BENEFIT
Boosting the telecommunications engineer profile to meet modern society and industry needs

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1 Introduction

This deliverable D2.1 titled "*Modernised and accredited study programmes in telecommunication engineering of 3 B&H and 3 Serbian universities in cooperation with ICT industry*" is the first deliverable in the Work package 2 and reports the results of the activities carried out in task T2.1.

The process of modernisation of telecommunication engineering study programmes at 3 B&H and 3 Serbian universities begins with the survey of telecommunication engineering study programmes, presented in WP1 deliverables, and the industry feedback obtained through the industrial survey. The 6 HEIs in the WB region are developing modern ICT engineering study programmes capable of providing future generation of a highly qualified work force and stimulate entrepreneurship. These efforts have been done in accordance with the guidelines developed in WP1, which was taken as an input to WP2.

The outcomes presented in the document are related to the three main activities:

a. Identification of the classes to be modernised within the project BENEFIT and class contents in cooperation with the regional industry.
b. Preparation of class material and restructuring the curricula.
c. Accreditation of the study programs at 6 Western Balkan (WB) universities participating in the project BENEFIT.

The participating universities have similar study programs, which was considered as an advantage to structure study programs through the definitions of a unique *body of knowledge* including *knowledge areas* and *knowledge units*, jointly defined by all participating partners. The bodies of knowledge have been designed to include the specificities of all study programs, the results of the industrial survey and trends of the development of all universities involved in the project.

The first phase of the project was focused on the identification of courses selected for enhancement and modernisation, as well as taking into account the need for introducing new courses. Activities in the second phase of the project were focused on the class materials development including lab equipment purchase and definitions of bodies of knowledge in telecommunications.

The methodology, used in BENEFIT project, for the enhancement and modernisation of telecommunication study programme is schematically presented in Figure 1-1. This schema shows main activities done within WP2 and interaction with other work packages. Modernisation of the selected courses is based on the body of knowledge concept, derived from the survey completed in WP1 [1]. New teaching methods are incorporated as a result of WP3 activities and included in the description of courses. New labs have been designed and equipped to support delivery of modernised and new courses. Activities related to the lab design and equipment purchase were coordinated between WP2 and WP3. New teaching materials (presentations, textbooks, lab session, video materials) have been developed to match the content of the modernised courses. Teaching materials are available at the BENEFIT portal: https://www.project-benefit.eu.

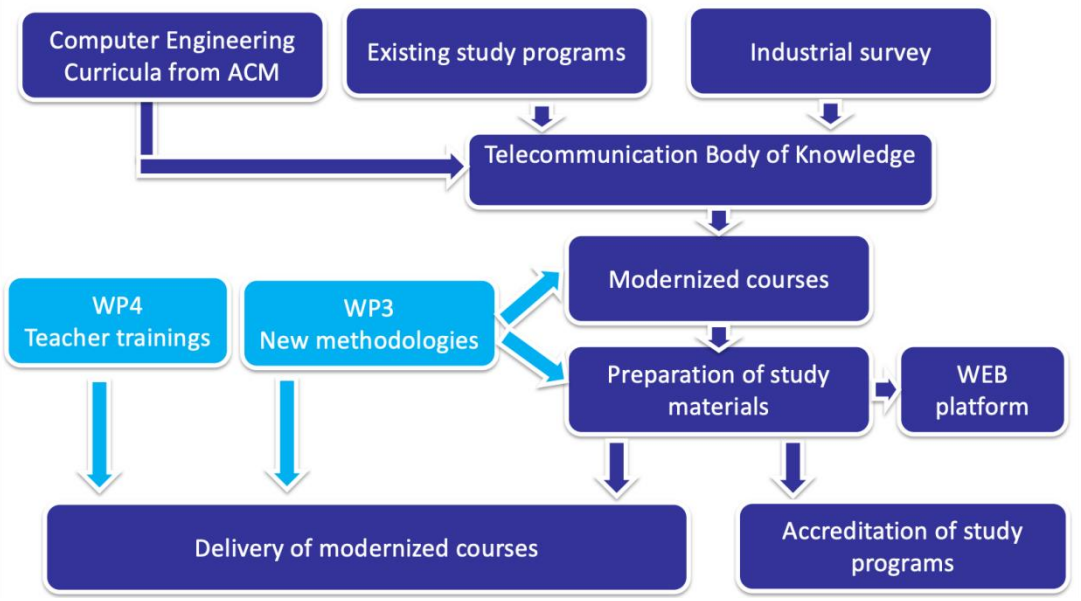

Figure 1-1 Modernisation of study programs

2 Objectives

Deliverable D2.1 is the first deliverable in WP2 and contributes to the fulfilment of the following objectives:

- Detection of deficiencies in the current study programs at WB universities;
- Definition of Telecommunication body of knowledge;
- Selection of courses to be modernised or introduced as novel;
- Restructuring curricula at 6 WB universities;
- Preparation of class materials for modernised and novel courses;
- Accreditation of the curricula;
- Delivery of modernised courses.

1. Detection of deficiencies in the current study programs at WB universities

Deficiencies in the current study programs have been analysed from the both academic and industry perspectives. From the academic perspective, deficiencies in the current study programs in all participating universities were determined through the study programs overview and comparison, as well as experience exchange and discussions between partners. Regional industry provided the feedback related to necessary knowledge, competencies and skills that are expecting from the graduate ICT engineers through online questionnaire. The received feedback was used to detect missing content in the existing study programs.

2. Definition of Telecommunication body of knowledge

Introduction of the concept of "Telecommunication body of knowledge" is essential for the overall process of study program modernisation. Originating from the overview of the current curriculum and knowledge expressed in the industry feedback through the questionnaire, knowledge areas were determined. Knowledge areas have further been divided into knowledge units and subunits.

3. Selection of courses to be modernised or introduced as novel

Partner universities from WB countries selected courses from the first and second cycle of study for modernisation as well as defined new courses for the development. The content of the courses have been correlated with determined knowledge areas.

4. Restructuring curricula at WB universities

This objective has been achieved with the enhancement of the selected courses. Enhancement process included preparation of new learning outcomes and/or competencies that a student will gain with a course, course content and teaching methods.

5. Preparation of class materials for modernised and novel courses

Teaching materials have been prepared for the modernised courses. These materials include presentations, textbooks, lab sessions and video materials. All materials have been made available for students at the BENEFIT teaching platform, without specific restrictions.

6. Accreditation of the curricula

The accreditation process at WB universities occurs periodically after 4 years and additional accreditations are not feasible. Different regulations between Serbia and Bosnia and Herzegovina, as well as within entities of Bosnia and Herzegovina, made this process even more complex. Therefore, while some universities successfully passed accreditation process, other universities are in the preparatory process.

7. Delivery of modernised courses

Delivery of the modernised courses strongly depends on the possibility of universities to introduce these courses in the teaching process. Some courses have been delivered in the full content in the 2019/20 winter semester, while other courses leveraged new teaching methods, materials and labs. Due to corona virus pandemic, teaching process is organised online. Development of new teaching materials and its availability through the BENEFIT platform has been found very useful for the students and teachers, beyond partner universities. All modernised and new courses will be delivered in the coming years, enabling sustainability of the project and usage of the project tangible results.

3 Identification of modernised classes and class contents in cooperation with industry

Activities in Work package 2 (WP2), Task 2.1 are focused on the selection of courses/subjects for modernisation and the modernisation/development of class content according to identified learning outcomes. This process was implemented in accordance with the procedure developed in the "Consolidated ex-ante analysis and guidelines aimed boosting the telecommunications engineer profile including a projection of needs for ICT engineers in the future" (subsection 4.4.3 Preparatory & development phase). This chapter presents overall process of the study program modernisation and lists of classes which have been modernised.

3.1 The approach to curriculum modernisation

Study program modernisation process leverages analysis of current study programs at the participating universities, industry feedback and requirements collected from the questionnaire and the labour market needs for telecommunication engineers. WB universities modernised their study programs according their specific needs and leveraging modernisation at other participating universities.

In the first stage, universities have identified list of courses to be enhanced or introduced as a novel. The course selection is based on the following criteria:

- Long term strategy of particular HEI,
- The inputs from the previous steps (academic and industrial survey),
- Deficiencies in the existing curricula,
- Local telecommunication labour market needs, and
- Accepted learning outcomes from particular study programs.

Each modernised course/subject includes the following components: content, teaching methodology and type of teaching material (e.g. presentations, books, lab sessions, audio and/or video lectures). The template used for description of enhanced courses in ongoing study programs and novel specific-knowledge course are given in the Appendix A.

Procedure for curriculum modernisation comprises the following steps:

1. Selection of courses to be enhanced or introduced as a novel course

Identification of courses/subjects for modernisation is based on:

- the inputs from WP1 (guidelines, academic and industrial survey) and
- accepted learning outcomes from particular study programs.

The result is a set of fully described specific classes to be modified/added in each WB HEI study program.

2. Allocation of courses into adopted Knowledge areas

The enhanced and novel courses will be allocated into adopted Knowledge Areas. Other courses from existing study programs will be distributed into Knowledge Areas.

3. Comparative analysis of the enhanced and novel courses according to the given Knowledge Areas

Comparative analysis has been conducted for the courses offered by six WB universities. This step will include:

- Identification of modern classes and class contents in cooperation with industry,
- Definition of knowledge units that will be studied at several universities,
- Preparation of class/teaching material, and
- Publishing of class materials (textbooks, lab sessions, …) at BENEFIT portal.

4. Adoption of Knowledge Units from course descriptions

The adopted knowledge units represent modernised telecommunication studies tailored to market demands and developments in telecommunications. Knowledge units include topics from existing, enhanced and novel courses. A set of learning outcomes defines each knowledge unit.

5. Adoption of Telecommunication Body of Knowledge

The body of knowledge contains knowledge areas that are applicable to all Telecommunication engineering programs. The seventeen knowledge areas form the Telecommunication body of knowledge. Each knowledge area comprises a thematic scope and a set of knowledge units.

6. Delivery of new study programmes

This step will cover the implementation of the modernised study programmes and the delivery of the new and upgraded classes in all WB universities.

7. Report on study program changes

The report presents the main information about the courses, point to the web repository where the complete course material can be retrieved and how the study offer has been changed throughout the project.

8. Accreditation of curricula

Final step is being completed according to the rules for accreditation of study programs in Serbia and B&H.

3.2 Telecommunication Body of Knowledge

Seventeen Knowledge Areas were identified during the analysis of existing study programs (Figure 3-1). The Knowledge Areas include courses/subjects in telecommunication engineering, mathematics and physics. It is important to point out that the Knowledge Areas are recognised as common at all universities participating in BENEFIT project. In the first phase of the project, Knowledge Units were not analysed. Based on existing, modernised and new courses, Knowledge Units need to be adopted as a standard part of the previously defined knowledge areas. It is necessary to analyse the individual Knowledge Areas in the WP2 and WP3 and define the knowledge units within each field.

The foundation for this deliverable is a telecommunication body of knowledge from which faculty or department can develop or modify a study program to fit its needs. This body of knowledge include broad knowledge areas applicable to all telecommunication engineering programs.

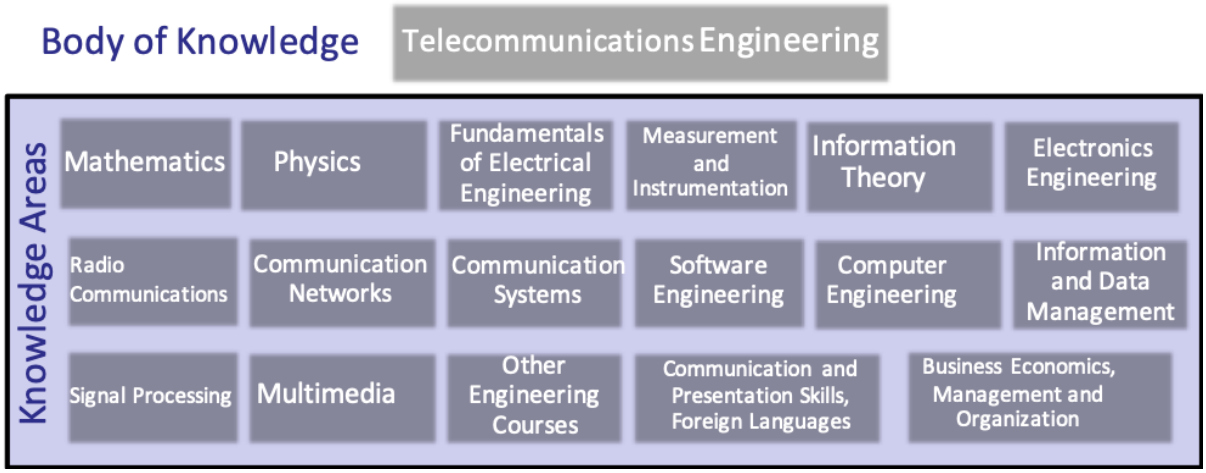

Figure 3-1 Telecommunication Body of Knowledge

3.2.1 Knowledge Areas

The telecommunication body of knowledge model consists of a set of knowledge areas, each consisting of a set of knowledge units which are composed of topics and learning outcomes. “A knowledge area is a subject area into which systems engineering knowledge is frequently classified” [2]. A Knowledge area represents a complete set of concepts, terms, and activities that make up a professional field or area of specialization. Presented areas are defined following the existing study programs of the project partners. Subsequently, these areas were analysed to obtain a full description of these areas in line with the development of telecommunication technology in the previous period.

3.2.2 Knowledge Units

Knowledge Units represent the content which is included in the Knowledge Areas. The project BENEFIT identifies Knowledge Units employing *traditional knowledge* that should be provided in Knowledge Areas and core competences that a student should obtain. This information is primarily extracted from the ongoing study programs at partner universities, fast technology changes in ICT and new concepts that students should learn, and industry expectations that are acquired with questionnaire as a part of activities in WP1.

Methodology for identification of knowledge is summarized into the four actions:

1. Creation of task groups for all knowledge areas.
2. Analysis is conducted by professors in a task group and a list of knowledge units is proposed.
3. Lists of knowledge units for all knowledge areas are collected and harmonized.
4. Reviewing process, to identify interdependencies between knowledge areas and unambiguous definition of knowledge units (e.g. depending only two one or more knowledge areas).

3.2.3 Knowledge Sub-units

The knowledge units are broken down into smaller divisions called knowledge sub-units that represent individual themes within a unit. Sub-units are defined in terms of topics and student learning outcomes.

3.3 Selection of courses to be enhanced or introduced as a novel course

The project BENEFIT targeted improvement of telecommunication engineering studies and its native transition into ICT engineering studies. On this road, a number of the existing courses have been enhanced and some new courses have been introduced as new. The methodology bases on Knowledge Areas and Knowledge Units has been adopted in order to determine course content that will reach aimed student

competences, harmonise content between universities and avoid overlapping between courses, what was not uncommon for WB universities. The full list of courses that have been enhanced or introduced as new, together with associated Knowledge Units and Knowledge Subunits were provided in the Appendix of this document. The majority of these courses have been delivered during project implementation.

3.3.1 The first cycle of study

Project BENEFIT has enhanced 32 courses and introduced 8 new courses in the first cycle of study at 6 WB universities. List of enhanced courses as well as new course is available in the Appendix (Section 8.3 of this document). More detailed information about courses, dates of enhanced courses delivery, available teaching materials and number of enrolled students is available in this chapter (Table 8-1 and Table 8-2).

3.3.2 The second cycle of study

Project BENEFIT has enhanced 27 courses and introduced 13 new courses in the second cycle of study at 6 WB universities. List of enhanced courses as well as new course is available in the Appendix (Section 8.4 of this document). More detailed information about courses, dates of enhanced courses delivery, available teaching materials and number of enrolled students is available in this chapter (Table 8-3 and Table 8-4).

3.4 Allocation of courses into adopted Knowledge Areas

The list of courses that partner universities identified for modernisation and/or development are presented in the previous chapter, while detailed description of the courses with the learning outcomes are given on the project web platform: https://www.project-benefit.eu/eplatform/?programmes. This chapter correlates selected courses with the knowledge area in telecommunications, which is an outcome of activities completed in WP1.

3.4.1 Allocation of courses at first cycle of study

Table 3-1overviews identified knowledge areas in telecommunications engineering for the first cycle of studies.

Table 3-1 Allocation of courses at first cycle of study

Knowledge Area	Course
Fundamentals of Electrical Engineering	Fundamentals of Electrical Engineering I UBL Fundamentals of Electrical Engineering II UBL
Measurement and Instrumentation	Electrical Measurements UBL Measurements in Telecommunications UNI
Electronics Engineering	Introduction to Electronics UNTZ Analog Integrated Electronics UNTZ Sequential Circuits UNTZ
Information and Data Management	Machine Learning 1 UNS Machine Learning 2 UNS

Knowledge Area	Course
Signal Processing	Digital Signal Processing UBL Systems for Digital Signal Processing UBL Signals and Systems UNTZ Signal Processing 2 UB Microprocessor Systems in Telecommunications UNTZ Data Analysis and Compression UNI
Multimedia	Multimedia Signals and Systems UBL Fundamentals of Speech Communication UB
Software Engineering	Software engineering for telecommunications UNSA Software in Telecommunication Systems UNS
Radio Communications	Antennas and Radio Wave Propagation UBL Fundamentals of Radar Systems UBL Mobile Communication Systems UNI Microwave Design for IoT UNI Wireless Communication Systems UNS Antennas and Wave Propagation UNSA
Communication Networks	Telecommunication Networks UBL Wireless Sensor Networks UBL Telemedicine UNTZ IoT Networks UB Smart Devices and Communications UB Computer Communications and Internet Access (II) UNI Design of Industrial IoT Systems UNS Communication Protocols and Networks UNSA
Communication systems	Fundamentals of communications UNTZ Digital communications UNTZ Telecommunications 1 UB Telecommunications 2 UB Advanced RFIC for Telecommunication Systems UNI Smart Systems and IoT UNI Modelling and Simulation of Communication Systems UNS

3.4.2 Allocation of courses at the second cycle of study

Table 3-2 Allocation of courses at first cycle of study

Knowledge Area	Course
Information Theory	Security and Cryptography UNS Network Security UNTZ
Multimedia	Intelligent Audio Algorithms UNI
Software Engineering	Human Computer Interaction UNSA

Knowledge Area	Course
Radio Communications	Cognitive Radio UNS Wireless Power Transfer and Energy Harvesting UNI
Signal Processing	Statistical Learning in Signal Processing UNI Image and video compression UNSA Principles of Software Radio UNI Multirate Systems UB
Information and Data Management	Artificial Intelligence and Machine Learning for communication systems UNI Big Data Analysis UNI Big Data - Management and Analysis UNS Network Science UNS
Communication Networks	IoT Networks UNTZ Wireless Sensor Networks UB IoT Networks Architecture UB Broadband Access Networks UNI Telecommunications Network Management UNSA
Communications Systems	Telecommunication System programming UNTZ Telecommunication and Information Technologies in Telemedicine UNI Computing for IoT Communications UNI Circuit Design for 5G Systems UNI Advanced telecommunication protocols and new generation networks UNSA

3.5 Procedure for creation of new courses

The previous section describes the Telecommunication body of knowledge. The body of knowledge is the basis for creating new courses and modernizing existing ones. The course may include knowledge units from one or more knowledge areas. It depends on the learning outcomes for a given course.

The process of creating a new course or upgrading an existing course is shown in Figure 3-2. The whole process was developed during the organization of the workshops and aligned with other work packages.

The first step is the selection of knowledge areas that cover the objectives and outcomes of the course. The course covers a narrower area, and the selection of knowledge units is required. This selection of knowledge units must be consistent with the course objectives and learning outcomes.

The course description also requires the description of learning outcomes. Within the BENEFIT project, we organized a special workshop dedicated to properly defining learning outcomes. These outcomes are part of the syllabus of a particular course.

