Additive manufacturing (AM) in medicine

Speaker: **Radovan Hudak**

Authors: **Radovan Hudak, Jozef Zivcak, Bruno Goban**

Co-operating surgeons: **Andrej Jenca, Branislav Kolarovszki, Dagmar Statelova, Bruno Rudinsky....**

Košice, Slovakia, 22.11.2016

R&D AND BUSINESS TEAM

Technical University of Kosice, Faculty of Mechanical Engineering Department of Biomedical Engineering of Kosice

- 10 emloyees involved into the medical AM led by professor **Jozef Zivcak** (head of department of biomedical engineering and measurement and co-owner of CEIT Biomedical Engineering, s.r.o.)

CEIT Biomedical Engineering, s.r.o.

- 8 emloyees involved into the medical AM led by **Bruno Goban**

ADDITIVE MANUFACTURING OR 3D PRINTING?

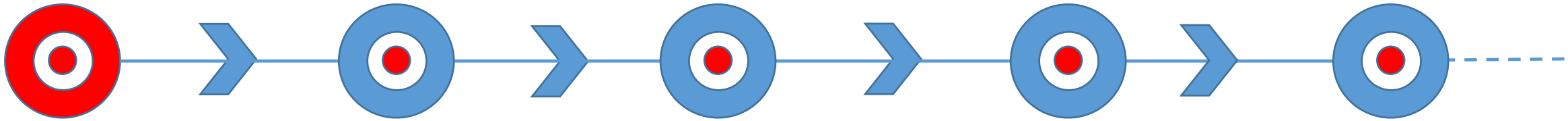
Process of joining materials to make objects from 3D model data, usually layer upon layer, as opposed to subtractive manufacturing methodologies. Synonyms are additive fabrication, additive processes, additive techniques, additive layer manufacturing, layer manufacturing, and freeform fabrication (ASTM F2792).

Those from the scientific and technical communities prefer to use ***additive manufacturing*** when referring to the group of processes that build parts layer upon layer. An important reason is that it is the official standard term according to the **ASTM F42 and ISO TC261 committees** (Wohlers Associates, 2016).

3D printing is, by far, most popular term. Google displays 20-30 times more references for 3D printing (or 3-D printing) compared to additive manufacturing. Today, many individuals and organizations use 3D printing and additive manufacturing interchangably (Wohlers Associates, 2016).

.

ADDITIVE MANUFACTURING IN MEDICINE



1971

Sir Godfrey Hounsfield

invents the **CT** scan
(Katie Weimer, MS, 2016)

1977

Raymond Vahan Damadian

invents an apparatus and method to use NMR safely and accurately to scan the human body (now known as **MRI**)

1981

Drs. Jeffrey Marsh & Michael Vannier

create 3D models from 2D, milled slices

(Katie Weimer, MS, 2016)

1983

Chuck Hull

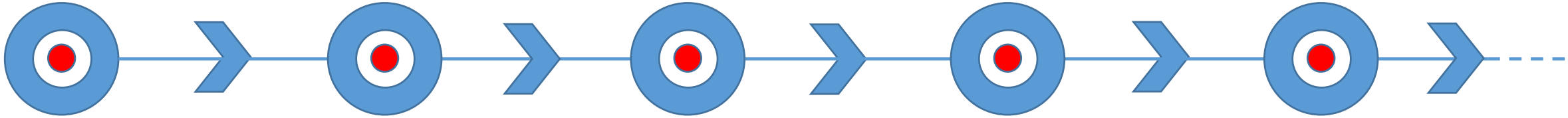
Invents 3D printing via Stereolitography

1988

Dr. Mankovich @ UCLA

The first model of anatomy is produced using 3D Printing
(Katie Weimer, MS, 2016)

ADDITIVE MANUFACTURING IN MEDICINE



1998

the first selectively colored SLA model in the US, produced in Colorado
(Katie Weimer, MS, 2016)

2000

medical applications of 3D printing date back to the early 2000s, with the production of dental implants and prosthetics
(Gross , Bethany C. at all, 2014).

2003

Dr. Kenneth Salyer

successfully separates conjoined Egyptian twins

2003

3D Printing in titanium gets its start for implants
(Katie Weimer, MS, 2016)

2007

Virtual Surgical Planning (VSP) gets it start and moves toward becoming the gold standard for surgical planning

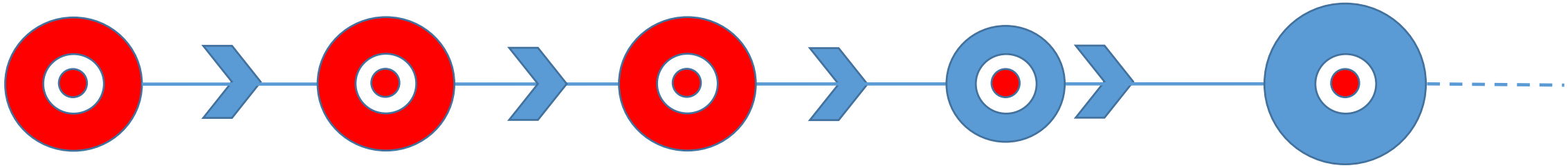
(Katie Weimer, MS, 2016)

2008

personalized surgical instruments for total knee surgery become commonplace

(Katie Weimer, MS, 2016)

ADDITIVE MANUFACTURING IN MEDICINE



2008

Radovan Hudák
Jozef Živčák

idea to produce implants by additive manufacturing in Slovakia

2010

FDA clears the first 3D printed metallic implant

2010

The company **CEIT –KE** was established, later

CEIT Biomedical Engineering s.r.o.

2013

first implant is implanted designed and produced by **CEIT Biomedical Engineering** Company

2014

anatomical models for surgical planning in hearts, kidneys and other organs becomes common

(Katie Weimer, MS, 2016)

2020 -....

3D printing as a surgery assist

the increased availability of biocompatible materials

patent expiry and the reduced cost of innovation

(Srinath, Aniruddha, June 2016)

IDEA TO REALIZATION

2008

Radovan Hudák
Jozef Živčák

idea to produce implants by additive manufacturing in Slovakia

Inspiration from Chicago (stay in 2006) and Slovenia (Maribor University)

2010

CEIT a.s.
TUKE
Jozef Živčák
Radovan Hudák

The spinn-off company CEIT –KE was established, later

CEIT Biomedical Engineering s.r.o.

without participation of TUKE

2010

Preparation of the project
STIMULS FOR R&D
Budget: 2 mil. EUR

Research of new diagnostic methods in invasive implantology

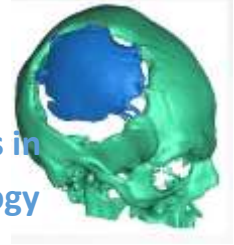
MINISTRY OF EDUCATION, SCIENCE, RESEARCH AND SPORT OF THE SLOVAK REPUBLIC

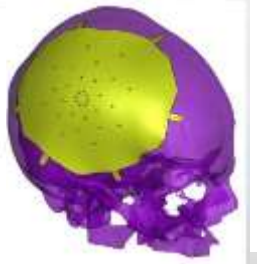
2013

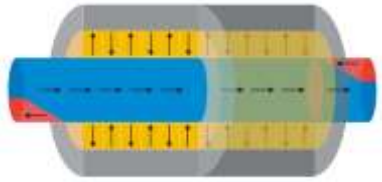
Project

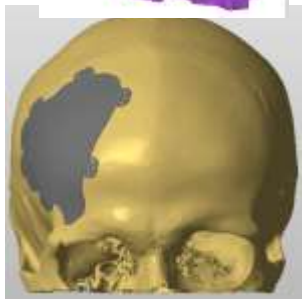
Research of new diagnostic methods in invasive implantology

FINISHED









CEIT Biomedical Engineering

Company was established on 2010 as spin-off company of Technical University of Košice (TUKE) and CEIT a.s. holding (Central European Institute of Technology).

Company employes are mostly biomedical, material and quality engineers who were students of TUKE, Faculty of mechanical engineering, Department of biomedical engineering and measurement.

free form modelling & development of prototypes

manufacturing of certified medical products, custom-made & in series

research & development of medical products

CEIT Biomedical Engineering

custom implants made of titanium alloy (Ti-6AI-4V) (Grade 5) manufactured by the 3D printing technology

plastic and metal prototypes manufactured by the 3D printing technology, manufacture of anatomic models

