López-Morales, M.J., et al. MOOC on "Ultra-dense networks for 5G and its evolution": challenges and lessons learned. In: *31st Annual Conference of the European Association for Education in Electrical and Information Engineering (EAEEIE 2022), Coimbra, Portugal, June 29-July 1 2022. IEEE, 2022, 6 p.*

# MOOC on "Ultra-dense Networks for 5G and its Evolution": Challenges and Lessons Learned

Manuel J. Lopez-Morales*, D. Alejandro Urquiza-Villalonga*, Diego Gonzalez-Morin†, Nidhi‡, Bahram Khan§**, Farinaz Kooshki¶, Ahmed Al-Sakkaf*, Leonardo Leyva§††, Hamed Farkhari§, Daniele Medda‖, Ilias-Nektarios Seitanidis‖, Ayman Abu-Sabah§‡‡, Joseanne Viana§ˣ, Pedro Cumino§††, Victor P. Gil-Jimenez*, M. Julia Fernández-Getino García*, Máximo Morales-Cespedes*, Ana Garcia-Armada*, Fernando J. Velez§

*Department of Signal Theory and Communications, Universidad Carlos III de Madrid, Spain,
†Nokia Bell Labs, Madrid, Spain, §Instituto de Telecomunicações, Portugal
**Universidade da Beira Interior, ††Universidade da Aveiro, ‡‡Universidade Nova de Lisboa, ˣISCTE-IUL, Portugal,
‡CGC Research Lab, Department of Business Development and Technology, Aarhus University, Denmark
¶IS-Wireless R&D, Warsaw, Poland, ‖International Hellenic University, Thessaloniki, Greece
Correspondence should be addressed to Manuel J. Lopez-Morales: mjlopez@tsc.uc3m.es

***Abstract*—Many of the new mobile communication devices will be things that power and monitor our homes, city infrastructure and transport. Controlling drones thousands of miles away, performing remote surgeries or being immersed in video with no latency will also be a huge game changer. Those are some of the few things that make the fifth generation (5G) a revolution expected to be a thrust to the economy. To that end, the design and density of deployment of new networks is also changing becoming more dense, what introduces new challenges into play. What else will it add to previous generations? The MOOC about Ultra-dense networks for 5G and its evolution has been prepared by the researchers of an European MSCA ITN, named TeamUp5G, and introduces the most important technologies that support 5G mobile communications, with an emphasis on increasing capacity and reducing power. The content spans from aspects of communication technologies to use cases, prototyping and the future ahead, not forgetting issues like interference management, energy efficiency or spectrum management. The aim of the MOOC is to fill the gap in graduation and post-graduation learning on content related to emerging 5G technologies and its applications, including the future 6G. The target audience involves engineers, researchers, practitioners and students. This paper describes the content and the learning outcomes of the MOOC, the main tasks and resources involved in its creation, the joint contributions from the academic and non-academic sector, and aspects like copyright compliance, quality assurance, testing and details on communication and enrollment, followed by the discussion of the lessons learned.**

***Index Terms*—Small Cells, energy efficiency, spectrum and interference management, HetNets, IoT, massive MIMO, cell-free, mmWave, VLC, prototyping, UAV, AR/VR, MOOC**

## I. Introduction

### A. Motivation and objectives

Massive Online Open Courses (MOOCs) are widely available for everybody with an internet connection. MOOCs are designed to acquire new skills, develop your career, and provide high-quality educational experiences to a large audience in a more affordable and flexible way. Millions of people use MOOCs throughout the world, for professional progress, career transition, and basically any professional training. Several universities and institutions have created and shared their own experience on virtual and remote content creation through MOOC development over the years. Authors from [1] submitted experimental findings from the Virtual Instrument Systems in Reality laboratory. The authors of [2] compared the results of several courses on signal processing and digital communication they had created over the years. In [3], a study about MOOCs' effectiveness in improving undergraduate students' performance in a normal Digital Signal Processing (DSP) class was conducted. There is also a discussion in [4] on the advantages and disadvantages of MOOC courses for microelectronics. The number of discussions in the literature is large, but to the best of our knowledge, there was no MOOC focusing on the $5^{th}$ generation of mobile communications (5G) and its advancement, which led to the creation of the MOOC addressed in this paper.