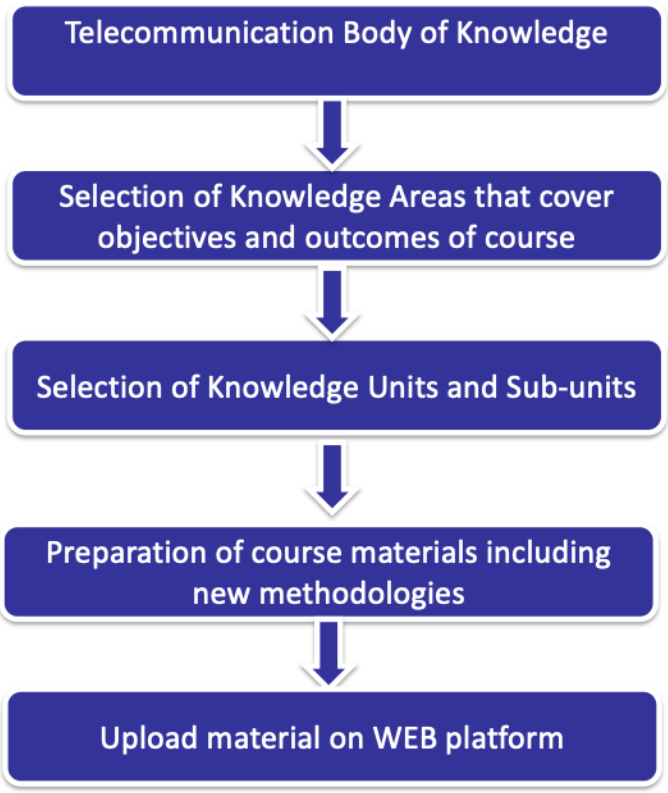

Figure 3-2 Creation of new course using Telecommunication Body of knowledge

Within the third work package, new learning methodologies were analysed and procurement of new laboratory equipment *performed*. The preparation of new educational materials involves the introduction of new teaching methods and the use of laboratory complexes for the realization of lab sessions. All *teaching* materials are uploaded to the e-platform and are accessible to all students from our universities.

In the coming period, it is necessary to update the telecommunication body of knowledge, in line with the further development of ICT technologies.

4 Class materials and restructuring the curricula

Based on the analysis of the study programs presented in the WP1 and the industrial survey, all universities had to decide which changes would be made to modernise their study programs. The aim was to eliminate the disadvantages of existing study programs and to adapt to the needs of the industry as expressed through industrial surveys.

In the first step, all universities make a decision which courses will be modernised, and which new courses will be introduced into study programs. In order to collect input data with a description ofa course for modernisation and introduction of the new course, a template was developed containing the following items:

- **Course**: *the name course*.
- **Current course content**: *the brief description of the ongoing course*.
- **Learning methodologies**: *learning methodologies used in the ongoing course*.
- **Examination**: *how exams and grading are currently organised*.
- **Category**: *indicate first/second cycle*.
- **Detected deficiencies**: *deficiencies obtained from the experiences that should be removed.*
- **Aim**: *define the course aim*.
- **Learning outcomes**: *what are expected learning outcomes*[1].
- **Modernised course content**: *detailed description of the enhanced/new course content*.
- **New learning methodologies**: *learning methodologies which will be used in the enhanced/new course*.
- **New lab equipment**: *list the equipment to be purchased in the scope of BENEFIT*.
- **Planned new course materials** (list): list type of new teaching materials (presentations, lab sessions/practicums, books, video lectures….)

Modernisation and introduction of new courses is classified into two categories, the first and second cycle of study.

4.1 List of class material for the first cycle of study

The full lists of developed teaching materials of the enhanced and new courses in the first cycle od study as well WEB links for the content on the BENEFIT portal are available in the Appendix. Table 8-1 contains this information for the enhanced courses, while Table 8-2 is related to the new courses of the first cycle of study.

[1]Methodology for learning outcomes of the course was subject of the teacher training in Ljubljana in 2019.

4.2 List of class material for the second cycle of study

The full lists of developed teaching materials of the enhanced and new courses in the second cycle od study as well WEB links for the content on the BENEFIT portal are available in the Appendix. Table 8-3 contains this information for the enhanced courses, while Table 8-4 is related to the new courses of the second cycle of study.

4.3 Achieved improvements in relation to the existing curriculum

Telecommunications/ICT Engineering study programs have been analysed and improved at six WB universities in the scope of the project BENEFIT. In this process, existing study programs have been analysed, a feedback from the industry has been received and deficiencies have been detected. Further improvements originated from this analysis. The overall improvements can be summarised as:

- *Improvement in the structure of study programs*. Through the exchange of experiences and good practice between universities, and taking account of trends in other European universities, university partners gained the knowledge how to balance between knowledge areas present in the study programs.
- *Improvements in the course contents*. Each university partner selected a list of courses they wanted to enhance or develop as a new one. Using the methodology that origins from the competences that a student obtains after a course, course content has been updated and new teaching methodologies have been proposed. This process includes alignment of the existing curriculum with the derived knowledge areas and knowledge units (harmonized among partner universities) as well as application of new skills in determination of learning outcomes, obtained in the scope of BENEFIT teacher trainings (e.g. training delivered in Ljubljana).
- *Improvements in lab sessions*. Project BENEFIT strengthen laboratory capacities at WB universities. These labs have been used for the improvement of the existing lab sessions and introduction of new. This improvement bridges the gap between theoretical knowledge and practical skill that contemporary graduate must have.
- *Development of new teaching materials*. Teaching materials in the digital form have been developed for all courses treated by project BENEFIT. These materials include presentations, text books, practicums for lab session, text books with solved problems and video tutorials. Availability of this materials and sharing was additional gain for the participating universities during the spring semester 2019/20 when all courses had to be delivered online due to covid-19 pandemic.
- *Enhanced collaboration between universities*. Universities enriched existing collaborations between them, what will be leveraged in the improvement of study programs in the future. Students enrolled at one university participating in BENEFIT project can use teaching materials prepared by other universities in the consortium. Such approach led to the large Partner universities leveraged BENEFIT project as platform to exchange knowledge and advises in search for appropriate response in high education on issues and restrictions raised due to covid-19 pandemic.

General description of completed improvements in study programs of partner universities

4.3.1 University of Banja Luka

At the University of Banja Luka 10 courses have been improved, all of them at the first cycle of study: Fundamentals of Electrical Engineering I, Fundamentals of Electrical Engineering II, Electrical Measurements, Telecommunication Networks, Wireless Sensor Networks, Fundamentals of Radio Systems, Antennas and

Radio Wave Propagation, Digital Signal Processing, Systems for Digital Signal Processing, and Multimedia Signals and Systems.

Delivery of almost all courses started in the academic year 2019/20, although some enhancement was made during the delivery in the academic year 2018/19 (two courses). Only two enhanced courses ware delivered in WS of the academic year 2020/21, after the acquiring all the equipment. From the march 2020, course delivery has been impacted by covid-19 pandemic.

Based on the adopted knowledge areas and knowledge units, courses contents were modernized, to better match the learning outcomes. Establishment of the Laboratory for signal processing in telecommunication, in cooperation with AlfaNum industry partner, enriched the courses with new laboratory exercises. New teaching methods were adopted, with more active students engagement even in the covid-19 pandemic time. The new teaching material publicly available via BENEFIT digital platform includes two textbooks and one book of solved problems, power point presentations for three courses, 17 laboratory classes with video material, and additional preparation material for 52 lab practice in textual form.

4.3.2 University of Sarajevo

University of Sarajevo has improved seven courses: three courses in the first cycle of study and four courses in the second cycle of study:

- *The first cycle of study*: Antennas and Wave Propagation; Software Engineering for Telecommunications; and Communication Protocols and Networks.
- *The second cycle of study*: Image and Video Compression, Telecommunications Network Management, Advanced Telecommunication Protocols and New Generation Networks, and Human Computer Interaction.

Improvements were introduced gradually, starting with the academic year 2018/2019, and afterwards 2019/2020. The following courses were improved based on introduction of the new labs and new equipment: Antennas and Wave Propagation (1st cycle) and Telecommunications Network Management (2nd). The courses were delivered with some improvements in 2019/2020 but mainly using the simulators, and full enhancement was implemented in 2020/2021 with the establishment of new Telecommunications lab. The new lab was equipped in collaboration with the industry partner in the project consortium: BIT Centre. The lab was equipped during the summer, but due to the pandemic condition lab works for the Spring semester 2019/2020 courses was conducted in July/August at the UNSA.

The course Software Engineering for Telecommunications (1st cycle) was in the curriculum before, but it was the first time that the course was delivered, and it could be considered as a newly developed course.

The study program enhancement included overview and modernisation of the courses content (after alignment of a course with derived knowledge areas and knowledge units) and learning outcomes (applying skills obtained in the teaching training process), adoption of new teaching methods, especially during the COVID-19 pandemics with focus on online learning and multimedia support in teaching. For the course Image and Video Compression the text-book was prepared and published in 2018/2019.

The course Human Computer Interaction (2nd cycle) was enhanced in order to include entrepreneurial skills for students and elements of product design (Product Market Fit canvas). The change is introduced through the co-operation with the industry (outside of the project consortium) since expert from BH Telecom is a lecturer in the course.

4.3.3 University of Tuzla

University of Tuzla has improved seven courses in the first cycle of study as well as two courses in the second cycle of study:

- *The first cycle of study*: Analog Integrated Electronics, Digital Communications, Fundamentals of Communications, Introduction to Electronics, Microprocessor Systems in Telecommunications, Sequential Circuits and Signals and Systems.
- *The second cycle of study*: Network Security and Telecommunication System Programming.

Furthermore, one specific-domain course in the first cycle of study was developed as well as one course in the second cycle:

- *The first cycle of study*: Telemedicine.
- *The second cycle of study*: Internet of Things.

Enhanced courses have been delivered in spring semester of academic year 2019/20 and winter semester of academic year 2020/21. In this period, course delivery has been impacted by covid-19 pandemic.

The study program enhancement includes overview and modernisation of the courses content (after alignment of a course with derived knowledge areas and knowledge units) and learning outcomes (applying skills obtained in the teaching training process), adoption of new teaching methods, establishment of new lab in collaboration with Bicom and BIT Centre (industry partners on the project) and preparation of the teaching materials. The new teaching materials include 98 presentations, 2 textbooks (solved problems) and videos presenting lab sessions and solving numerical problems (3 videos are available at BENEFIT digital platform and 65 videos through YouTube channel). The majority of videos are delivered through the YouTube channel (link is available at BENEFIT platform), that we found more convenient under covid-19 pandemic conditions. Two new courses have also been prepared, but their delivery is planned for the coming period, after the start of the new study program. All teaching materials are publicly available via BENEFIT digital platform, without any restrictions, in order to share knowledge and increase impact of the project.

Besides above listed courses, four other courses in the existing curriculum leveraged establishment of the new lab: Measurements in Telecommunications, Digital Signal Processing, Telecommunication networks and Mobile Communications.

4.3.4 University of Belgrade

At the University of Belgrade, School of Electrical Engineering, four courses have been enhanced within the project at the first cycle of study, and two course have been enhanced within the project at the second cycle of study, i.e.,

- *Enhanced courses at the first cycle*: Fundamentals of Speech Communications, Signal Processing 2, Telecommunications 1, and Telecommunications 2;
- *Enhanced courses at the second cycle*: Multirate Systems, and Wireless Sensor Networks.

These enhanced courses have been first time delivered by using teaching materials developed within the project in the winter semester of academic year 2019/2020 (Multirate Systems and Telecommunications 2) and spring semester of academic year 2019/2020 (Signal Processing 2, Telecommunications 2, Wireless Sensor Networks and Fundamentals of Speech Communications), while the course Telecommunications 2 is also currently being delivered for the second time in winter semester of academic year 2020/2021. It should be noted that the delivery of these enhanced courses was done under to the previously accredited study programmes for the first and second cycle of study (accredited in 2013), which allowed (according to the local rules) full implementation of these enhanced courses, except the course Telecommunications 2 which was not delivered in full accordance to the enhanced course content (that will be done in academic year 2022/2023 in under the new study programme accredited in 2019).

Also, within the project, two specific-domain course in the first cycle of study were developed and included into the new accredited (in 2019) study programme, as well as one course in the second cycle of study, i.e.

- *Developed new courses at the first cycle*: IoT Networks, and Smart Devices and Communications;
- *Developed new course at the second cycle*: IoT Networks Architecture.

The two new developed courses, e.g. course IoT Networks at the first cycle of studies and IoT Networks Architecture at the second cycle of studies, have been first time delivered in the winter semester of academic year 2019/2020 (since the local rules allowed inclusion of these as the elective courses into the existing study programmes at the first and second cycle of studies that were accredited in 2013), and are currently delivered for the second time in the winter semester of academic year 2020/2021. It should be noted, that the course IoT Networks Architecture was delivered under the name IoT Networks in the winter semester of academic year 2019/2020 (included in the study programme at the second cycle of study accredited in 2013), but is currently being delivered in winter semester 2020/2021 under its final name (i.e. IoT Networks Architecture) as defined in the new study programme at the second cycle of study accredited in 2019 (the first students for this new accredited programme have been enrolled in current academic year 2020/2021). The elective course Smart Devices and Communications will be first time delivered in the spring semester of academic year 2020/2021 under the new study program at the first cycle of studies accredited in 2019.

Also, it should be noted that in the previous period course delivery has been strongly impacted by covid-19 pandemic, especially in the part related to the delivery of laboratory exercises in spring semester of academic year 2019/2020 and winter semester of academic year 2020/2021. In this period, the most of the courses were partly or fully delivered on-line (lectures, auditory exercises, laboratory exercises, projects and so on), with laboratory exercises realized partly on premises, partly through on-line sessions, or through the homework tasks for students by using specifically developed and customized software tools.

The study programmes and the above specified courses at both cycle of studies, have been modernized, enhanced and developed according to the current needs and trends in ICT area (Information and Communications Technologies) and in line with the industry demands and needs assessed within project, which included overview and modernisation of the courses content (aligned with derived knowledge areas and knowledge units defined within the project) and learning outcomes (through applying the skills obtained in the teaching training process), adoption of new teaching methods that were defined and recommended in the project, through the establishment of the new laboratory (Networks and IoT Lab that was established in collaboration with Cisco as the industry partner in the project) and by preparation of the specific teaching materials. The new teaching materials have been developed in compliance with the defined enhanced or developed courses' content, as well as the teaching tools and methods that were selected, accepted and recommended within the project. The new laboratory equipment acquired in scope of the project, was used to form the Networks and IoT Lab, which enabled development and delivery of new laboratory exercises for students (for courses IoT Networks, IoT Networks Architecture and Wireless Sensor Networks delivered in this lab), realization of different types of student projects and graduation theses (at both cycle of studies). Also, some of this equipment (i.e. the oscilloscopes and signal generators) were used to develop and deliver laboratory exercises for the enhanced courses Signal Processing 2, Telecommunications 1 and Telecommunications 2. In total, the UB team has prepared 95 presentations (lectures) with the lecture slides, and lab notes for 24 new or enhanced laboratory exercises (in the form of practicum or individual lab exercises notes).

The preparation of teaching material for the course Smart Devices and Communications that is included in new accredited programme at the first cycle of study, and will be delivered after the end of the project, has been started and will be finished during 2021. Also, some video teaching material that was planned is to be recorded and available as soon as possible. All teaching materials are posted on BENEFIT project E-platform, some without any restrictions in order to share knowledge and increase impact of the project, while some of these materials are protected by password and are available on demand.

4.3.5 University of Niš

At the University of Niš, Faculty of Electronic Engineering, four courses have been enhanced within the project at the first cycle of study: Mobile Communication Systems, Microwave Design for IoT, Measurements in Telecommunications and Data Analysis and Compression. The new specified courses are Computer Communications and Internet access (II), Smart Systems and IoT as well as Advanced RFIC for Telecommunication Systems.

At the Master level (the second cycle) three courses have been modernized: Circuit Design for 5G systems, Broadband access networks and Principles of Software Radio, whereas seven new courses have been developed and included into the study programme: Wireless power transfer and energy harvesting, Artificial Intelligence and Machine Learning for communication systems, Intelligent audio algorithms, Statistical Learning in Signal Processing, Computing for IoT Communications, Telecommunication and Information Technologies in Telemedicine and Big Data Analysis.

The Master new accredited study programme was implemented for the first time in 2019/20 school year. Some of modernized courses at the Bachelor study level have been delivered in spring semester of academic year 2019/20 and winter semester of academic year 2020/21, such as Mobile Communication Systems and Measurements in Telecommunications, while another enhanced courses (Microwave Design for IoT and Data Analysis and Compression) that changed the name will be offered in incoming years within the new accredited study programme, which has started at 2020/21 school year. Delivery of courses at Bachelor and Master study levels in the spring semester of 2019/20 school year and winter semester of 2020/21 has been influenced by covid-19 pandemic. The lecturing and solving problems were delivered on-line whereas the laboratory exercises were realized either in laboratory or over interactive on-line tutorials, video sessions, and small projects performed by using specialized software tools.

The modification and development of new courses has been performed according to the up to date needs and trends in the area of Communications and Information technologies and in agreement with industry partner instructions and demands. The new teaching materials have been developed in compliance with the teaching methods and tools selected and accepted for implementation during the project. Additionally, the new laboratory equipment purchased during the project and Machine to Machine communications lab formed together with UNI industrial partner NiCAT cluster of advanced technologies, enables organizing new measurement setups and laboratory exercises for students and researchers, as well as new lab practicum development. As the results, UNI team has prepared 128 presentations for lecturing, 3 textbooks and 3 laboratory practicums as well as 9 videos with the instructions for laboratory exercises.

The preparation of teaching material for some courses that will be delivered in three or four-year time within new accredited programme has been started and will be finished after the project end. Also, some video teaching material that was planned is to be recorded and available as soon as possible. All teaching materials are posted on BENEFIT project E-platform, some of them are protected by password and will be available on demand. The lab videos are posted on YouTube channels and links on them is available on project E-platform.

4.3.6 University of Novi Sad

University of Novi Sad has improved 3 courses in the first cycle of study:

- *The first cycle of study*: Modelling and Simulation of Communication Systems, Machine Learning 1 and Software in Telecommunication Systems.

Furthermore, 3 specific-domain courses in the first cycle of study were developed as well as 4 courses in the second cycle:

- *The first cycle of study*: Machine Learning 2, Wireless Communication Systems and Design of Industrial IoT Systems.
- *The second cycle of study*: Big Data - Management and Analysis, Cognitive Radio, Network Science and Cryptography.

The courses that have been expanded and upgraded were delivered in the spring semester of academic year 2019/2020 and in the winter semester of 2020/2021. Course delivery in this period has been impacted by covid-19 pandemic, when most curricular activities have been delivered online.

The enhancement of study programmes includes modernisation of the content of courses (after alignment of a course with derived knowledge areas and knowledge units) and learning outcomes (applying skills obtained in the teaching training process), adoption of new teaching methods, establishment of the "Wireless Communications and Information Processing Lab" in collaboration with industry partners on the

project, companies RT-RK (Novi Sad) and Saga (Belgrade) and preparation of the teaching materials for new or modernized courses. The new teaching materials include one handbook, 7 sets of lecture notes in the form of presentations, 3 laboratory practicums or notes for laboratory exercises as well as 1 video set presenting theoretical lectures, as well as lab sessions and solving numerical problems, depending on the course. Links to videos are available at the BENEFIT digital platform and they are also available at the digital platform of the Chair of Telecommunications and Signal Processing of the Faculty of Technical Sciences. These videos have been found to be a very convenient means for transmitting knowledge under the conditions of the covid-19 pandemic. The newly developed courses will be delivered in the coming period, in accordance with the new accreditation of study programmes at the Faculty of Technical Sciences, carried out in 2020. All teaching materials that were developed within the BENEFIT project have been made publicly available via BENEFIT digital platform, without any restrictions, in order to share knowledge and increase the impact of the project.

Besides the above listed courses, a number of other courses in the existing curriculum will benefit from the establishment of the new lab, including: Digital Signal Processing, Digital Filters, Introduction to Communication networks, Modelling and Simulation of Communication Systems, as well as Measurement Systems in Telecommunications.

5 Accreditation of study programs

5.1 Status of study programs accreditation at Bosnia and Herzegovina universities

The Council of Ministers of Bosnia and Herzegovina adopted on June 3, 2008. document "Strategic directions of development of higher education in B&H 2008-2015" with the implementation plan. The Federal Ministry of Education and Science adopted the “Strategic Directions for the Development of Higher Education in the FB&H for the period from 2012 to 2022” in 2012, and they are not binding for the cantonal levels of government.
The criteria for accreditation of higher education institutions in B&H are regulated within the activities of the Agency for Development of Higher Education and Quality Assurance of B&H by the “Decision on Criteria for Accreditation of Higher Education Institutions in Bosnia and Herzegovina” no. 01-50-633-11/10 of July 12th 2010.

