sport Protectors

Shear Thickening Fluid

Commercial Soccer Protectors



STF: Soccer Protectors

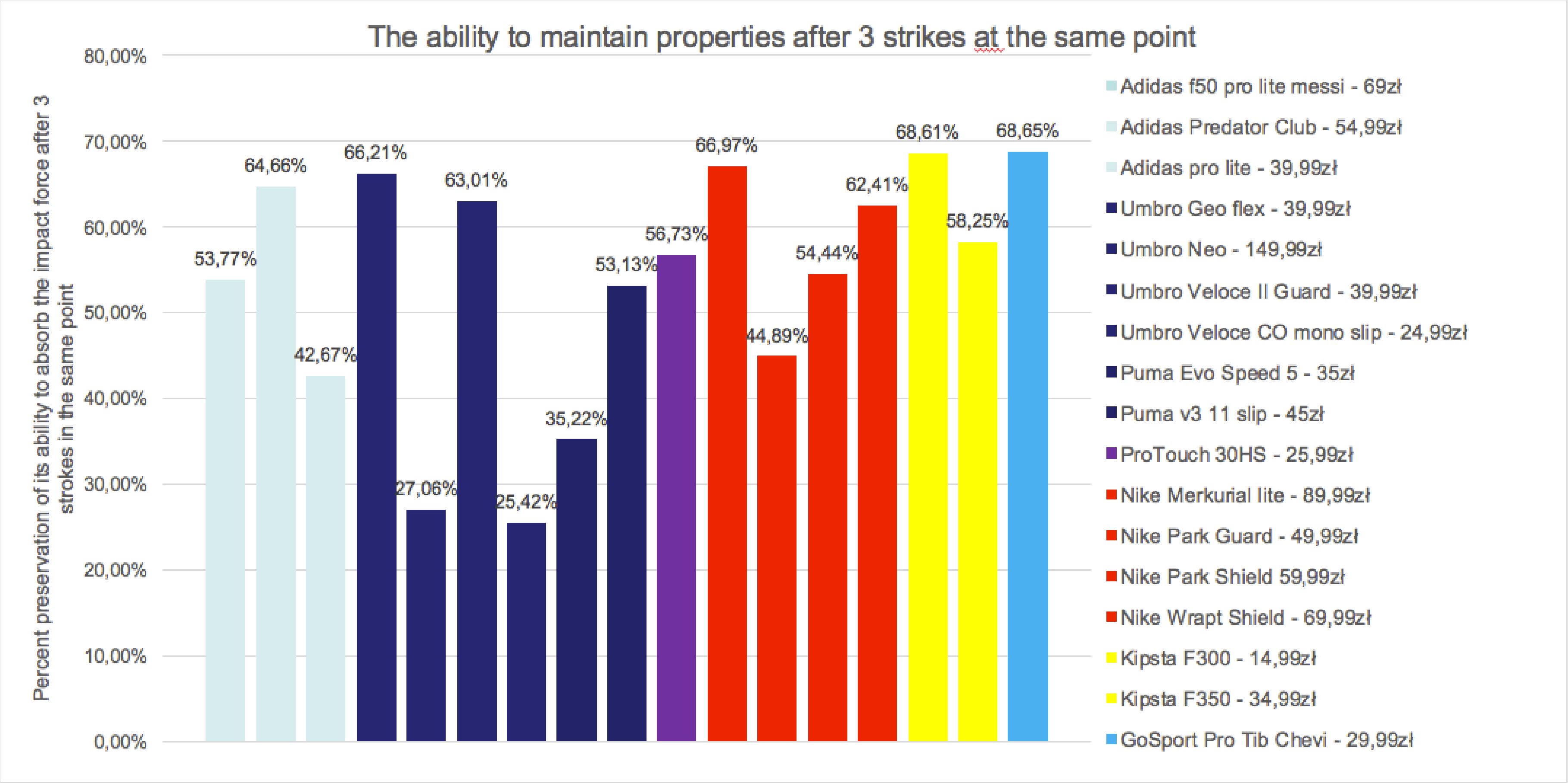


The sheen protectors were built of pockets with STF, embedded in 3D fabrics and polyurethane foams of various density (48, 270 and 400 kg/m^3) and covered by various fabrics.