3D scanning, digitalisation and modelling of medical products

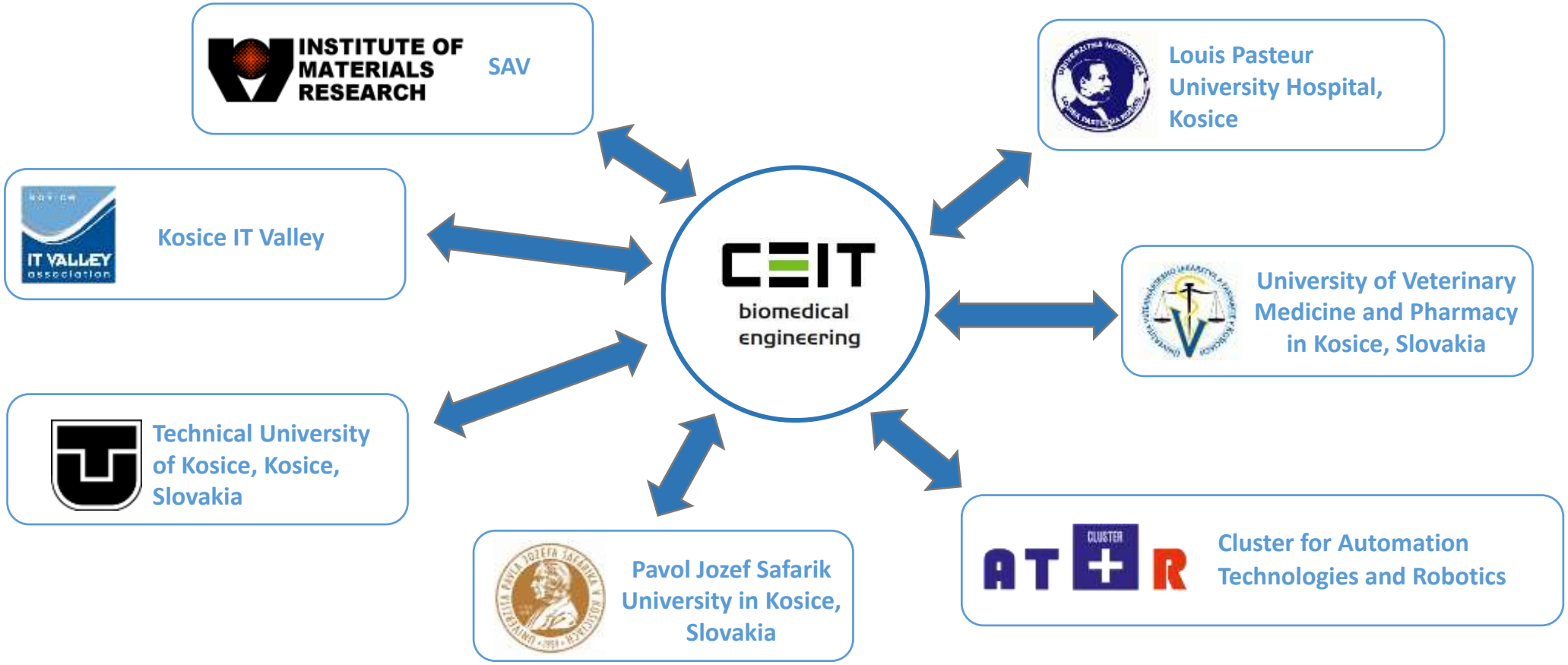
medical data processing and adjustment

verification and validation of medical products medical metrology and diagnostics

science and research in the field of implantology, implant manufacturing and medical sensorics

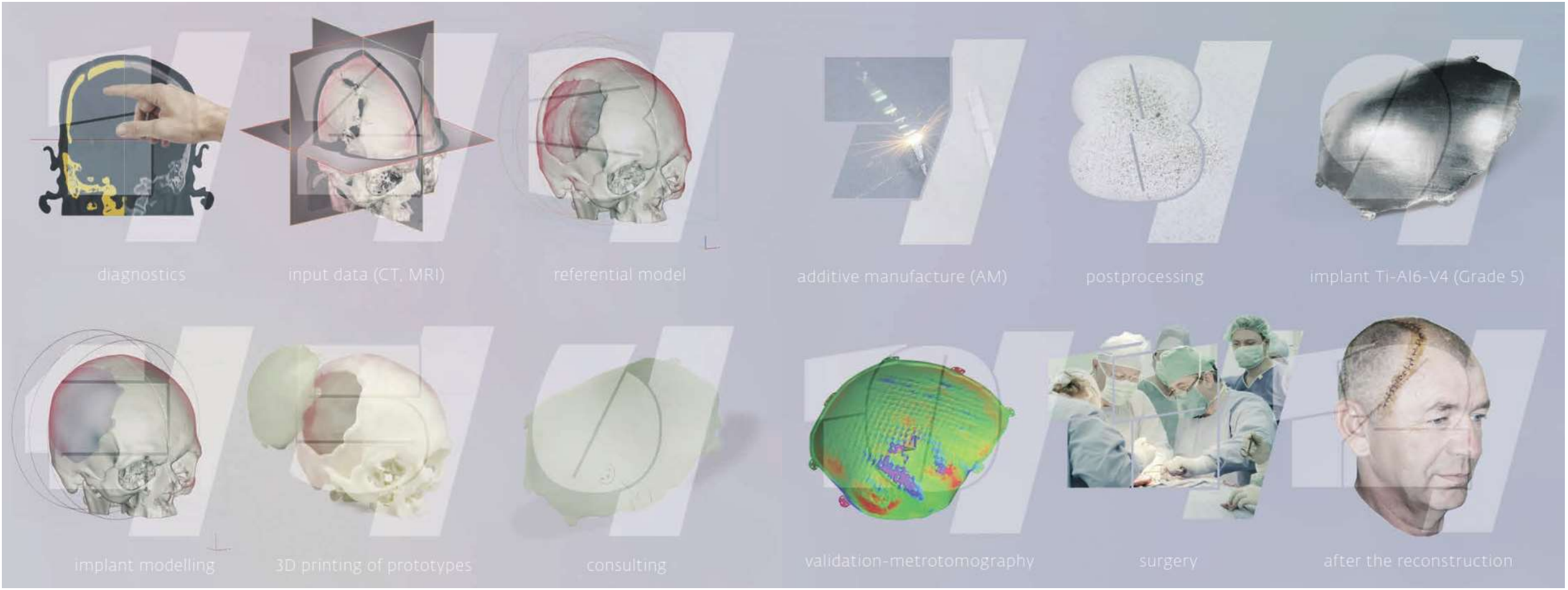
- Company is acredited producer of CMF custom-made implants: SIDC code – SK-13-0224
- Approved medical devices:
  - Custom-made cranial implant P91710
  - Custom-made maxillo-facial implant P91709
  - Custom-made cranio-maxillo-facial implant P91708
  - Custom implant for chest surgery

CEIT Biomedical Engineering



MEDICAL AM WORKFLOW

MEDICAL AM WORKFLOW



MEDICAL AM WORKFLOW – INPUT DATA

Body surface:
Optical and laser scanning

Bones:
CT/MRI/ DICOM data

Inner organs:
CT/MRI/USG DICOM data

MEDICAL AM WORKFLOW – PRODUCTION TECHNOLOGY

Direct metal laser sintering lab – EOSINT M280

Building volume
(including building platform)
250 mm x 250 mm x 325 mm

Laser type
Yb-fibre laser, 200 W

Precision optics
F-theta-lens, high-speed scanner

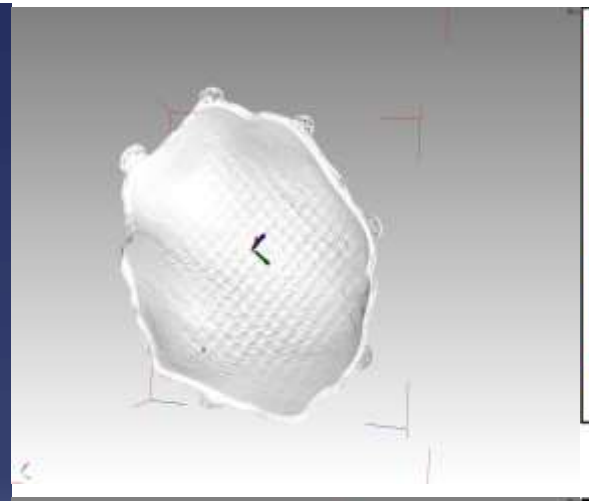
Scan speed
up to 7.0 m/s (23 ft./sec)

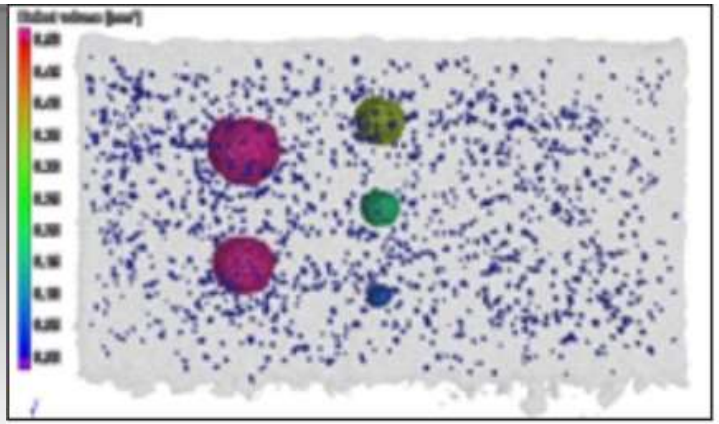
Variable focus diameter
100 - 500 µm (0.004 - 0.02 in)

Material:
Ti-6Al-4V (Grade 5), Ti-6Al-4V ELI (Grade 23)

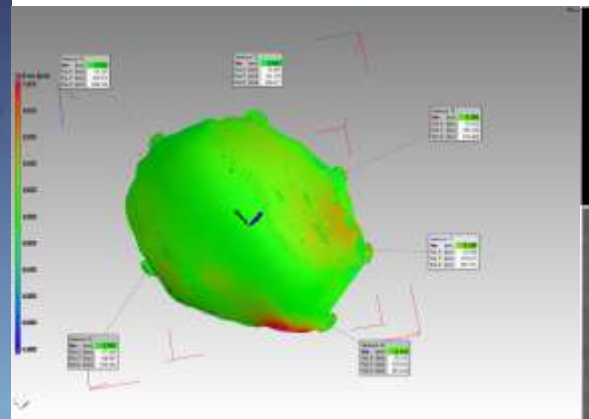
MEDICAL AM WORKFLOW – PRODUCTION TECHNOLOGY

