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BRIGHT

Erasmus+ strategic partnership for Higher Education

BOOSTING THE SCIENTIFIC EXCELLENCE AND INNOVATION CAPACITY OF 3D PRINTING METHODS IN PANDEMIC PERIOD

O4 - BRIGHT 3D Printing e-learning webinar

Project Title	**Boosting the scientific excellence and innovation capacity of 3D printing methods in pandemic period 2020-1-RO01-KA226-HE-095517**
Output	**O4 - BRIGHT e-learning webinars on the use of 3D printing technologies in development, testing and producing of medical parts in pandemic period – 3D Printing e-learning webinar description**
Date of Delivery	**30th of November 2022**
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Version	**FINAL VERSION**

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1 Introduction

This is a documentation regarding the webinar #3 of the BRIGHT project, focused on additive manufacturing (3D printing) of selected medical products. It presents methodology of manufacturing for 3 specific product cases:

1. individualized wrist ortosis
2. individualized pre-operative model of a tongue, including mold for casting and the casting process itself
3. personal protection shield

It is shown how to realize the manufacturing processes using various technologies, including Fused Deposition Modelling (FDM), stereolithography (SLA), PolyJet and others. Full processes are shown, including pre-processing and post processing.

The webinar was realized in the scope of BRIGHT project in year 2022 and is a direct result of IO4 - BRIGHT e-learning webinars related to the use of 3D printing technologies in the process of development, producing and testing of medical parts that can support hospitals in pandemic period.

The webinar is available on the BRIGHT project website by accessing the following link: https://bright-project.eu/?p=342

Webinar can be accessed directly also from YouTube, by accessing the following link: https://www.youtube.com/watch?v=qjtj8nDT0LU

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2 BRIGHT e-learning webinar #3 – 3D Printing

2.1 Main concepts and scheme of work

The BRIGHT e-learning webinar on 3D Printing is the third in the series of freely available educational videos, in which lecturers, scientists and practitioners from BRIGHT consortium present various aspects related to 3D printed medical parts, based on selected practical cases. The webinar presents various techniques of additive manufacturing of medical parts designed in previous webinars. Different technologies and materials are presented, as well as post processing techniques. Place of this webinar in the whole series is marked in Figure 1.

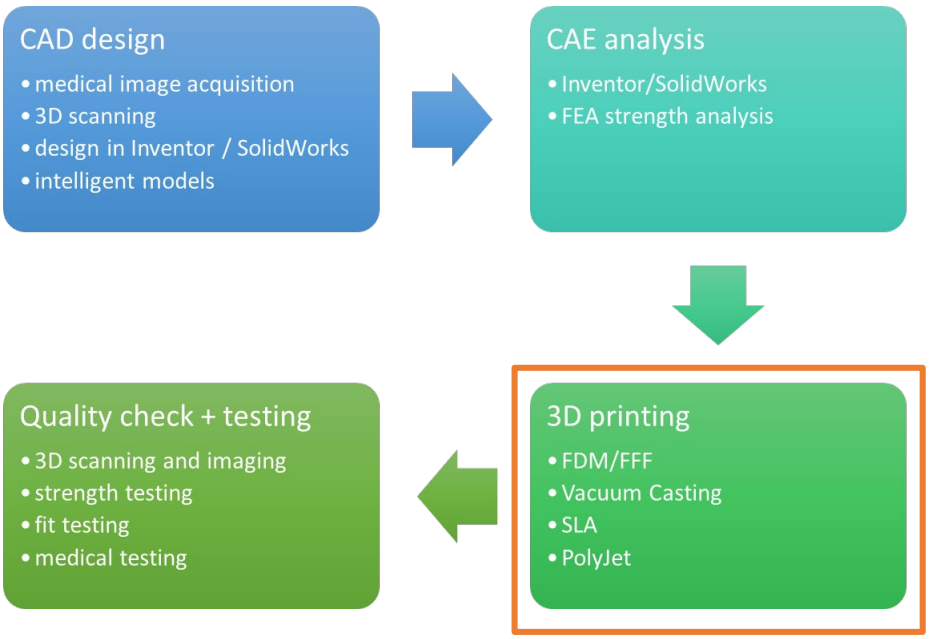

Figure 1. Place of 3D Printing webinar among other webinars

The 3D printing webinar presents the actual manufacturing of the case studies designed in the first webinar and analyzed in the second webinar. However, as in the other cases, it can be viewed as a standalone movie. It shows preparation of the processes and materials, realization of the various processes (3D printing and also casting), as well as post processing

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of obtained parts. This webinar is the longest of all, approximately 90 minutes in length, with many parts of the material sped up (timelapse recordings were made for some longer 3D printing processes). It is available directly on YouTube under the following link: https://www.youtube.com/watch?v=qjtj8nDT0LU

The webinar was taken for preparation by the team of Slovakian University of Technology. However, as all teams are experienced with the 3D printing and manufacturing processes, this webinar is the most diversified in terms of task distribution – all universities in BRIGHT consortium were engaged here. The general scenario is presented in Table 1.

