

# Implementing Master Program on Digital Broadcasting and Broadband Technologies

Siniša Ilić, Mile Petrović, Branimir Jakšić, Slobodan Bojanić, Petar Spalević and Ranko Babić

**Abstract** — The paper presents the mid-term results of the implementation of Master study program on Digital Broadcasting and Broadband Technologies in Western Balkans countries. In this period the teaching courses are developed and the corresponding laboratory equipment is acquired. The project takes part of the Erasmus+ program for Capacity Building in Higher Education. In the rest of the project lifetime the new courses will be carried out altogether with laboratory exercises.

**Index Terms** — Digital Broadcasting and Broadband Technologies, Western Balkans, Erasmus+, Capacity Building in Higher Education.

*Review Paper*

DOI: 10.7251/ELS17211001

## I. INTRODUCTION

The paper presents the mid-term results of Erasmus+ project which aims to implement the modern master study programme and thus provide education for the specialists in the field of Digital Broadcasting and Broadband Technology [1]. This study profile is in line with the needs of labour market and upcoming transfer from Analogue to Digital Broadcasting in regional partner countries.

The graduated students will be capable to apply acquired knowledge in the business environment, to speed up digitising of broadcast services and to implement and maintain modern and improve existing Broadcast and Broadband Communication Systems. In this way, the long-term sustainability of the project will be achieved. To acquire theoretical and practical knowledge immediately applicable in the real circumstances, the new laboratories are created with appropriate hardware and

Manuscript received: May 18th, 2017

Received in revised form: February 7th, 2018

The paper is created within the project “Implementation of the study program – Digital Broadcasting and Broadband Technologies (Master studies)” that is co-funded by the Erasmus+ Programme of the European Union.

Siniša Ilić, Mile Petrović, Branimir Jakšić, Petar Spalević and Ranko Babić are with Faculty of Technical Sciences, University of Pristina in Kosovska Mitrovica, Serbia (phone: +381-28-425-325; fax: +381-28-425-322; e-mail: ({sinisa.ilic, mile.petrovic, branimir.jaksic, petar.spalevic, ranko.babic}@pr.ac.rs).

Slobodan Bojanić is with the ETSI Telecomunicacion, Universidad Politecnica de Madrid, Spain (e-mail: slobodan.bojanic@upm.es).

\*Kosovo under UN resolution 1244.

software equipment for analysis and design of broadcasting and broadband systems with digital multimedia High-definition television (HDTV) studio and environment for implementation of digital services. This Master will improve existing state in the area of digital technologies (particularly in digitising of Radio and Television and improving of multimedia broadband services) in Western Balkans (WB) countries in accordance with the best practice [2] in European Union (EU).

The project will have an impact on the current state in the field of digital communications technologies in Kosovo (under UN resolution 1244), Bosnia and Herzegovina and Serbia due to the mandatory digitisation of broadcast services according to standards established by competent international organizations and adopted also by the EU. As a consequence, the development of digital communications technologies activates other business branches in the Western Balkans.

Therefore the project enables professional training for effective digitization of existing analogue services, maintenance, upgrading, innovation and technical sustainability of new digital services: Digital Video Broadcasting - Terrestrial (DVB-T), Digital Video Broadcasting - Handheld (DVB-H), Digital Audio Broadcasting (DAB), Digital Radio Mondiale (DRM), Digital Multimedia Broadcasting (DMB) and Hybrid Broadcast Broadband TV (HbbTV) for the region of Southeast Europe.

## II. BACKGROUND

International Telecommunication Union (ITU) at the Radio-Communication conference in Geneva (RRC-06) made a decision that all European countries (including countries of the former Yugoslavia) have obligation to no later than 17 June 2015 to change analogue video broadcasting with digital television and radio signals broadcasting [3].

Trough digitalization of analogue terrestrial television frequent spectrum become free for purpose of digital television and various digital services such as digital radio with supplement services, digital mobile TV and other mobile services with multimedia content.

All European and the Western Balkan countries committed to start digital terrestrial broadcasting by June 17<sup>th</sup> 2015 the latest (by the acts of the Regional Radio Communication conference in Geneva RRC-06 organised by ITU) and stop with analogue broadcasting of TV signal. Many European countries have already started digital broadcasting and they already have some new digital services parallel to digital TV and Radio. The countries of south-east Europe: Serbia, Montenegro, Romania,

Albania and Greece have already started the process of transferring to digital broadcasting, but Bosnia and Herzegovina and Kosovo\* have not yet [4].