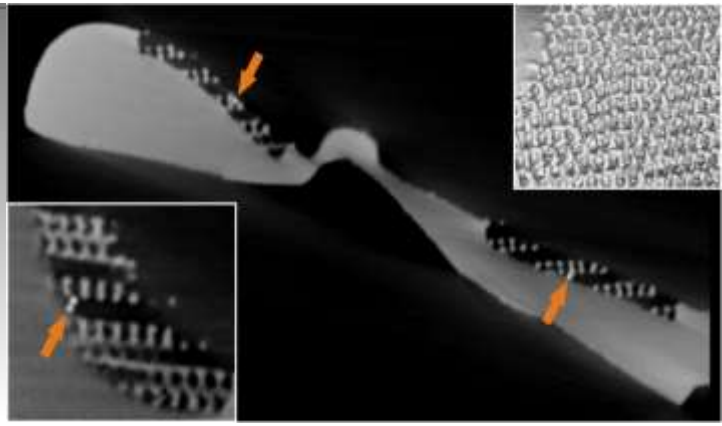
MEDICAL AM WORKFLOW – QUALITY CONTROL





60 mm





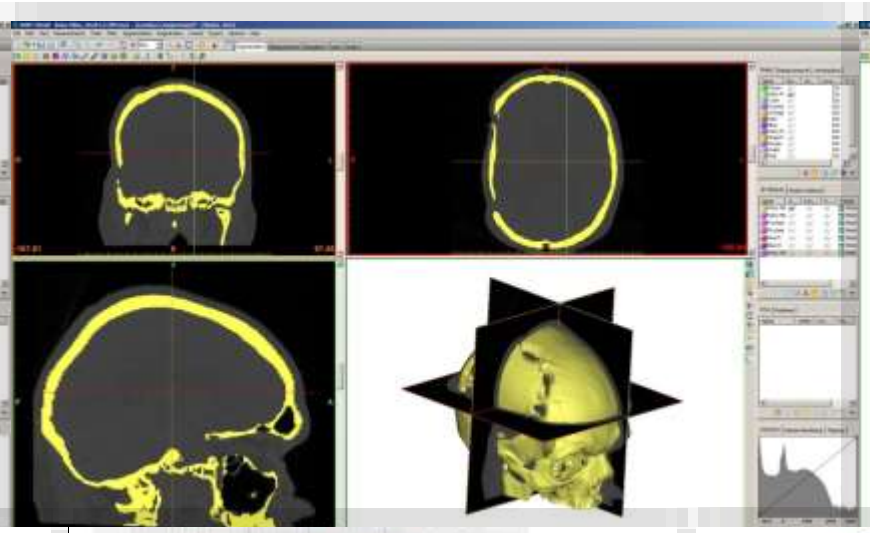
MEDICAL AM WORKFLOW – QUALITY CONTROL

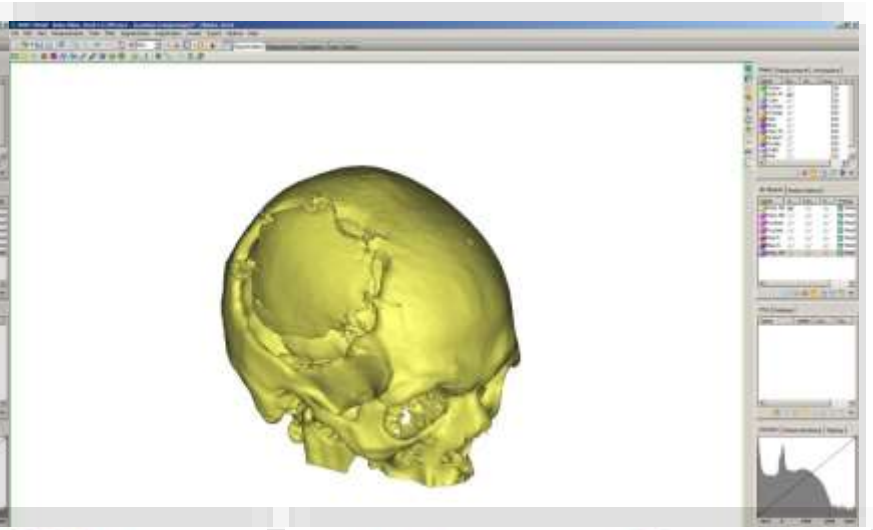


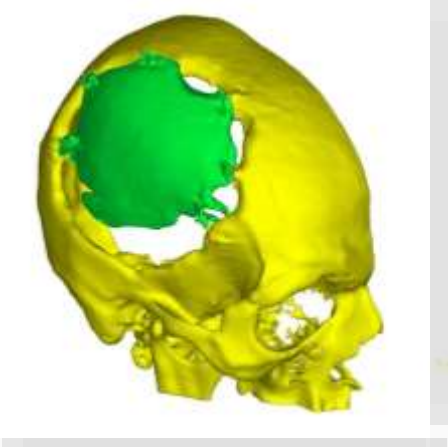


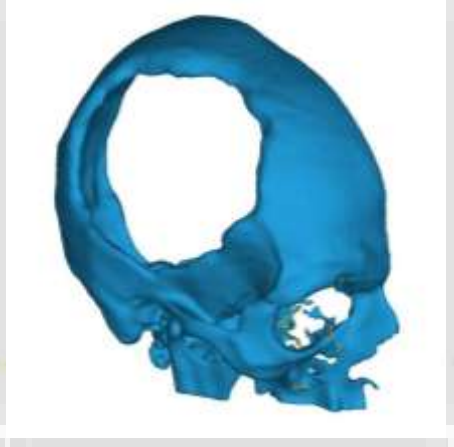


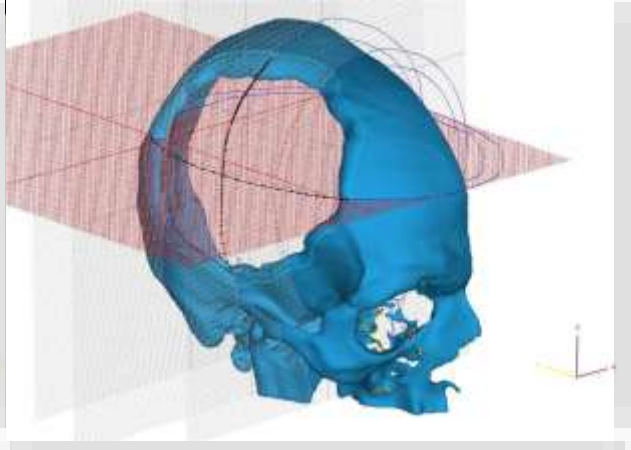

MEDICAL AM – CASE STUDY 1

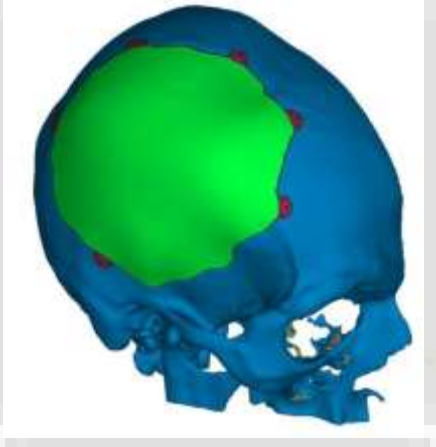


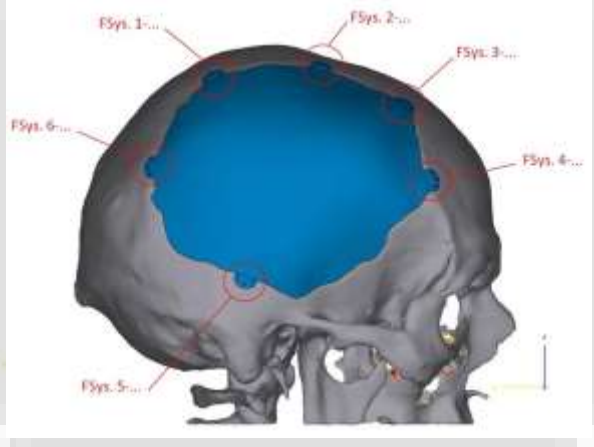




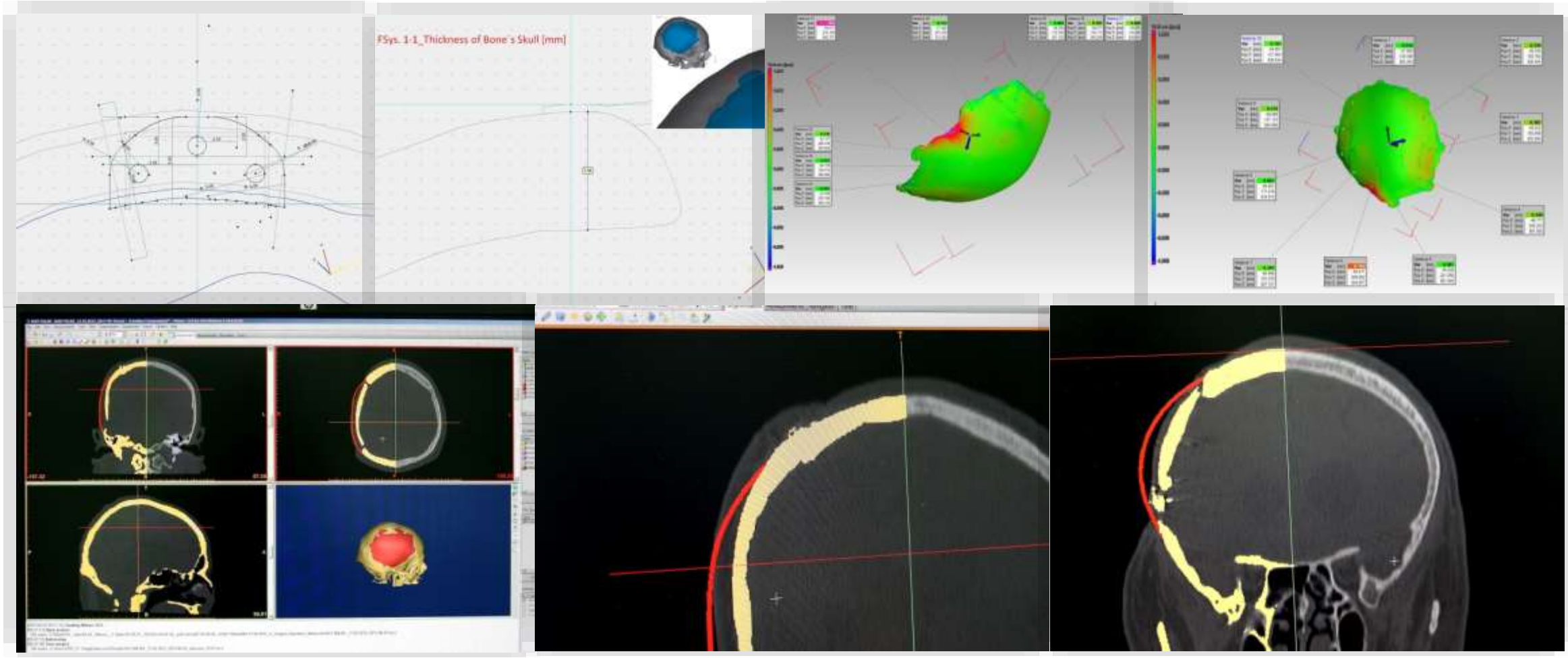




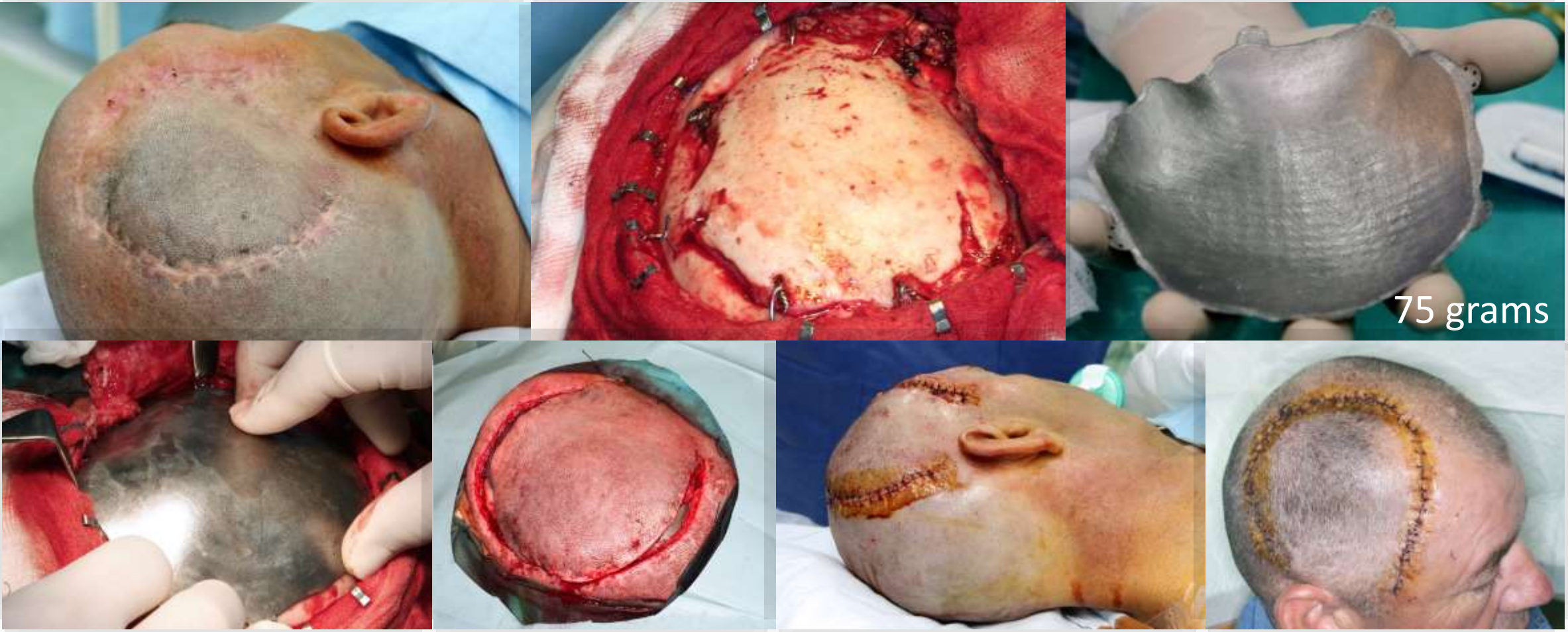