The project "New RAN TEchniques for 5G UltrA-dense Mobile networks" (TeamUp5G) [5] is a prestigious Marie Skłodowska-Curie Innovative Training Networks (MSCA ITN) in the frame of the European Commission's Horizon 2020 framework [6], with grant-agreement number 813391. The team is investigating the evolution of the 5G wireless communications and has been preparing an extensive MOOC under the scope of "Ultra-Dense Networks for 5G and Its Evolution". The goal is sharing the recent research advances and the knowledge about the main technological innovations and new 5G mobile networks applications. Motivated by MOOCs' role in the scope of higher education while providing a positive impact on student's performance, a well-designed, structured, and open comprehensive accessible online course

This work has received funding from the European Union Horizon 2020 research and innovation programme under the Marie Skłodowska-Curie ETN TeamUp5G, grant agreement No. 813391.

has been prepared by the TeamUp5G team. As an outcome of this join effort, this paper provides the detailed steps and procedures about the methodology adopted and experienced during the preparation of the MOOC, highlighting the experience acquired, challenges, and potential opportunities.

### *B. Targeted audience*

The MOOC was prepared to be simple, understandable and intelligible to the majority of users. In this sense, it can be used for professionals and students who are related to the research and development of 5G New Radio networks and their evolution. Based on the targets for learning outcomes, the transfer of basic concepts is eloquently expressed for beginners and students to make it easier to understand. People with a background in telecommunications can be familiar with the latest objectives and state-of-the-art research areas in which the EU and related companies are willing to invest, research, and develop. Finally, teachers who want to transfer the fundamentals and basic concepts of the 5G networks to their students can also benefit from this MOOC.

### *C. Content formatting*

The "Ultra-dense Networks For 5G And Its Evolution" MOOC [7] is prepared by 14 Early-Stage Researchers (ESRs) under the supervision of an international team of highly qualified professors from different backgrounds and disciplines. The course is divided into six modules and each module contains five different items to cover a wide range of concepts and enabling technologies for the 5G and future 6G. For each item, learning, evaluation, and motivational materials have been created, as shown in Fig.1.

Video-recorded presentations and textual extensions are the main learning materials. The script documents were prepared to assist the presenter in recording the video and to make text transcription easier on the edX platform. The textual extensions have been devised to present students with both reading and hearing information in addition to the video, along with some extra information. The assessment procedure was developed as a method for reviewing the educational material. It is composed of four question types: true/false, multiple-choice, drag and drop, and input number type. Additionally, open questions after each module encourage students to reflect more deeply on the subject through a forum discussion. In this forum, the students and teachers can interact for learning engagement purposes. In total, roughly 2 hours of material was generated for each item, split among 10 minutes of video content each week, 50 minutes of written information to support the video material, plus 1 hour of questions and forum discussion.

### *D. Paper Organization*

The remainder of the paper is organized as follows: Section II outlines the objective of the MOOC, Section III describes the available resources, Section IV presents the production process, Section V addresses the beta testing and broadcast and Section VI concludes the paper.

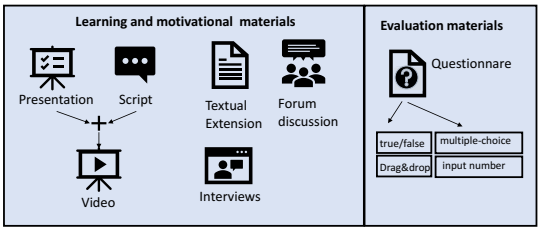


Fig. 1. Block diagram of the content formatting to summarize the contents.