According to the data of National Agencies for Radiocommunication, 21 TV and 83 Radio stations need to start digital broadcasting in Kosovo\* [5], 43 TV and 141 Radio station in Bosnia and Herzegovina [6], 319 Radio stations in Serbia [7], 52 Radio stations in Montenegro [8], 79 Radio stations in Macedonia [9], and 69 Radio stations in Albania [10].

One of the reasons why digital broadcasting is not completed is the lack of experts and experience in this area. The number of specialists in WB countries is low compared to the number of needed digital services. By transferring to the digital broadcasting, the frequency range occupied by analogue broadcasting can be used for: digital TV, Radio, digital services, digital TV for mobiles and other services with multimedia content. Also, some additional broadband technologies can be used in this frequency spectrum. Broadband services (internet TV, 3G and 4G networks for mobile devices) in WB countries are implemented partially and compared to the EU countries in arrears in both: quality and quantity of services. The WB countries that aim to join EU will have to increase quality of broadcast and broadband services according to the standards of EU countries.

For the purpose of speeding up digitization of existing analogue services, maintenance, upgrading, innovation and technical sustainability of new digital services, University of Pristina - Faculty of Technical Sciences, Kosovska Mitrovica, Kosovo\*, applied for Erasmus+ project under the name: Implementation of the study program Digital Broadcasting Technologies (DBBT) - Master studies. It is based on the fact that there is a lack of experts in the area of information and communication technologies (ICT) in the Western Balkan countries, especially in broadcast and broadband technologies.

The rapid increasing of the number of Radio and TV stations in transition period of WB countries and the lack of professionals resulted in lower quality of multimedia services. A large number of Broadcasting stations in Kosovo\*, Serbia and Bosnia and Herzegovina do not respect quality standards for the moving images, sound and multimedia. The main reason is broadcasting of analogue signal. Transfer to the digital broadcasting will solve the problem of multimedia quality.

Therefore the project aims to introduce the new master study programmes for academic and vocational studies in the field of Digital Broadcasting and Broadband Technologies (DBBT) which is in line with the needs of business partners from the regional labour market and in line with modern study programmes from EU countries. The students will be able to apply their practical and theoretical knowledge immediately after graduation.

The graduated students will be able to develop the multimedia applications on smart phones and tablets, applications for smart TV, modelling of IP and wireless networks and wave propagation, etc. The master study programme enables formation of the specialists needed for the process of digitising,

maintenance of the digital systems and introduction of new broadcast and broadband technologies in line with the needs of enterprises – potential employers.

The curricula of the study programme are implemented in master studies at universities in Kosovo (UN resolution 1244), Serbia and Bosnia and Herzegovina. The study programs are certified (accredited) by National certification bodies for Higher education. The project pursues the establishment of the infrastructure (organisational, methodological and technical) for implementation of developed study programmes (Fig. 1). It involves also the EU universities in order to transfer their experience in target area as well as certain local broadcast companies to designate the requirements for the future specialists.

### III. PARTICIPATING UNIVERSITIES

The consortium is composed of 10 Higher education institutions (HEI), 6 from WB and 4 from EU, and 3 industrial partners. Each participating WB country is presented with two Higher education institutions (HEI) interested to design the new modern curricula, and with one professional enterprise with competencies in broadcasting, multimedia creation and digital TV, available and suitable for students' internship and future employment. Also the partners from business are directly included in design of curricula specifications according to the business needs and thus have greater opportunity to find adequate future graduates.

Table I.  
Course List at University of Pristina in Kosovska Mitrovica

Course	Semester	Mandatory /Elective	ECTS
Audio-Video Technologies	1	elective	6
Audio-Video Technologies	1	elective	6
Data Compression	1	elective	6
Digital TV Broadcasting	1	elective	6
IP Technologies	1	elective	6
Cable and Wireless Broadband Communications	1	elective	6
Sound Engineering	1	elective	6
Security Multimedia Systems	1	elective	6
Interactive Multimedia Applications	2	elective	6
Human and multimedia	2	mandatory	6
Student Internship	2	mandatory	2
Master thesis work	2	mandatory	16