MEDICAL AM – CASE STUDY 1



MEDICAL AM – CASE STUDY 1

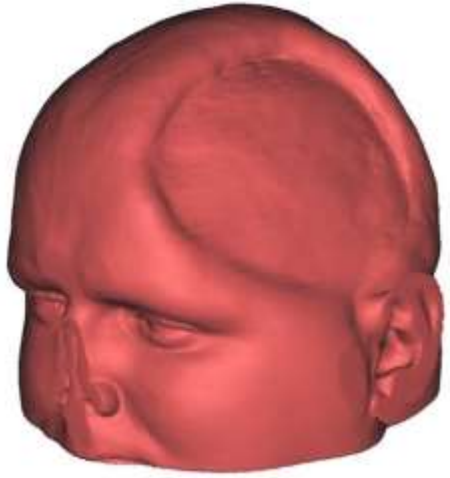


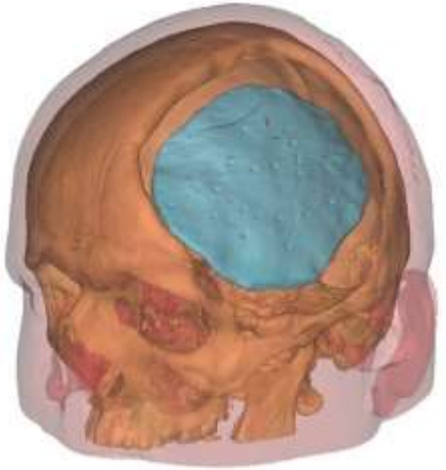
MEDICAL AM – CASE STUDY 1

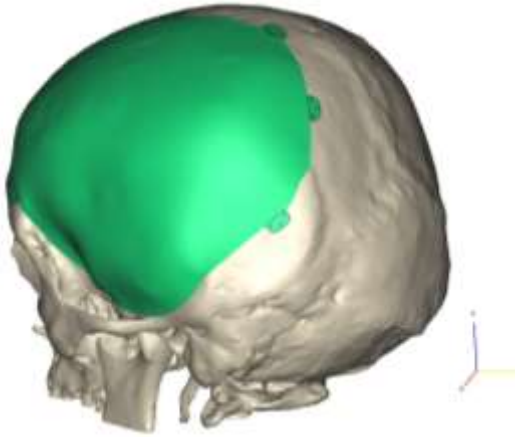
MEDICAL AM – CASE STUDY 2

Age: 30
Cause of the injury: fall from the building (9 year ago)
In coma after the accident
Difficulty to walk and speak
Large cranial deffect: 33,8%

Material: Ti-6Al-4V (Grade 5) titanium alloy
Weight: 125 g
Size: 120 cm^2
Technology: DMLS
Fixation: 21 screws, f 1,2 mm