## II. Objective

The technological development has grown continuously and fast, and the discoveries made by the scientific community and the emergence of new patents bring new challenges at a time when such innovations need to be inserted into people's daily lives. Qualified professionals capable of assimilating new technologies and making good use of them in society are needed. The ESRs, with the help of their supervisors, have observed a gap between innovative evolutionary technologies and the current students' vision over 5G and beyond networks. Addressing this gap is beneficial for students, professionals, and researchers to get updated and understand the latest novel technologies in communication and computer networks. Indeed, after looking more closely at the scope of the necessary road map of the target technologies and their evolution impacting the telecommunications industry, we identified the gaps that could be covered through our MOOC. It is worthwhile to mention that there could be a mismatch between materials provided at university bachelor levels and the online resources from the internet. In general, they do not focus on summarizing the target technologies in a well-developed plan. There is also a mismatch between the research publications which need a prior understanding of the related topic and a very high level of knowledge. They would not be at the level of young students and motivated target researchers.

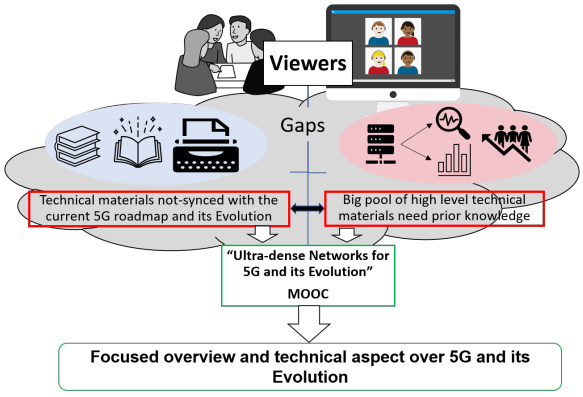


Fig. 2. Showcasing of the objectives (created from free open license CC).

The goal of this MOOC is to minimize these gaps through efficiently disseminating current research by sharing it into a simple and understandable way to students and young researchers as illustrated in Fig.2. The aim is to deliver this

knowledge not only in a high-level view of the 5G mobile network but also exploring the beyond enabling technologies and technical aspects behind each. It is important to consider the need for a creative method for such knowledge sharing to attain effective results. Therefore, the production of the current MOOC package efficiently covers the high-level vision and digs into the technical perspective over the "Ultra-dense Networks for 5G and its Evolution".

As learning outcomes, this MOOC focuses on understanding, designing and optimizing the 5G heterogeneous small cell ultra-dense networks. Several topics are covered mainly related to 5G and its evolution, its system requirements and new transmission technologies such as beamforming, full-duplex communication, among other. Aspects of interference management and energy efficiency, low power networks, packet and multi-band scheduling, data sensing, spectrum sharing, carrier aggregation, use cases and prototypes (such as augmented and virtual reality), security, unmanned aerial vehicles (UAVs), simultaneous radar and communications (RADCOM), followed by a vision on the future ahead (e.g., 6G and terahertz communications) are also addressed in this MOOC. Students, researchers and practitioners will understand how, motivated by user needs, mobile networks are evolving toward 5G new radios, and how this evolution enable other industrial sectors, such as medical science, transport, entertainment, and education. Practical considerations on these topics are complemented by development and deployment aspects.

Through our produced visionary MOOC, we target the transfer of knowledge in a crystal-clear technical language. After developing a good understanding of the vision for the audience, we share the technical perspective of each key technology player in a smooth manner. It would enable the audience to get the readiness for understanding the latest developments. So, their mind's creativity for contribution in their future careers would be enhanced.