Electives Courses – Semester 1: 5 out of 8

Electives Courses – Semester 2: 1 out of 2

Weeks in Semester: 15

**University of Pristina in Kosovska Mitrovica** (UPKM) is the project coordinator i.e. in charge for project management, financial management, coordination among partners and also the target user of developed study Master program. It is a higher education institution founded in 1969 and today has more than 10.000 students and 800 teachers and assistants and 350 non-teaching staff. Faculty of Technical Sciences (FTS) is one of 10 UPKM faculties, established by merging 4 technical faculties (Electrical, Mechanical, and Civil Engineering and Faculty of

Mining). Academic studies are based on Bologna education process and carried out at three levels. Faculty laboratories are carriers of practical exercises and scientific research work. Studies of electrical engineering and computer engineering are covered by departments of Power engineering, Electronics and Telecommunications, and the Computing and Informatics. Departments are specialized in digital signal processing, multimedia systems and applications, digital image processing, mobile communications, data protection, software engineering and network technology.

**Higher Technical School of Professional Studies Zvečan** is a state school founded in 1961, with a long tradition in education of technical personnel, as well as with developed transnational cooperation with similar institutions in the region. Throughout the school a thousands of students has passed, taught to become skilled professionals ready for all kinds of professional challenges. The goal is to maintain and improve the status of the leading high vocational school in this field in the Balkans. The evidence of quality is the license of the Ministry of Education of the Republic of Serbia. There are five study programmes in vocational studies (180 ECST): Energetic, Management in Electrical Engineering, Engineering Informatics, Production Management, Fire Protection. Also there are three study programmes in specialist studies (180+60 ECST): Energetics, Production Management, and Fire Protection. The School has a long record of engagement with industry, communities and external research partners.

Table II.  
Course List at HTPSZ Zvečan

Course	Semester	Mandatory /Elective	ECTS
Multimedia systems	1	mandatory	6
Measuring in telecommunications	1	mandatory	6
Computer animation	1	elective	6
WEB programming	1	elective	6
Electric lighting design	1	mandatory	6
Human-computer interaction	1	mandatory	6
Image and sound digital editing	2	mandatory	5
Audio and video production	2	elective	5
Internet and wireless sensor networks	2	elective	5
Entrepreneurship and innovations	2	elective	5
Research marketing	2	elective	5
Professional practice	2	mandatory	5
Final thesis	2	mandatory	10

**University of Banja Luka** consists of 16 faculties and has 54 licensed study programs. The Faculty of Electrical Engineering (FEE) is the oldest faculty and offers 3 study programs at the 1<sup>st</sup> and 2<sup>nd</sup> study cycle. Since 2009 it has been organized the third cycle of ICT studies in collaboration with the University of Paderborn. Since the establishing of FEE, one of the main departments is the Department for telecommunications, which organized teaching in the field of radio and TV techniques. The FEE formed engineers who managed the production of analog TVs in the Cajavec factory (1966-1995). Most of the engineers who work today in the field of broadcasting, graduated at the

FEE Banja Luka. Since 2014, the Institute RT-RK is established at FEE, and one of its activities is also a digital broadcasting software support.

**University of Bihać** was established in 1997. It has seven member units, 6 Faculties (Technical Faculty, Faculty of Pedagogy, Faculty of Law, Biotechnical Faculty, Islamic Faculty of Pedagogy and Faculty of Economy) and School of Health Studies. Total number of students is 4000. Teaching process at UNBI is organized through total 46 study programs, 27 study programs within 1st study cycle and 19 study programs within 2nd study cycle. At the Technical Faculty there are 5 Departments: Civil Engineering, Mechanical Sciences, Wood processing technology, Electromechanical Sciences, Textile Design and Technologies; the network of institutes and laboratories is wide.