Table 1. General scenario and responsibilities for the webinar #3 – 3D Printing

No.	Step (partial video)	Who?
1	Intro	STU
2	Review of 3D printing methods	UNIPU
3	Case 1 – FDM + post processing	PUT
4	Case 2 – FDM tongue	PUT
5	Case 2 – Vacuum Casting, PolyJet + post processing	PUT
6	Case 2 – SLA + post processing	TUCN
7	Case 3 – FDM	UNIPU
8	Case 3 – SLA + post processing	TUCN
9	Outro	STU

2.2 3D printing case studies

3.2.1. Case 1 – Wrist Hand Orthosis

The first case study is an orthosis used for wrist joint stabilization (see Figure 2). It is 3D printed using FDM technology, with one of the basic FDM technology materials: PLA, ABS, PET-G and PA-12 (nylon).

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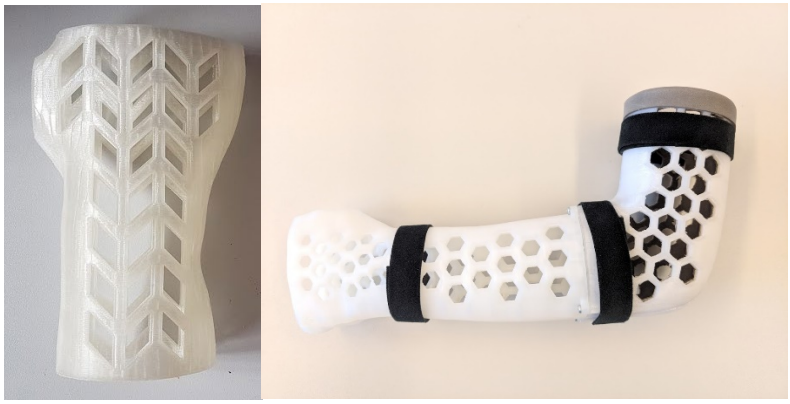

Figure 2. Wrist hand orthosis – different examples

For the webinar, an actual case has been selected – a patient with current wrist injury was invited specially for realization of the webinars. The patient was a 26-year old man, with an injury to his right wrist, caused by bite of a dog resulting in some bone crush. A full process was undergone and recorded for him, finished with obtaining a complete functional orthosis (see Figure 3).

Figure 3. Patient with the manufactured orthosis

3.2.2. Case 2 – Tongue with cancer tumor

The second case study is an anatomical model of a tongue with cancer tumor. The anatomical models of soft tissues can be produced either as hard models (for mid-surgery) using FDM technology and standard materials (ABS, PLA) or as soft ones (for simulated

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surgery before the operation) using resin casting, as shown in Figure 4. The soft models require 3D printed molds – these are prepared using FDM technology (Figure 5). For increased accuracy, hard or semi-soft models can be also obtained using SLA and/or PolyJet technology.