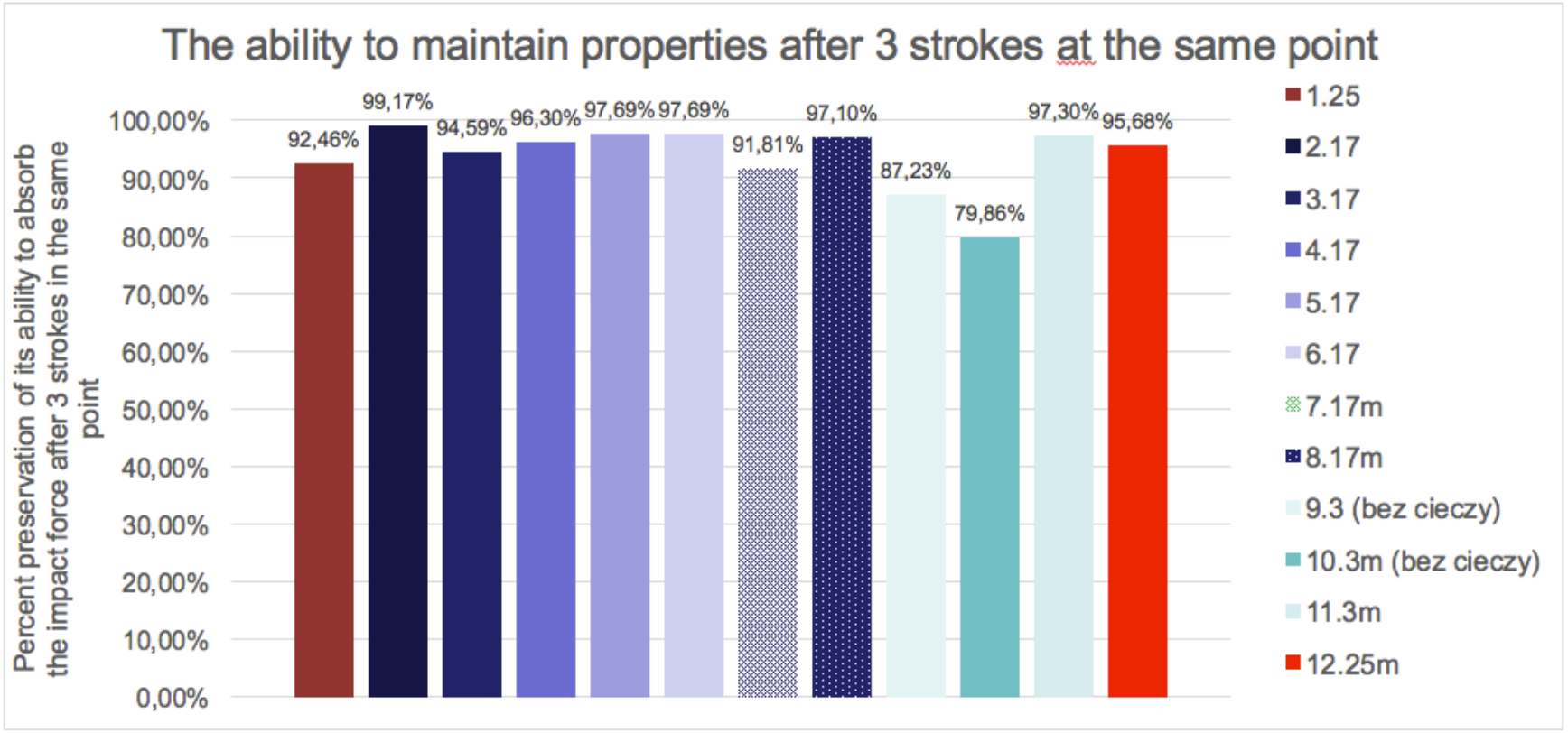
smartfluid®

45 stages®

Commercial Soccer Protectors



STF: Soccer Protectors



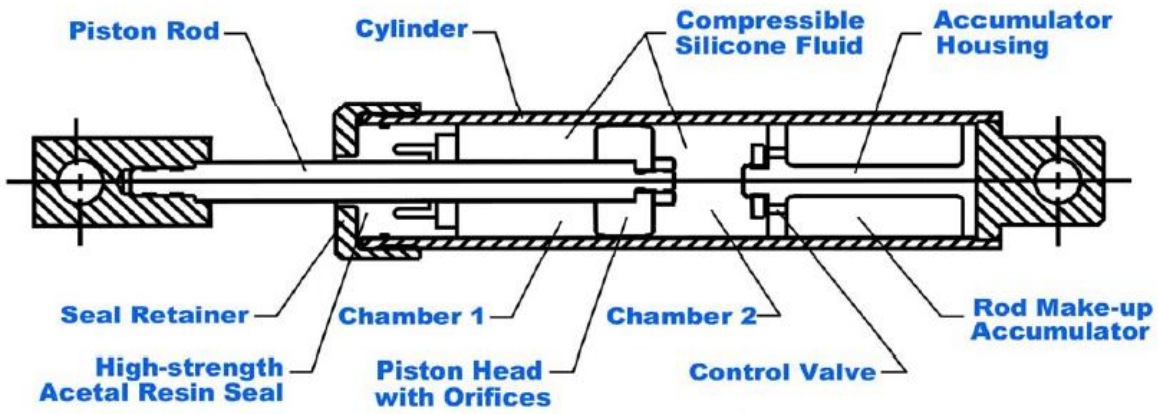
The best stability of the energy absorption properties (99.17%) was obtained for the prototype based on polyurethane foam having density of 270 kg/m^3.