Table III.  
Course List at University of Bihac

Course	Semester	Mandatory /Elective	ECTS
Signal processing and Acoustics	1	mandatory	5
HD and 3D TV	1	mandatory	5
Wireless and satellite communications systems	1	mandatory	5
Multimedia TV systems	1	mandatory	5
Digital Image processing	1	elective	5
Broadcasting engineering	1	elective	5
Internet telephony and television	2	elective	5
DVB-X systems	2	elective	5
Audio-Video production	2	elective	5
Publishing research paper	2	elective	5
Master thesis	2	mandatory	20

Table IV.  
Course List at University of Banja Luka

Course	Semester	Mandatory /Elective	ECTS
Digital broadcasting systems and technologies	1	mandatory	6
Digital TV receivers and DVB software	1	mandatory	6
Studio audio and video production	1	elective B1	6
Digital technologies for broadband access	1	elective B1	6
Advanced digital TV – middleware, interactive TV, IPTV	1	elective B1	6
Regulations, standards and radio monitoring	1	elective B1	6
Multimedia Web content	1	elective B2	6
Multimedia content search	1	elective B2	6
Graphics and animation	1	elective B2	6
Multimedia content security	1	elective B2	6
Modern application framework of digital TV receivers	1	elective B2	6
Human-computer interaction	1	elective B2	6
Research work	2	elective C	10
Student practice	2	elective C	10
Master thesis work	2	mandatory	20

B1, B2 – Students have to choose at least one course from the group B1.  
C – Students have to choose one of two C options.

**School of Electrical and Computer Engineering of Applied Studies, VISER**, is the public higher education institution with more than 2500 students attending courses

in seven different specializations at the first level of higher education and 5 different specializations at the second level of higher education of applied studies. VISER has particularly long tradition, as well as, well known reputation in the field of applied studies in Telecommunications, Audio and Video Technologies and Computer Engineering. It is equipped with 24 different laboratories among which stand out Modern radiotone studio and HDTV studio. Through TEMPUS curriculum innovation project "Innovation and Implementation of the Curriculum Vocational Studies in the Field of Digital Television and Multimedia" VISER established very successful one year specialized study programme Multimedia and Digital Television.

Table V.  
Course List at VISER

Course	Semester	Mandatory /Elective	ECTS
Research Methods	1	mandatory	6
Audio and video compression	1	elective	8
Digital communication systems	1	elective	8
Audio devices and systems	1	elective	8
Video devices and systems	1	elective	8
Interactive multimedia	1	elective	8
Digital radio and TV technologies	2	elective	8
Wireless systems technologies and protocols	2	elective	8
Signal processing	2	elective	8
Audio and video production systems	2	elective	8
Multimedia postproduction	2	elective	8
Student internship 1	2	mandatory	6
Broadcasting systems and technologies	3	elective	8
Multimedia internet transmission	3	elective	8
Communications standards and technologies	3	elective	8
Studio design	3	elective	8
Telecommunication measurements	3	elective	8
Student internship 2	3	mandatory	6
Entrepreneurship and Incentives in Electrical and Computer Engineering	3	elective	6
Electronic communication regulation	4	elective	6
Applied research work	4	mandatory	8
Master thesis work	4	mandatory	16

**Singidunum University** founded in 1999 is the first private university in the country to be awarded accreditation for the realization of bachelor's, master's and PhD degree programmes in three scientific-research fields: social sciences and humanities, technical sciences and natural sciences and mathematics. They put emphasis on the study programmes that require and support ICT implementation (Electrical Engineering and Computing, Advanced Cryptosystems, ICT, Informatics and Computing, Engineering Management). There are currently around 10 000 students enrolled. Lectures are held by over 400 eminent professors from the country and abroad. The University is also conducting undergraduate studies via distance learning platform.

Partners from the EU countries are involved to jointly and successfully develop study programme in the field of DBBT. The partners from EU have the large experience in successful education of students in the field of Information and

Communication Technologies where Digital Broadcasting and Broadband Technologies are part of as well. Universities from EU countries have qualified experts, modern laboratories for studying and testing of Digital Broadcasting and Broadband Technologies, and rich experience in implementation of many projects in improving the higher education. The EU countries has successfully transferred from analogue to digital broadcasting and they are also implementing new digital broadcasting and broadband services now. Also, the quality and quantity of these services are on advanced level. The EU partners have advanced knowledge of interactive multimedia applications on smart phones and tablets, networks modelling and radiocommunications engineering that is today the state of the art.