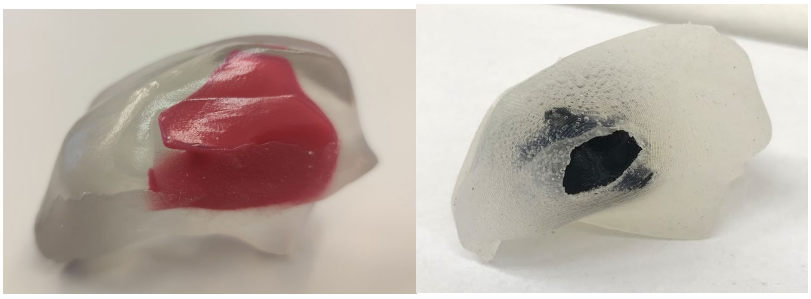

Figure 4. Models of tongue with cancer tumor, printed and cast

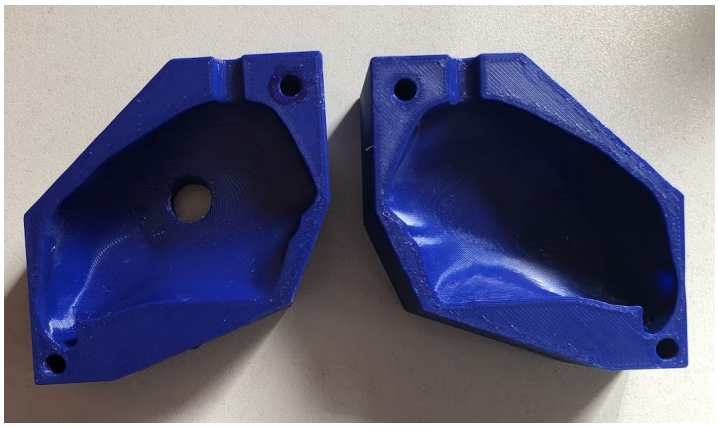

Figure 5. Casting mold of tongue printed with FDM technology

For the webinar, a clinical case of a cancer was selected in cooperation with Poznan University of Medical Sciences – it was a 53-year old woman with tongue cancer. By the time of webinars realization, the patient was already recovering after surgery, so it was not a current clinical case – however still relevant.

3.2.3. Case 3 – Face shield

The third case study is a 3D printable face shield, used in times of COVID pandemic as a quick-resort disposable protection device for medical personnel dealing with the infected. The 3D printed part is the head section, to which a transparent shield is attached, along with

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a rubber band holding the whole shield at user's head. The product was printed with success in Poland in beginning of 2020's pandemics, during the action "print for the doctor" (orig. "*drukuj dla lekarza*"), where hundreds of shields were supplied to hospitals and other medical facilities off charge (Figure 6).

Figure 6. 3D Printed assembled face shields for a hospital

The shield is printable by FDM technology (Figure 7) of any material – PLA and PET-G are recommended as being known for proper behavior in contact with user's skin. ABS and other materials could also be used, provided that there is no direct skin contact or sterilization is performed before and also after use. 3D printing of the head part takes approx. 20-40 minutes, depending on the material and printer used. For the purpose of webinar, both FDM and SLA prints were implemented, with SLA taking considerably longer time and requiring more advanced post processing.

Figure 7. 3D Printing of face shields using generic FDM printer

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2.3 Hardware and software, manufacturing parameters

For the FDM technology prints, the following machines were used:

1) FlashForge Creator Pro (Figure 8) – for all cases
2) Creality XR-10 (Figure 7) – for case study 3

The FDM process utilized standard settings – with layer thickness of 0,25 mm and 30% of internal filling. The used materials were PET-G (case 3), PLA (all cases) and ABS (case 2 – mold), with their temperature and velocity settings as recommended by their respective producers. Different colors were used, mostly white, blue and red.

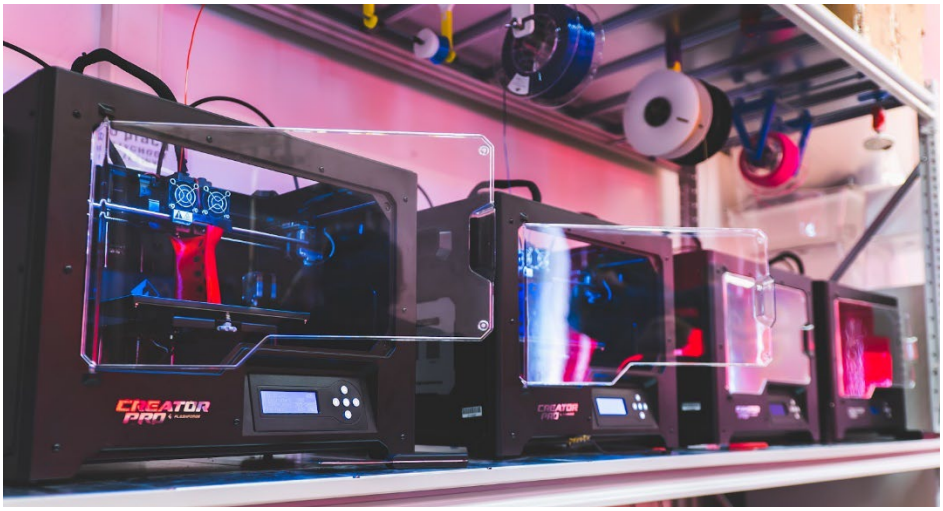

Figure 8. FlashForge Creator Pro – orthosis 3D printing

In case of the PolyJet technology, MediJet J5 printer by Stratasys was used (Figure 9). Standard settings were utilized during the printing, with 18 micron layer thickness. For the tongue, transparent VeroUltra Clear S material was used. For the tumor, combination of four colors (VeroCyan, VeroMagent, VeroYellow and VeroBlack Plus) were used to obtain a dark red color (as visible in Figure 4). Also, a post processing station with water jet device was used (as visible in Figure 9). Support structures in PolyJet are soluble (synthetic wax) and can be removed just by pressurized stream of water.