smartfluid® 45 stages®

Earthquake Protection

Shear Thickening Fluid

Earthquake Protection: Viscous Dampers



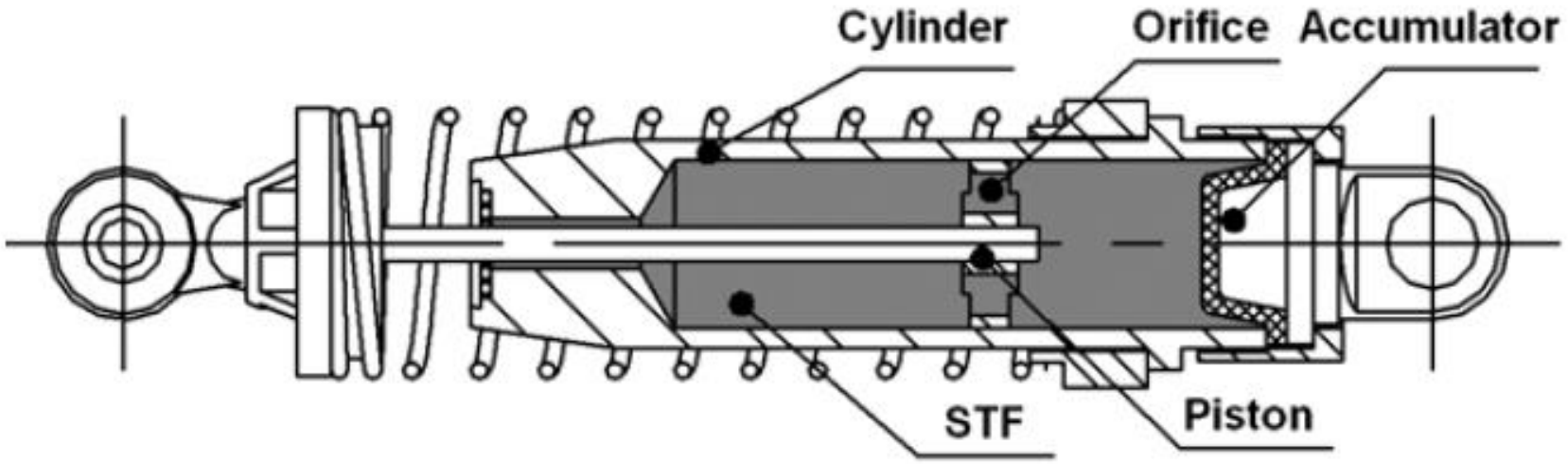
Typical viscous dampers (Taylor Devices, Inc., USA). Such dampers are used in many building and structure in seismic areas, including: airports, hospitals, stadiums, city halls, office buildings and bridges. Example of use of viscous dampers is Tokyo Rinkai Hospital.

Earthquake Protection: Viscous Dampers

TOKYO RINKAI HOSPITAL
LOCATED IN TOKYO, JAPAN
45 - 200 KIP DAMPERS USED WITH BASE ISOLATION BEARINGS
ENGINEER: TOKYO-KENCHIKU STRUCTURAL ENGINEERS

Example of use of viscous dampers is Tokyo Rinkai Hospital.