## III. Resources

### A. Team and project

TeamUp5G is a multi-partner research training network whose beneficiaries come from academic and non-academic sectors to form a structured, international, intersectoral, and interdisciplinary research and training environment for PhD students and young researchers, which is spread in different countries in Europe. It aims to optimize the existing 5G in various domains in terms of throughput, energy and spectral efficiency. Some challenges are the demand for increasing data rates and users served per $km^2$ and the energy efficiency of the entire system. The goal of the ETN is to propose metrics and develop energy-aware algorithms and protocols to enhance small cells in ultra-dense deployments, making use of massive antenna solutions (mMIMO), millimeter wave (mmWave) bands and Visible Light Communications (VLC), in relevant scenarios, through a combination of analytical work, simulation and prototyping. The details and information regarding our ESRs, their works, and the hosting institutions can be found in [5].

### B. University facilities and prior experience

The technical team of Universidad Carlos III de Madrid (UC3M) and some of the involved supervisors had prior experience creating and organizing MOOCs [8]. UC3M provided around 35 different MOOCs both in English and Spanish in the edX and MiriadaX platforms. For instance, the course on mobile communications from the Signal Theory and Communications department at UC3M is published in edX [9]. This MOOC is open to the public, and targets an audience who have no previous knowledge on mobile communications. UC3M experience guided the journey of this MOOC and helped the team to overcome the challenges.

The MOOC was fully recorded at UC3M, utilizing the in-campus Audio/Video (AV) facilities. UC3M has three recording studios, to allow university staff and students to generate teaching materials for various purposes, such as MOOCs or teaching innovation projects. The rooms are provided with all the recording facilities such as HD cameras, a system for mixing and compositing images in HD, special background lighting for generating virtual background, and a teleprompter, as shown in Fig. 3. Concerning the prior experiences in MOOC production, UC3M has experienced staff for editing, mixing, and processing videos. UC3M also provides support for creative process such as covers, course images, and original creation of materials, like animations or even small interactive materials.

Fig. 3. Recording room facilities available at UC3M Leganés Campus.

### C. ETN contributions and resources

The MOOC "Ultra-Dense Networks for 5G and its Evolution" results from a great teamwork, supervision and constant guidance. In its production, 14 ESRs and 9 supervisors have participated. From the 14 ESRs, 2 acted as both producers and supervisors of the MOOC, as it happened with 3 of the supervisors of the TeamUp5G project. The other 12 ESRs and the other 6 supervisors acted only as producers and as supervisors of the MOOC, respectively. Each producer was responsible for the content of the MOOC relevant to one's research area. The contributions by the supervisors were invaluable in coordinating the teams, reviewing and providing continuous insights on improving the content. In Section IV, the MOOC's structure and contents are discussed in detail. To ensure high-quality videos and synchronization, UC3M took the responsibility of recording and coordinating the MOOC. Some producers could not travel to the UC3M premises

amid the COVID-19 pandemic. For this reason, some of the producers residing in Madrid recorded most of the videos.

## IV. Production of the MOOC

This Section includes information about the timeline of the main tasks, the creation of the material, the copyright compliance, the contribution from the non-academic sector and the quality assurance. Fig. 4 shows an overview of the timeline, involved tasks, copyright, and quality processes of the production of the MOOC.

### A. Main tasks and timeline

The kick-off meeting was in early March 2021, when the MOOC structure was defined. The two major goals were to begin the video production phase in late July 2021 and to finish the entire MOOC in January 2022, in order to begin the lessons at the end of February 2022. Six different modules were identified, each one divided into five items, spanning from introductory topics to more technical ones. To structure the overall work, a table of contents for each item was proposed in April 2021. Based on this defined structure, the production of the presentations and scripts of all the modules was carried out during May and June 2021. A common template was used to maintain a homogeneous environment throughout the entire MOOC. We focused on having as less text as possible in the videos, in order to keep an adequate level of attention. Also, a great number of illustrations (both images and schematics) were used to take advantage of visual learning. In the end, this phase has proven to be the most challenging one, both in terms of research and time. Since the maximum duration for each video was set to 7 minutes, the use of written scripts became essential to ensure compliance with this limitation.