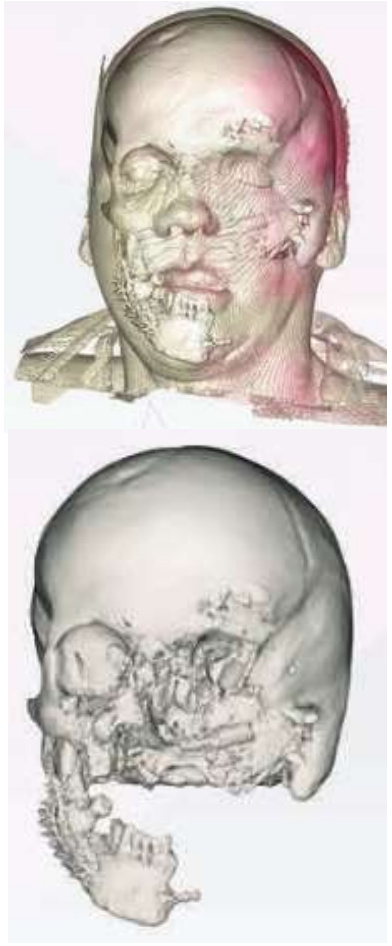


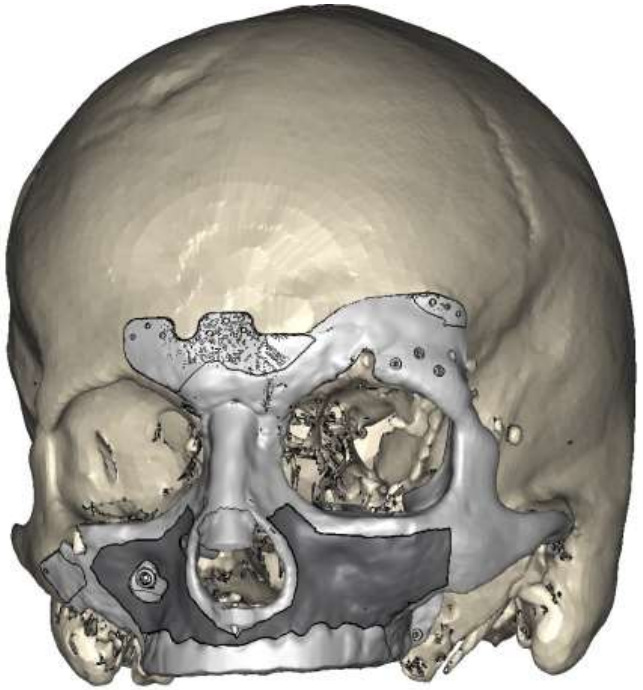


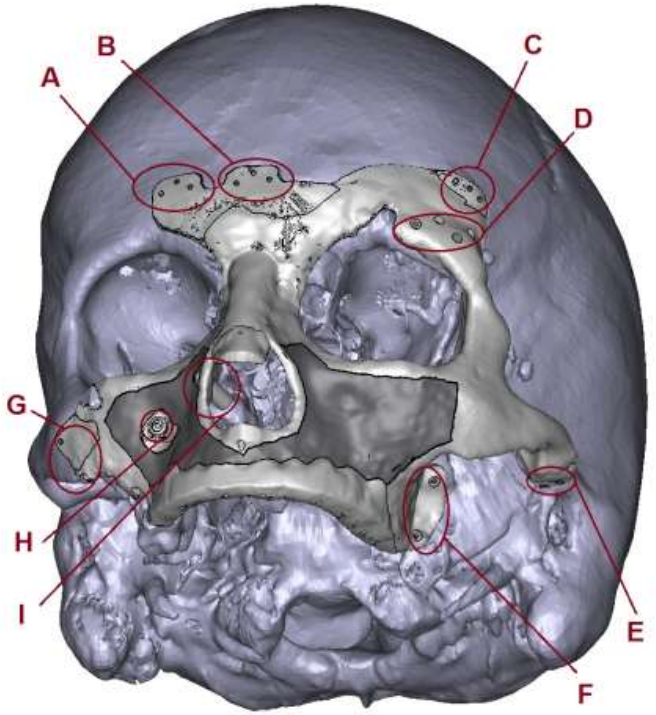


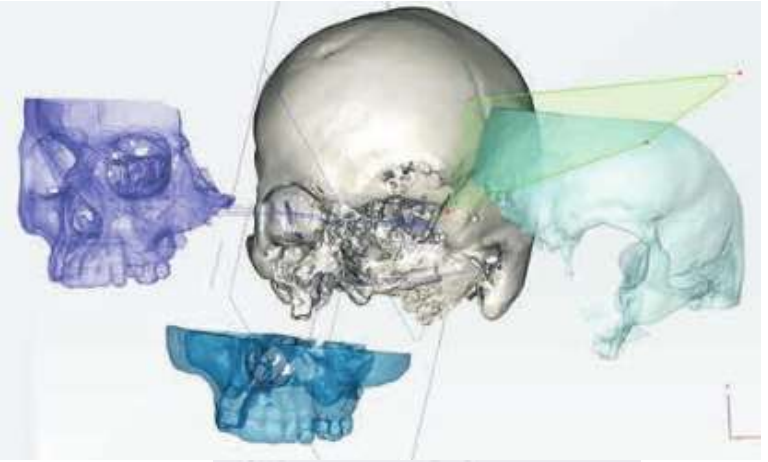
MEDICAL AM – CASE STUDY 2

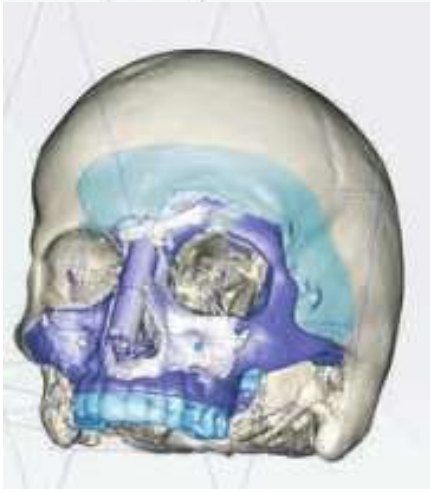
MEDICAL AM – CASE STUDY 3



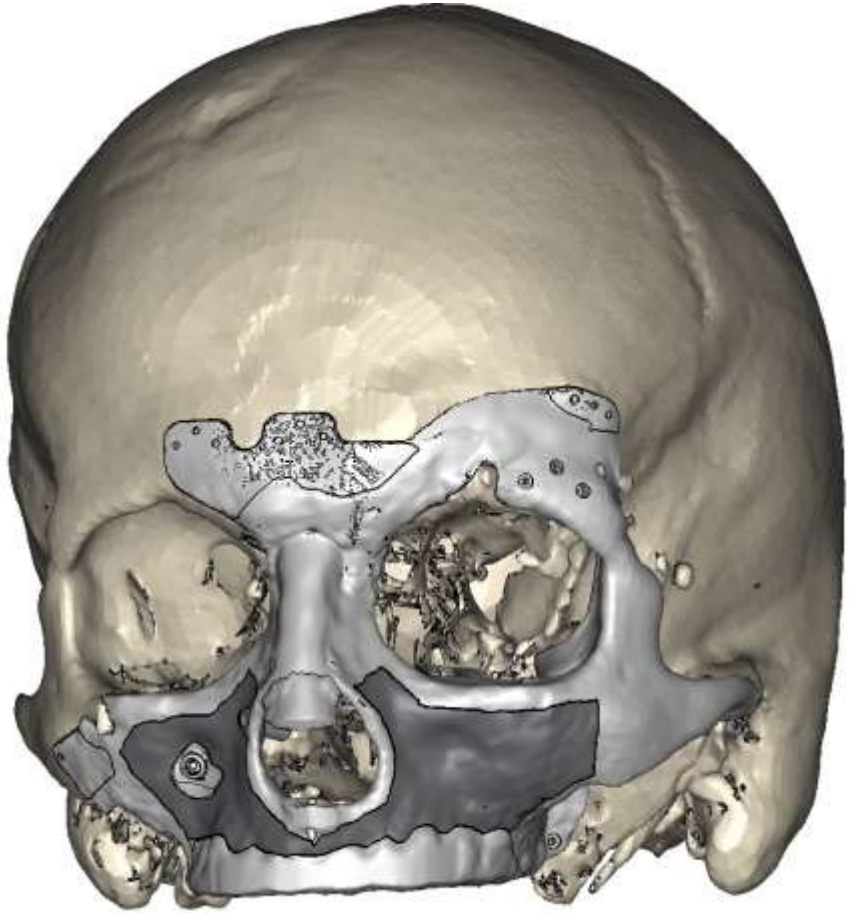


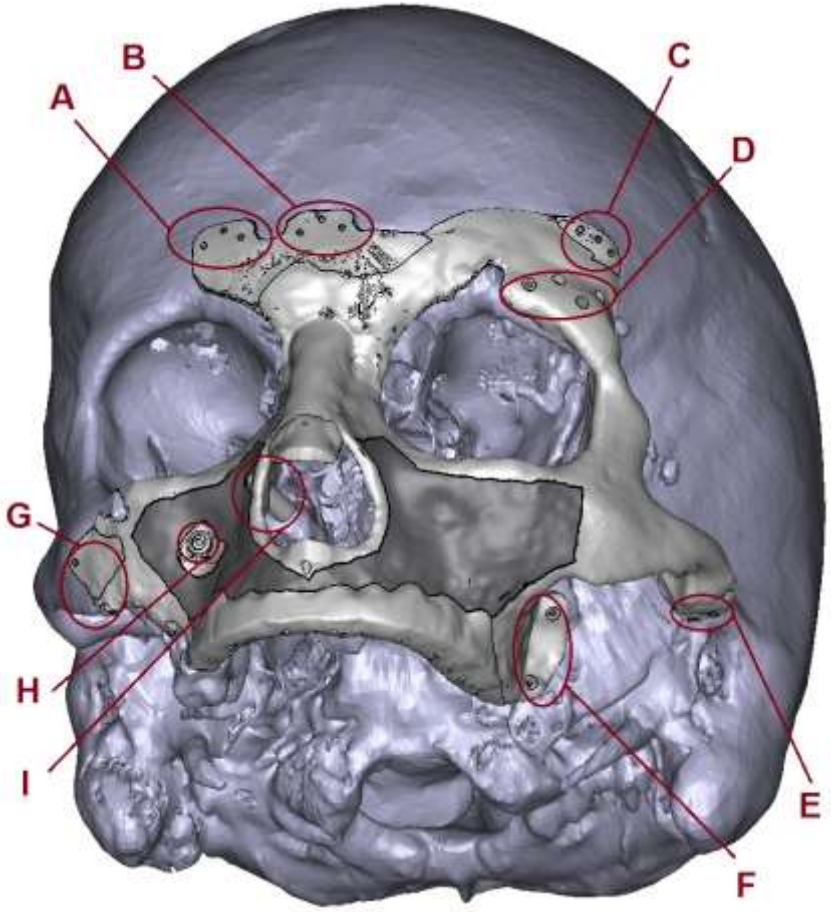






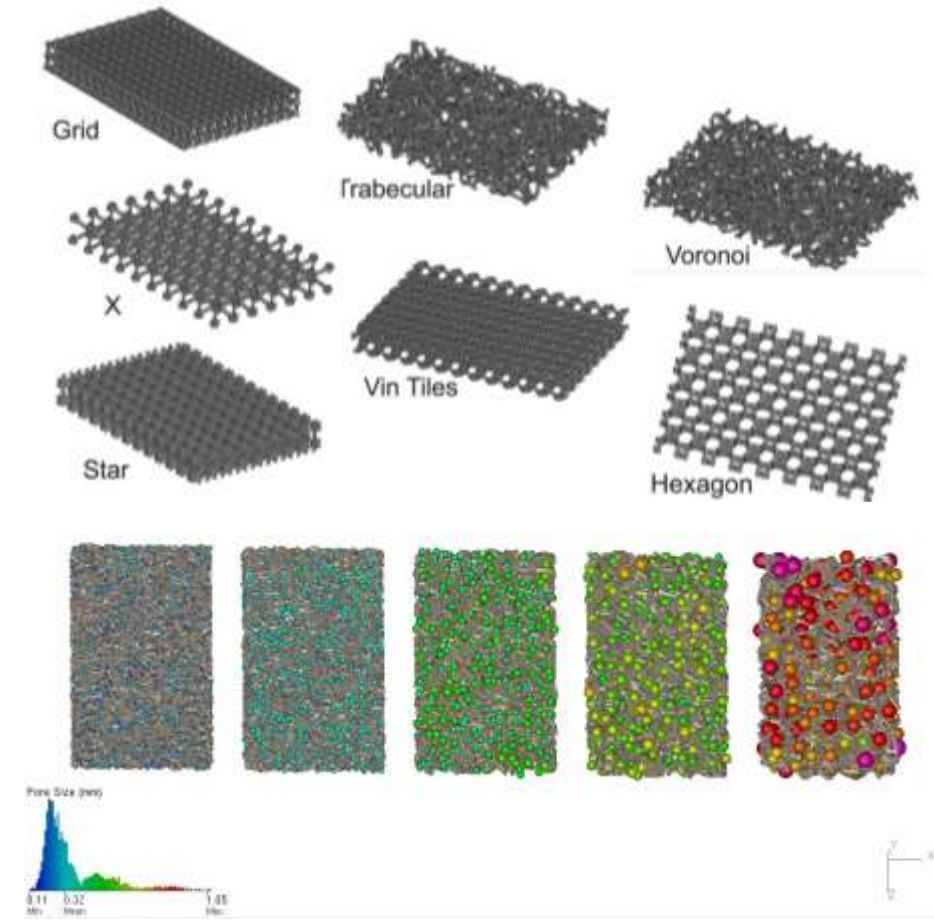
MEDICAL AM – CASE STUDY 3



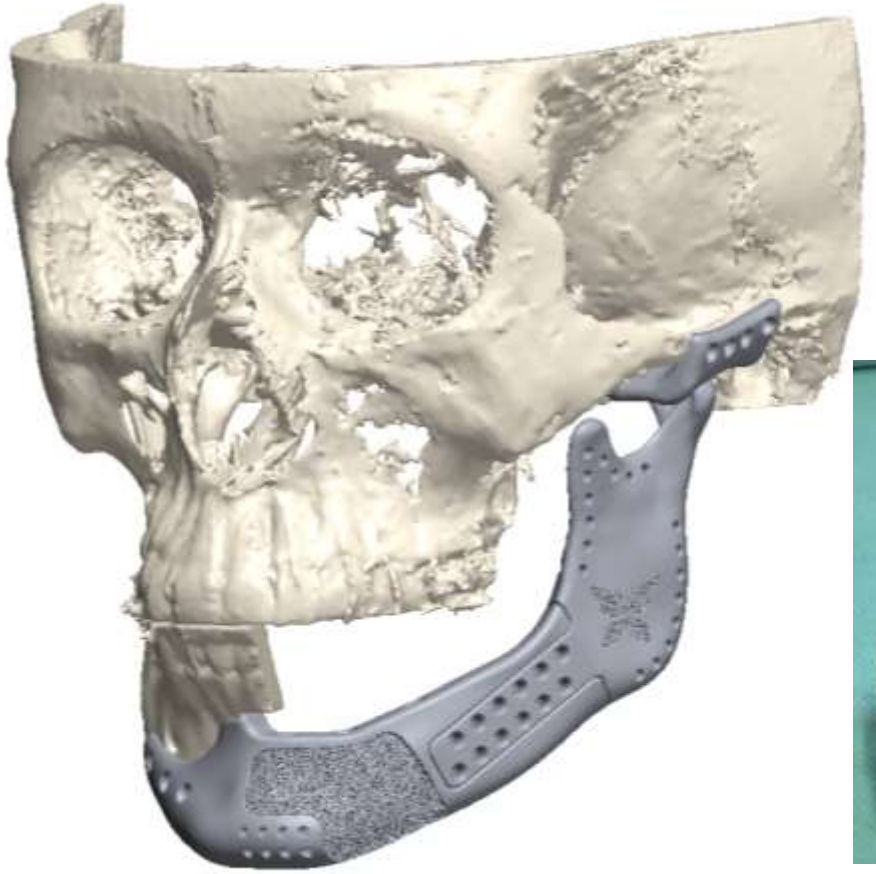


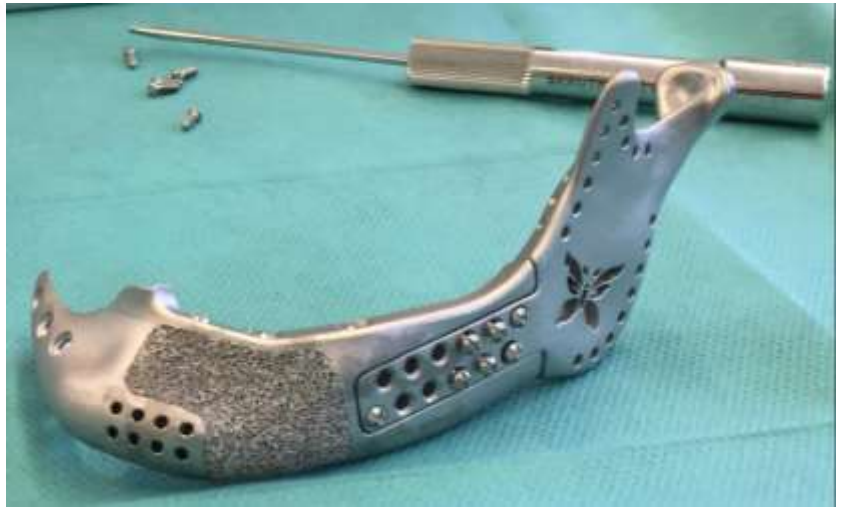
MEDICAL AM – CASE STUDY 3

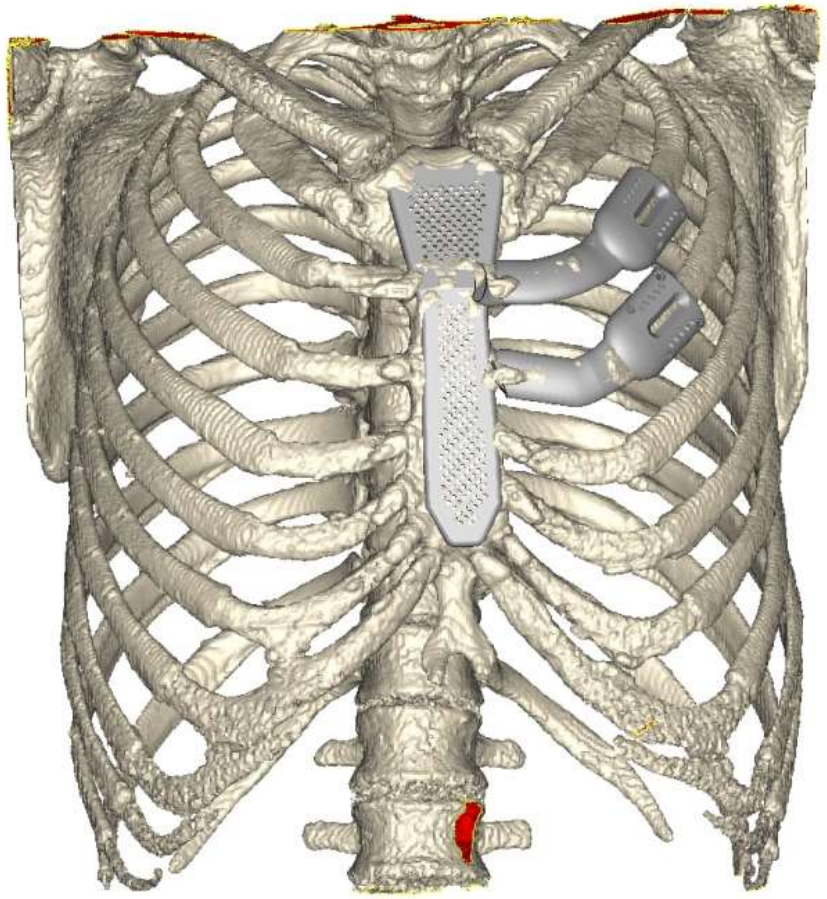
MEDICAL AM – POROUS STRUCTURES



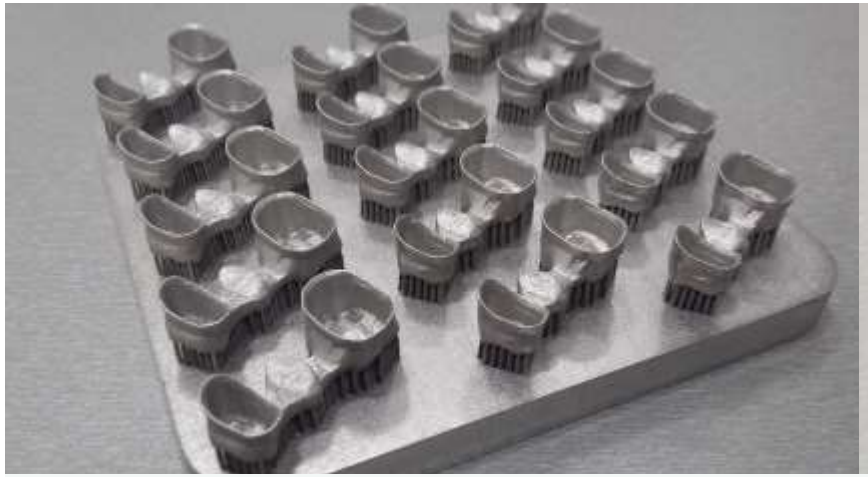
MEDICAL AM – OTHER CUSTOM IMPLANTS