Earthquake Protection: STF Viscous Dampers

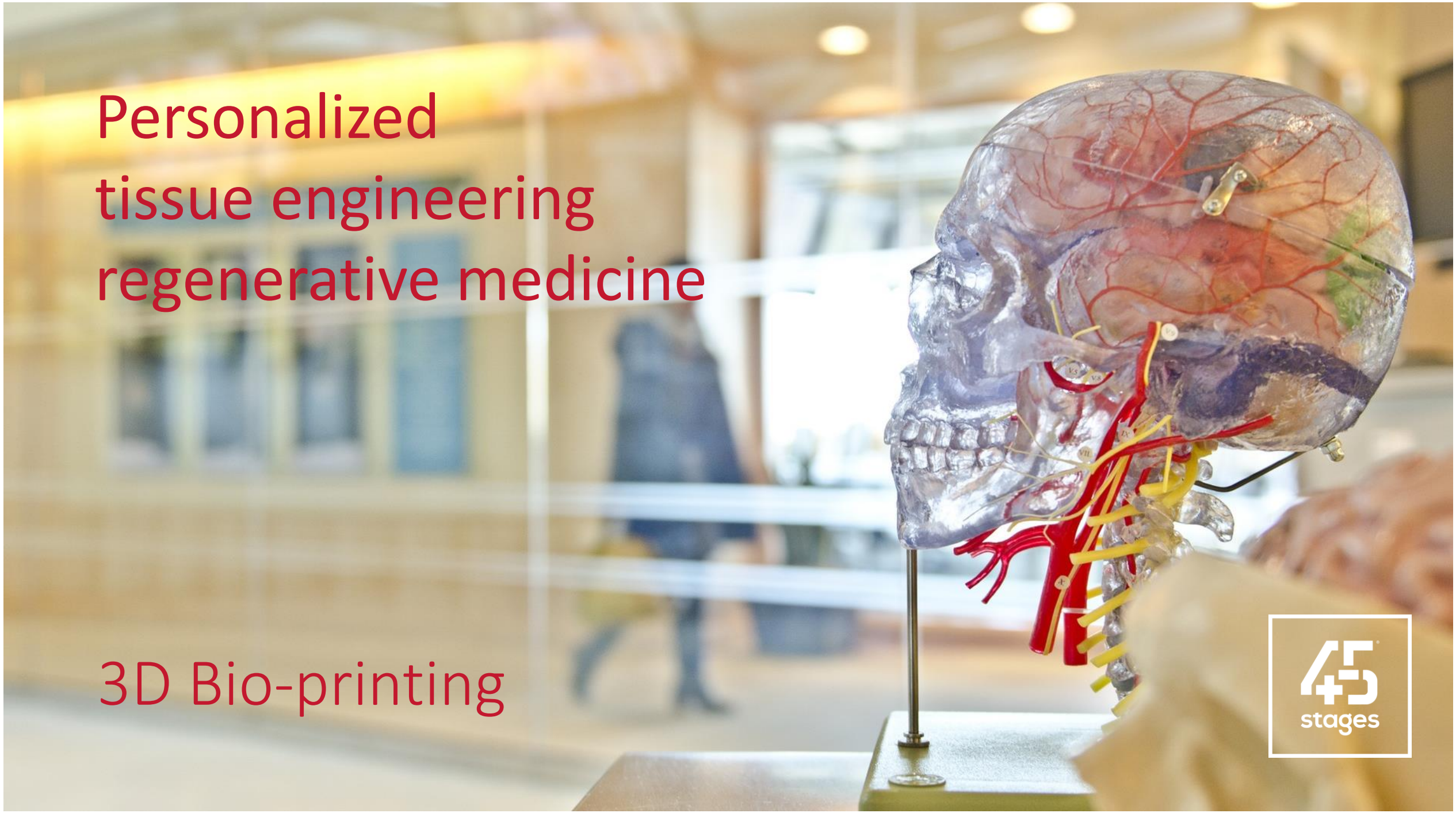


STF fluid viscous dampers – schema

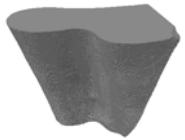
smartfluid 45 stages

Corrosion inhibition

ikorol


Personalized
tissue engineering
regenerative medicine
3D Bio-printing
45
stages

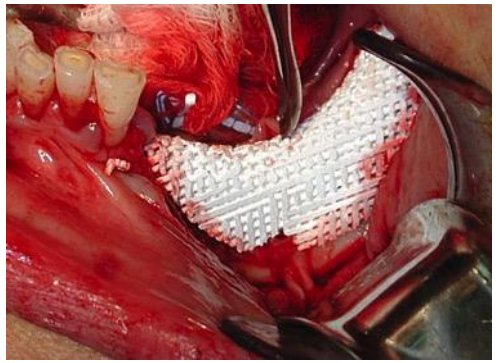
Medical imaging



Model 3D

3D Bio-Printer
(BioCloner 3D)

Biodegradable Implant
(BioScaffold)



Implantation

Regeneration

Personalized
tissue engineering
regenerative medicine
3D Bio-printing

45 stages


BioCloner 3D
The first Polish biomedical 3D printer dedicated for biodegradable implants
3D bio-printing
45 stages

BioCloner 3D

- The project BioCloner 3D covers the design and construction of the 3D bio printer that is able to produce scaffold for reconstruction of almost every part of our body.
- BioCloner 3D is designed for printing biodegradable implants (BioScaffolds).
- Implants (BioScaffolds) are manufactured from biodegradable materials (e.g.: PCL, PLA) that can be used to regenerate natural bone or cartilage defects.
- BioCloner 3D is biomedical printer currently under development. Will be available on market in 2 years from now.

45stages project received financial support from National Centre for Research and Development of Poland. Amount: 6 480 789 PLN (1,5 mln EUR).

1st September 2016 start of the project. Financing period of 24 months.

