SYLLABUS

1. Data about the program of study

1.1 Institution	Technical University of Cluj-Napoca
1.2 Faculty	Faculty of Electronics, Telecommunications, and Information Technology
1.3 Department	Communications
1.4 Field of study	Electronic Engineering, Telecommunications, and Information Technologies
1.5 Cycle of study	Master of Science
1.6 Program of study / Qualification	Telecommunications / Master Multimedia Technologies / Master Artificial Intelligence and Signal Processing in Electronics and Telecommunications / Master
1.7 Form of education	Full time
1.8 Subject code	TC-E16.20

2. Data about the subject

2.1 Subject name	Intelligent Wireless Communications Systems						
2.2 Subject area	Theoretical area Methodological area Analytic area						
2.3 Course responsible	Professor Emanuel PUSCHITA, Emanuel.Puschita@com.utcluj.ro						
2.4 Teacher in charge with seminar / laboratory / project	Professor Emanuel PUSCHITA, Emanuel.Puschita@com.utcluj.ro						
2.5 Year of study	2	2.6 Semester	3	2.7 Assessment	E	2.8 Subject category	DS/DO

3. Estimated total time

3.1 Number of hours per week	4	of which: 3.2 course	2	3.3 laboratory	1
3.4 To Total hours in the curriculum	42	of which: 3.5 course	28	3.6 laboratory	14
Distribution of time					hours
Manual, lecture material and notes, bibliography					20
Supplementary study in the library, online specialized platforms and in the field					12
Preparation for seminars / laboratories, homework, reports, portfolios and essays					20
Tutoring					3
Exams and tests					3
Other activities:					

3.7 Total hours of individual study	58
3.8 Total hours per semester	100
3.9 Number of credit points	4

4. Pre-requisites (where appropriate)

4.1 curriculum	Cellular Radiocommunications, Radiocommunications, Fixed and mobile communications systems.
4.2 competence	N. A.

5. Requirements (where appropriate)

5.1. for the course	Technical University of Cluj-Napoca (video projector, screen, whiteboard, MS Office 365/MS Teams account for online activities)
5.2. for the seminars / laboratories / projects	Technical University of Cluj-Napoca (PCs with internet access, video projector, screen, dedicated software and hardware, MS Office 365/MS Teams account for online activities)

6. Specific competences

Professional competences	**C4. Conception, implementation and operation of data, voice, video, multimedia services, based on the understanding and application of fundamental notions in the field of communications and information transmission.** C4.3 Explanation and interpretation of the main requirements and specific approach techniques for data, voice, video, multimedia transmissions. **C5. Selection, installation, configuration and operation of fixed or mobile telecommunications equipment and equipping a site with the usual telecommunications networks.** C5.2 Explanation and interpretation of fundamental technologies and protocols for integrated fixed and mobile communication systems. **C6. Solving specific problems for broadband communication networks: propagation in different transmission media, circuits and equipment for high frequencies (microwave and optical).** C6.3 Solving practical problems using microwave circuit design methods, planning, coverage, selection and placement of transmission and reception equipment. **C7. Understanding the principles and techniques of machine learning, deep learning, optimization** C7.1 Design, implementation, testing and exploitation of neural networks. C7.2 Design, implementation, testing and exploitation of deep neural networks. C7.3 Design, implementation, testing and exploitation of convolutional neural networks. C7.4 Use of Matlab, Python environments for application development.
Cross competences	N.A.

7. Discipline objectives (as results from the key competences gained)

7.1 General objective	The development of professional skills in the field of current wireless communications systems.
7.2 Specific objectives	1. Assimilation of theoretical knowledge regarding applications based on antenna arrays and SDR technology. 2. Developing skills and competencies for programming SDR platforms.

8. Contents

8.1 Lecture (syllabus)	Teaching methods	Notes
1. Radio waves propagation: absorption, reflection, scattering, refraction, diffraction, attenuation, amplification.	Presentation, exemplification,	Use of .ppt presentations,