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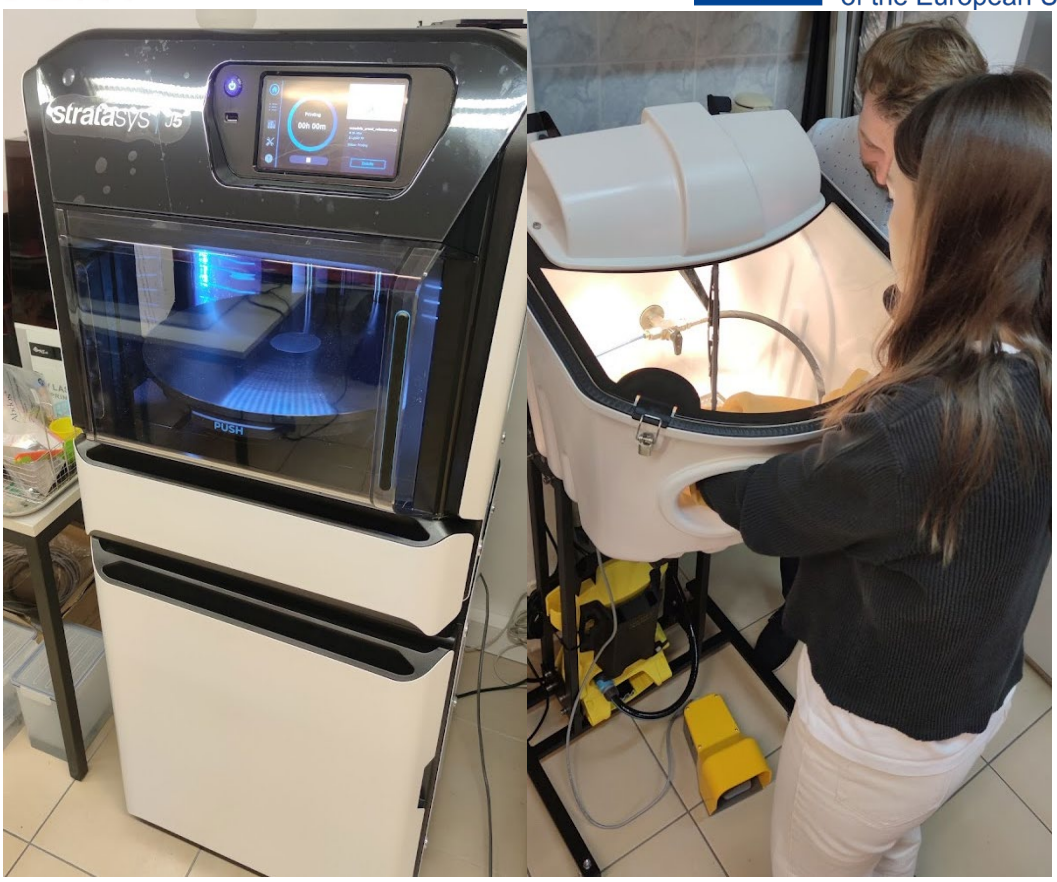

Figure 9. MediJet J5 PolyJet printer (left) and cleaning station (right)

In the case of SLA, two machines were used: Anycubic Photon Mono for the tongue and Anycubic Photon Mono X 4k for the face shield (Figure 10). Both work in the LCD-based SLA technology. Anycubic Standard Resin+ material was used in both cases. For the face shield, 0.5 mm layer thickness was used, while for the tongue, lower value of 0.1 was used. In both cases, the products were post-cured using Anycubic Cure Plus Machine (Figure 11), in time of 5 minutes, after previous cleaning in isopropyl alcohol.

The following slicer software was used:

1) Simplify 3D
2) Cura
3) Stratasys PolyJet software (issued with the machine)
4) Photon Workshop V2 (Figure 12)