BioCloner 3D comparison with the competition

			Features						
			Material			Printer parameters			
Company	3D printer	Country	hydrogel + cell + growth factors + drugs	thermoplastic polymer in granular form	thermoplastic polymer in form of fialment	system of mixing of 2 materials inside the printer	environmental chamber	needle autopositioning	UV lamp
Bioprinting Solutions	*Fabion*	Russia	+	–	–	–	–	–	–
EnvisionTEC's	*Bioplotter Manufacturer Series*	Germany	+	+	–	–	–	+	–
Sys&Eng	*Bioscaffolder*	Germany	+	+	–	–	–	–	–
GeSim	*Bioscaffolder 2.1*	Germany	+	+	–	–	–	+	+
RegenHU	*3DDiscovery - Biofactory*	Switzerland	+	+	–	–	–	–	–
Ourobotic	*Revolution*	UK	+	–	–	–	+	+	–
3Dynamic System	*Alpha & Omega*	UK	+	–	–	–	–	–	–
Bio3D's SYN	*E–plorer*	Singapore	+	–	–	–	–	–	–
BioBot	*BioBot1*	USA	+	–	–	–	–	–	+
CELLINK	*Inkredible*	USA	+	–	–	–	+	–	–
Organovo	*NovoGen MM*	USA	+	–	–	–	+	+	–
Advanced Solutions	*BioAssemblyBot*	USA	+	–	–	–	–	–	–
n3Dbio	*Bioassembler*	USA	+	–	–	–	+	+	–
Aspect Biosystem	*Lab–on–a–printer*	Canada	+	–	–	–	–	–	–
45stages	*BioCloner 3D*	POLAND	+	+	+	+	+	+	+

Bio4med©

45 stages

BioCloner 3D comparison with the competition

			Features						
			Printer parameters						
Company	3D printer	Country	process monitoring cameras	material monitoring and refilling during printing system	separated heating zones	controlled fiber output diameter	modular work table	monitoring and automatic reporting of process parameters changes	easy installation of the needle
Bioprinting Solutions	***Fabion***	Russia	–	–	–	–	–	–	–
EnvisionTEC's	***Bioplotter Manufacturer Series***	Germany	–	–	–	–	–	–	–
Sys&Eng	***Bioscaffolder***	Germany	–	–	–	–	–	–	–
GeSim	***Bioscaffolder 2.1***	Germany	+	–	–	–	–	–	–
RegenHU	***3DDiscovery - Biofactory***	Switzerland	–	–	–	–	–	–	–
Ourobotic	***Revolution***	UK	+	–	–	–	–	–	–
3Dynamic System	***Alpha & Omega***	UK	+	–	–	–	–	–	–
Bio3D's SYN	***E–plorer***	Singapore	–	–	–	–	–	–	–
BioBot	***BioBot1***	USA	–	–	–	–	–	–	–
CELLINK	***Inkredible***	USA	–	–	–	–	–	–	–
Organovo	***NovoGen MM***	USA	–	–	–	–	–	–	–
Advanced Solutions	***BioAssemblyBot***	USA	+	–	–	–	–	–	–
n3Dbio	***Bioassembler***	USA	–	–	–	–	–	–	–
Aspect Biosystem	***Lab–on–a–printer***	Canada	–	–	–	–	–	–	–
45stages	***BioCloner 3D***	**POLAND**	+	+	+	+	+	+	+