The videos were recorded during June, July, and September 2021, supported by the presentations and scripts. Among the parties involved, only the UC3M had adequate facilities for multimedia production (i.e., filming and video production) and the best way to have a centralized quality control was to record all the videos in the UC3M, using a small selected group of people, containing both instructors and speakers. The filming process took about three months.

Apart from the video, a textual extension as additional studying material was provided. The starting point for the textual extensions was the previously written scripts. In addition, some particularly complex topics were further extended to provide a more complete information. In order to provide a homogeneous result, a common template was used for all textual extensions. The textual extensions were created in October and November 2021.

The evaluation questions were also created during these months. Two different evaluation phases were defined: a test related to each item and a more general test for the entire module. The item-wise test contained 6 questions and a starting point topic (including references) to be used for general discussion purposes. The module-wise test featured 10 questions regarding every item included in the module. Both the item and module tests featured different test modalities (true/false, multiple-choice, drag&drop, and numerical answer), to avoid them becoming tedious.

Besides, a forum discussion was proposed in each item to motivate the active participation of all the students of the MOOC. December 2021 was used as a quality assurance month of the contents produced to correct them and to ensure a proper quality. Finally, the beta testing was realized in January and February 2022. Fig. 4 shows the general timeline of the MOOC.

### B. Organization and creation of the study material

The content of the MOOC was divided into six modules, each with 5 items:

- Module 1 – "Ultra-dense networks and small cells" introduces to the audience the ultra-dense network, 5G, new scenarios as well as innovative applications. Besides, it introduces the emerging technologies for 5G.
- Module 2 – "New transmission technologies" focuses on the physical layer transmission technologies like massive MIMO, beamforming and full-duplex technologies, as well as VLC.
- Module 3 – "Interference management and energy efficiency" presents scheduling mechanisms, the cell-free paradigm and approaches for energy efficiency.
- Module 4 – "Spectrum sharing and carrier aggregation" introduces the fundamentals of Carrier Aggregation (CA), the coexistence of small cells and Low Power Wide Area Networks and architectures for spectrum sharing.
- Module 5 – "Use cases and prototyping" presents testbeds, the privacy issue in communications and some insight about AR/VR and immersive rendering.
- Module 6 – "The future ahead" introduces emerging technologies like RADCOM, THz communications, and early discussion about what 6G will be. Besides, it summarizes the own experience of the TeamUp5G ETN.

The content for each of the items was created by the ESRs and supervisors within the TeamUp5G ETN. Besides, it is important to highlight that TeamUp5G members are spread all over Europe. Therefore, the pandemic situation originated by COVID-19 highly limited the planning and brainstorming events for the MOOC. This meant that almost all the content creation process was carried out online, mainly with email exchange and teleconference meetings.

After defining the MOOC structure and recording capabilities (i.e., facilities and human resources), the specific content of each item was discussed between the members of each module, targeting coherence, and avoiding content overlap between items. This discussion was a nice experience that allowed ESRs and supervisors to share knowledge and find ideas for networking. The next step was the writing of the main ideas for the script of the video and initial structure of the items. This initial content was reviewed by the supervisors of each module and feedback was given to the researches in charge of the items. The initial iteration identified several issues like the heterogeneity of the slideshows (e.g., design, animations, fonts, and number of slides) and the use of