Table VI.  
Course List at Singidunum University

Course	Semester	Mandatory /Elective	ECTS
Principles of digital broadcasting	1	mandatory	8
Communication networks and system design	1	mandatory	8
Principles of modern communication	1	elective	8
Digital image processing	1	elective	8
Study research work 1	1	mandatory	6
Broadband access networks	2	elective	6
Principles of wireless communication	2	elective	6
Digital TV Design	2	mandatory	10
Study research work 2	2	mandatory	4
Professional practice	2	mandatory	2
Master thesis work	2	mandatory	8

**Technical University of Ostrava** - Faculty of Electrical Engineering and Computer Science contributes in direction of the balanced education both theoretical and practical. They possess equipment which is very well suited for the project, such as many analysers in field of radio communications (DVB-T, PXI or USRP). More than ten years long history of study branch "Mobile Technology" in Technical University of Ostrava, results and a reputation of staff provide an essential contribution to the project.

**University of Ljubljana** - Laboratory for Telecommunications at the Faculty of Electrical Engineering (LTFE) team has extensive experience in development and deployment of interactive multimedia applications on a number of interactive platforms (iOS, Android, smart TV, HbbTV, etc.). Additionally, they have equipment for DVB-T broadcasting and studio production, which is being used for project development as well as for teaching purposes. In addition to student training and education, they have extensive experience in industry training and transfer of knowledge to production oriented environments.

**Universidad Politecnica de Madrid** and its ETSI Telecommunication (Superior Technical School of Telecommunication) extensive teaching and research facilities in courses on digital television, handling multimedia information as well as TV and HDTV signals, visual static and dynamic information encoding, etc. so it contributes fully on capacity building of the partnering universities and also on all other project activities due to previous experience in wide range of similar projects.

**University of Tartu** through the Institute of Technology as the part of the Faculty of Sciences and Technology of has a lot of experience in digital image and signal processing that proves with a number of scientific papers and the knowledge that can be used in this project especially in the area of efficient transmission of the signal.

**TV Mreža** is an association of 5 TV stations and independent production. It was established in 2009 in Priština and consists of TV Mir /Peace/ in Leposavić, TV Most /Bridge/ in Zvečan, TV Puls /Pulse/ in Šilovo, Gjilan/Gnjilane municipality, TV Herc /Hertz/ in Štrpce (regional TV station broadcasting program for viewers in the East, Central and North Kosovo), and New Press Production in Čaglavica. Programs of the TV Mreža are available for viewing to most members of the Serb ethnicity communities in Kosovo and other citizens using Serbian language. It is estimated that all members of the TV Mreža together cover more than 80 % of the territory of Kosovo\*. TV Mreža is “en course” to develop its own and unique TV program, branded as “independent TV Mreža program”.

**JP Emisiona tehnika i veze** (JP ETV) is broadcasting media network service. It is the national broadcasting operator of the Republic of Serbia whose core business is wireless telecommunications, and the main task is planning, building and maintenance of transmission infrastructure on the territory of Serbia, providing radio and television broadcasting services to the home radio and TV receivers. JP ETV established digital terrestrial network for free multiplex, based on DVB-T2 system as standard for digital broadcasting and MPEG-4 version 10 (H.264/AVC) as compression standard, which consists of 208 transmitting location for first multiplex and 89 transmitting sites for second and third mux, and which covering more than 95% of population in each allotment zone for the first MUX, and more than 90% of population in the other two multiplex.

**Alternativna televizija** (ATV) has 17 years in business and over 110 employees. It is one of the leading broadcasters in the Republic of Srpska and the first in the Banja Luka region, and the first commercial broadcaster to build own TV home. ATV broadcasts 24 hours a day, 30% of programming is ATV produced, which includes the best rated and most influential news and current affairs shows, with terrestrial coverage with 1,5 million people in BH and neighboring countries: the Republic of Srpska, north-west of Federation BH, border areas in Croatia and Serbia. ATV can be seen also on IPTV (m:tel and BH Telecom), cable operators, satellite (Total TV) and internet (Bosnia TV). Thus the role of ATV in the project is to transfer knowledge and experience to higher education institutions staff and students and help in designing the new curricula in the field of digital broadcasting according to the needs in labour market.

## II. DEVELOPED COURSES

The universities, both from EU and Western Balkan countries, analysed study programmes of counterparts, compared them and with assistance of business partners with the view from the labour market, defined the guidelines for design of new curricula (Tables I-VI).

The representatives of WB universities carried out study visits at EU partner HEIs and got trained by corresponding EU professors, getting the adequate knowledge to design the curricula for new study programmes and to start teaching newly introduced study programme after WB HEIs got accreditation from National accreditation body.