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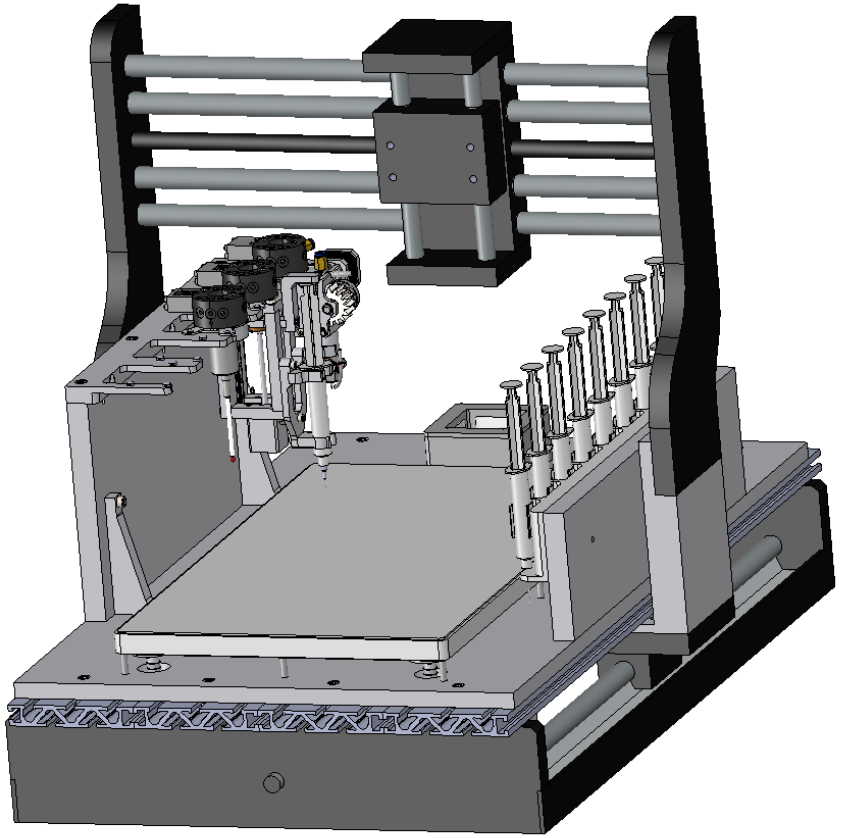
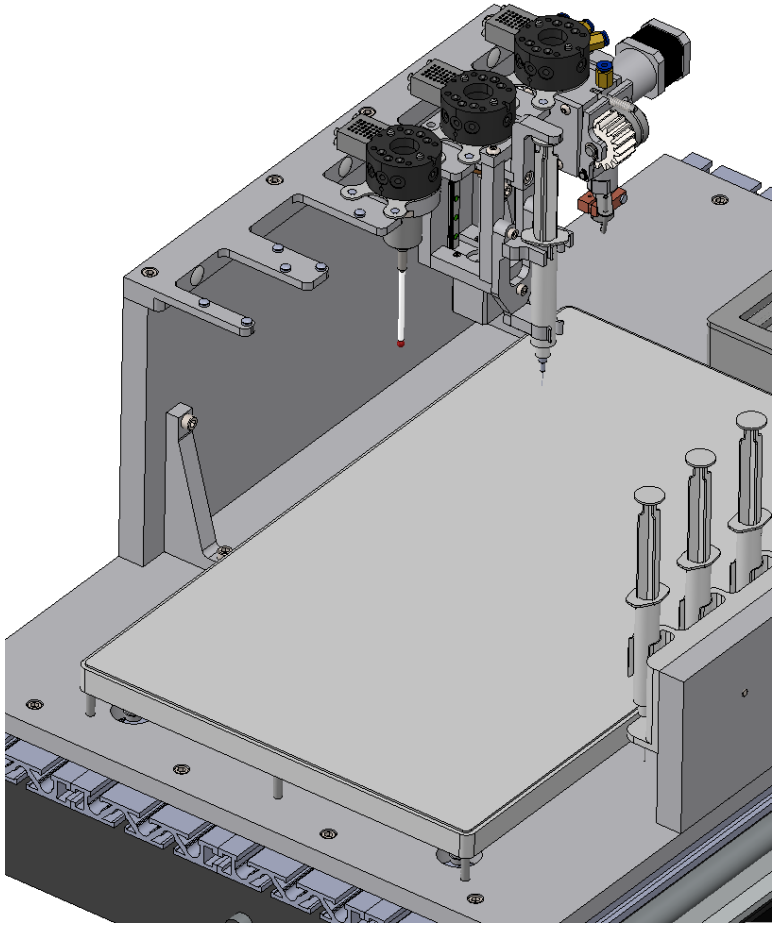
45 stages