5.1.1 University of Banja Luka

At the beginning of 2013, the University of Banja Luka (UNIBL) entered the process of institutional accreditation by submitting a self-evaluation report to the Agency for Accreditation of Higher Education Institutions of the Republic of Srpska (HEAARS). After that, in March, the Commission of Domestic and International Experts conducted an external visit and evaluation of UNIBL, and after preparing the report, issued a recommendation on institutional accreditation. HEAARS issued a decision on accreditation under number 178/13, on 15.08.2013, which confirms the quality standard of UNIBL in accordance with the Standards and Guidelines for Quality Assurance in the European Higher Education Area (ESG) and the Criteria for Accreditation of Higher Education Institutions in Bosnia and Herzegovina. The Faculty of electrical engineering study programs were accredited 14.8.2014, by the Ministry for education and culture, Republic of Srpska. After the expiration of the validity of the accreditation, in 2018 UNIBL entered the process of institutional re-accreditation and accreditation of 16 study programs. After the submission of the UNIBL self-evaluation report and 16 self-evaluation reports of study programs according to HEAARS, an external visit and evaluation of the Commission of domestic and international experts followed. Completing the visit and evaluation, the Commission issued a recommendation on institutional accreditation (re-accreditation) of UNIBL and 16 study programs. HEAARS is March 26, 2019. under ordinal number 0l / 1 .4.92-7 / 18 issued a decision on institutional accreditation of UNIBL which confirms the standard of quality of work of UNIBL in accordance with the Standards and Guidelines for Quality Assurance in the European Area of Higher Education (ESG) and Criteria for Accreditation of Higher Education Institutions in Bosnia and Herzegovina, as well as confirmation of quality standards of study programs of the first cycle of UNIBL that were selected for this accreditation in relation to the Criteria for accreditation of study programs of the first and second cycle of studies in Bosnia and Herzegovina and the Standards and Guidelines for Quality Assurance in European Higher Education (ESG).

5.1.2 University of Sarajevo

The University of Sarajevo is accredited by the Decision of the Ministry of Education, Science, and Youth of Canton Sarajevo number: 11 /05-38-3709-3/10 dated September 10th 2019, according the Recommendation on accreditation of high education institution – University of Sarajevo, number 05-33-1-166-7/19, dated September2nd 2019, issued by the Agency for the Development of Higher Education and Quality Assurance. The validity period of the accreditation of the University of Sarajevo is 5 years. Accreditation procedures and other accreditation documents of the University of Sarajevo can be found on the Agency's link:

http://hea.gov.ba/akreditacija_vsu/akreditovani/Default.aspx?id=5385

Faculty of Electrical Engineering accredited all 4 I cycle study programmes in 2012, and re-accredited in 2019, by the Accreditation Agency for Study Programmes in Engineering, Informatics, Natural Sciences and

Mathematics (ASIIN e.V.), including the Telecommunications Bachelor study programmes. The Report on the accreditation is available at:

http://www.asiin-ev.de/akkr_dokumente/Abschlussbericht_Accr.Report_File1_Sarajevo_IU_Verf.ID_241_2019_06_28.pdf

It is important to note that in the report it is stated that although the equipment is suitable to carry out Bachelor programme, the equipment in Telecommunication could still be enhanced. This recommendation is now fulfilled thanks to the activities in the BENEFIT project.

5.1.3 University of Tuzla

On September 9th 2014, the Agency for the Development of Higher Education and Quality Assurance appointed a Commission of domestic and international experts for quality assessment and audit and making recommendations on the accreditation of the University of Tuzla. The University of Tuzla is accredited by the Decision of the Ministry of Education, Science, Culture and Sports of Tuzla Canton number: 10 / 1-38-14718-3/14 dated April 14th 2015. The validity period of this accreditation of the University of Tuzla is 6 years. Accreditation procedures and other accreditation documents of the University of Tuzla can be found on the Agency's link:

http://hea.gov.ba/akreditacija_vsu/akreditovani/Default.aspx?id=6095.

Preparatory activities for the next accreditation of the University of Tuzla are underway.

The evaluation of the study programs quality at the University of Tuzla is carried out in accordance with the Rulebook on Quality Assurance of the University of Tuzla. Faculties / academy conduct the quality assessment procedure of their study programs at least once a year. The procedure is carried out according to the instructions defined by the Centre for Quality Assurance and Internal Evaluation and the Quality Management Committee, which oversee the complete procedure.

Criteria for assessing the quality of study programs are defined in the “Decision on Amendments to the Decision on Standards Determining Minimum Standards in the Field of Higher Education in Bosnia and Herzegovina”, adopted by the Agency for Development of Higher Education and Quality Assurance of B&H on March 8th, 2019.

An overview of the criteria that are evaluated in the process of self-evaluation of study programs is given in the form defined by the Centre for Quality Assurance and Internal Evaluation.

The organizational units (faculties/academy) completed the first assessment of the quality of study programs, whose reports was finished on October 15th 2020.

The University of Tuzla is currently in the process of institutional reaccreditation. Self-evaluation reports of organizational units and self-evaluation report of the University of Tuzla were prepared. After the completion of the institutional reaccreditation procedure, according to the “Rulebook on the accreditation procedure of higher education institutions and study programs”, adopted by the Ministry of Education and Science TK (Official Gazette TK, 18/2013), the University of Tuzla is obliged to submit the accreditation plan of study programs within three months after institutional reaccreditation.

The next accreditation will be completed in 2021.

5.2 Status of study programs accreditation at Serbian universities

The National Entity for Accreditation and Quality Assurance in Higher Education (hereinafter referred to as NEAQA) established by the Decision of the Government of the Republic of Serbia (“Official Gazette of the Republic of Serbia”, No. 9/2018 of 2 February, 2018) in accordance with the Law on Higher Education of 2017, and the Commission for Accreditation and Quality Assurance [CAQA], which was constituted as an expert body of NEAQA, perform activities of accreditation and quality assurance of higher education institutions and their units, evaluation of study programs and quality assurance in higher education in Serbia.

In Republic of Serbia the Law on Higher Education from 2005 introduced the principles of the Bologna Declaration and the Lisbon Strategy into the higher education system of the Republic of Serbia and has set the ground for the inclusion of Serbia in the European Higher Education Area (EHEA). In accordance with the aforementioned Law in June 2006 the Commission for Accreditation and Quality Assurance (CAQA) was formed as the body of the National Council for Higher Education. The financial, administrative and technical affairs for both bodies were performed by the Ministry of Education, Science and Technology Development. CAQA has become a full ENQA (European Association for Quality Assurance in Higher Education) member in April 2013. CAQA has been registered on EQAR (European Quality Assurance Register) since November 2014. In February 2018 ENQA did not renew CAQA's full membership status and designated its position as "Member under review" for a period of two years.

In 2018, the new National Entity for Accreditation and Quality Assurance in Higher Education (hereinafter referred to as NEAQA) was established by the Decision of the Government of the Republic of Serbia ("Official Gazette of the Republic of Serbia", No. 9/2018 of 2 February, 2018) as a national independent body in institutional, financial, administrative and professional matters in accordance with the Law on Higher Education of 2017 ("Official Gazette of the Republic of Serbia", No. 88/2017, 27/2018 and 73/2018). NEAQA was enlisted in the state register on 9 March, 2018 and its Steering Committee was constituted on 3 May, 2018. On the basis of a public competition the NEAQA's Director was elected on 19 July, 2018, as well as the members of the Commission for Accreditation and Quality Assurance (CAQA), which was constituted on 30 August, 2018 as an expert body of NEAQA. As CAQA's universal legal successor, NEAQA kept in ENQA the same status "member under review".

The NEAQA performs activities of accreditation and quality assurance of higher education institutions and their units, evaluation of study programs and quality assurance in higher education in Serbia. NEAQA has changed the methodology and procedure of accreditation and quality assurance in higher education established by CAQA in order to meet the all ESG requirements, https://www.nat.rs/en/regulations/. To this end particular emphasis is placed on the strengthening of the independence of NEAQA, which is the key pillar of the accreditation and quality assurance process. NEAQA has put into the forefront activities to ensure the implementation of a new methodology of the accreditation and quality assurance process in Serbia in accordance with the quality principles in the EHEA, the Standards and Guidelines for Quality Assurance in the EHEA (ESG), and the regulations of the Republic of Serbia. Its main goal is to achieve full membership in ENQA and registration on EQAR, to attain more complete internationalization and take adequate place in the European higher education area.

5.2.1 University of Belgrade

In 2017, at the beginning of BENEFIT project, the School of Electrical Engineering at University of Belgrade had two accredited study programmes at the Bachelor academic study (the first cycle of study): Electrical and Computer Engineering (accredited in 2013) with six study modules (including Telecommunication and Information Technology with 4 module options, sub-modules) and Software Engineering (accredited in 2017), the one accredited study program at the Master academic study (the second cycle if study): Electrical and Computer Engineering (accredited in 2013) with the twelve study modules (including System Engineering and Radio Communications and Audio and Visual Technologies), and the one accredited Doctoral study program: Electrical and Computer Engineering (accredited in 2013).

In 2019, on the basis of peer-review panel's reports of CAQA, the NEAQA declared two documents related to the approval of accreditation for study programmes on University of Belgrade, School of Electrical Engineering (UB-SEE), as well as for the accreditation of UB-SEE as higher education institution:

- Certificate on accreditation, No. 612-00-00298/6/2019/03 issued on 04.10.2019. by NEAQA, for the University of Belgrade, School of Electrical Engineering (UB-SEE) as the higher education institution _(*https://www.nat.rs/wp-content/uploads/2019/10/BG-ETF-VSU-UB-Elektrotehnicki-fakultet.pdf*), with CAQA peer-review panel's report (*https://www.nat.rs/wp-content/uploads/2019/10/BG-ETF-VSU-UB-Elektrotehnicki-fakultet-RI.pdf*)

- Certificate on accreditation, No. 612-00-00296/6/2019/03 issued on 04.10.2019. by NEAQA, for the Bachelor academic studies (the first cycle studies) at UB-SEE for the Study Programme Electrical and Computer Engineering *(https://www.nat.rs/wp-content/uploads/2019/10/BG-ETF-OAS-Elektrotehnika-i-racunarstvo-ETF.pdf),* with the corresponding CAQA peer-review panel's report (*https://www.nat.rs/wp-content/uploads/2019/10/BG-ETF-OAS-Elektrotehnika-i-racunarstvo-ETF-RI.pdf*);
- Certificate on accreditation, No. 612-00-00300/6/2019/03 issued on 04.10.2019. by NEAQA, for the Master academic studies (the second cycle studies) at UB-SEE for the Study Programme Electrical and Computer Engineering *(https://www.nat.rs/wp-content/uploads/2019/10/BG-ETF-MAS-Elektrotehnika-i-racunarstvo-ETF.pdf),* with the corresponding CAQA peer-review panel's report (*https://www.nat.rs/wp-content/uploads/2019/10/BG-ETF-MAS-Elektrotehnika-i-racunarstvo-ETF-RI.pdf*).

The Study Programme Electrical and Computer Engineering (accredited in 2019) at the Bachelor academic study level (the first cycle of study) at UB-SEE is organized in 8 semesters (four academic years), and the first students were enrolled into this study programme in academic year 2020/2021. The studies are characterized by students acquiring general engineering knowledge within the first year (the first two semesters), while from the third semester the students choose within the six study modules among which is Telecommunications and Information Technology module (that was enhanced and modernized in scope of BENEFIT project) that offers three submodules (study module options): Information-Communication Technologies, Audio and Video Technologies and Microwave Engineering. This accredited study programme for the first time incorporates the course at the first academic study year related to the ICT (Information and Communication Technology) area, i.e. course Smart Devices and Communications developed in scope of BENEFIT project, which is expected to provide the more interest of students for the election and enrolment in Telecommunications and Information Technology module in the second and higher study years. This new accredited study programme incorporates all six enhanced and new courses that are observed in BENEFIT project. Total number of credits necessary for obtaining the academic title Bachelor in Electrical and Computer Engineering is at least 240 ECTS

The Study Programme Electrical and Computer Engineering (accredited in 2019) at the Master academic study level (the second cycle of study) at UB-SEE is organized in 2 semesters (one academic years), and the first students were enrolled into this study programme in academic year 2020/2021. The students choose within the twelve study modules among which is Information Communication Technologies module (that was enhanced and modernized in scope of BENEFIT project). This new accredited study programme incorporates all three enhanced and new courses that are observed in BENEFIT project. Total number of credits necessary for obtaining the academic title Master in Electrical and Computer Engineering is at least 300 ECTS, with the condition for enrolment in the study programme is at least 240 ECTS.

5.2.2 University of Niš

The NEAQA and CAQA accreditation bodies in Serbia mentioned above, declared the documents of approval of accreditation of the Study Programme Electrical Engineering and Computing at the Bachelor academic study, the five study programmes at Master academic study, as well as the Doctoral study programme at the University of Nis, Faculty of Electronic Engineering (UNI-FEE) on 3rd of October 2019.

Study Programme Electrical Engineering and Computing at the Bachelor academic study level at UNI-FEE, which was started in 2020/21 school year, is organized in 8 semesters (four academic years). The studies are characterized by students acquiring general engineering knowledge within the first year (two semesters), and from the third semester the students may choose narrower fields within the 6 modules among which is Communications and Information Technologies, with the following submodules (from the 5th semester): Communications and Information Processing and System Engineering and Radio Communications. In new accredited study programme for the first time the course at the first academic study year named Introduction to engineering is partly relates to Communications and information technologies that will provide the more

interest of students for election and enrolment of Communications and information technologies module on second and higher study years.

The Study Programme Communications and Information Technologies at the Master Academic Studies started in 2019/20 school year. It is to ensure students acquiring the necessary knowledge and skills, offering them big opportunities of employment and/or further education in the field of Communications and Information Technologies, and more, in the field of Electrical and Computer Engineering. The teaching process at Master studies at the study programme Communications and Information Technologies lasts one academic school year . Total number of credits necessary for obtaining the academic title Master in Electrical Engineering and Computing (M.E.Eng.Comp.) - Communications and Information Technologies is at least 300 ECTS. The condition for enrolment in the study programme is at least 240 ECTS. Within this Study Programme, there are two modules as follows:

- Communications and Information Processing
- System Engineering and Radio Communications.

Education at the study programme is realized through: Mandatory and elective courses (each lasts one term), professional practice or team project (3 ECTS), research work (in each term, 7 ECTS), to achieve independence in research and enable students to work on the master thesis, and Master thesis (15 ECTS).

5.2.3 University of Novi Sad

Commission for Accreditation and Quality Assurance (CAQA), which was constituted as an expert body of NEAQA declared the documents of approval of accreditation of the Undergraduate Academic Studies (1st study level) – Study Programme “Power, Electronic and Telecommunication Engineering”, including Module “Information and Communications Technologies and Signal Processing”, as well as Master Academic Studies (2nd study level) – Study Programme “Power, Electronic and Telecommunication Engineering”, including the Module “Information and Communications Technologies”, on October 26th, 2020. Previously, the accreditation of UNS-FTS as higher education institution was carried out.

Bachelor Study Programme “Power, Electronic and Telecommunication Engineering” consists of 5 modules for 240 students per year, including the Module “Information and Communications Technologies and Signal Processing” from the 2nd year, which has been improved within the BENEFIT project through 3 novels and 3 enhanced courses. The recently accredited Study Programme has just started in the winter semester of the school year 2020/21, while ICT&SP Module includes courses from the 2nd year. However, the 3 enhanced courses have been used for enhancement of the old version of these courses and already implemented, while the 3 novel courses will start in the next years.

The Master Study Programme “Power, Electronic and Telecommunication Engineering” consists of 9 modules for 175 students per year, including the Module “Information and Communications Technologies”, which has been improved within the BENEFIT project through the development of 4 novel courses (all of them are elective courses among 12 courses). The ICT Module was started in the 2020/21 school year and 3 of 4 courses developed within the BENEFIT project have been just delivered for the first time during the current winter semester.

6 Conclusions

This report describes the process of the modernisation of study programmes in telecommunication engineering of 3 B&H and 3 Serbian universities in cooperation with ICT industry. The methodology used for modernisation of study programs leverages outcomes of WP1, detecting deficiencies in the current study programs have been analysed from the both academic and industry perspectives. In order to enable systematic approach for the study program modernisation, utilized approach is founded on the introduction of the Telecommunication body of knowledge. Originating from the overview of the current curriculum and knowledge expressed in the industry feedback through the questionnaire, knowledge areas were determined. These knowledge areas have been essential for the determination of the content of modernised courses as well as learning outcomes. All knowledge areas are described with all details in the Appendix A of this report.

Enhancement process of the existing curricula at 6 WB universities included preparation of new learning outcomes and/or competencies that a student will gain with a course, course content and teaching methods. Partner universities from WB countries selected courses from the first and second cycle of study for modernisation as well as defined new courses for the development. BENEFIT project modernised 30 courses and introduced 10 new courses at the first cycle study at 6 WB universities. Besides the course description, content, learning outcomes and teaching methods, new teaching materials (e.g. presentations, textbooks, video materials) have been developed and made publicly available through BENEFIT portal. With the same approach, 11 courses have been modernised and 13 new courses developed at the second cycle of study. The full lists of modernised and new courses at the first and second cycles of study are given as the Appendix B of this report.

The overall improvements in the curriculum restructuring and improvement within the BENEFIT project can be summarised as: improvement in the structure of study programs, improvements in the course contents, improvements in lab sessions, development of new teaching materials and enhanced collaboration between universities.

The accreditation process at WB universities occurs periodically after 4 years and additional accreditations are not feasible. Different regulations between Serbia and Bosnia and Herzegovina, as well as within entities of Bosnia and Herzegovina, made this process even more complex. Therefore, while some universities successfully passed accreditation process, other universities are in the preparatory process.

In the scope of the project BENEFIT, majority of the modernised courses have been delivered in the spring semester of 2019/2020 and winter semester of 2020/21. Delivery of the modernised courses strongly depended on the possibility of universities to introduce these courses in the teaching process. Some courses have been delivered in the full content in the 2019/20 winter semester, while other courses leveraged new teaching methods, materials and labs. Due to covid-19 pandemic, teaching process is dominantly organised and implemented online. Development of new teaching materials and its availability through the BENEFIT platform has been found very useful for the students and teachers, beyond partner universities. All modernised and new courses will be delivered in the coming years, enabling sustainability of the project and usage of the project tangible results.