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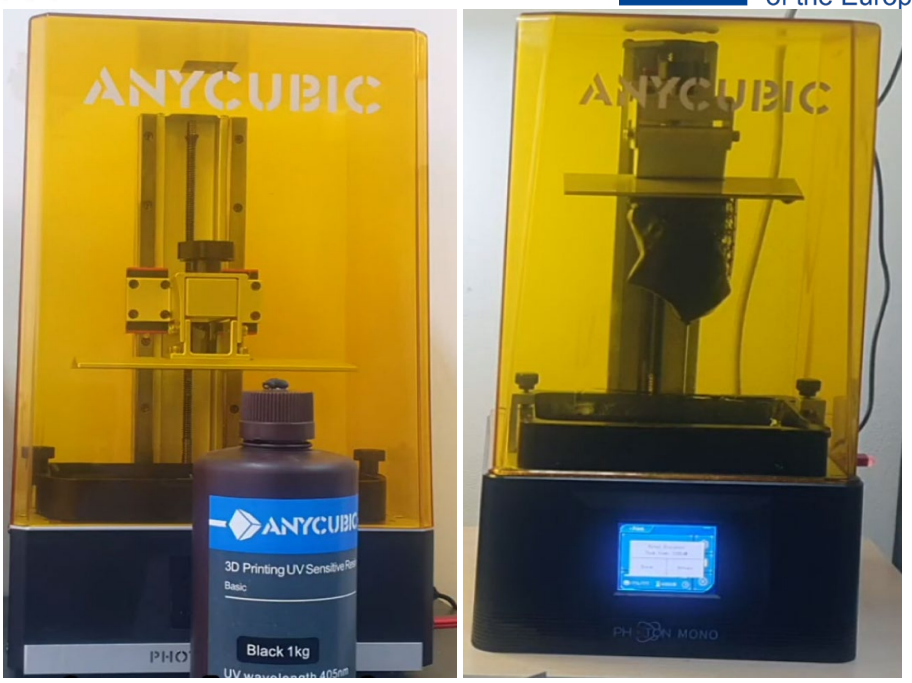

Figure 10. Anycubic SLA machines used for case 2 and 3

Figure 11. Anycubic SLA post-curing machine

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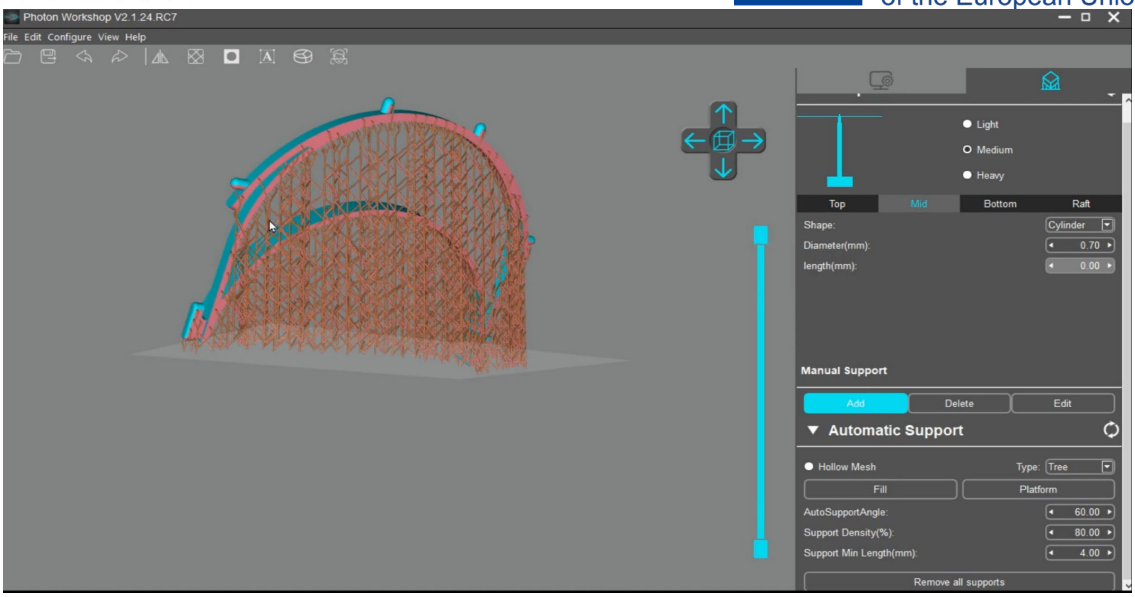

Figure 12. Photon Workshop slicer for SLA

2.4 Course of the webinar

The webinar starts with the intro credits and then the introduction is realized. It is done by representatives of UNIPU team. The 3D printing technology is introduced and shortly described (Figure 13).

Figure 13. Webinar #3 – introduction

Then, it's all focused on manufacturing of specific case studies. Case 1 is 3D printed using a FlashForge Creator Pro 3D Printing machine. The preparation of the machine, as well as the

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printing itself is presented in Figure 14. Figure 15 shows how the post processing stage was recorded – the orthosis needs a number of specific manual operations and they are fully covered in the webinar.