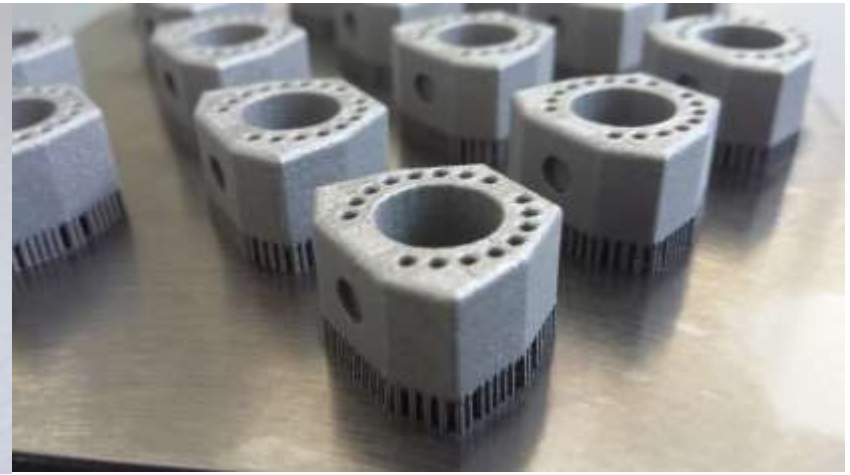






MEDICAL AM – R&D&CO-OPERATIONS





e-Manufacturing Solutions

ProSpon

ZEISS

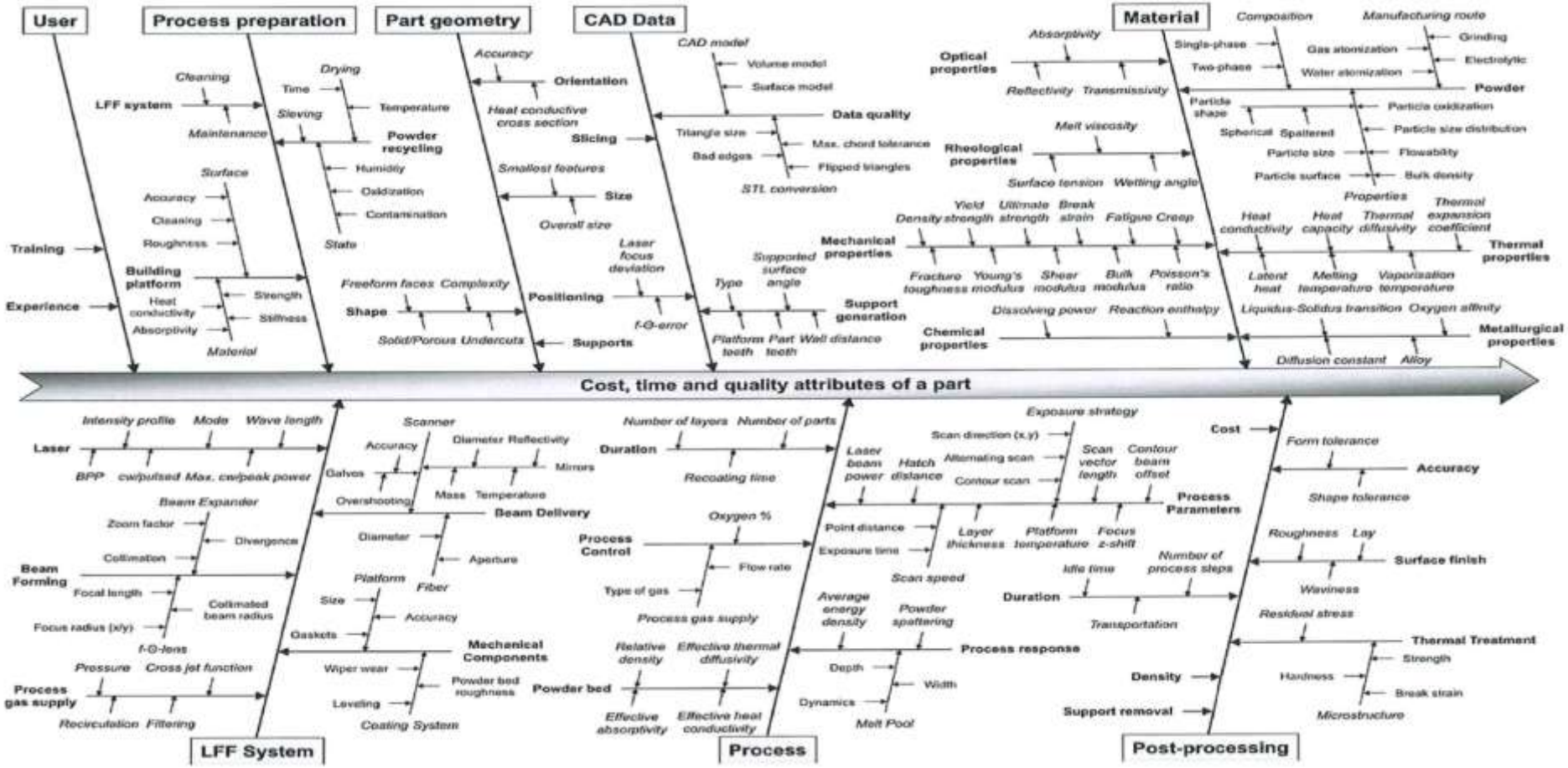
WITHIN

BEZNOSKA

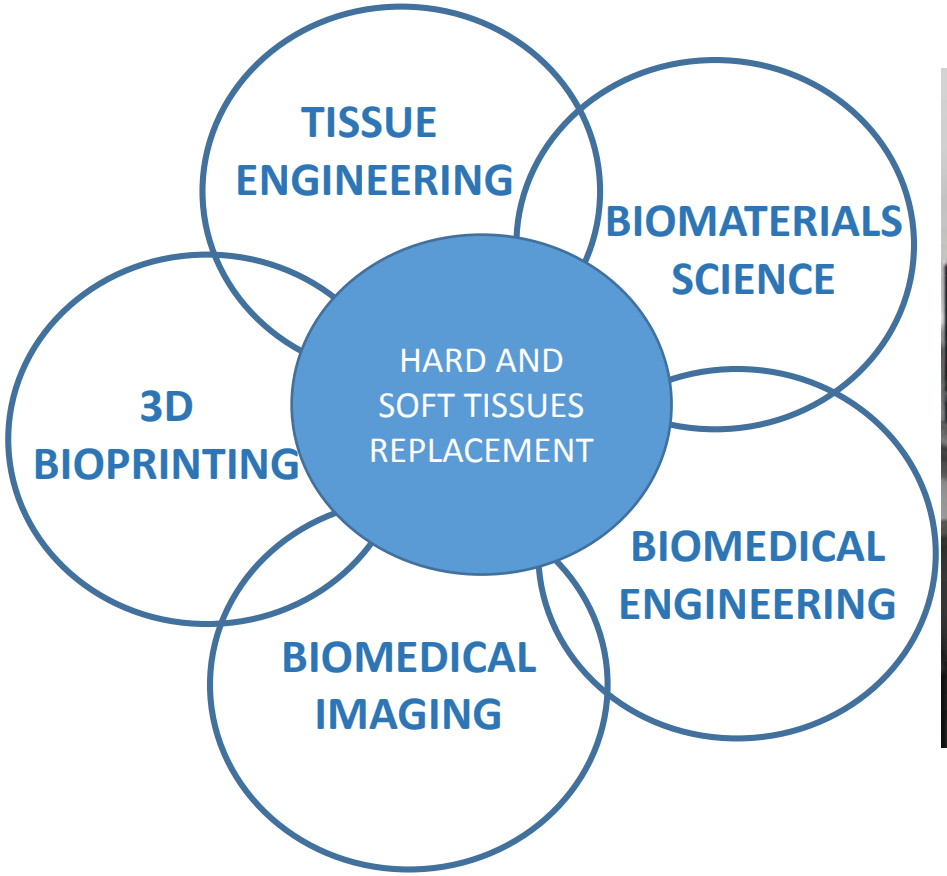
Materialise
innovators you can count on

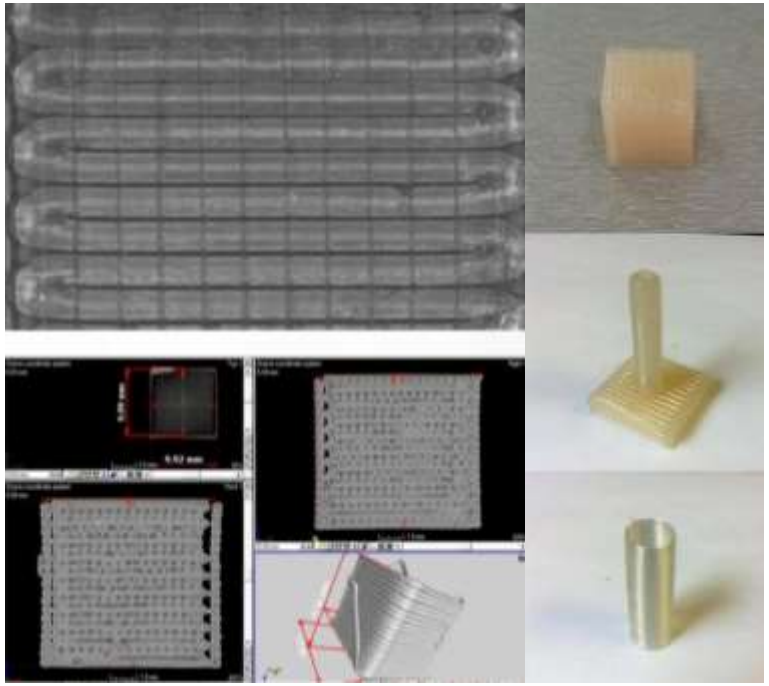
enbicore

AM PARAMETERS OPTIMIZATION COMPLEXITY - EXPERIENCES



FUTURE OF MEDICAL ADDITIVE MANUFACTURING





FUTURE OF MEDICAL ADDITIVE MANUFACTURING

ACTIVE PROJECTS

Manufacturing and testing of custom made bone scaffolds made of hydroxyapatite (HA) by use of 3D printing technology
(Budget: 250k €)

Analysis of the PEEK polymer and the additive manufacturing possibilities
(Budget: 250k €)