7 Appendix A

7.1 List of Knowledge Areas and Knowledge Units

Knowledge Areas and Knowledge Units	
Mathematics	**Physics**
1. Numbers and general concepts about numeric functions 2. Elements of mathematical logics and set theory 3. Vector spaces theory elements 4. Matrices 5. Systems of linear equations 6. Linear operators 7. Vector algebra 8. Analytical geometry in plane 9. Analytical geometry in space 10. Complex numbers 11. Single variable real functions 12. Differential calculus of single variable real functions 13. Integral calculus of single variable real functions 14. Infinite sequences and series of numbers and functions 15. Ordinary differential equations of the first order 16. Ordinary differential equations of the higher order 17. Laplace transform 18. Fourier series, integrals and transforms 19. Complex functions 20. Basis of differential calculus of functions of several real variables 21. Optimization of functions of several real variables 22. Relative extrema-relative maximum or minimum 23. Vector field theory 24. Integral calculus of functions of several real variables 25. Probability and Statistics	1. Introduction to classical mechanics 2. Introduction to oscillations and waves 3. Introduction to electricity and magnetism

Knowledge Areas and Knowledge Units	
Fundamentals of electrical engineering	**Measurements and Instrumentation**
1. Electrostatics 2. DC currents 3. Electromagnetics 4. AC currents 5. Theory of Electromagnetic Fields	1. Introduction to metrology 2. Measurement quantities, units and standards 3. Measurement accuracy and uncertainty; Reliability, reproducibility and repeatability 4. Measurement methods and principles 5. Instrumentation 6. Software tools, measurement automation and virtual instruments 7. Processing and visualization of measurement results 8. Specific aspects of measurements in communications 9. Power measurements of RF and microwave signals; Time domain reflectometry 10. Measurements in fibre optic communication systems 11. Measurements in spectral domain 12. Characterization of digital communication systems 13. Measurements on audio and video signals 14. Telemetry

Knowledge Areas and Knowledge Units	
Information Theory	**Electronics Engineering**
1. Introduction to Information Theory 2. Information-theoretic measures 3. Source coding theorem 4. Data compression algorithms 5. Channel coding theorem 6. Channel capacity and methods of calculation 7. Block codes 8. Introduction to Channel Decoding 9. Convolutional codes 10. Trellis codes and Coded Modulation 11. Turbo codes 12. Linear Block codes 13. BCH and RS codes 14. LDPC codes 15. Polar codes 16. Codes for error detection 17. Applications of channel codes 18. Data encryption 19. Algebraic encryption methods 20. Data protection on the Internet	1. History and overview 2. Relevant tools, standards, and/or engineering constraints 3. Fundamentals of semiconductor 4. Semiconductor components 5. Semiconductor circuits 6. Operational amplifiers 7. Signal conversion circuits 8. DCDC converters 9. Impulsive electronics 10. Digital electronics

Knowledge Areas and Knowledge Units	
Radio Communications	**Communication Networks**
1. History and overview 2. Relevant tools, standards, and/or engineering constraints 3. Radio-communication concepts: system components, services, spectra 4. Radio wave propagation mechanisms and properties 5. Architecture of radio transmitters and radio receivers 6. Antenna fundamentals 7. Introduction to microwaves 8. RF amplifiers and mixers. Modulators and demodulators 9. Multiple access (FDMA, TDMA, CDMA, SDMA) and diversity techniques 10. Noise and interference in radio systems. Multipath fading and unavailability. 11. Microwave radio links. Link budget. 12. Design of fixed and mobile radio links: propagation modelling and prediction of EM field level 13. Public mobile cellular networks (GSM/UMTS/LTE/5G) 14. Satellite telecommunications 15. Wireless local area networks 16. Fundamentals of radar systems 17. Cognitive radio 18. Electromagnetic compatibility 19. Exposure to RF and microwave radiation 20. Principles, potentials and limitations of next-generation wireless systems	1. Network fundamentals 2. Local area networks 3. Internet architecture 4. Wireless and mobile networks 5. IoT networks 6. Network security

Knowledge Areas and Knowledge Units	
Communication Systems	**Software Engineering**
1. Signals and systems fundamentals 2. Communication systems basics 3. Analog to digital conversion and pulse modulation 4. Baseband digital transmission 5. Passband analogue and digital transmission 6. Coding in digital communication systems 7. Multiplexing and multiple access 8. Design and optimization 9. Synchronization in digital communication systems 10. Advanced band pass transmission 11. Advanced transmission with spatial processing 12. System modelling and simulation 13. Optical communications 14. Examples of communication technologies and systems 15. Other	1. Introduction to programming 2. Object oriented programming 3. Data structures, algorithms and databases 4. Core software engineering topics 5. Advanced programming topics 6. Specific application areas
Computer Engineering	**Information and Data Management**
1. Digital Electronics 2. Computer Architecture and Organization 3. Computer Systems Design 4. Embedded Systems	1. Database fundamentals 2. Data storage 3. Data compression and transmission 4. Data encryption 5. M2M communications 6. Algorithmic complexity 7. Concepts of detection and estimation 8. Design of estimators 9. Artificial intelligence systems 10. Basic ML algorithms (Bayesian learning theory, Discriminative classifiers, Dimensionality reduction, Unsupervised learning: clustering) 11. Advanced ML algorithms 12. Data mining and Big Data analytics 13. Deep learning 14. Graphical data structures and models 15. Graph analytics: network topology, processes, and algorithms 16. Data privacy methods, techniques and legislation

Knowledge Areas and Knowledge Units	
Signal Processing	**Multimedia**
1. Continuous signals and systems 2. Discrete time signals and systems 3. Implementation of DSP algorithms 4. Audio signal processing 5. Image processing 6. Video processing 7. Advanced signal processing 8. Machine learning for signal processing 9. Signal processing applications	1. Multimedia technology 2. Multimedia signal types 3. Multimedia signal processing 4. Human perception 5. Single- and multi-dimensional discrete algorithms and transformations for audio and video signals 6. Coding of multimedia signals 7. Content recognition for multimedia services 8. Multimedia content editing and management 9. Multimedia quality management 10. Design of multimedia services 11. Ambient intelligence 12. Multimedia terminals 13. Multimedia network protocols
Other Engineering Courses	**Communication and Presentation Skills, Foreign Languages**
1. Industrial engineering 2. Health – bio engineering 3. Environmental engineering 4. Energy and robotics	1. Technical writing 2. Communication and presentation 3. Another language (Mandarin, Arabic, Spanish, Russian, German, French, Italian) 4. Marketing and fund raising 5. Gender studies 6. Team building and collaborative work
Project Management	
1. Introduction to project management in ICT 2. Project life cycle 3. Project goal and scope 4. Project planning 5. Project execution 6. Product life cycle 7. Analysis of selected ICT systems and services 8. Project presentation	

7.2 List of Knowledge Sub-units

	Knowledge units	Sub-units
Mathematics		
1.	Numbers and general concepts about numeric functions	1. Algebraic operations involving real numbers. 2. Decimal representation of real numbers. 3. Triangle inequality. 4. Bounded and unbounded intervals. 5. General concepts on real-valued functions of a single real variable. 6. Bounded, monotone, symmetric (even and odd), periodic functions. 7. Functions composition, identity maps, injective functions, inverses. 8. Elementary functions: power function (with real exponent), exponential and logarithmic functions, hyperbolic and their inverse functions, trigonometric and their inverse functions.
2.	Elements of mathematical logics and set theory	1. Operations, algebraic structures. 2. Group, rings and modules.
3.	Vector spaces theory elements	1. Vector spaces and subspaces. 2. Calculation properties. 3. Linear combinations. linear dependence and independence. 4. Basis, dimension and generators.
4.	Matrices	1. Definition and types of matrices. 2. Operations (addition, multiplication by scalars, multiplication, transposition). 3. Matrix rank. 4. Inverse matrix. 5. Determinants (presenting, *Sarrus* rule, *Laplace* rule, properties).
5.	Systems of linear equations	1. Definitions of systems of linear equations and solutions. 2. Determined, undetermined and impossible system. 3. Cramer's rule. 4. Method for solving quadratic systems using matrices. 5. Gauss elimination method. 6. Kronecker-Capelli method.

6.	Linear operators	1. Definition of linear operator. 2. Kernel and image of an operator. 3. Linear operators and matrices. 4. Linear functional and dual vector spaces. 5. Polynomials. 6. Eigenvalues and Eigenvectors. 7. Diagonalization.
7.	Vector algebra	1. Definition of vectors. 2. Magnitude and direction. 3. Basic vector operations. 4. Dot, cross and triple product of vectors.
8.	Analytical geometry in plane	1. Concept of line and surface equation. 2. Equations of a line in the plane. 3. Parallel and perpendicular lines. 4. 9.The distance between two points. 5. Set of lines passing through specific point in the plane.
9.	Analytical geometry in space	1. Equations of a plane in space. 2. Equations of a line in space. 3. Mutual relations between two lines, two planes, and plane and line in space. 4. Set of plains containing specific line.
10.	Complex numbers	1. Algebraic form: real and imaginary part, modulus, conjugated complex numbers and their properties. 2. Triangle inequality, argument. 3. Trigonometric form. 4. De Moivre's theorem about product, quotient and power of complex numbers, n^{th} root of a complex number.

11.	Single variable real functions	1. Limits and asymptotes: Neighbourhood and infinity on real axis. 2. Limit (finite and infinite) of a function at a point and at infinity. 3. One-sided limits: from the left and from the right. Inequalities for limits of functions. 4. Algebraic operations with limits. Indefinite expressions. 5. Limit existence of a monotone function. 6. Limit inferior and limit superior of a monotone function. 7. Techniques for evaluating a limit. 8. Limits for common functions (power, exponential, logarithmic and trigonometric functions). 9. Hierarchy of infinity: logarithms, power functions, exponential functions. 10. Application of asymptotic expansions for evaluations of limits. Asymptotes: horizontal, vertical and oblique (slant). 11. Mean-value theorem and Bolzano's theorem for continuous functions on an interval. 12. Definition of continuous functions on an interval. 13. Continuity of inverse function to a continuous monotone function on an interval. 14. Continuity of elementary functions and algebraic combinations of continuous functions. 15. Point of absolute maximum and minimum of a function. 16. Weierstrass theorem about minimum and maximum of continuous functions on a segment.

12.	Differential calculus of single variable real functions	1. Differentiability and properties of differentiable functions. 2. Derivate of a function at a point. 3. Left and right derivatives. 4. Tangent line to the graph of a function. 5. Differentiation rules of elementary functions. 6. Derivatives of compositions and inverses. 7. The connection between continuity and differentiability of functions at a point. 8. 13.Theorems of Fermat, *Rolle's* theorem and *Lagrange's theorem* (mean-value). 9. Properties of monotone differentiable function at an interval determined with the sign of derivative. 10. Function with zero derivative at an interval. 11. Derivatives of higher order, finding extrema and linear approximations. 12. Concavity and convexity. 13. Flexion: definition and application of second derivative. 14. Application of first and second derivatives to examination of a graph of a function. 15. *L'Hospital* rule. 16. Taylor series. 17. Remainder of an approximation of second order in *Peano's* and *Lagrange's* form.
13.	Integral calculus of single variable real functions	1. (Definite/Riemann) integral, primitive functions and fundamental theorems. 2. Riemann integral single variable real functions defined of closed intervals. 3. Basic properties of definite integrals. 4. Mean-value theorem. 5. Primitive and integral functions defined on an interval. 6. Fundamental theorems of integral calculus. 7. Definition and basic properties of indefinite integral. 8. Methods of integration and improper integrals. 9. Methods for evaluation of definite and indefinite integrals. 10. Integration by substitution and integration by parts. 11. Techniques for finding integrals of some classes of functions (rational, trigonometric, irrational). 12. Definition of improper integral. 13. Integrality criterion: (limit) comparison criterion.

14.	Infinite sequences and series of numbers and functions	1. Concept of an (infinite) series, n^{th} partial sum. 2. Convergence and divergence, regular and alternating series. Geometric series. 3. Necessary condition for convergence of series; harmonic series. 4. Series with non-negative terms, (limit) comparison test, (limit) ratio test, (limit) root test. 5. General harmonic series. 6. Absolute and conditional convergence of infinite series. 7. Absolute convergence is sufficient for ordinary convergence. 8. *Leibniz criterion* for alternating series. 9. Complex sequences and series. 10. Infinite sequences and series of functions: uniform convergence, *Cauchy* and *Weierstrass's* criterion of uniform convergence; power series with complex terms. 11. Taylor and Laurent series.
15.	Ordinary differential equations of the first order	1. Basic concepts and ideas. 2. Geometrical consideration. 3. 16.Isoclines. 4. Separation of variables. 5. Linear differential equations of the first order. 6. Variation of constants.
16.	Ordinary differential equations of the higher order	1. Homogeneous linear differential equations of second order with constant coefficients. 2. General solution, *Cauchy's* equation. 3. Homogeneous differential equations of higher order with constant coefficients. 4. Nonhomogeneous linear differential equations. 5. General method for solving nonhomogeneous equations. 6. Systems of differential equations.
17.	Laplace transform	1. Direct and inverse Laplace transforms. 2. Basic properties. 3. Laplace transform of derivatives and integrals. 4. Transformation of ordinary differential equations. 5. Unit step function. Periodic functions.
18.	Fourier series, integrals and transforms	1. Periodic functions, trigonometric series. 2. Fourier series. 3. Euler's formulas; functions with arbitrary period; even and odd functions. 4. Fourier integrals. 5. Fourier transform

19.	Complex functions	1. Series of complex functions. 2. Singularities and their Classification. 3. Residue calculus, the Cauchy's Residue theorem. 4. Conformal mappings. Mobius Transformations. 5. The Discrete Laplace Transform. 6. The Z-transform. 7. The Inverse Z-transform. 8. Properties of Z-transform. 9. Recurrence Equations. 10. Application of the Z-transform. 11. The Modified Z-transform.
20.	Basis of differential calculus of functions of several real variables	1. Functions of several real variables. 2. Continuity, limits. 3. Polar coordinates in the plane, calculating limits using a coordinate transformation. 4. Directional derivative. 5. Higher order partial derivatives. 6. Gradient. 7. Derivative of a composite function.
21.	Optimization of functions of several real variables	1. Local extreme. 2. Necessary condition for existing local extremes (Fermat's theorem). 3. Second order derivative of scalar function of two variables. 4. Quadratic forms, classification. 5. Necessary condition for the local extrema to have an inner point. 6. Sufficient condition for local extrema.
22.	Relative extrema-relative maximum or minimum	1. Presentation of curve and surface in implicit form. 2. Tangent space and normal space on the curve given by the equation $f(x, y) = 0$. 3. Equation of a tangent, equation of a tangent plane and equation(s) of the normal line. 4. Points in which there is related extrema, critical points, gradient in a critical point. 5. Necessary condition for the local extrema of function defined on the curve or surface (interpretation of the Lagrange multipliers and applications to optimization problems).
23.	Vector field theory	1. Scalar and vector fields. 2. Vector calculus, curves, arc length, and tangent. 3. Curvature and involution, speed and acceleration. 4. Directional derivative, gradient of a scalar field. 5. Divergence and rotor of vector fields.

24.	Integral calculus of functions of several real variables	1. Line integrals of the first and second kind. 2. Double integrals and *double integrals as iterated integrals*. 3. Transformation of double integrals into line integrals. 4. Surfaces, tangent plane. 5. Surface integrals of the first and second kind. 6. Triple integrals, triple integrals as iterated integrals and multiple integrals. 7. *Gauss'* divergence theorem. *Stokes'* theorem. Consequences and applications of *Gauss'* and *Stokes'* theorems. Line integrals & independence of path.
25.	Probability and Statistics	1. Introduction to statistics and data analysis. 2. The sample mean, median, variance, standard deviation. 3. Discrete and continuous data, 4. Graphical diagnostics. 5. Combinatory: combinations, permutations, definition of the probability. Additive rules. 6. Conditional probability, independence and Bayes' rule. 7. Random variables, distributions. 8. Mathematical expectation, mean, median, variance and covariance of random variables. 9. Means and variances of linear combinations of random variables, *Chebyshev's* theorem. 10. Some discrete probability distributions: binomial, multinomial, hypergeometric, Poisson 11. Some continuous probability distributions: normal, Gamma, exponential, Chi-square. 12. Fundamental sampling distributions and data description. Central limit theorem. 13. One and Two-Sample estimation problems: mean, prediction intervals, proportion, variance 14. Statistical hypothesis. 15. Testing statistical hypothesis. 16. Simple linear regression and correlation.
Physics		
1.	Introduction to classical mechanics	1. Linear and rotational motion of one particle and system of particles. 2. Rigid body motion. 3. Conservation laws. 4. Equations of motion. 5. Transformation of coordinates and other physical quantities between inertial and non-inertial frames of reference. 6. Lagrangian points.

2.	Introduction to oscillations and waves	1. Free harmonic oscillator with one degree of freedom and many degrees of freedom. 2. Forced oscillation and resonance. 3. Damped oscillation. 4. Normal modes. 5. Dispersion equation. 6. Standing and traveling waves. 7. Reflection. 8. Modulations, pulses and wave packets. 9. Signals and Fourier analysis. 10. Waves in two and three dimensions, wave vector, planar boundary, waveguides. 11. Polarisation. 12. Interference and diffraction.
3.	Introduction to electricity and magnetism	1. Electrostatics. 2. Electric potential, capacitance, electric current and resistance, circuits. 3. Magnetic field, magnetic fields due to currents, induction and inductance. 4. Electromagnetic oscillations and alternating current. 5. Maxwell equations. 6. Magnetisation of matter. 7. Electromagnetic waves.
Fundamentals of electrical engineering		
1.	Electrostatics	1. Structure of matter. 2. Electric charge, Coulomb's law and electric field vector. 3. Electric potential and voltage. 4. Flux of electric field vector. 5. Gauss's Law. Conductors in electrostatic field. 6. Electrostatic induction. 7. Capacitance, capacitors. 8. Dielectrics in electrostatic field. 9. Dielectric polarization and polarization vector. 10. Maxwell's postulate. 11. The electric field at the boundary of two dielectrics. 12. Dielectric characteristics. 13. Electrostatic field energy and forces. 14. The movement of charged particles in a vacuum under the influence of electrostatic field.

2.	DC currents	1. Electric current and electrical phenomena. 2. Concepts, elements and topology of electric circuits. 3. Ohm's Law. 4. Kirchhoff's laws. 5. Elementary DC circuits. 6. Complex DC circuits (bridge circuits, star-delta transformation, circuits with multiple sources). 7. Methods for analysis of complex electrical circuits (Superposition, Thevenin's, Norton's, reciprocity and Millman's theorem). 8. Circuits with capacitors. 9. Charging and discharging process of capacitors. 10. Stationary and transient states in electrical circuits with capacitors.
3.	Electromagnetics	1. Lorentz force, magnetic flux density. 2. Sources: current. 3. Charge in uniform motion: Ohm's law, resistance. 4. Biot-Savart's law, Ampere's circuital law, magnetic materials, energy in magnetic field, inductances, magnetic circuits. 5. Time-dependent fields, Faraday's law, sinusoidal fields. Characteristics of magnetic materials. 6. Magnetic circuits. 7. Inductance and mutual inductance. 8. Magnetic field energy.
4.	AC currents	1. Current and voltage waveforms. 2. Amplitude, average and effective values of current or voltage. 3. AC Generator. 4. Complex calculus in analysis of AC circuits. 5. RLC circuits. 6. Topographic and locus diagrams. 7. Frequency characteristics. 8. Apparent, real power and reactive power and instantaneous power. 9. AC circuits with multiple sources. 10. Polyphaser systems. 11. Harmonic analysis, applications in circuit analysis. Transients. 12. Transformers.

5.	Theory of Electromagnetic Fields	1. Presentation of the electromagnetic fields. 2. Definitions of vector fields E and B and their sources. 3. Singular density sources. Discontinuities in the field. 4. Maxwell's equations in vacuum in differential and integral form. 5. The electromagnetic field in the presence of substances, which is at rest. 6. Conductor and dielectric in electric field. 7. The magnetization of the material. 8. Model with magnetic charges and current density. Maxwell's equations for vector fields E, B, D and H. 9. Electromagnetic potentials. Wave equation. 10. Integral equations to solve electromagnetic task. 11. Retarded potentials. Energy and forces in electromagnetic field. 12. Spatial forces and surface stresses. Vector electromagnetic stress. 13. The static electric field. 14. Capacity. 15. Static current field. 16. Static magnetic field. Inductance. 17. Quasi-static field. Equations fields in phasor domain and quasi-static sinusoidal changing fields.
Measurements and Instrumentation		
1.	Introduction to metrology	1. Fundamental principles. 2. Meaning of metrology. 3. Quality control. 4. Objectives of metrology. 5. Process of measurement.
2.	Measurement quantities, units and standards	1. Measurement basics. 2. Electrical and non-electrical quantities. 3. Unit systems and etalons (based and derived units).
3.	Measurement accuracy and uncertainty; Reliability, reproducibility and repeatability	1. Measurement accuracy and precision. 2. Measurement uncertainty. 3. Reliability, reproducibility and repeatability of measurements. 4. Errors in measurements. 5. Traceability.
4.	Measurement methods and principles	1. Measurement methods (procedures). 2. Measuring system. 3. Measurement principles. 4. Sensitivity and readability. 5. Calibration, verification and validation.