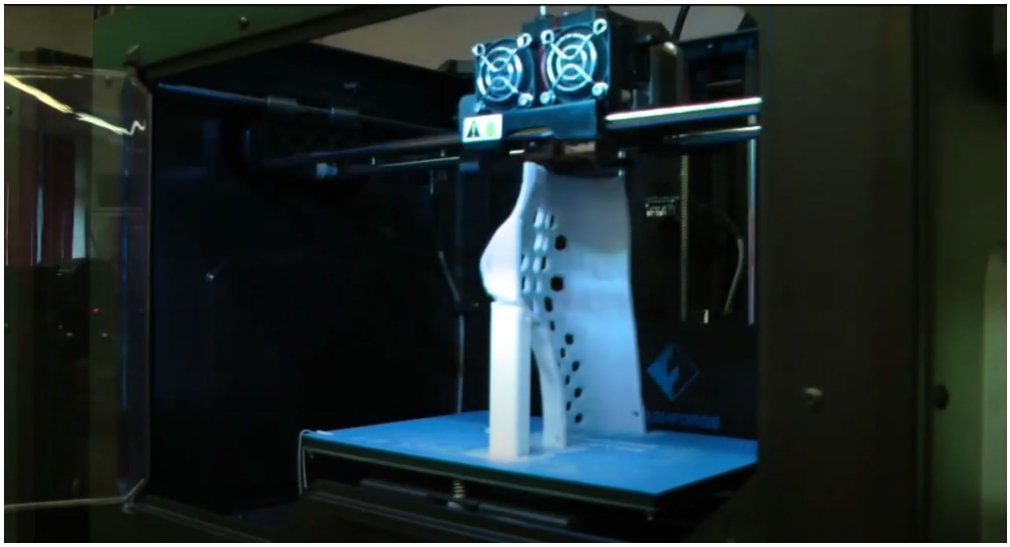

Figure 14. Webinar #3, 3D printing, case 1

Figure 15. Webinar #3, 3D printing – post processing, case 1

Then, the second case study is presented. First, very short timelapse of FDM printing of tongue is presented (Figure 16). Then, casting process is presented in full, using 3D printed mold (Figure 17).

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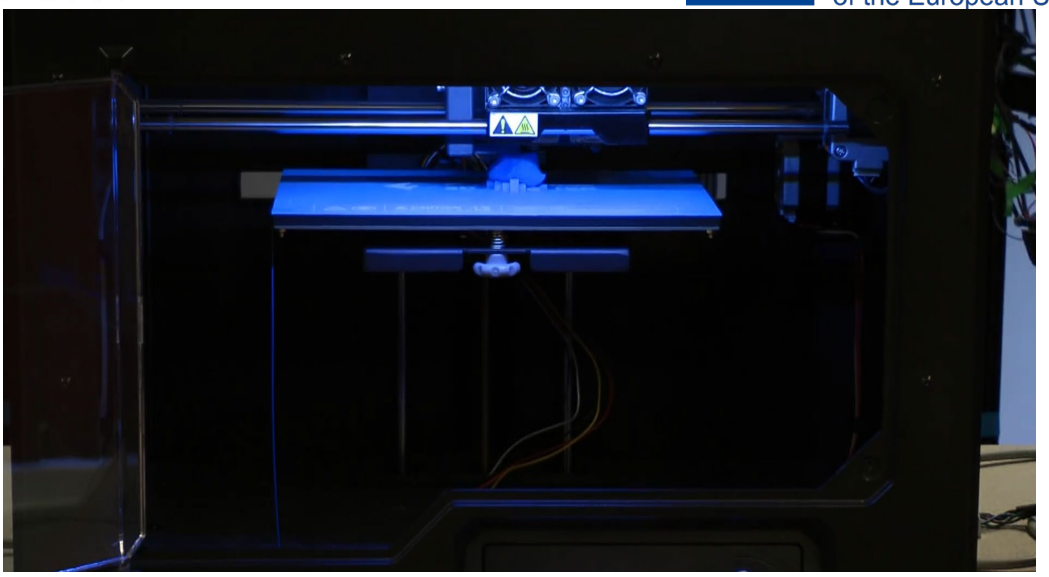

Figure 16. Webinar #3, FDM 3D printing – case 2

Figure 17. Webinar #3, resin casting – case 2

Then, the 3D printing of second case is shown using the PolyJet technique. Software part is shown (as opposed to FDM, this is not trivial), then timelapse of the layer deposition is presented (sped up x250, Figure 18). Finally, post processing (support removal by use of water jet) is presented (Figure 19).