Design and complex characterization of biocompatible tubular 3D-scaffolds made of biosynthetic extracellular matrix intended as potential substitutes of damaged human urethra
(Budget: 250k €)

All projects are supported by Slovak Research and Development Agency (SRDA), Ministry of Education, Science, Research and Sport of the Slovak Republic

FUTURE OF MEDICAL ADDITIVE MANUFACTURING

PROJECTS IN PREPARATION PHASE

Project H2020: Distribute – Digitalization of supply chain and manufacturing digital transformation

MBP-22-2017 Business models and industrial strategies supporting novel supply chains for innovative product-services".

Applicant: *Aalto University School of Engineering, Department of Engineering Design and Production, Finland*

Partner: *CEIT Biomedical Engineering, Kosice, Slovakia*

Project INTERREG: INNOMED3D

Applicant: *Ortotip, d.o.o., Maribor, Slovenia*

Partner: *CEIT Biomedical Engineering, Kosice, Slovakia*

FUTURE OF MEDICAL ADDITIVE MANUFACTURING

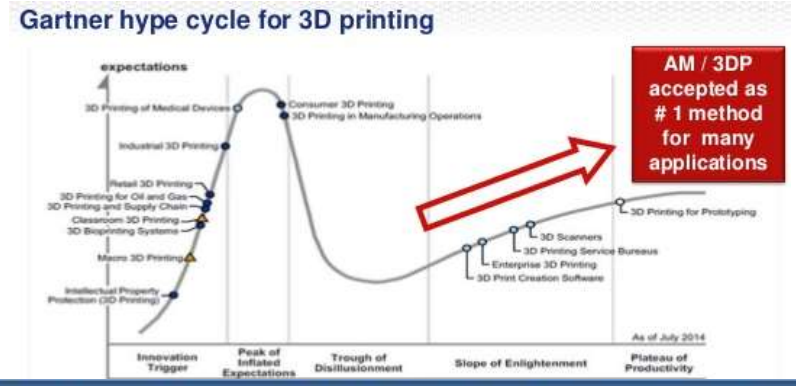
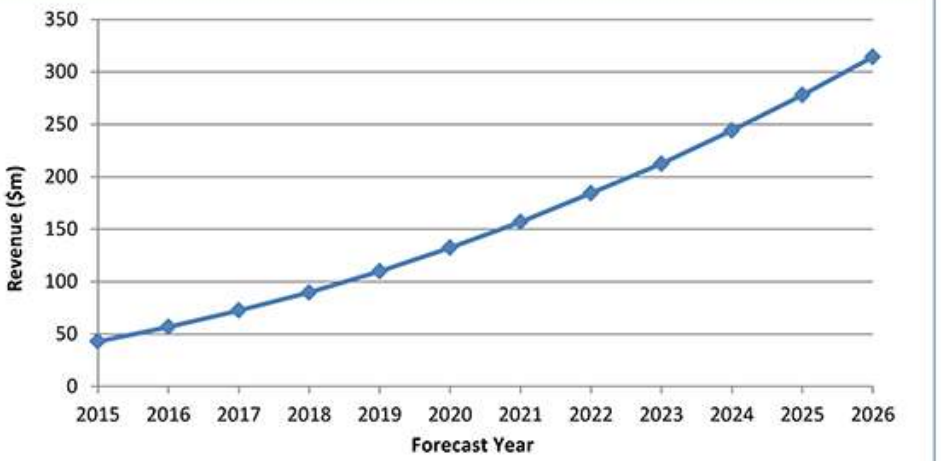


Figure 4.16 Spain: 3D Printing Market for Healthcare Revenue Forecast ($m), 2016-2026



-2026

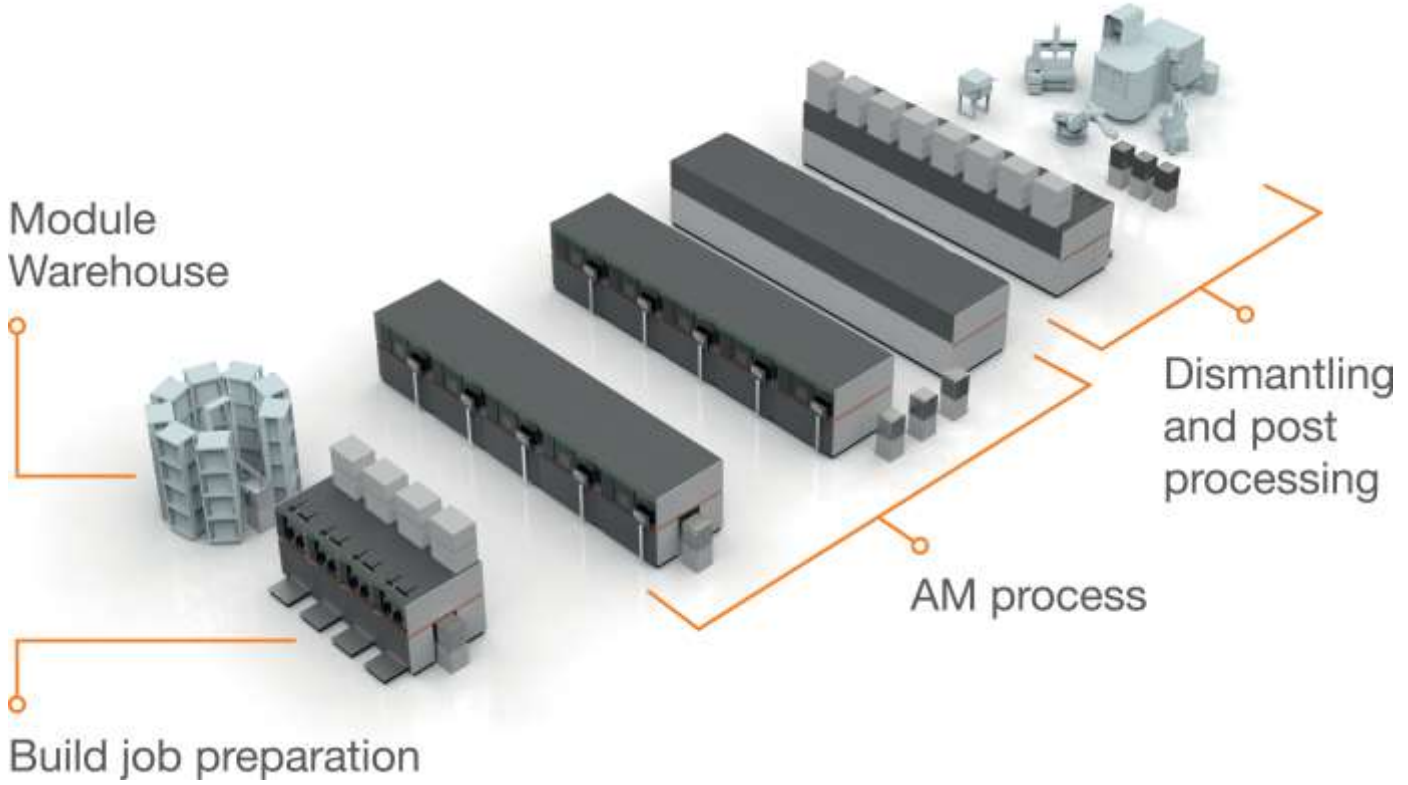


Photo courtesy of Concept Laser GmbH, May, 2016

FUTURE OF MEDICAL ADDITIVE MANUFACTURING

MORE INFORMATION

Contact:

Radovan Hudák

E-mail: radovan.hudak@ceit-ke.sk

Tel.: +421 905 820734