5.	Instrumentation	1. Structure of measurement instrumentation. 2. Instrumentation - meters (ampermeter, voltmeter, wattmeter, ohmmeter, RLC meter, teslameter). 3. Analogue and digital analyzers - oscilloscope, spectrum analyzer, vector network analyzer, logic analyzers, etc.). 4. Miscellaneous instruments - bridges, power supplies, signal sources, sensors and actuators. 5. Usage of laboratory equipment.
6.	Software tools, measurement automation and virtual instruments	1. Software measurement tools (acquisition and processing). 2. Automation of measurements (control of measuring devices). 3. Virtual instrument models - stand-alone, computer-assisted, modular instrument and network instrument. 4. Virtual instrument component - measurement, computation and user interface (physical and computer-controlled), communication infrastructure (bus and network) and software. 5. Virtual instrument classes - virtual front panel, software defined instrument and distributed measurement instrument. 6. Implementation of virtual instrument systems.
7.	Processing and visualization of measurement results	1. Measurement result processing. 2. Statistical analysis of measurement data. 3. Data management. 4. Visualization of measurement results - visualization models, effectiveness, graphs and charts.
8.	Specific aspects of measurements in communications	1. Different types of measurements in communications. 2. Specific features of communication measurements. 3. Time and frequency domain measurements. 4. Channel measurements and estimation of channel parameters. 5. Traffic measurement. 6. Performance evaluation. 7. Quality of service.
9.	Frequency and power measurements of RF and microwave signals	1. Fundamentals of frequency counters. 2. Conventional counter elements - Schmitt trigger circuit, time base oscillator, main gate, sources of measurements errors. 3. Automatic microwave frequency counters and down-conversion techniques. 4. Transmission-type and absorption-type power measurements. 5. Power sensors and meters - types, calibration and transfer standards, effect of multiple reflections

10.	Time domain reflectometry, optical time-domain reflectometry	1. Time-domain reflectometry – general principles. 2. Time domain from frequency-domain measurements. 3. Interpretation of time-reflectometry displays. 4. Optical time-domain reflectometry (OTDR) – fundamentals. 5. OTDR specifications and measurement types - fiber length and attenuation, splice and connector attenuation, detection and location of catastrophic faults, etc.
11.	Measurements in fibre optic communication systems	1. Specific measurements on optical fibers - measurement of optical fiber transfer characteristics, mechanical and temperature measurements. 2. Dispersion and bandwidth. 3. Measurements in optical communication systems – optical signal analysis (light sources, optical power meters, optical signal analyzers, optical spectrum analyzers and optical polarization analyzers). 4. Signal quality Factor-Q. 5. Optical component analyzers - modulation domain, wavelength domain and reflection-based component analyzers.
12.	Measurements in spectral domain	1. Measurements in spectral domain - modulation, distortion, noise and pulse measurements. 2. Types of spectrum analyzers: fast Fourier transform and swept spectrum analyzers. 3. Phase noise measurements - quantification and measurement techniques. 4. Network analyzers - component characteristics and elements of network analyzer. 5. Scalar and vector network analyzers.
13.	Characterization of digital communication systems	1. Characterization of digital communication systems. 2. Eye diagram. 3. Jitter tolerance. 4. Latency. 5. Attesting and fault measurements on the first and second OSI layer. 6. Bit error rate (BER) measurements - test pattern generators, error detection and analysis, methods for calculating BER, BER tester architecture and specification. 7. Digital domain instruments - logic and protocol analyzers - basic operation and architecture.

14.	Measurements on audio and video signals	1. Audio measurements - signal and noise level, SNR, frequency response. 2. Distortion, phase and crosstalk measurements in audio. 3. Audio testing environments. 4. Measurements on video signals and systems. 5. Monitoring, amplitude and timing measurements in video. 6. Video frequency response and picture mode display.
15.	Telemetry	1. Telemetry basics and systems overview. 2. Data collection and multiplexing. 3. Radio, propagation and antenna systems. 4. Telemetry radio range. 5. Data processing, handling and display. 6. Supporting equipment and operations. 7. Airborne and ground systems.
Information Theory		
1.	Introduction to Information Theory	1. Brief overview of information theory concepts and goals. 2. Basic introduction to information theoretic quantities. 3. High-level intuition and why we need information theory.
2.	Information-theoretic measures	1. Entropy, Joint and Conditional Entropy, Relative Entropy (Kullback-Liebler Distance). 2. Mutual Information, Chain Rules for Information Measures. 3. Jensen's Inequality. 4. Data Processing Inequality.
3.	Source coding theorem	1. Introduction to source coding for discrete sources. 2. Asymptotic Equipartition Property. 3. Source Codes taxonomy (Non-singular, Uniquely Decodable, Instantaneous). 4. Kraft-MacMillan Inequality. 5. Source Coding Theorem.
4.	Data compression algorithms	1. Optimal prefix code (Huffman code). 2. Arithmetic coding. 3. Universal codes. 4. Lempel-Ziv algorithms.
5.	Channel coding theorem	1. Model of the communication channel. 2. Discrete channel models. 3. Channel model examples (BSC, BEC, AWGN). 4. Channel Capacity. 5. Channel Coding Theorem, Proof of Channel Coding Theorem.

6.	Channel capacity and methods of calculation	1. Calculating channel capacity, Basic examples. 2. Channel Capacity of BSC, BEC and AWGN channel. 3. General methods for channel capacity calculation. 4. Blahut-Arimoto method.
7.	Block Codes	1. Introduction to Block Codes. 2. Hamming distance. 3. Minimum distance. 4. Weight Spectrum. 5. Complexity of Minimum Distance Calculation. 6. Bounds on Minimum Distance.
8.	Introduction to Channel Decoding	1. Channel Decoding Problem. 2. Optimal Decoding. 3. MAP/ML Decoding. 4. Minimum distance decoding. 5. Soft-Decision Decoding and Hard-Decision Decoding.
9.	Convolutional codes	1. Introduction to Convolutional codes. 2. Trellis representation. 3. Decoding of Convolutional Codes. 4. Hard-Decision Decoding (Viterbi Decoder). 5. Soft-Decision Decoding (BCJR Decoder).
10.	Trellis codes and Coded modulation	1. Introduction to Trellis Codes. 2. Binary and non-binary signals. 3. Signal constellations. 4. Lattices and Lattice Codes. 5. Introduction to Coded Modulation. 6. Ungerboeck codes. 7. TCM - Trellis Coded Modulation. 8. Set partitioning. 9. Bit-Interleaved Coded Modulation (BICM).
11.	Turbo codes	1. Introduction to Turbo Codes. 2. Serially Concatenated Convolutional Codes (SCCC) and Parallel Concatenated Convolutional Codes (PCCC). 3. Iterative decoding of Turbo Codes.
12.	Linear Block codes	1. Introduction to Linear Block Codes. 2. Binary Linear Block Codes. 3. Properties of Binary Vector Spaces and Subspaces, Minimum Distance and Bounds on Minimum Distance. 4. Algebraic Theory of Block Codes, Finite fields, Minimal polynomials of elements of a finite field, Circuits for manipulation of polynomials. 5. Cyclic codes.
12.	BCH and RS codes	1. BCH codes construction and properties. 2. RS codes construction and properties. 3. Decoding of BCH and RS codes. 4. Berlekamp-Massey decoding.

13.	LDPC codes	1. Introduction to LDPC codes. 2. Tanner Graphs. 3. Regular and Irregular LDPC codes. 4. Iterative decoding of LDPC codes. 5. Examples of LDPC decoding algorithm for BEC, BSC and AWGN channel.
14.	Polar codes	1. Introduction to Polar Codes. 2. Channel polarization principle. 3. Decoding algorithms for Polar Codes.
15.	Codes for error detection	1. Introduction to error detection codes. 2. Cyclic redundancy codes (CRC).
16.	Applications of channel codes	1. History of deep space communications. 2. Codes for magnetic channels. Codes for reliable multicast (fountain codes). 3. Application-level Forward Error Correction. 4. Codes for distributed storage systems. 5. Coding in wireless systems: Turbo codes for 4G, LDPC codes for Wi-Fi, DVB and 5G. Polar Codes for 5G.
17.	Data encryption	1. Symmetric and asymmetric key algorithms. 2. Symmetric cryptography: stream ciphers, block ciphers, hash functions.
18.	Algebraic encryption methods	1. Public key cryptography: RSA, elliptic curve cryptography, digital signatures.
19.	Data protection on the Internet	1. Block chain and other distributed ledger technologies. 2. Aspects of security: protection of communication and information systems. 3. Cybersecurity on the application and user levels. 4. Regulatory aspects, data protection and SLA.
Electronics Engineering		
1.	History and overview	
2.	Relevant tools, standards, and/or engineering constraints	
3.	Fundamentals of semiconductor	1. Physics and material properties. 2. Semiconductor properties. 3. PN junction.
4.	Semiconductor components	1. Diodes and rectifiers. 2. Transistors: BJT, unipolar, hybrid. 3. Multi-junction components: triac, optotriacs, thyristors.

5.	Semiconductor circuits	1. Four port model of transistors. 2. Frequency analysis of transistor based circuits. 3. Differential amplifiers. 4. Low noise amplifiers. 5. Power amplifiers.
6.	Operational amplifiers	1. Properties of OPAMP's. 2. Linear and non-linear circuits with OPAMP's. 3. Waveform generators & comparators. 4. Oscillators.
7.	Signal conversion circuits	1. AD Converters. 2. DA Converters. 3. Filters.
8.	DCDC converters	1. Linear regulators. 2. Switching regulators: buck and boost. 3. Offline converters. 4. Inverters.
9.	Impulsive electronics	1. Transistor as a switch. 2. Multivibrators. 3. Schmitt trigger. 4. Digital generators and oscillators. 5. Logic gates.
10.	Digital electronics	1. Numbering systems and binary codes. 2. Flip Flops. 3. Registers and counters. 4. Multiplexers and decoders. 5. Circuits for mathematical operations. 6. Memories. 7. Programmable circuits.
Radio communications		
1.	Introduction and history	1. Introduction to wireless communications. 2. Radio-communication concepts: system components, services. 3. Overview of wireless communication systems. 4. Frequency spectrum. 5. History of wireless communications.
2.	Radio wave propagation	1. Sources, properties and classification of EM radiation. 2. Radio wave propagation in the atmosphere -effects of air refractive index and content, various obstacles, Earth's ground and ionosphere on EM wave propagation: reflection, refraction, dispersion, Fresnel zones, fading. 3. Propagation models in radio communications propagation and prediction of EM field level.

3.	Fundamentals of wireless communications	1. Cellular concept; interference in wireless networks. 2. Multiple access techniques: FDMA, TDMA, CDMA, SDMA. 3. Radio channel properties; statistical fading channel models: concepts of time and frequency selectivity, received signal envelope distributions, second order statistics (level crossing rate and average fade duration). 4. Digital modulation and detection - an overview: signal space concept, PSK, FSK based modulations. 5. Performance evaluations of digitally modulated signals over AWGN and fading channels. 6. Diversity techniques for signal quality improvement during its transmission over time variant multipath channel. 7. Channel coding techniques for signal quality improvement during its transmission over time variant multipath channel. 8. Spread spectrum techniques and their applications in wireless communications. 9. Multicarrier modulation: basic principles, OFDM.
4.	Antennas	1. Definition and classification of antennas; basic principles of antenna theory. 2. Antenna parameters: radiation diagram, directivity, efficiency and gain, polarization, antenna impedance, frequency band and other parameters. 3. Antenna types: isotropic, dipole, monopole, reflector, aperture, loop, printed antennas. 4. Antenna arrays. 5. Aperture antennas: rectangular horn antenna in H-plane and E-plane, pyramidal horn antenna. 6. Reflector Antennas: parabolic reflector antenna, dual parabolic reflector antenna, other types of reflector antennas. 7. Micro strip antennas: rectangular micro strip antenna, circular micro strip antenna, micro strip antenna arrays. 8. Broadband antennas. 9. Frequency independent antennas. 10. Antenna modelling and Simulation: introduction to simulation tools.
5.	Microwave technique	1. Properties of radio wave propagation in the microwave frequency band. 2. Basics of the transmission line theory. 3. Resonant circuits and impedance matching. 4. Smith chart. 5. Representation of microwave networks by S-parameters.

		6. Planar transmission lines (micro strip and other types) . 7. Waveguides.
6.	RF circuit design	1. Passive components at RF; LC structures with concentrated parameters; basic matching networks. 2. Receiver input circuit: antenna impedance matching, noise factor, receiver sensitivity. 3. Filter design fundamentals: low-pass, high-pass and band pass filters. 4. Microwave active components – diodes and transistors. 5. Small signal amplifiers: amplifier gain, amplifier stability, noise, input/output impedances, etc. 6. Effects of transistor nonlinearity on amplified signal – distortion, intermodulation products, amplifier sensitivity and dynamic range. 7. RF large signal amplifiers (PA – Power Amplifiers): Application of PA in RF circuit design, power transistors, linear PA Design, non-linear PA design. 8. Mixers: Application of mixers in RF circuit design, Mixers - general considerations (performance parameters, noise figure…); simple diode mixers, single and double balanced mixers. 9. Oscillators and frequency synthesizers: frequency instability, oscillators design, VCO (Voltage Controlled Oscillators), PLL (Phase Locked Loop). 10. Architectures of radio transmitters and radio receivers: heterodyne and direct RF transceiver architectures.
7.	Microwave communication system design	1. Functional blocks of the microwave radio communication system. 2. Microwave radio link analysis; Friis transmission formula; path loss modeling; link budget. 3. Communications system design: ITU-T standards; frequency planning, ITU-T recommendations for particular communication systems.
8.	Transmission performances of microwave communication systems	1. Fading (flat fading, multipath fading, polarizing fading and scintillations). 2. Effects of amplitude and phase distortion of the radio channel characteristic and noise. 3. Influence of the receiver bandwidth on the noise power and signal distortion. 4. Theoretical probability of a bit error; practical system performance (BER); implementation margin, diversity techniques, error control (ARQ and FEC).
9.	Mobile cellular networks	1. Cellular approach; propagation modelling. 2. GSM, GPRS and UMTS systems (mobile station, base station, other parts of the system architecture). 3. Multiple access, handover and roaming.

		4. Power control techniques. 5. HSPA and HSPA+ techniques. 6. LTE - architecture, principle of operation, services. 7. 5G systems and their role in IoT. 8. Principles, potentials and limitations of next-generation wireless systems. 9. Exposure to RF and microwave radiation
10.	Satellite communication systems	1. Introduction to satellites and their applications. 2. Satellite orbits and trajectories. 3. Satellite hardware. 4. Multiple access techniques. 5. Satellite Link Design. 6. Satellite applications (communication satellites, remote sensing satellites). 7. Satellite navigation systems.
11.	Wireless local area networks	1. Introduction to standards. 2. OSI model. 3. WLAN Architecture. 4. WLAN Devices-Wireless network interface card, Access point. 5. Service sets: basic, infrastructure, extended. 6. WLAN network topologies. 7. PAN Bluetooth technology. 8. Bluetooth network architecture.
12.	Fundamentals of radar systems	1. Basic principles of radiolocation and radar architecture. 2. Modern radar systems-classification and applications. 3. The radar equation. 4. Specifics of radar signals. 5. Radar cross-section. 6. Methods of radar signals processing. 7. Detection of radar signals in noise. 8. Extraction of radar information. 9. Radar clutter. 10. Types of radar: Moving Target Indicator Radar MTI and pulse Doppler radar. SAR radars, weather radars, military radar systems, automotive radars. 11. Radar equipment (transmitters, receivers, antennas).
13.	Cognitive radio	1. Introduction to cognitive radio. 2. Dynamic spectrum usage. 3. Available spectrum analysis techniques. 4. User localization in cognitive radio networks. 5. Application of cognitive radio.
14.	Electromagnetic compatibility	1. Introduction to electromagnetic compatibility. 2. Sources of electromagnetic interference. 3. Penetration through shields and apertures. 4. Propagation, conductive penetrations and general multipath coupling.

		5. Electromagnetic susceptibility. 6. Electromagnetic interference control techniques. 7. Basic principles of EMC design. 8. Numerical simulation techniques for solving EMC problems on computer. 9. EMC standards. 10. EMC measurement methods. 11. Safety issues of exposure to RF radiation.
Communication Networks		
1.	Network fundamentals	1. Packet communication basics. 2. Network layer models – OSI-ISO, TCP/IP. 3. Basic network topologies. 4. Networking devices. 5. Traffic modelling. 6. Error detection/correction and flow control. 7. Queuing systems. 8. Performance analysis. 9. QoS.
2.	Local area networks	1. Technologies and protocols. 2. Basic LAN topologies. 3. Addressing. 4. Physical and Medium access control layer. 5. Basic switching concepts. 6. Virtual LAN and Inter-VLAN routing. 7. Multilayer switching. 8. High Availability and Redundancy in LAN. 9. Spanning Tree protocol. 10. First-Hop Redundancy protocols.
3.	Internet architecture	1. History of the Internet. 2. Elements of Internet architecture. 3. Addressing for IPv4 and IPv6, and IP services. 4. Basic principles of DNS. 5. Routing on the Internet. 6. Static routing. 7. Dynamic routing protocols: RIP, OSPF, EIGRP and BGP. 8. Major Internet services.

4.	Wireless and mobile networks	1. Overview, basic principles and characteristics of modern wireless networks. 2. Architecture, MAC layer protocols, physical layer, mobility management protocols, security in wireless networks. 3. Public land mobile networks. GSM. GPRS. EDGE. UMTS. HSPA/HSPA+/MC-HSPA. LTE. TETRA. Radio navigation. 4. Wireless LAN – WLAN. 5. Wireless Personal Area Networks – WPAN. 6. Wireless body area network – WBAN. 7. Wireless Sensor Networks – WSN. 8. FWA (Fixed Wireless Access). 9. WLL (Wireless Local Loop). 10. Broadcasting systems. 11. Radar systems. 12. Satellite communication networks. 13. Routing in wireless and mobile networks. 14. Interoperability between networks.
5.	IoT networks	1. Principles of IoT and convergence of different concepts. 2. Architecture and design of IoT networks. 3. Smart devices and networking technologies. 4. IoT network layer. 5. Application protocols in IoT. 6. Principles of IoT application development. 7. Data processing and analysis in IoT networks. 8. Security in IoT networks. 9. Standardization in IoT networks. 10. Practical examples of IoT networks.
6.	Network security	1. Network Security Threats and Attacks. 2. Basics of encryption. 3. Authentication, Authorization and Accounting. 4. Access control policy and procedures. 5. Firewall technologies. 6. Virtual Private Networks – VPN. 7. Systems for protection. 8. Cyber Security.

Communication Systems		
1.	Signals and systems fundamentals	1. Signal classification – continuous/discrete, analogue/digital, deterministic/random. 2. Signal modelling/analysis in time and frequency domain. 3. Random processes and signals. Random signal modelling/analysis. Noise. AWGN. 4. Linear and non-linear systems. Filters. 5. Signal (deterministic and random) transmission through linear systems. 6. Signal sampling and reconstruction.
2.	Communication systems basics	1. Communication process. Communication system model - Analog and digital systems. 2. Information sources. Resources (energy, spectrum). 3. Communication channel model. Information capacity of the channel. Transmission lines/media – types and characteristics. 4. Modulation – Pulse and Carrier-wave modulation. 5. Communication networks - concept.
3.	Analog to digital conversion and pulse modulation	1. Signal digitalization – sampling, quantization and coding. PCM, DPCM, DM, ADM. 2. Pulse modulations – PAM, PWM, PPM.
4.	Baseband digital transmission	1. Digital signal modelling - statistical analysis, scrambling and line coding. 2. Detection of signal in noise - probability of error. 3. Intersymbol interference. Nyquist criteria. Pulse shaping and correlative-level coding. 4. Optimal receiver. Matched filter and correlation receiver in AWGN channels. Channel equalization. 5. Binary and M-ary transmission (BER and spectrum efficiency). Regenerators and repeaters. 6. Elements of decision theory – Bayes, ML, MAP, MINIMAX and Neyman-Pearson criteria.
5.	Passband analogue and digital transmission	1. Product (continuous-wave) modulation/demodulation 2. Narrowband (band-pass) modulated signal and noise representation. Quadrature modulator/demodulator. 3. Coherent and non-coherent reception. 4. Analog modulations – Amplitude, phase and frequency modulations. 5. Carrier synchronization – PLL, Costas loop. 6. Linear digital modulations – PSK, ASK, QAM and phase-amplitude modulations. 7. Digital frequency modulation – Coherent and non-coherent FSK, Continuous-Phase FSK (MSK/GMSK).