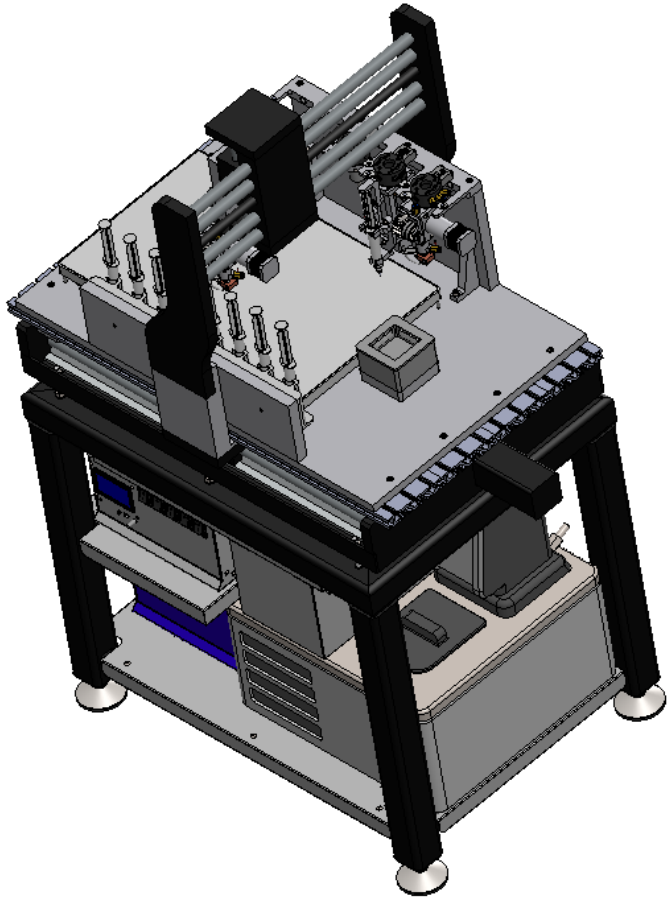
BioCloner 3D

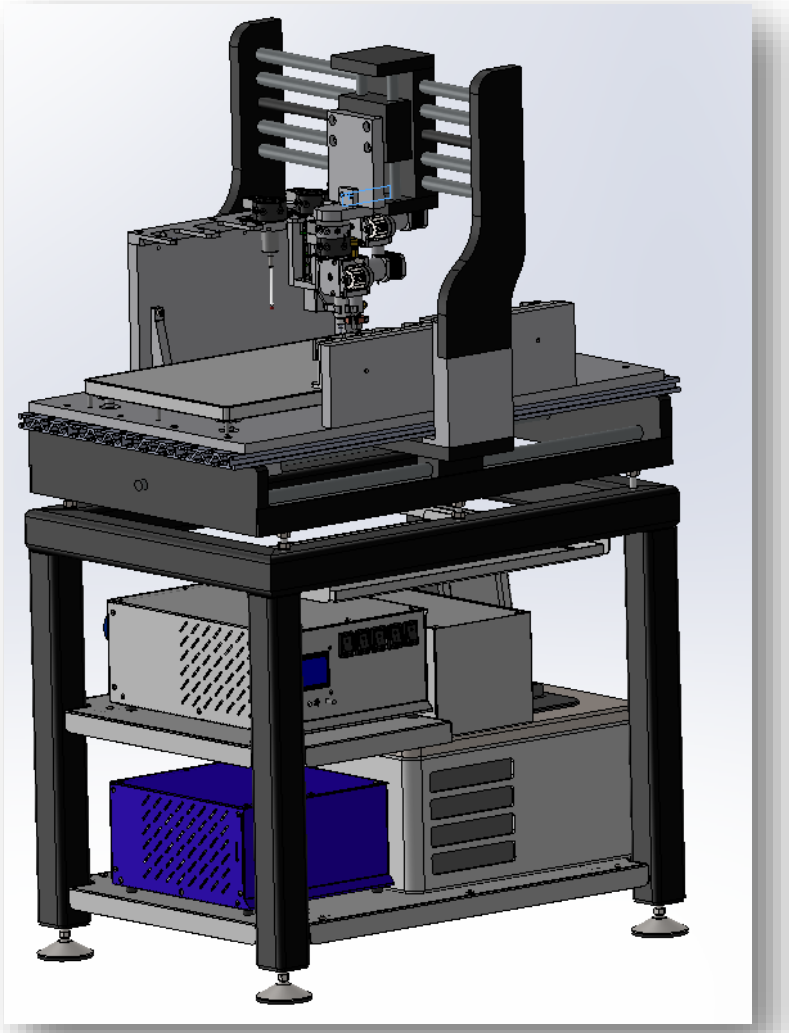




Gantry carrying frame with printing head components, parking system and hydrogel storage compartment.