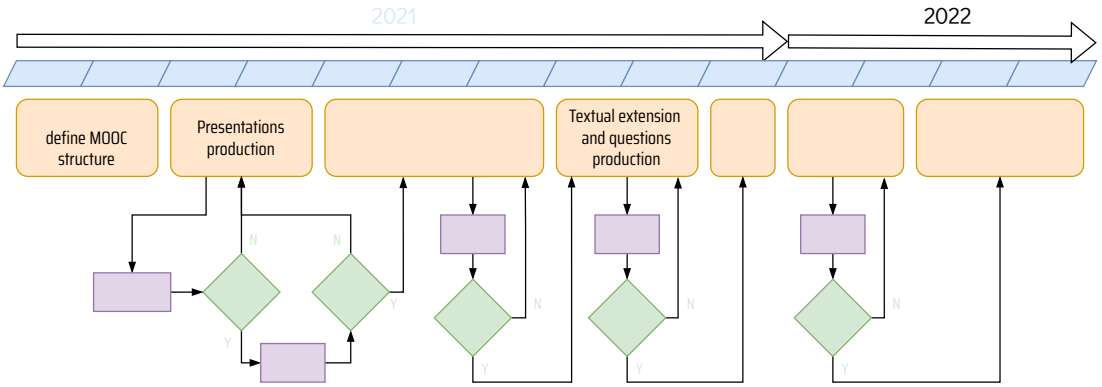


Fig. 4. Overview of the production timeline, involved tasks and copyright and quality processes of the production of the MOOC.

images with poor quality or subject to copyright. Many of the original images were used in the classroom during teaching activities, so they did not fulfill the required quality for a MOOC. Consequently, in a second iteration, a slideshow/video template and specific guidelines were provided for the content creation, which ensured homogeneity between items. When the slideshows and scripts were ready, the video recording process started, which led to the production team to provide specific guidelines for recording, but induced changes in the already approved slideshows. Some of the main issues found were the use of a large amount of text in the slideshows. Replacing it with illustrations was challenging because of the copyright constraint of the MOOC, explained in the next Section. The videos did not exceed the seven-minute timing constraint and achieved the required presentation quality.

### C. Copyright compliance

Any useful lecture requires well designed illustrations to provide useful and complementary visual information to the explained topic. Public and massive lectures as the one in a MOOC not only require the quality and suitability of the selected illustrations to be high, but also to ensure that all of them, with no exception, are copyright compliant. The selection process is more complex, as the content creators not only need to find or produce high quality illustrations but ensure only the ones with appropriate licensing are selected. We mainly used the following sources: commercial or license-free online repositories, proprietary academic or industrial resources, and custom-made illustrations by the MOOC contributors. Even though all the MOOC authors were very cautious with the aforementioned requirements, all the used resources were double checked by the UC3M production team, which validated each resource's license individually.

### D. Contribution from the non-academic sector

The TeamUp5G consortium involves multiple non-academic partners which contributed to give the MOOC a practical approach:

- Nokia Bell Labs: the team from Madrid is focused on the study of the most relevant use cases for 5G and beyond ecosystems. Their research is focused on immersive media offloading and industry 4.0. They have produced or revised the lectures related to the description and analysis of 5G use cases.
- PDMFC: a Portuguese company with the goal of providing solutions in areas such as digital transformation, big data, cloud or security. The contributing team have developed the modules related to network security and how it can be improved with the use of machine learning.
- IS-Wireless: a Polish company that targets software-defined 4G and 5G deployments, with a strong support to the Open RAN community. Their knowledge has been gathered in a module focused on cell-free communications.

### E. Quality assurance

A successful MOOC requires high quality content, which demands updated and relevant topics, which have to be adequately explained, up to date and with a professional appearance. For this reason, we have followed a multi-layer quality assurance approach. The first quality check came from the authors themselves: we strongly encourage all the authors to make a huge effort to produce high quality content with the goal of reducing the overhead from successive quality checks. Most of the authors were PhD students. Consequently, the second checking layer were their supervisors, which had a crucial role in the development of the MOOC. To add an extra layer for quality checking, we used a peer-to-peer approach, in which the authors and contributors had to check other contributors' work. In every production step, each author had to review at least two other contributions. We believe this process has helped us accelerating the production of the MOOC while ensuring high quality standards. Finally, all the content was checked by the production team, who was in charge of evaluating the quality from the audiovisual point of view. Each of the mentioned layers involved several iterations: feedback was given, and new versions were produced. Quality assurance requires available time and effort, and in this MOOC we have committed ourselves to both of them.