6.	Coding in digital communication systems	1. Model of digital communication systems – IT model 2. Source coding, Error correction coding (FEC), Error detection coding – Role and application.
7.	Multiplexing and multiple access	1. Multiplexing and multiple access. 2. FDM/FDMA,TDM/TDMA,CDM/CDMA, OFDM/OFDMA, SDM/SDMA, … 3. Examples of applications.
8.	Design and optimization	1. Spectrum and energy efficiency. 2. Application of coding and diversity. 3. Capacity optimization. Adaptive modulation concept. 4. Global communication systems structure. 5. Principles of design of modern communication system. 6. Trends in future developments of modern communications.
9.	Synchronization in digital communication systems	
10.	Advanced band pass transmission	1. Spread spectrum (SS) systems – DS, FH, TH, Chirp. PS-SS. CDMA systems. 2. Multi-carrier (MC) systems. COFDM/OFDM systems. OFDMA systems. MC-CDMA systems. 3. Ultra-Wide Band (UWB) systems.
11.	Advanced transmission with spatial processing	1. Spatial diversity, multiplexing and multiple access. 2. Principles of smart antenna processing 3. Principles of MIMO systems – SU-MIMO, MU-MIMO 4. Massive MIMO systems
12.	System modelling and simulation	1. Implementing communication systems or/and its main elements in MATLAB (or other environment) - Signal processing and/or stochastic analysis. 2. Baseband modelling and simulation of passband communication systems. 3. Presentation and interpretation of simulations results.
.13.	Optical communications	1. Optoelectronic components – generation, transmission and detection of optical signals. 2. Design of optical communication systems – PTP links, WDM. Standards. 3. Basic concepts of optical access networks.
14.	Examples of communication technologies and systems	1. Copper lines - xDSL systems, cable distribution systems, PLC, xBASE-T 2. Optical access – GPON 3. Wireless access – WLAN, WPAN, WMAN, Mobile 4. SDH systems

15.	Other	1. Telecommunication standards and protocols. 2. Services. Quality of Service concepts. 3. Availability and accessibility of system, redundancy. 4. Management and control of telecommunication networks and systems. 5. Management models, protocols and information models. 6. Accounting and Billing.
Software Engineering		
1.	Introduction to programming	1. Introduction to C programming 2. Data types. 3. Data structures: static (array, string), semi-dynamic (stack, line, deck, sequence) 4. Operators and expressions. 5. Program flow control. 6. Program modularization, passing parameters to a procedure/function, recursion. 7. File management. Sequential and random access files. 8. Pointers and dynamic memory allocation and deallocation. 9. Complexity of the algorithms. 10. User defined data types.
2.	Object oriented programming	1. Programming in C++. 2. Programming in Java. 3. Programming in C#. 4. Object and Class. 5. Template class types. 6. Inheritance and dynamic binding. 7. Polymorphism. 8. Exceptions.
3.	Data structures, algorithms and databases	1. Basic data structures and algorithms. 2. Complex data types. 3. Dynamic data structures (lists, trees, graphs). 4. Databases and transactions. 5. MySQL database and the PHP code.

4.	Core software engineering topics	1. Scope of software engineering: Historical aspects. Economic aspects. 2. Software life-cycle models: Waterfall approach; Iterative and incremental development; Agile development. Life-cycle models comparison. 3. Determining client needs. Requirements review. Business process model. User cantered design. 4. Analysis: Entity classes identification. Use cases (object-oriented analysis, class models, dynamic modelling). 5. Design: Design and abstractions. Data-oriented design. Object-oriented design. Real-time design. Design tools. 6. Implementation: Programming language selection. Coding standards. Integration. Implementation. 7. Testing. Black box and white box testing. Test planning and reporting. Tools and metrics for the implementation. 8. Software quality assurance. Software metrics. Code inspections. 9. Documentation. Version management. 10. Maintenance 11. Object oriented approach: Cohesion. Abstraction. Data encapsulation. Inheritance, polymorphism and dynamic linking. 12. UML diagrams. Diagram usage and review. 13. Software architectures, design patterns 14. Web services and service-oriented architectures
5.	Advanced programming topics	1. IoT case studies based on Arduino 2. Mobile Applications with Android 3. HTML and CSS 4. Web programming with JavaScript 5. Time sliding principle, synchronization and arbitrage, multitasking and time slicing 6. Java Class Library with focus on file system handling, GUI, network programming and multi-threading. 7. Java Cryptography Architecture / Java Cryptography Extension.

6.	Specific application areas	1. Application of OOP principles in implementation and optimization of DSP algorithms. 2. Development Tools in Telecommunications and Signal Processing 3. Understand business strategies, models and processes Understand and use XML Web Technologies Use servers, platforms and middleware in e-business systems Use Web services and service-oriented architectures in e-business Know e-business protocols and standards Develop web-based e-business application using J2EE platform 4. Web-based e-business application using J2EE platform 5. Telecommunication Systems Modelling and Simulation: Languages for telecommunication system specification: MSC, SDL; UML language – specific examples for telecommunication software; Specification of software according to the ISO OSI model; HDLC communication operator; Digital switchboard software: user signalling, regional processors, call management; The mobile network software and the intelligent network software; The software for network virtualization technology (VLAN, VXLAN, multilayer VPN). 6. The analysis, design and implementation of embedded telecommunication systems using RF System on Chip; RF SoC architecture, tool-chain setup and programming using C/C++ languages.
Computer Engineering		
1.	Digital Electronics	1. Digital circuit features and overview. 2. History. 3. Number systems. 4. Digital arithmetic. 5. Codes. 6. Logic functions and simplification. 7. VHDL of basic logic circuits. 8. Digital integrated circuits, features and technologies. 9. Combination and sequential circuits. 10. Analysis and synthesis. 11. State diagram. 12. Asynchronous, synchronous circuits and VHDL design. 13. Counters and registers. 14. Memory types and technologies. 15. Magnetic and optical media. 16. Programmable logic. 17. Displays. 18. Digital design and test tools. 19. Reliability.

2.	Computer Architecture and Organization	1. Introduction. 2. Measuring performance. 3. Computer arithmetic. 4. Processor organization. 5. Instruction set architecture. 6. Instruction performing and formats. 7. Architecture: Von Neuman, Harvard, RISC and CISC. 8. Buses. 9. Memory system organization, architecture and technologies. 10. Memory design, performances and management. Virtual memory systems. 11. Storage technologies. 12. Input and output interfacing and communication. Interrupts. 13. DMA. 14. Peripheral subsystems. 15. Multi and many core architectures. 16. FPGA and CUDA. 17. Distributed systems architectures.
3.	Computer Systems Design	1. Microprocessor architecture, from 8 to 64 bit. 2. State diagrams in design. 3. Instruction set. 4. Addressing modes. 5. Microinstructions, RTL, VHDL. 6. Microprocessor design. 7. PLD, FPGA design. 8. Simple CPU design. 9. Single bus, two and three buses microprocessor design and verification. 10. Control unit design. 11. Micro sequencer. 12. Microinstructions and Nano instructions. 13. Computer arithmetic: Fixed and floating-point arithmetic. 14. Memory system design. 15. Cache and virtual memory. 16. Input/output unit organization. 17. Input/output processors. 18. RISC architecture. 19. Instruction set. Pipelining. 20. CISC architecture. 21. Parallel processing. 22. Parallelism in uniprocessor system. 23. Multiprocessor architecture and communication. 24. Alternative parallel architectures.

4.	Embedded Systems	1. Embedded systems feature. 2. Basic software techniques for embedded applications. 3. Parallel input and output. 4. Asynchronous and synchronous serial communication. 5. Periodic interrupts, waveform generation, time measurement. 6. Data acquisition, control, sensors, actuators. 7. Strategies for Complex Embedded Systems. 8. Techniques for low-power operation. 9. Mobile and networked embedded systems. 10. Advanced input/output issues. 11. Computing platforms for Embedded Systems.
Information and Data Management		
1.	Databases fundamentals	1. Conceptual, logical and physical data modelling. 2. Data Abstraction. Relational Data Model. SQL. 3. Optimization of Relational Queries. 4. Object-Oriented Database Systems. 5. Transaction processing. Validation techniques. Crash recovery. Commercial Systems.
2.	(Big) Data storage	1. Network infrastructure for storage of large amounts of data 2. Technology for building a virtual storage 3. Distributed file systems. Map Reduce – basic principles and algorithm design
3.	Data compression and transmission	1. Optimal coding. 2. Lossless source coding. 3. Error control coding.
4.	Data encryption	1. Symmetric and asymmetric key algorithms. 2. Symmetric cryptography: stream ciphers, block ciphers, hash functions. 3. Public key cryptography: RSA, elliptic curve cryptography, digital signatures. 4. Block chain and other distributed ledger technologies. 5. Aspects of security: protection of communication and information systems. 6. Cybersecurity on the application and user levels. 7. Regulatory aspects, data protection and SLA.
5.	M2M communications	1. Intelligent objects, definition and applications. 2. M2M communications and applications. 3. Integration of M2M intelligent objects with mobile communication systems. 4. M2M platforms analysis. 5. Operating systems. 6. Overview of communication protocols for interaction and cooperation with intelligent objects.

6.	Algorithmic complexity	1. Basic concepts of algorithm theory and the notion of complexity. 2. Understanding the algorithm concept, classification of problems and algorithms. 3. Methods to prove that an algorithm solves the analysed problem and complexity assessment.
7.	Concepts of detection and estimation	1. Concepts of analytical and machine estimation, detection and classification as a gateway to more advanced techniques for ICT applications and signal processing. 2. Introduction to statistical and machine learning.
8.	Design of estimators	1. Analytical and machine estimation: Bayesian estimation theory, design of estimators. 2. Probability distributions – parameter estimation 3. Non-parametric density estimation – kernel density estimation. 4. Non-parametric density estimation – k-nearest neighbours. 5. Signal parameter estimation & hypothesis testing in Gauss noise on a single/multi-channel observation. 6. PLL as an estimator of the phase and frequency. Parameter estimation with a finite number of states.
9.	Artificial intelligence systems	1. Artificial perception, artificial intelligence, soft computing, machine learning. 2. Intelligent problem solving. 3. Expert systems, Knowledge representation. 4. Basics statistic methods, Algorithm and numerical analysis. 5. Graph theory, The finite fields. 6. Introduction to operational research and optimization. 7. Network analysis, Nonlinear optimization, Decision theory.

10.	Basic ML algorithms	1. ML system components, evaluation of algorithm's performance. 2. Linear regression, Bayesian decision theory. 3. Logistic regression and Linear Discriminant Functions. 4. Support Vector Machines. 5. Dimensionality reduction algorithms – PCA and LDA. 6. Neural Networks: Architectures and training procedures. 7. Neural Networks: Evaluation and application. 8. Understanding and implementation of supervised and unsupervised learning algorithms. 9. Analytical and machine decision: design of classifiers - ML and MAP decision, Binary classification. 10. Bayesian inference, learning algorithms for sources, channels, and transmission formats. 11. Optimum filtering: Kalman filtering, Wiener filtering.
11.	Advanced ML algorithms	1. Ensemble learning: Bagging and boosting. 2. Advanced clustering algorithms and Ensemble clustering approaches. 3. Mixture models and Expectation-maximization algorithm. 4. Semi-supervised algorithms. 5. Sequential data, Markov models and Hidden Markov models. Applications. 6. Probabilistic graphical models. Inference in graphical models (Belief propagation).
12.	Data mining and Big Data analytics	1. Frequent-item set mining, association rules, market-baskets. 2. Algorithms for clustering very large, high-dimensional datasets. 3. Recommendation and advertising systems. 4. Dimensionality reduction for obtaining the important properties of a large dataset. Singular-value decomposition and CUR decomposition. 5. Machine-learning algorithms applicable to very large data 6. Deep learning.
13.	Network Science	1. Graphical data structures and models. 2. Graph analytics: network topology, processes, and algorithms. 3. Data privacy methods, techniques and legislation.

Signal Processing		
1.	Continuous signals and systems	1. Continuous-time signals and systems – Concepts and definitions. 2. LTI systems: differential equations representation, impulse response, and convolution. 3. Fourier series and Fourier transform. 4. Laplace transform. 5. Transfer function and frequency response. 6. Analog filters design and realization.
2.	Discrete time signals and systems	1. Discrete-time signals and systems – Concepts and definitions. 2. Signal sampling and reconstruction. 3. LTI systems: difference equations representation, impulse response, convolution, and frequency response. 4. Z-transform. 5. Discrete Time Fourier Transforms and Discrete Fourier Transform. 6. Discrete Cosine Transform. 7. Short Time Fourier Transform. 8. Wavelet Transform. 9. Digital processing of a continuous time signal. 10. Random signal analysis.
3.	Implementation of DSP algorithms	1. Real-time signal processing 2. Basic structures for digital signal processing 3. Digital filters design 4. Software vs. hardware implementation 5. Architectures of digital signal processors 6. Programming languages and development tools of digital signal processors 7. Interfaces 8. Fixed point and floating point implementation 9. Quantization effects 10. Using FPGAs to implement DSP algorithms 11. Multiprocessor digital signal processing systems 12. Hybrid solution for implementation of DSP algorithms
4.	Audio signal processing	1. Sound waves and perception. 2. Electroacoustic. 3. Audio signal processing. 4. Speech signal processing. 5. Audio signal analysis. 6. Localization of sound. 7. Room acoustics. 8. Electroacoustic and transduction. 9. Acoustics in human-machine interaction.

5.	Image processing	1. Human vision: image perception. 2. Image acquisition and representation. 3. Two-dimensional signals and systems. 4. Image enhancement and restoration. 5. Image segmentation. 6. Mathematical morphology for image processing. 7. Geometry transformations of images. 8. Image compression methods and standards.
6.	Video processing	1. Human vision: video perception. 2. Video acquisition and representation. 3. Multi-dimensional signals and systems. 4. Video enhancement and restoration. 5. Motion estimation and tracking. 6. Video segmentation. 7. Video filtering. 8. Video compression methods and standards.
7.	Advanced signal processing	1. Multirate signal processing. 2. Digital filter banks. 3. Statistical signal processing. 4. Adaptive filters design and applications. 5. Linear estimation. 6. Linear prediction and signal modelling. 7. Spectrum estimation. 8. Multidimensional signals and systems. 9. Advanced topics in audio processing. 10. Advanced topics in image processing. 11. Advanced topics in video processing. 12. Distributed signal processing.
8.	Machine learning for signal processing	1. Pattern recognition and classification. 2. Machine learning in signal processing. 3. Audio analysis and interpretation. 4. Image analysis and interpretation. 5. Video analysis and interpretation. 6. Data mining for signal processing.

9.	Signal processing applications	1. Signal processing for communications. 2. Signal processing for antenna arrays. 3. Signal processing in smart grid communications. 4. Biomedical signal processing. 5. Sonar and radar signal processing. 6. Ultrasound and X-ray image processing. 7. Signal processing in sensor networks. 8. Signal processing and Nano-scale technology. 9. Signal processing in Reconfigurable/Cognitive Radar. 10. IoT and signal processing. 11. Signal processing in Cloud and Service Computing. 12. Signal processing in Smart TV and 3D TV. 13. Signal processing in augmented reality. 14. Signal processing in autonomous vehicles .
Multimedia		
1.	Multimedia technology	1. Historical overview. 2. Definition of multimedia. 3. Terminology. 4. Classifications.
2.	Multimedia signal types	1. Text 2. Stationary graphics. 3. Audio. 4. Image. 5. Video and 3D video. 6. Haptic signals. 7. Multimodal nature of the information. 8. Modern concept of signals in ICT; signals related to user and the environment, bio-signals, social signals, ambient signals.
3.	Multimedia signal processing	1. Digital multimedia signal processing. 2. Time/spatial and frequency domain. 3. Fundamentals of multimedia signal capture. 4. Digital recording of sound, image and video signals.
4.	Human perception	1. Perception of sound, images and video. 2. Physiology and psychology of multimedia content perception. 3. Understanding of limitations of human perception. 4. Concept of lossy notation of multimedia content.
5.	Single- and multi-dimensional discrete algorithms and transformations for audio and video signals	1. Unitary transforms. 2. Discrete Fourier transform. 3. Discrete cosine transform. 4. Wavelet transform. 5. Eigen analysis, PCA, ICA. 6. Digital audio and video filters.

6.	Coding of multimedia signals	1. Lossless compression. 2. Redundancy. 3. Packetisation and encapsulation. 4. Standardization, commercial formats and containers of audio-visual materials, (MPEG, ...).
7.	Content recognition for multimedia services	1. Identification of objects and states in multimedia systems for implicit interactivity in communication services involving electronic devices.
8.	Multimedia content editing and management	1. Algorithms and procedures for synthesis and integration of multimedia content. 2. Content management systems for multimedia. 3. Content adaptation in audio-visual services to characteristics of the communication channel and terminal equipment. 4. Digital rights management and conditional access to multimedia content.
9.	Multimedia quality management	1. Algorithms and methods for evaluation of quality of services in electronic media. 2. Qualitative and quantitative evaluation of quality. 3. Standardization. 4. Quality of experience.
9.	Design of multimedia services	1. UX and UI design. 2. Human Computer interaction. 3. User-cantered design. 4. User adapted communication (principles, approaches, related fields, terminology).
10.	Ambient intelligence	1. Principles of ambient intelligence. 2. Related fields, terminology and definitions.
11.	Multimedia terminals	1. Multimedia terminal hardware. 2. Multimedia terminal software. 3. Multimedia terminal architecture. 4. Embedded systems for multimedia services.
12.	Multimedia network protocols	1. Overview of network protocols. 2. Real-time streaming of multimedia content.

Other engineering courses		
1.	Industrial engineering	1. Principles of mechanical engineering. 2. Basic laboratory: Control engineering and mechatronic systems. 3. Principles of chemical engineering. 4. Industry 4.0 and robotics. 5. Innovation and project management. 6. Process engineering and automation. 7. Industrial plants and logistics. 8. Industrial design and production. 9. Materials and manufacturing.
2.	Health – bio engineering	1. Principles of biomedical engineering. 2. Principles of bio-physiology and neuroscience. 3. Ambient assisted living. 4. Healthcare system and institutions management. 5. Telemedicine and medical informatics. 6. Device and IT for diagnostics. 7. Robotics for health.
3.	Environmental engineering	1. Principles of environmental engineering. 2. Energy and renewables. 3. Waste management and resource recovery. 4. Climate and global change.
4.	Energy and robotics	1. Principles and applications of robotics. 2. Automation and control. 3. Energy and smart grids. 4. Principles of power electronics and power engineering.
Communication and Presentation Skills, Foreign Languages		
1.	Technical writing	1. Scientific reading, writing and quoting. 2. Conventions and structure of scientific texts. 3. Open writing group. 4. Text seminar: how to write a good text.
2.	Communication and presentation	1. Communication skills. 2. Presentation skills.
3.	Another language (Mandarin, Arabic, Spanish, Russian, German, French, Italian)	1. Grammar rules. 2. Vocabulary 3. Communication skills .
4.	Marketing and fund raising	1. Marketing strategies. 2. Fundraising strategies. 3. Crowdfunding.

5.	Gender studies	1. Intersectional gender studies. 2. Theories and methods of gender studies. 3. The gender of computer games.
6.	Team building and collaborative work	1. Address the value of collaboration. 2. Tools for collaborative work. 3. Overcome barriers in collaboration activities.
Project management		
1.	Introduction to project management in ICT	1. Historical background. 2. Terminology. 3. Project management in ICT domain.
2.	Project life cycle	1. Project phases. 2. Project conceptualization and initial planning. 3. Project analysis and planning.
3.	Project goal and scope	1. Defining project goals. 2. Defining project scope. 3. Case studies.
4.	Project planning	1. Methods and techniques in project planning. 2. Analysis of Gantt diagram. 3. Project risks and milestones. 4. Software for project planning.
5.	Project execution	1. Plan optimization and resource management. 2. Closing project. 3. Project evaluation.
6.	System development life cycle	1. Phases in product life cycle. 2. Prototyping in engineering. 3. Methods and techniques for system development.
7.	Analysis of selected ICT systems and services	1. Product life cycle. 2. Requirements analysis. 3. Design process. 4. Solution evaluation.
8.	Project presentation	1. Team work. 2. Presentation skills. 3. Writing technical documentation.