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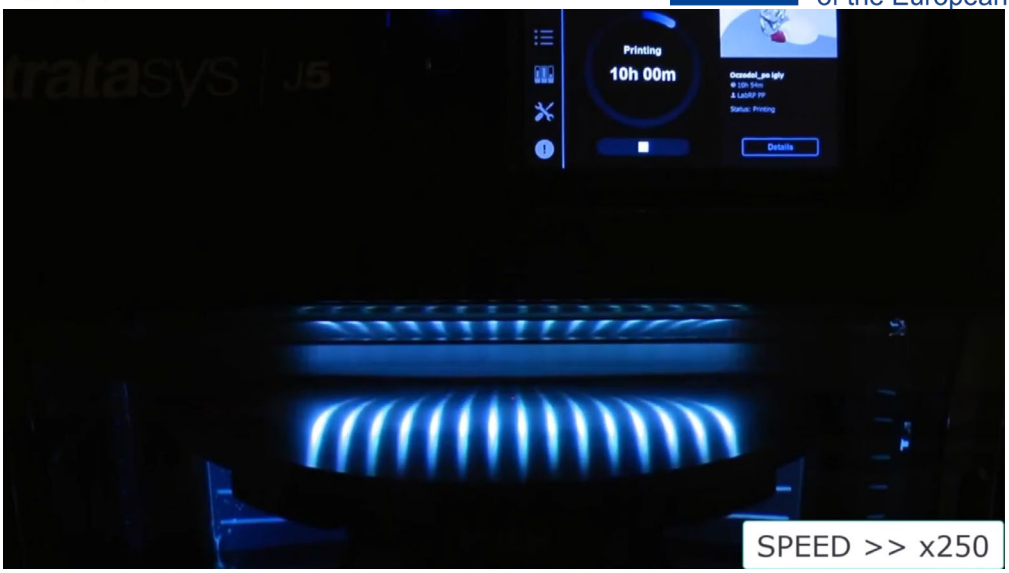

Figure 18. Webinar #3, PolyJet 3D printing – case 2

Figure 19. Webinar #3, PolyJet 3D printing – post processing – case 2

Another, last 3D printing technology for that case is SLA – resin printing. Here again everything is shown – machine preparation, software part, 3D printing (Figure 20) and post processing (cleaning and post curing – Figure 21).

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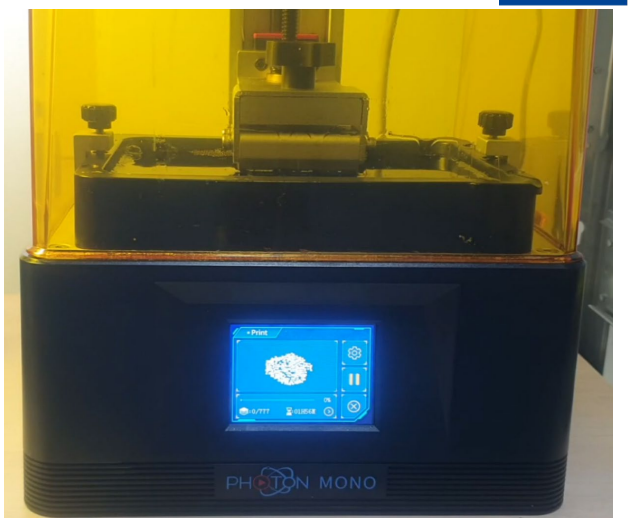

Figure 20. Webinar #3, SLA 3D printing – case 2

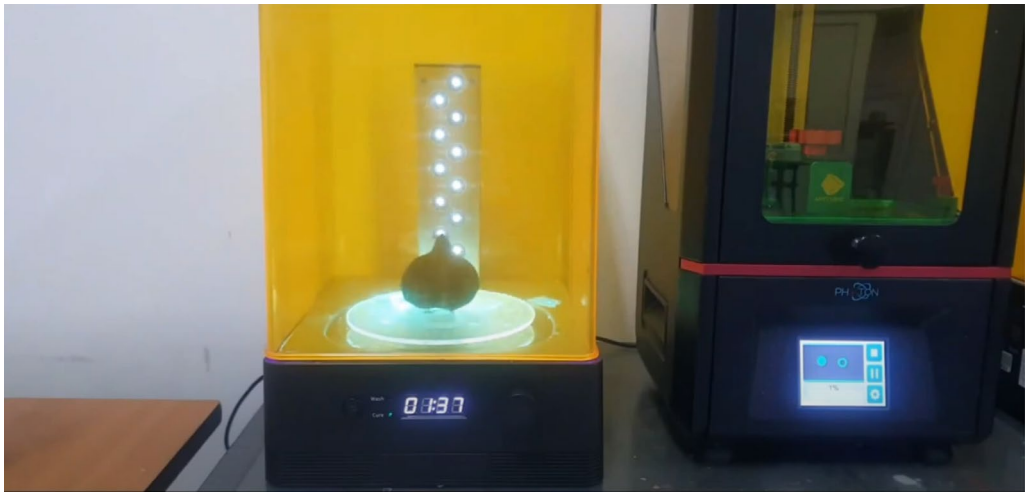

Figure 21. Webinar #3, SLA 3D printing – post processing – case 2

For the final case, two processes are shown: FDM and SLA 3D printing. The product is relatively simple, so for the FDM it was done really shortly (Figure 22). For the SLA, to show capabilities of supporting structures in SLA, it was printed at an angle, also – a different machine was used for the process. Again, whole process is demonstrated (Figure 23).