BioCloner 3D





Gantry carrying frame with additional base for the control and power modules

BioScaffold

Biodegradable implants
for tissue engineering
and regenerative medicine

Implants

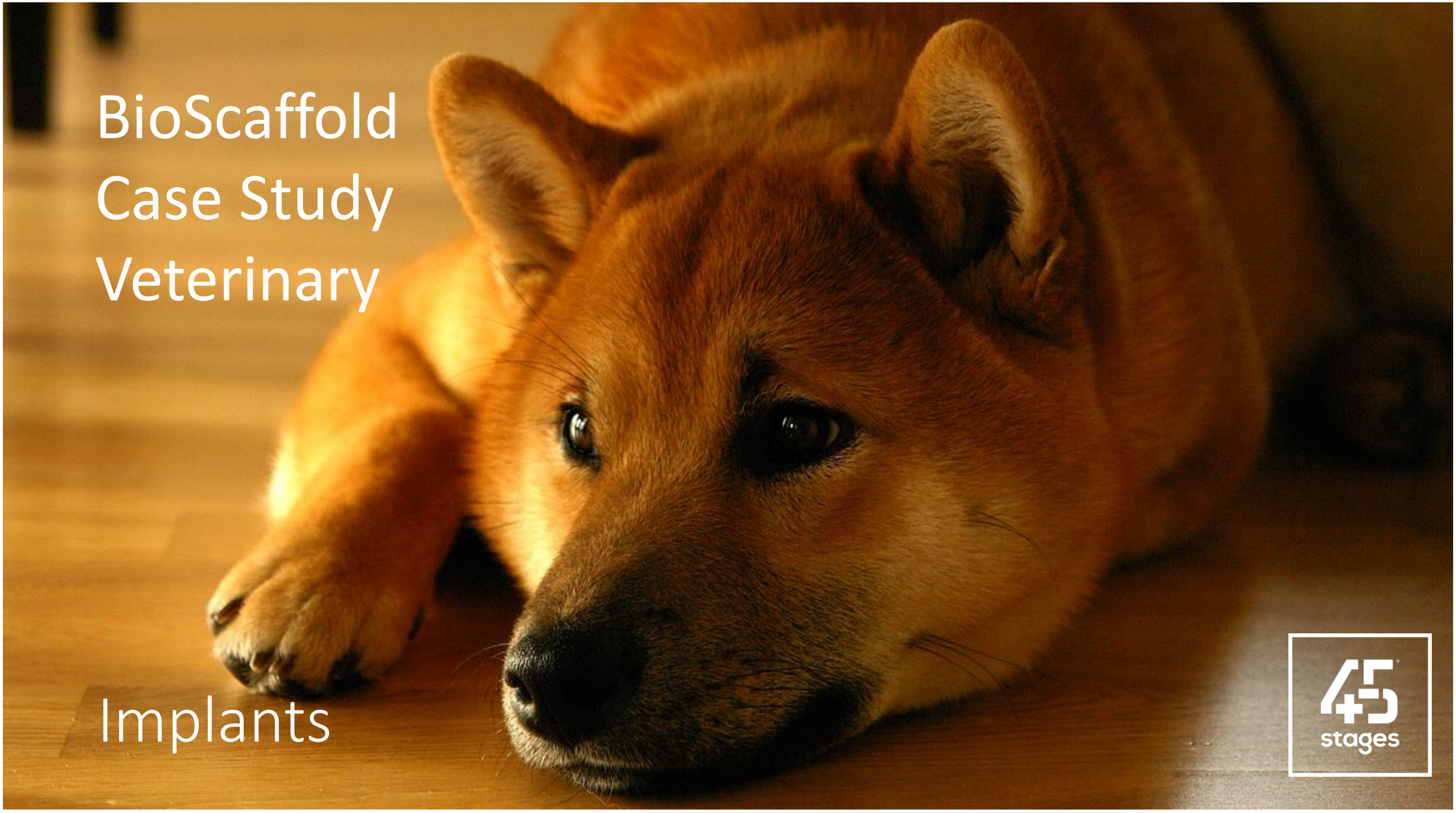
45 stages

BioScaffold – Biodegradable scaffolds/implants for regeneration of tissue defects

BioScaffolds

- Body is not able to regenerate itself large bone or cartilage tissue defects (critical defect) caused by cancer or trauma
- Implant (BioScaffold) designed based on medical imaging
- Produced by 3D printing for specific patient
- Biological scaffold made of biodegradable polymers or composites
- Implanted in place of bone or cartilage defects caused by illness or trauma
- Implant (BioScaffold) gradually dissolves natural tissue: bone or cartilage takes it place.

Bio4med 45 stages


BioScaffold
Case Study
Veterinary
Implants
45
stages

Personalized regenerative medicine: case study - veterinary

Dog before surgery. Radiographs of the affected limb revealed proliferative changes and lysis of the radial metaphysical cortex with an irregular periosteal reaction in the distal radius.

Limb-sparing surgery was offered because the owner refused limb amputation. In this study a 10 cm of radius bone region was removed and the defect was reconstructed with the BioScaffold.

MATERIALS CARE

www.materialscare.eu

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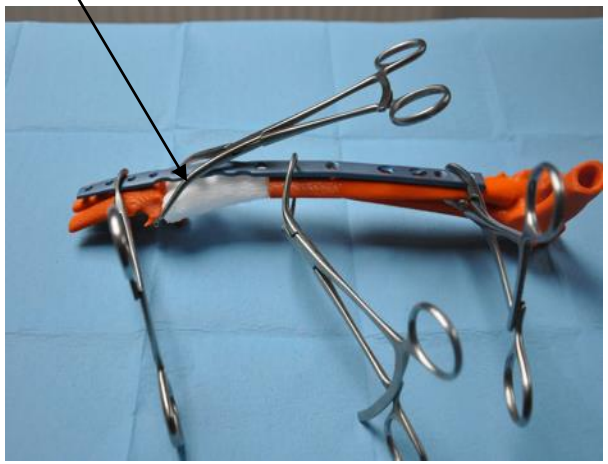
45 stages

Personalized regenerative medicine: case study - veterinary

3D printed personalized BioScaffold



The aim was to reconstruct a radius bone loss after cancer treatment in 8 years old dog. Reconstruction done with BioScaffold.

MATERIALS CARE

www.materialscare.eu

Bio4med

45 stages

Personalized regenerative medicine: case study - veterinary

Dog after surgery. After scaffold implantation a significant improvement of the dog movement have been obtained. Every month implanted scaffold using radiographs was evaluated.

After 3 months of implantation of BioScaffold, we observed that sufficient tissue formation can be induced in segmental bone defect.

VersaBox Cargo Robots

MAX PAYLOAD

CONTINUOUS WORK

VERSABOT 1500

AUTONOMIC TRANSPORT SYSTEM

This SGV is the heavy lifter of Versabox SGV fleet. It handles twice as much cargo as the basic VB500 unit with the same grace and agility and shares its modular design. Extra strength has been achieved without compromising its operational footprint, with just a minimum extension of body height.

1500 KG
MAX PAYLOAD

8 HRS
CONTINUOUS WORK

https://versabox.eu/versabots/versabot1500/

MJW RnD

ご清聴ありがとうございました !!!

MJW RnD

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