8 Appendix B

8.1 List of courses for modernisation at the first cycle of study

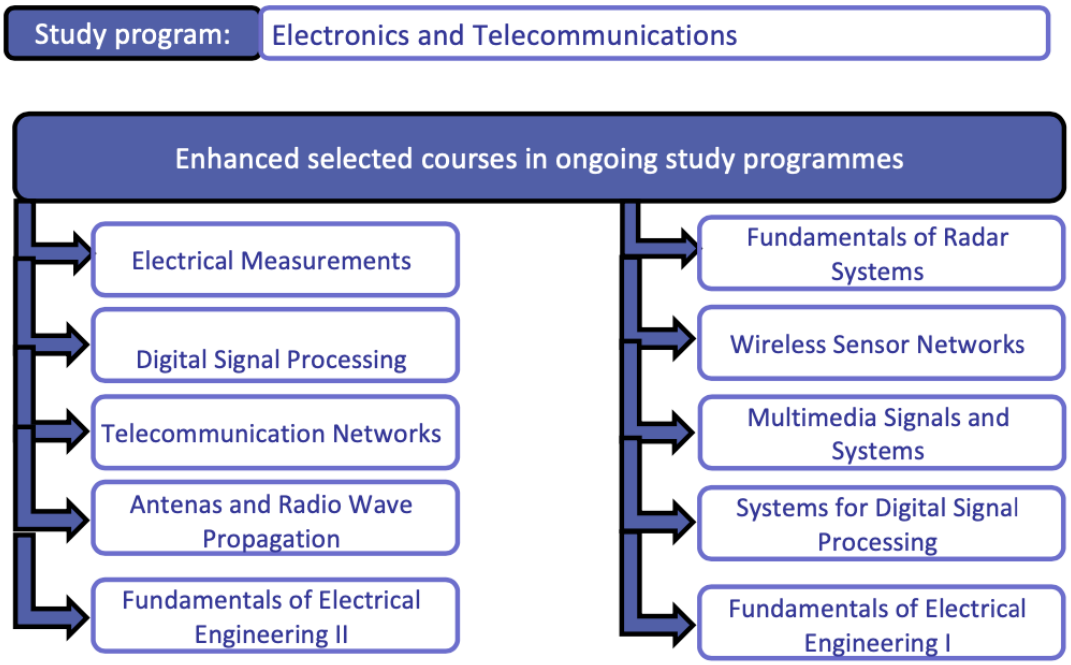

Figure 8-1 List of courses for modernisation at the Faculty of Electrical Engineering in Banja Luka

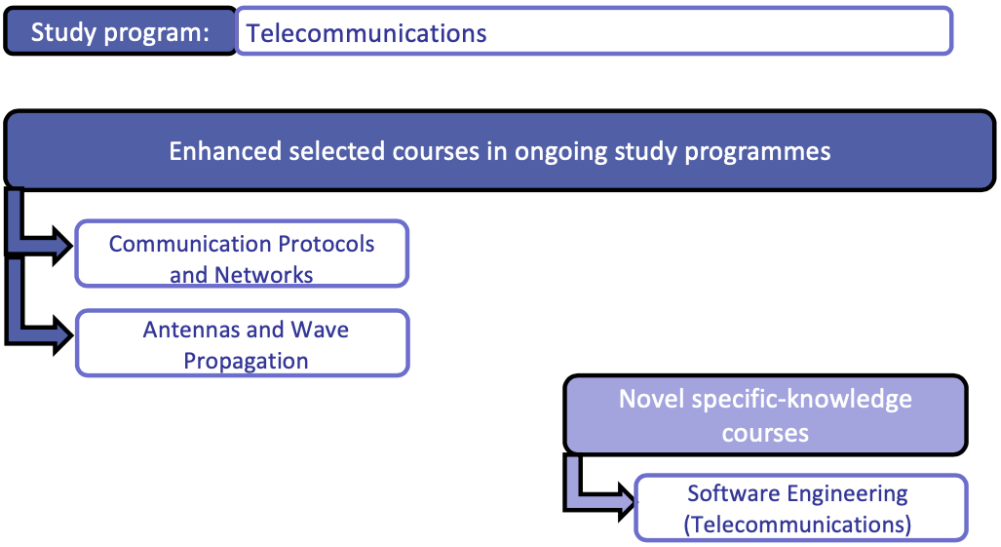

Figure 8-2 List of courses for modernisation at the Faculty of Electrical Engineering in Sarajevo

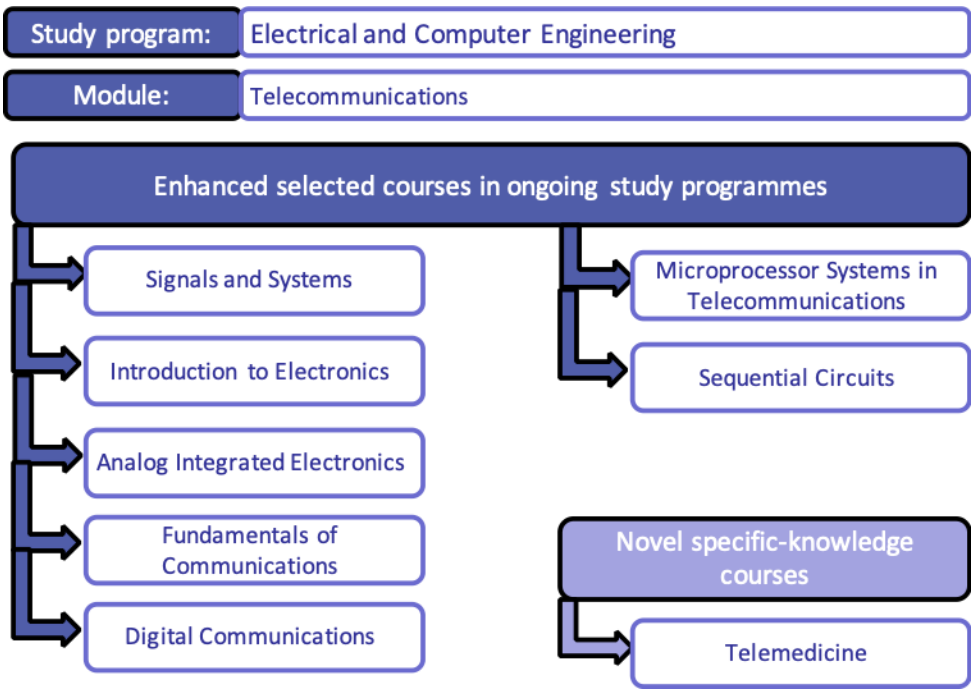

Figure 8-3 List of courses for modernisation at the Faculty of Electrical Engineering in Tuzla

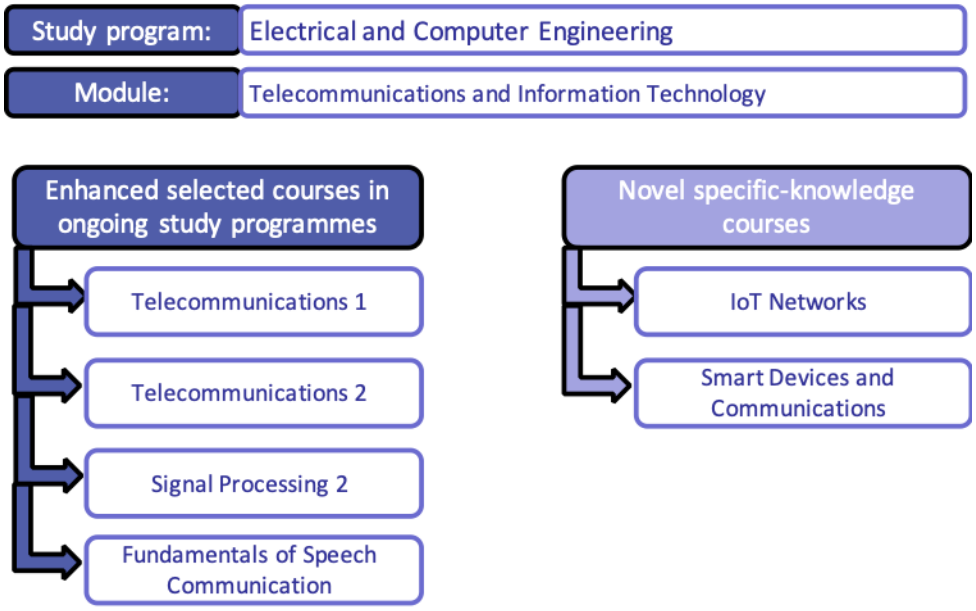

Figure 8-4 List of courses for modernisation at the School of Electrical Engineering in Belgrade

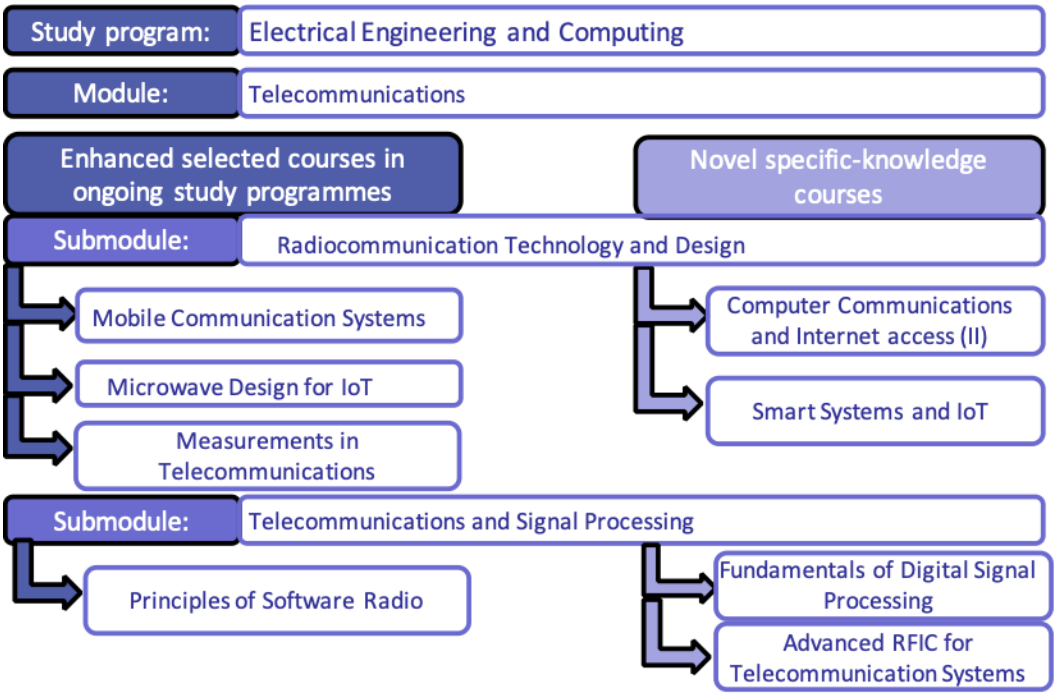

Figure 8-5 List of courses for modernisation at the Faculty of Electrical Engineering in Niš

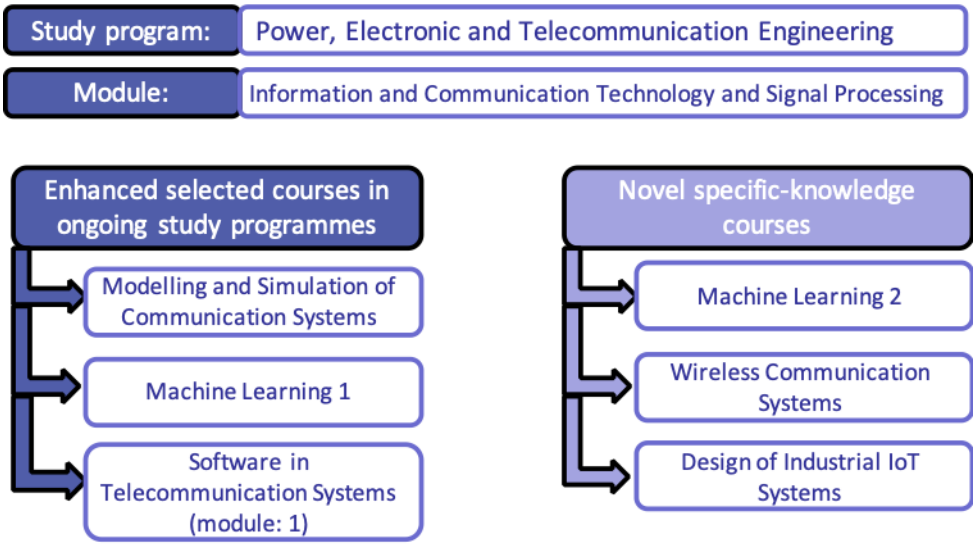

Figure 8-6 List of courses for modernisation at the Faculty of Technical Sciences in Novi Sad

Table 8-1 List of enhanced courses with detailed descriptions (First cycle)

No.	Course ID	University	Course name	Teacher(s)	Type of developed material					Semester of starting implementation	Date of posting material on e-platform	Links		Number of enrolled students
					Book	Lectures slides	Lab practicum notes	Video on BENEFIT platform	Video on other platform	Spring Semester (SS), Winter Semester (WS), After project end (After)		e-platform (brief course description and teaching materials)	University website (course description as in accreditation)	
1	1	UBL	Electrical Measurements	Aleksej Avramović	1					20WS	2020/04	https://www.project-benefit.eu/eplatform/?courses=16	https://etf.unibl.org/index.php/sr-RS/studiranje/1-ciklus/259-2244-program	27
2	2	UBL	Digital Signal Processing	Zdenka Babić	1	8	9			19WS	2020/02	https://www.project-benefit.eu/eplatform/?courses=14	https://etf.unibl.org/index.php/sr-RS/studiranje/1-ciklus/268-2316-program	38
3	3	UBL	Telecommunication Networks	Gordana Gardašević			5			20SS	2020/04	https://www.project-benefit.eu/eplatform/?courses=22	https://etf.unibl.org/index.php/sr-RS/studiranje/1-ciklus/525-2324-program	3
4	4	UBL	Antenas and Radio Wave Propagation	Slavko Šajić			9			20WS	2020/04	https://www.project-benefit.eu/eplatform/?courses=13	https://etf.unibl.org/index.php/sr-RS/studiranje/1-ciklus/531-2335-program	2
5	5	UBL	Fundamentals of Radar Systems	Slavko Šajić			6			20SS	2020/04	https://www.project-benefit.eu/eplatform/?courses=19	https://etf.unibl.org/index.php/sr-RS/studiranje/1-ciklus/539-2347-program	0
6	6	UBL	Wireless Sensor Networks	Gordana Gardašević			3			19WS	2020/04	https://www.project-benefit.eu/eplatform/?courses=23	https://etf.unibl.org/index.php/sr-RS/studiranje/1-ciklus/305-2330-program	12
7	7	UBL	Multimedia Signals and Systems	Vladimir Risojević	1	12	9			20SS	2019/11	https://www.project-benefit.eu/eplatform/?courses=20#view	https://etf.unibl.org/index.php/sr-RS/studiranje/1-ciklus/493-2305-program	5
8	8	UBL	Systems for Digital Signal Processing	Zdenka Babić, Mladen Knežić		6	11			19WS	2020/02	https://www.project-benefit.eu/eplatform/?courses=21	https://etf.unibl.org/index.php/sr-RS/studiranje/1-ciklus/308-2289-program	23
9	9	UBL	Fundamentals of Electrical Engineering I	Aleksej Avramović, Mitar Simić				8	8 (Moodle)	18WS	2020/02	https://www.project-benefit.eu/eplatform/?courses=17	https://etf.unibl.org/index.php/sr-RS/studiranje/1-ciklus/245-2226-program	563

10	10	UBL	Fundamentals of Electrical Engineering II	Aleksej Avramović, MitarSimić				9	9 (Moodle)	19SS	2019/11	https://www.project-benefit.eu/eplatform/?courses=18#view	https://etf.unibl.org/index.php/sr-RS/studiranje/1-ciklus/251-2234-program	331
11	12	UNSA	Antennas and Wave Propagation	Mirza Hamza			3	3		20SS	2020/06	https://www.project-benefit.eu/eplatform/?courses=38	https://c2.etf.unsa.ba/course/view.php?id=129 https://www.etf.unsa.ba/index.php?id=378	41
12	13	UNSA	Communication Protocols and Networks	Saša Mrdović		14				18WS	2020/02	https://www.project-benefit.eu/eplatform/?courses=40	https://c2.etf.unsa.ba/course/view.php?id=136 https://www.etf.unsa.ba/index.php?id=378	44
13	18	UNTZ	Signals and Systems	Nermin Suljanović	1	9	1	3	8 (Youtube)	19WS 20WS	2020/02	https://www.project-benefit.eu/eplatform/?courses=48	https://fet.ba/ciklus-1.html https://www.youtube.com/channel/UC9-YQqnm96vQVq7GRt-N8Ug/playlists	134
14	19	UNTZ	Introduction to Electronics	Aljo Mujčić	1	15	1	-	-	19WS 20WS	2020/02	https://www.project-benefit.eu/eplatform/?courses=45	https://fet.ba/ciklus-1.html	252
15	20	UNTZ	Analog Integrated Electronics	Aljo Mujčić		12			3 (Youtube)	20SS	2020/07	https://www.project-benefit.eu/eplatform/?courses=42	https://fet.ba/ciklus-1.html	54
16	21	UNTZ	Fundamentals of Communications	Nermin Suljanović		9			1 (Youtube)	19WS 20WS	2020/02	https://www.project-benefit.eu/eplatform/?courses=44	https://fet.ba/ciklus-1.html	26
17	22	UNTZ	Digital Communications	Nermin Suljanović, Asmir Gogić		10			16 (Youtube)	20SS	2020/07	https://www.project-benefit.eu/eplatform/?courses=43	https://fet.ba/ciklus-1.html	17
18	23	UNTZ	Microprocessor Systems in Telecommunications	Asmir Gogić		11		-	-	19WS	2019/11	https://www.project-benefit.eu/eplatform/?courses=46	https://fet.ba/ciklus-1.html	16

19	24	UNTZ	Sequential Circuits	Asmir Gogić		7		-	-	20SS	2020/07	https://www.project-benefit.eu/eplatform/?courses=47	https://fet.ba/ciklus-1.html	31
20	29	UB	Telecommunications 1	Vesna Blagojević		8				20SS	2020/07	https://www.project-benefit.eu/eplatform/?courses=10	https://www.etf.bg.ac.rs/fis/karton_predmeta/13E032T1-2019	154
21	30	UB	Telecommunications 2	Goran Marković		20	3			19WS, 20WS	2020/04 - 2020/08	https://www.project-benefit.eu/eplatform/?courses=11	https://www.etf.bg.ac.rs/fis/karton_predmeta/13E033T2-2019	109(19WS)+138(20WS) = 247
22	31	UB	Signal Processing 2	Jelena Ćertić		14	4			20SS	2020/04 - 2020/08	https://www.project-benefit.eu/eplatform/?courses=8	https://www.etf.bg.ac.rs/fis/karton_predmeta/19E034OS2-2019	24
23	32	UB	Fundamentals of Speech Communication	Dragana Šumarac Pavlović, Miloš Bjelić		11	6			20SS	2020/02 – 2020/07	https://www.project-benefit.eu/eplatform/?courses=4	https://www.etf.bg.ac.rs/fis/karton_predmeta/13E033OGK-2019	26
24	38	UNI	Mobile Communication Systems	Vera Marković, Zlatica Marinković		11				20SS	2020/05	https://www.project-benefit.eu/eplatform/?courses=27	https://www.elfak.ni.ac.rs/downloads/akreditacija-2019/oas/kit/3OEK6O07-mobilni-komunikacioni-sistemi.pdf	10
25	39	UNI	Microwave Design for IoT	Nataša Maleš-Ilić, Olivera, Pronić-Rančić		11	1			24SS	2020/05	https://www.project-benefit.eu/eplatform/?courses=26	https://www.elfak.ni.ac.rs/downloads/akreditacija-2019/oas/kit/3OEK8O04-projektovanje-mikrotalasnih-kola-za-iot.pdf	0
26	40	UNI	Measurements in Telecommunications	Nebojša Dončov		15	1			19WS	2020/03	https://www.project-benefit.eu/eplatform/?courses=25	https://www.elfak.ni.ac.rs/downloads/akreditacija-2019/oas/kit/3OEK7O04-merenja-u-telekomunikacijama.pdf	10
27	41	UNI	Data Analysis and Compression	Zoran Perić, Aleksandra Jovanović, Jelena Nikolić		12				23WS	2020/01	https://www.project-benefit.eu/eplatform/?courses=30	https://www.elfak.ni.ac.rs/downloads/akreditacija-2019/oas/kit/3OEK6B02-analiza-i-kompresija-podataka.pdf	0
28	55	UNS	Modelling and Simulation of Communication Systems	Milan Narandžić		14			33 (Moodle/Google Drive)	19SS	2020/08	https://www.project-benefit.eu/eplatform/?courses=35	http://www.ftn.uns.ac.rs/674464826/power--electronic-and-telecommunication-engineering	44
29	56	UNS	Machine Learning 1 (former Pattern Recognition)	Tatjana Lončar-Turukalo		9	1	1		19WS	2020/06	https://www.project-benefit.eu/eplatform/?courses=33	http://www.ftn.uns.ac.rs/674464826/power--electronic-and-telecommunication-engineering	195