The knowledge that students gain through the studies is both theoretical and practical because the DBBT laboratory will be set up during the project. Also, the partnership protocol will be signed between HEIs and regional business partners for the students' internships and among partner HEIs for long-term cooperation on teachers' and students' mobility.

As the project develops curricula for academic and vocational master studies in the field of DBBT, the new curricula are in line with those used at the world's leading schools in the field and in concordance with the Europe 2020 strategy, the Strategic Framework for European Cooperation in Education and Training and the Bologna process.

The teaching of all courses in curricula is based on the use of contemporary teaching methods, such as problem based learning, game based learning, case study method, etc. Courses are organised using blended learning concept – a combination of traditional and e-learning concepts. All course materials and activities will be available to students through a distance learning system. During their studies, students will be involved in practical work and internships in broadcast & broadband companies that participate in the project.

After setting up methodological bases for curricula development and development of curricula for academic and vocational master studies, methodology for implementation of study programmes is set up, equipment purchase and installation in laboratories is carried out.

Also in the second year of project the activities concerning the introduction of study programmes like accreditation at National Accreditation offices, training of the teachers and enrolment of students are being carried out. The third project year will be dedicated to the activities of teaching and learning within innovated and designed study programmes, as well as evaluation of students' success and their feedback. All project deliverables have public access.

## III. EQUIPMENT

In order to students gain theoretical and practical knowledge that can be applied immediately after the graduation, the laboratories are set up at all universities of WB countries. The laboratories are equipped with appropriate hardware and software infrastructure for analysis of broadcasting & broadband technologies and, digital multimedia HDTV studio with appropriate equipment needed for implementation of digital multimedia services.

Since UPKM is particular target university for the implementation of the Master and setting up the laboratories, in this paper, the equipment corresponding to the HDTV studio (Fig. 1.) at UPKM is presented, although all other universities have equipped their laboratories.

Equipment purchased at UPKM is presented in the following tables:

- Video equipment (Table VII),
- Audio equipment (Table VIII),
- Computers (Table IX),
- Lighting equipment (Table X),
- Measuring equipment (Table XI), and
- Installation equipment (Table XII).

Table VII.  
Video Equipment

Type	Pieces
Camcorder HD / 4K	3
Console: ATEM 1, Broadcast panel	1
Video Mixer: ATEM 2 M/E Production Studio 4K	1
Matrix: Smart Videohub 20 x 20 za 4K	1
Controls Matrix: Video-hub Master Control	1
Controls: Video-hub Smart Control	1
Conversion: Mini Converter HDMI – SDI 4K	3
Conversion: Mini Converter SDI – HDMI 4K	1
Conversion: Mini Converter SDI to Audio 4K (embeder)	1
Conversion: Mini Converter Audio to SDI 4K (deembeder)	1
Recorder: Hyper Deck Studio	1
2,5” SATA 3Gb/s 500GB	2
Communication: Data Video ITC 100	1
GPI/Tally Interface	1
LG 40UF695V LED UHD 4K Smart	5
LG 43UF680V LED UHD 4K Smart	4
Bracket LED monitor for 32” to 63”	8
HDMI extender up to 60m	8
HDMI switch 5-IN/2-OUT	1
HDMI splitter 1-IN/4-OUT	1
USB 1.1 & 2.0 extender up to 50 m	3
Computer Switch 1-IN/5 OUT	1
Encoder MSE - RS265	1
Decoder BD - RS 265	1
Camera: Canon EOS 100D 18-55IS	1
Camera: Panasonic Lumix DMC-GH4	1
4K Video Jackfields 2X26 (4K Video Patch Panels)	1
Patch Cable 0.5 m	20

Table VIII.  
Audio Equipment

Type	Pieces
Digital Mixer: Behringer x32 Compact	1
Studio Monitor 5”: Fluid Audio F5	1
Studio Monitor 8”: Fluid Audio FX8	1
AKG Perception Wireless 45 Presenter Set	3
AKG Perception Wireless 45 Vokal Set	1
Microphone: Sennheiser MD-46	1
Microphone: Rode NT1-A set	1
Studio Headphones: Superlux HD-681 Evo	3
Studio Headphones: Superlux HD-669	5
Telephone Hybrid	1
Smartphone or Tablet	3
Bluetooth Headphones with Microphone for Smartphone or Tablet	3