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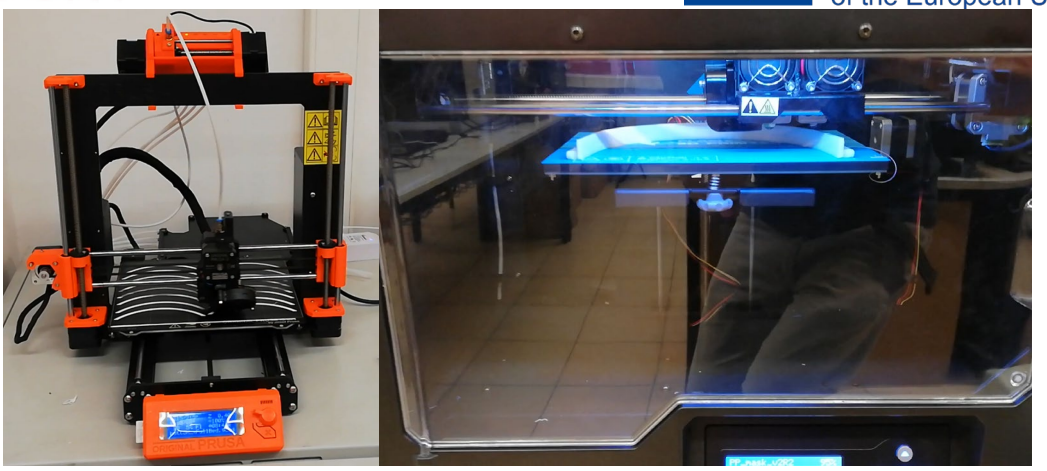

Figure 22. Webinar #3, FDM 3D printing – case 3

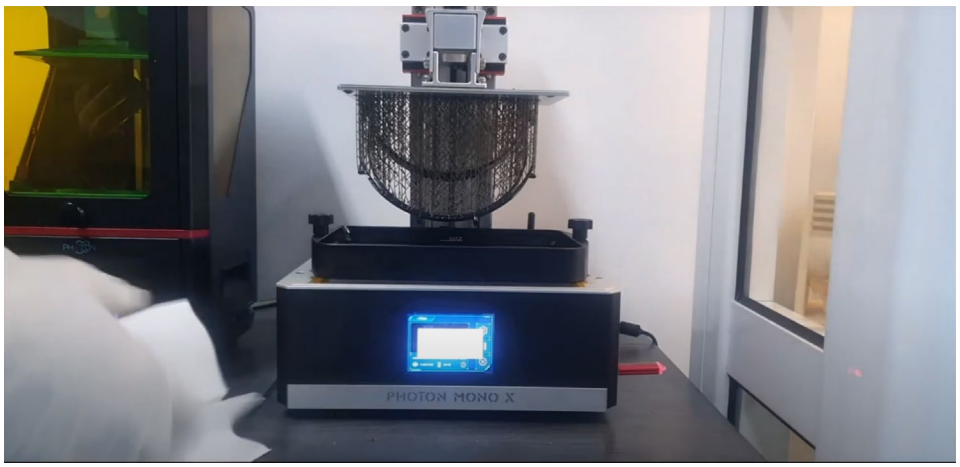

Figure 23. Webinar #3, SLA 3D printing – case 3

The case studies and technologies presented in the third webinar show great diversity and capabilities of current 3D printing technology. It was shown how a single product can be manufactured directly using various technologies – FDM, SLA, PolyJet – and also how 3D printing and casting can be combined to get products of controllable properties (notably, of soft materials), by using a technique of resin casting in FDM 3D printed molds, with aid of vacuum. The viewer can learn how this should be done using different types of technologies, also including the preparation of programs, as well as post processing, which makes for a full picture, very important from educational point of view.

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3 Summary

In this document, third webinar of BRIGHT project was briefly described. Motivations, concepts, work plan and distribution were presented, as well as selected case studies. Used software and input data were specified. Course of the webinar was also presented. All the screens come from the webinar itself. The webinar is also a documentation of manufacturing phase of 3 out of 5 case studies realized in the BRIGHT project. The webinar is of high educational value for students wanting to learn how to manufacture various medical products using various modern 3D printing technologies.

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