2. Propagation models. Basic communications systems. The radio channel.	problem discussion, case study.	video projector, blackboard.
3. Antennas. Types: omnidirectional, directional, sector. Antenna arrays.		
4. MIMO systems. Spatial diversity. Spatial multiplexing. MIMO channel model. MIMO channel capacity. Introduction in space-time codes.		
5. Massive MIMO systems. Massive MIMO channel model. Case study. Future trends.		
6. Beamforming: analog, digital, hybrid. Conventional beamforming.		
7. Adaptive beamforming. Adaptive algorithms: Least Mean Squares, Direct Sample Covariance Matrix Inversion, Recursive Least Squares.		
8. Error effects in digital beamforming.		
9. Adaptive beamforming in mobile communications. Adaptive beamforming in indoor communications.		
10. Narrowband beamforming. Wideband beamforming. MIMO beamforming.		
11. Spectrum monitoring. Estimation of RF signal direction of arrival (DOA). Interferometry.		
12. Subspace based algorithms: MUSIC algorithm.		
13. ESPRIT Algorithm.		
14. Case study: Drone detection / Recapitulation		

Bibliography
1. C. Balanis, P. Ioannides, *Introduction to Smart Antennas,* Morgan & Claypool Publishers, 2007.
2. J. Litva, *Digital Beamforming in Wireless Communications,* Artech House Mobile Communications Series, 1996.
3. Jian Li and Petre Stoica, *Robust Adaptive Beamforming,* Wiley Series in Telecommunications and Signal Processing, 2006.
4. Wei Liu and Stephan Weiss, *Wideband Beamforming Concepts and Techniques,* Wiley Series on Wireless Communications and Mobile Computing, 2010.
5. A. Manikas, *Beamforming Sensor Signal Processing for Defence Applications,* Imperial College Press, 2015.
6. T. Marzetta, E. Larsson, H. Yang, H. Ngo, *Fundamentals of Massive MIMO,* Cambridge University Press, 2016.
7. R. Kshetrimayum, *Fundamentals of MIMO Wireless Communications,* Cambridge University Press, 2017.

8.2 Laboratory	Teaching methods	Notes
1. Linux installation. Gnu Radio Installation. Gnu Radio tutorial, Python.	Didactic and experimental demonstrations, didactic exercises, simulations, teamwork.	Use of laboratory instrumentation, SDR platforms + programming environment, computers
2. SDR architecture. HackRF, BladeRF, USRP. Installation of drivers, libraries, dependencies.		
3. SDR programming. Receiver application. Comparative analysis of the performance parameters of SDRs. Spectrum monitoring.		
4. Transmitter application. Packet transmission Tx-Rx.		
5. MIMO 2x2 application. Synchronization.		
6. Antenna array applications. DOA, MUSIC, ESPRIT.		

7. Antenna array applications. Beamforming.		
Bibliography 1. Laboratory manual. 2. ***, https://wiki.gnuradio.org/index.php/Tutorials.		

9. Bridging course contents with the expectations of the representatives of the community, professional associations and employers in the field

The discipline content and the acquired skills are in agreement with the expectations of the professional Competences acquired will be used in the following COR occupations (Electronics Engineer; Telecommunications Engineer; Electronics Design Engineer; System and Computer Design Engineer; Communications Design Engineer) or in the new occupations proposed to be included in COR (Sale Support Engineer; Multimedia Applications Developer; Network Engineer; Communications Systems Test Engineer; Project Manager; Traffic Engineer; Communications Systems Consultant).

10. Evaluation

Activity type	10.1 Assessment criteria	10.2 Assessment methods	10.3 Weight in the final grade
10.4 Course	Solving 1 problem plus a set of theoretical questions.	Written exam	50%
10.5 Seminar/ Laboratory	Checking the level of acquired knowledge and abilities	Laboratory tests during the semester	50%
10.6 Minimum standard of performance			

Qualitative point of view

Minimal theoretical and practical knowledge:

- ✓ To know fundamental concepts related to SDR architecture.
- ✓ To know fundamental concepts related to Python.
- ✓ To know the principles of current wireless communications systems.
- ✓ To know the principles of antenna array-based technologies.

Minimal acquired competences:

- ✓ To be able to install and configure at least one type of SDR.
- ✓ To be able to design and implement an SDR application for spectral monitoring.

Quantitative point of view

- ✓ Attending and completing all lab activities.
- ✓ At least 5 both for exam and lab.
- ✓ Final mark = 0.5 x Exam + 0.5 x Lab.

Date of filling in:	Responsible	Title First name SURNAME	Signature
20.06.2024	Course	Professor Emanuel PUSCHITA, Ph.D.	
	Applications	Professor Emanuel PUSCHITA, Ph.D.	

Date of approval in the Council of the Communications Department 10.07.2024	Head of Communications Department Prof. Virgil DOBROTA, Ph.D.
Date of approval in the Council of the Faculty of Electronics, Telecommunications and Information Technology 11.07.2024	Dean Prof. Ovidiu POP, Ph.D.