Table IX.  
Computer Equipment

Type	Pieces
Computers (desktop or lap top, for the installation measuring equipment and software)	6
Computer (laptop) with Gigabit Ethernet port	1
Monitor for Computers: Samsung S 24C300HS	6
Keyboard and Mouse	6
Speakers for Computers: GENIUS SP-HF500	4
Speakers for Computers: GENIUS SP-M200	2
Speaker: Genius SW-HF5.1 4800	1
DeckLink 4K Extreme Card	1
DeckLink Studio 4K Card	1
Blackmagic UltraScope (PCIe card Mac OS X and PC hosted waveform monitoring with 6 simultaneous scopes)	1
D-LINK DES-1005D 5-Port Fast Ethernet Unmanaged Switch	1
HDMI splitter (mini)	1
CKL HD-94M 1-IN/4-out, Fully HDMI 1.4 Complaint up to 1080p	1
Software: Elements Systems Playout	1
Software: V Mix	1
Software: Wowza Streaming Engine	1

Table X.  
Lighting Equipment

Type	Pieces
Fluorescent softlights 4 lamps 55W, 3200K, with standard accessories	4
Fluorescent softlights 2 lamps 55W, 3200K, with standard accessories	4
Digital Luxmeter	1
Instrument for measuring the color temperature	1
DMX Controller	1
Chroma Key Green Screen 3x6 m	1

Table XI.  
Measuring Equipment

Type	Pieces
DTA-2115 All-standard all-band modulator for PCIe or DTU-215-T2-SP USB-2 VHF/UHF modulator with modulation and StreamXpress	1
T2Xpress DVB-T2 signal generator software	1
DiviCatch RF-T/C T2/C2, DVB-T DVB-C DVB-T2 DVB-C2 Professional RF Analyzer	1
Meter Field and Spectrum Analyzer Teledes H60	1
Professional DVB TS multiplexer ASI/TS Multiplexer 8 ASI in ASI out	1
TBS6910 DVB-S2 Dual Tuner Dual CI PCIe Card	1
INTEX TV/FM USB DVB-T/T2 HDTV PCIe Card	1
LEADTEK WinFast TV2000 XP Global TV/FM	1
DVB-S2 receiver Amiko HD8150	1
Combo Receiver DVB-T2/C Amiko Imuplse T2/C	1
Internet IPTV / DVB-S2 Combo Receiver	1
Amiko mini HD combo receiver dvb-s2 dvb-t2	1
DVB-T2 PCTV nanostick HDTV tuner	1
SMA-BulkHeadCable	1
RTL2832U + R820T Mini DVB-T + DAB+ + FM USB Digital TV Dongle	1
Hot DVB-T2 Digital USB TV Stick Tuner Satellite receiver DVB T2 USB 2.0 TV Receiver Support DVB-T DVB-C FM DAB	1
DRM Receiver	1
DTU-245-SY-SXP FantASI USB-2 ASI/SDI, DtGrabber+, SdEye, StreamXpert and StreamXpress (adapter for analysis, generation and monitoring ASI and SD-SDI video streams and MPEG-2 transport stream)	2
SDR ETTUS Research USRP N210	2
DVB-T2 PCTV nanostick HDTV tuner	1

Type	Pieces
RTL2832U + R820T Mini DVB-T + DAB+ + FM USB Digital TV Dongle	1
Hot DVB-T2 Digital USB TV Stick Tuner Satellite receiver DVB T2 USB 2.0 TV Receiver Support DVB-T DVB-C FM DAB	1
DRM Receiver	1
DTU-245-SY-SXP FantASI USB-2 ASI/SDI, DtGrabber+, SdEye, StreamXpert and StreamXpress (adapter for analysis, generation and monitoring ASI and SD-SDI video streams and MPEG-2 transport stream)	1
SDR ETTUS Research USRP N210	1
CardSBX 400MHz-4,4GHz	1
SMA-BulkHeadCable	2
VERT900 Antenna	2