30	57	UNS	Software in Telecommunication Systems	Živko Bojović	1	13	1			19WS	2020/01	https://www.project-benefit.eu/eplatform/?courses=36	http://www.ftn.uns.ac.rs/674464826/power--electronic-and-telecommunication-engineering	5

Table 8-2 List of new courses with detailed descriptions (First cycle)

No.	Course ID #	University	Course name	Teacher(s)	Type of developed material					Semester of implementation	Date of posting material on e-platform	Links		Number of enrolled students
					Book	Lectures slides	Lab practicum notes	Video on BENFIT portal	Video on other portals (e.g. YouTube)	Spring Semester (SS), Winter Semester (WS), After project end (After)		e-platform (brief course description and teaching materials)	university website (course description as in accreditation)	
1	11	UNSA	Software Engineering (Telecommunications)	Dušanka Bošković		9	9			18WS	2020/02	https://www.project-benefit.eu/eplatform/?courses=39	https://www.etf.unsa.ba/index.php?id=378	6
2	25	UNTZ	Telemedicine	Alma Šećerbegović		3				After	2020/10	https://www.project-benefit.eu/eplatform/?courses=49	https://fet.ba/ciklus-1.html	NA
3	33	UB	IoT Networks	Goran Marković, Mladen Koprivica		12	4			19WS, 20WS	2020/02 - 2020/07	https://www.project-benefit.eu/eplatform/?courses=5	https://www.etf.bg.ac.rs/fis/karton_predmeta/13E034IoT-2019	51(19WS) + 61(20WS) = 112
4	34	UB	Smart Devices and Communications	Mladen Koprivica						21SS- After	2021/02	https://www.project-benefit.eu/eplatform/?courses=9	https://www.etf.bg.ac.rs/fis/karton_predmeta/19E031PUK-2019	0
5	42	UNI	Advanced RFIC for Telecommunication Systems	Dejan Milić		2	1			24SS-After	After – (1)	https://www.project-benefit.eu/eplatform/?courses=29	https://www.elfak.ni.ac.rs/downloads/akreditacija-2019/oas/kit/3OEK8B03-napredna-rf-integrisana-kola.pdf	0
6	43	UNI	Computer Communications and Internet access (II)	Nebojša Dončov, Zoran Stanković		0	1		5	23WS	After – (1)	https://www.project-benefit.eu/eplatform/?courses=24	https://www.elfak.ni.ac.rs/downloads/akreditacija-2019/oas/kit/3OEK7F01-racunarske-komunikacije-i-pristup-internetu-ii.pdf	0
7	44	UNI	Smart Systems and IoT	Nataša Maleš-Ilić, Olivera		0	0			24SS-After	After – (1)	https://www.project-benefit.eu/eplatform/?courses=28	https://www.elfak.ni.ac.rs/downloads/akreditacija-2019/oas/kit/3OEK7O05-pametni-sistemi-i-iot.pdf	0

				Pronić-Rančić									
8	58	UNS	Machine Learning 2	Milan Sečujski, Tatjana Lončar-Turukalo, Nikša Jakovljević			1		24SS-After	2020/10	https://www.project-benefit.eu/eplatform/?courses=34	http://www.ftn.uns.ac.rs/674464826/power--electronic-and-telecommunication-engineering	-
9	59	UNS	Wireless Communication Systems	Dejan Vukobratović, Milan Narandžić		10		1		23WS (part 19WS)	2020/06	https://www.project-benefit.eu/eplatform/?courses=37	http://www.ftn.uns.ac.rs/674464826/power--electronic-and-telecommunication-engineering	-
10	60	UNS	Design of Industrial IoT Systems	Živko Bojović, Milan Narandžić, Dejan Vukobratović		6	1			24SS (part 20SS)	2020/05	https://www.project-benefit.eu/eplatform/?courses=32	http://www.ftn.uns.ac.rs/674464826/power--electronic-and-telecommunication-engineering	-

8.2 List of courses for modernisation at the second cycle of study

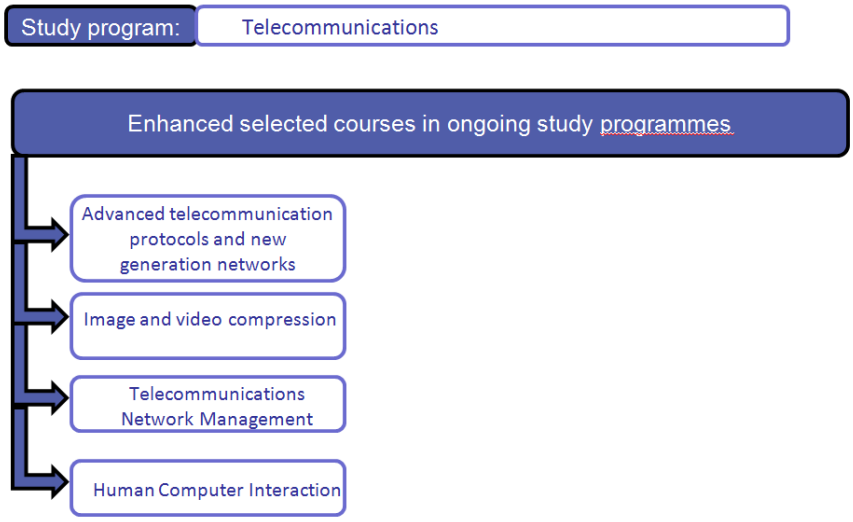

Figure 8-7 List of courses for modernisation at the Faculty of Electrical Engineering in Sarajevo

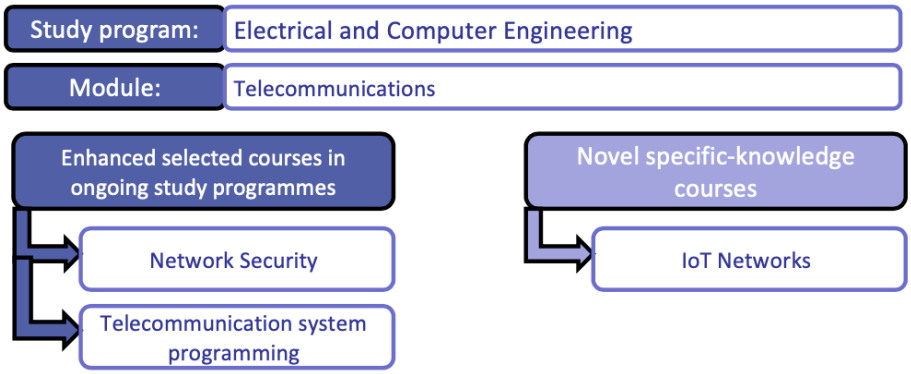

Figure 8-8 List of courses for modernisation at the Faculty of Electrical Engineering in Tuzla

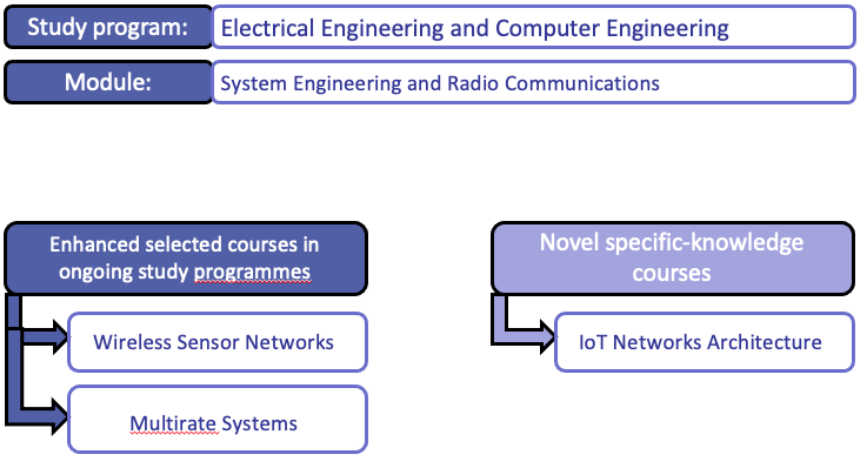

Figure 8-9 List of courses for modernisation at the School of Electrical Engineering in Belgrade

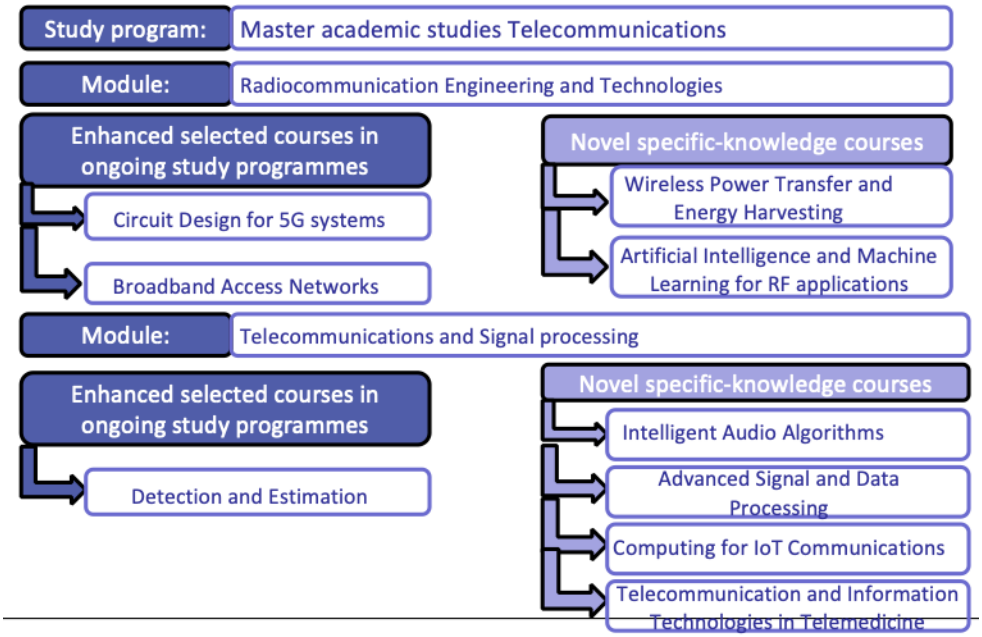

Figure 8-10 List of courses for modernisation at the School of Electronic Engineering in Niš

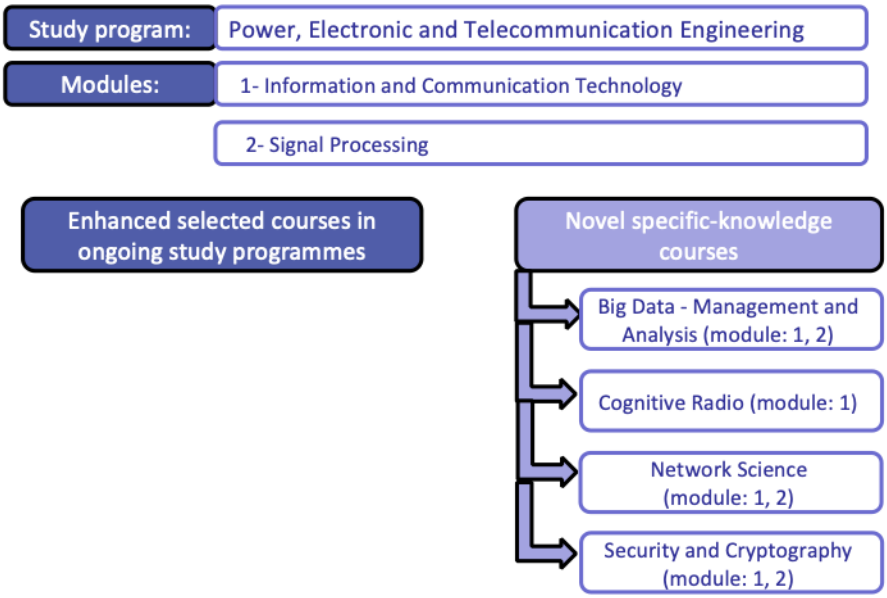

Figure 8-11 List of courses for modernisation at the Faculty of Technical sciences in Novi Sad

Table 8-3 List of enhanced courses with detailed descriptions (Second cycle)

No.	Course ID #	University	Course name	Teacher(s)	Type of developed material					Semester of implementation	Date of posting material on e-platform	Links		Number of enrolled students
					Book	Lectures slides	Lab practicum notes	Video o on BENEFIT portal	Video on other portals (e.g. YouTube)	Spring Semester (SS), Winter Semester (WS), After project end (After)		e-platform (brief course description and teaching materials)	University website (course description as in accreditation)	
1	14	UNSA	Human Computer Interaction	Dušanka Boškoviće	0	14	16	0	12 (GSuite)	18WS	2019/12	https://www.project-benefit.eu/eplatform/?courses=72	https://c2.etf.unsa.ba/course/view.php?id=204	160
2	15	UNSA	Advanced Telecommunication Protocols and New Generation Networks	Saša Mrdović	0	13	0			20SS	2020/06	https://www.project-benefit.eu/eplatform/?courses=67	https://c2.etf.unsa.ba/course/view.php?id=232	14
3	16	UNSA	Image and video compression	Emir Turajlić	1	11				19SS	2020/06	https://www.project-benefit.eu/eplatform/?courses=65	https://c2.etf.unsa.ba/course/view.php?id=167	35
4	17	UNSA	Telecommunications Network Management	Miralem Mehić			1			20WS	2020/06	https://www.project-benefit.eu/eplatform/?courses=66	https://c2.etf.unsa.ba/course/view.php?id=227	30
5	26	UNTZ	Network Security	Nermin Suljanović, Aljo Mujčić		12				19WS 20WS	2020/07	https://www.project-benefit.eu/eplatform/?courses=69	https://fet.ba/ciklus-2.html	7
6	27	UNTZ	Telecommunication system programming	Asmir Gogić		10				20SS	2020/10	https://www.project-benefit.eu/eplatform/?courses=75	https://fet.ba/ciklus-2.html	5
7	35	UB	Wireless Sensor Networks	Goran Marković, Dejan Drajić		12	3			20SS	2020/07	https://www.project-benefit.eu/eplatform/?courses=51	https://www.etf.bg.ac.rs/fis/karton_predmeta/13M031BSM-2019	67

8	36	UB	Multirate Systems	JelenaĆ ertić		6				19WS	2020 /02	https://www.project-benefit.eu/eplatform/?courses=74	https://www.etf.bg.ac.rs/fis/karton_predmeta/13M031SVB-2019	2
9	45	UNI	Circuit Design for 5G systems	Nataša Maleš-Ilić, Olivera Pronić-Rančić	1	7				19WS	2020 /03	https://www.project-benefit.eu/eplatform/?courses=54	https://www.elfak.ni.ac.rs/downloads/akreditacija-2019/mas/kit/projektovanje-kola-za-5g-sisteme.pdf	6
10	46	UNI	Broadband Access Networks	Nebojša Dončov Zoran Stanković	1	10			4	19WS	2020 /03	https://www.project-benefit.eu/eplatform/?courses=53	https://www.elfak.ni.ac.rs/downloads/akreditacija-2019/mas/kit/sirokopojasne-mreze-za-pristup.pdf	6
11	47	UNI	Principles of Software Radio	Zorica Nikolić, Nenad Milošević		15				19WS	2020 /03	https://www.project-benefit.eu/eplatform/?courses=71	https://www.elfak.ni.ac.rs/downloads/akreditacija-2019/mas/kit/principi-softverskog-radija.pdf	3

Table 8-4 List of new courses with detailed descriptions (Second cycle)

No.	Course ID #	University	Course name	Teacher(s)	Type of developed material					Semester of implementation	Date of posting material on e-platform	Links		Number of enrolled students
					Book	Lectures slides	Lab practicum notes	Video on BENEFIT portal	Video on other portals (e.g. YouTube)	Spring Semester (SS), Winter Semester (WS), After project end (After)		e-platform (brief course description and teaching materials)	University website (course description as in accreditation)	
1	28	UNTZ	IoT Networks	NerminSuljanović, Aljo Mujčić		9				After	2020/10	https://www.project-benefit.eu/eplatform/?courses=68	https://fet.ba/ciklus-2.html	NA
2	37	UB	IoT Networks Architecture (IoT Networks in 19WS)	Goran Marković, Mladen Koprivica		12	4			19WS, 20WS	2020/02-2020/08	https://www.project-benefit.eu/eplatform/?courses=50	https://www.etf.bg.ac.rs/fis/karton_predmeta/13M034IoT-2020	16(19WS) + 10(20WS) = 26
3	48	UNI	Big data analysis	Daniela Milović		3	1	0		20SS	2020/06	https://www.project-benefit.eu/eplatform/?courses=58	https://www.elfak.ni.ac.rs/downloads/akreditacija-2019/mas/kit/analiza-velikih-skupova-podataka.pdf	2
4	49	UNI	Wireless Power Transfer and Energy Harvesting	Nataša Maleš-Ilić, Nebojša Dončov		0				19WS	After –(1)	https://www.project-benefit.eu/eplatform/?courses=55	https://www.elfak.ni.ac.rs/downloads/akreditacija-2019/mas/kit/bezicni-i-efikasni-prenos-energije.pdf	0
5	50	UNI	Artificial Intelligence and Machine Learning for communication systems	Zlatica Marinković, Zoran Stanković		9				19WS	2020/03	https://www.project-benefit.eu/eplatform/?courses=52	https://www.elfak.ni.ac.rs/downloads/akreditacija-2019/mas/kit/vestacka-inteligencija-i-masinsko-ucenje-za-komunikacione-sisteme.pdf	9
6	51	UNI	Intelligent Audio Algorithms	Dejan Ćirić		15				19WS	2020/03	https://www.project-benefit.eu/eplatform/?courses=59	https://www.elfak.ni.ac.rs/downloads/akreditacija-2019/mas/kit/inteligentni-audio-algoritmi.pdf	2
7	52	UNI	Statistical Learning in Signal Processing	Zoran Perić, Aleksandra Jovanović, Jelena Nikolić		9				19WS	After –(1)	https://www.project-benefit.eu/eplatform/?courses=56	https://www.elfak.ni.ac.rs/downloads/akreditacija-2019/mas/kit/statisticko-ucenje-u-obradi-signala.pdf	0
8	53	UNI	Computing for IoT Communications	Dejan Milić	1	4		0		20SS	2020/06	https://www.project-benefit.eu/eplatform/?courses=57	https://www.elfak.ni.ac.rs/downloads/akreditacija-2019/mas/kit/racunarstvo-za-lot-komunikacije.pdf	0

9	54	UNI	Telecommunication and Information Technologies in Telemedicine	Goran T. Đorđević, Dejan Milić, Daniela Milović		5	0	0		20SS	2020/05	https://www.project-benefit.eu/eplatform/?courses=60	https://www.elfak.ni.ac.rs/downloads/akreditacija-2019/mas/kit/telekomunikacione-i-informacione-tehnologije-u-telemedicini.pdf	0
10	61	UNS	Big Data - Management and Analysis	Tatjana Lončar-Turukalo, Živko Bojović		8	1			20WS	2020/06	https://www.project-benefit.eu/eplatform/?courses=61	http://www.ftn.uns.ac.rs/n1847675942/power--electronic-and-telecommunication-engineering	20
11	62	UNS	Cognitive Radio	Milan Narandžić		6	1		12 (Moodle/GoogleDrive)	20WS (part 19WS)	2020/03	https://www.project-benefit.eu/eplatform/?courses=62	http://www.ftn.uns.ac.rs/n1847675942/power--electronic-and-telecommunication-engineering	10
12	63	UNS	Network Science	Dragana Bajović		4				20WS (part 19WS)	2020/01	https://www.project-benefit.eu/eplatform/?courses=63	http://www.ftn.uns.ac.rs/n1847675942/power--electronic-and-telecommunication-engineering	-
13	64	UNS	Security and Cryptography	Mladen Kovačević, Vojin Šenk		6				20WS	2020/12	https://www.project-benefit.eu/eplatform/?courses=64	http://www.ftn.uns.ac.rs/n1847675942/power--electronic-and-telecommunication-engineering	11