Table XII.  
Installation Equipment

Type	Pieces
Rack 800x800/600	2
Shelf fixed heavy duty - for the rack depth 800 mm	8
L carriers for supporting equipment - for rack depth of 800 mm (pair)	8
Blank panel 1U/19"	4
Blank panel 2U/19"	8
220V junction boxes	6
Cable FTP kabl kat. 6 DRAKA tip UC400 S27 4P FRNC	100 m
Connector RJ-45 connector FTP/STP cat. 6 - shielded, 8P8C 8-pin	60
HD/SDI Video cable Belden 1855	100 m
HD/SDI Video cable Belden 1505 flexi 50 m Connector BNC for cable as Belden 1855	100
Connector BNC for cable as Belden 1505 flex	15
Connector XLR-F Neutrik NC3FD-LX	15
Connector XLR-M Neutrik NC3MD-LX	15
Connector XLR-F Neutrik NC5FD-LX	15
Connector HDMI Neutrik NAHDMI-W	15
Connector BNC Neutrik NBB75DFI Isolated	15
Connector XLR-F Neutrik	15
Connector XLR-M Neutrik	15
Connector XLR-M 5 pin NC5MXX	10
Connector TRS Neutrik	15
Connector RCA Neutrik	15
Audio multicore 16 line	30 m
Microphone cable	50 m

#### IV. CONCLUSION

The master study programme in the field of Digital Broadcasting and Broadband Technology is being implemented



Fig. 1. HDTV studio at University of Priština in Kosovska Mitrovica

in the Western Balkans countries through the Erasmus+ project DBBT to enable education of specialists needed in the process of transfer of analogue to digital broadcasting, maintenance of digital systems and introducing of new broadcasting and broadband technologies. In this way, also the process of digitizing the broadcast services will be accelerated as well as the development of digital communications technologies will be followed by activation of other business opportunities in the Western Balkans. The graduated students will be able to apply acquired knowledge in the labour market since they will acquire

the knowledge how to introduce and maintain modern and to improve existing broadcasting and broadband communication systems, and also how to develop the multimedia applications on smart phones and tablets, applications for smart TV, modelling of IP and wireless networks and wave propagation, etc

The laboratories with appropriate hardware and software equipment for analysis and design of broadcasting and broadband systems with digital multimedia, HDTV studio and environment for implementation of digital services are being created. The formation of the experts will improve the existing state in the area of digital technologies, particularly in digitising of Radio and TV, and multimedia broadband services in WB countries in accordance with the best EU practice. The Master will impact the current state in the field of digital communications technologies in WB countries due to mandatory digitisation of broadcast services according to standards established by international organizations and adopted also by the EU.

## REFERENCES

- [1] DBBT project: [www.dbbt.pr.ac.rs](http://www.dbbt.pr.ac.rs).
- [2] The Education, Audiovisual and Culture Executive agency EACEA: [https://eacea.ec.europa.eu/erasmus-plus/funding/key-action-2-capacity-building-in-field-higher-education-2015\\_en](https://eacea.ec.europa.eu/erasmus-plus/funding/key-action-2-capacity-building-in-field-higher-education-2015_en).
- [3] M. Petrović, B. Jakšić, I. Milošević, V. Trifunović, B. Gara, "Pregled DVB-T u zemljama bivše Jugoslavije", *Zbornik radova XII međunarodnog naučno-stručnog simpozijuma INFOTEH 2013*, Jahorina, Bosna i Hercegovina, 20-22 mart 2013, Vol. 12, pp. 354-359.
- [4] B. Jaksic, M. Petrovic, M. Smilic, B. Gvozdic, A. Markovic, "Terrestrial Digital Transmission of the High-Definition Television in Europe", *Proceedings of the 23 International Electrotechnical and Computer Science Conference ERK 2014*, Portorož, Slovenia, 20-24 September 2014, pp. A: 61-64.
- [5] Independent media commission: [www.kpm-ks.org](http://www.kpm-ks.org)
- [6] Communications Regulatory Agency BiH: [www.rak.ba](http://www.rak.ba)
- [7] Regulatory Agency for Electronic Communications and Postal Services: [www.ratel.rs](http://www.ratel.rs)
- [8] Agency for Electronic Media of Montenegro: [www.ardcg.org](http://www.ardcg.org)
- [9] The Agency for electronic communications: [www.aek.mk](http://www.aek.mk)
- [10] Authority for electronic communications and postal services: [www.akep.al](http://www.akep.al)
- [11] Budget allocation regional and national priorities protected: <https://eacea.ec.europa.eu/sites/eacea-site/files/budget-allocation-regional-and-national-priorities-protected.xls>