## V. Tests and broadcasts

### A. Beta-testing

After the MOOC was uploaded to edX, a beta-testing process was done by the producers of the MOOC, to find possible deficiencies. A total of 2 weeks were allocated to this process, and the work was divided among the beta-testers, with at least 3 beta testers (2 ESRs and 1 supervisor) per module, to ensure enough people to review each module. After feedback was provided, any remaining issues were corrected.

### B. Communication and enrollment

The dissemination of the MOOC was mainly conducted via social networks, email messages, and webpage announcement. Announcements were done using the TeamUp5G project social networks, and the researches involved in the creation of the MOOC were also invited to advertise the MOOC. Several colleagues in academia and industry were contacted, and the MOOC was announced via specialized mailing lists, such as that of the IEEE Communications Society. In each outreach event where the TeamUp5G members participated, the MOOC was advertised. The industry actors involved in the creation of the MOOC were also involved in the communication. The enrollment started 3 months before the broadcast, which was scheduled for the $22^{nd}$ of February 2022, and a strong communication campaign started 3 weeks before this date, i.e. the $1^{st}$ of February 2022. A total of 144 students were enrolled at the start date of broadcast, and it finished with a bit less than 250 students, with a diverse geographical distribution of about 65 countries/regions and a diverse education distribution from secondary school to doctorate, with the masters being the most representative and the secondary the less representative.

### C. Broadcast

The broadcast started on February 22nd, 2022. Two ESRs which were part of the main authors, were actively involved in the forums to respond to doubts and to ensure no inappropriate messages were posted. Active participation among students was suggested and positively followed by them, and supported by the two above mentioned ESRs, with positive feedback. Some corrections were made during the broadcast whenever necessary, by supporting on the comments from students.

## VI. Lessons learned and conclusions

The production of a MOOC involves a great amount of work. The most complex task was not only the production of the content itself, but also the coordination of the producers and supervisors. More than 20 people from 5 different countries have been involved in the production of this MOOC and all the work has been carried out online. Therefore, although our project is composed of great professionals, there were some coordination and miscommunication problems between the supervisors and the content producers causing some delays. Besides, the resources to guarantee the recording quality were available at the UC3M premises in Madrid. Hence, some items were not recorded by the authors but by producers residing in Madrid. All these coordination issues implied that efforts had to be doubled to achieve a high-quality outcome.

MOOC planning is a crucial task. From the beginning, it is necessary to have a well-defined structure with all the expected content, and the resources available to produce this content. The deadlines for the production, review, and acceptance of the content with the expected quality should be properly scheduled. Periodic monitoring should be planned to check the work progress and to ensure there are no doubts on the producers. In addition, the active cooperation of all authors of the MOOC is essential. Although, in general, many of the MOOC producers were not initially aware of the work required to create high-quality content that meets the expectations of a well-prepared audience, they all agree that it has been a rewarding learning experience.

To conclude, the MOOC on "Ultra-dense Networks for 5G and its Evolution" has been presented. We have addressed the objectives, the resources that were available, the production of the MOOC itself and its broadcast. Although there have been some mistakes during content creation and recording, lessons have been learned and important conclusions have been drawn to improve future MOOC recordings.

## Acknowledgements

We would like to acknowledge the audiovisual team at UC3M in charge of the edition and the support team in charge of copyright checking and uploading the content to the edX platform. We would also like to acknowledge the work of all the people involved in the development of this MOOC who do not explicitly appear as authors of this manuscript.

## References

[1] F. García, G. Díaz, M. Tawfik, S. Martín, E. Sancristobal, and M. Castro, "A practice-based MOOC for learning electronics," in *2014 IEEE Global Engineering Education Conference (EDUCON)*, 2014, pp. 969–974.

[2] T. A. Baran, R. G. Baraniuk, A. V. Oppenheim, P. Prandoni, and M. Vetterli, "MOOC Adventures in Signal Processing: Bringing DSP to the era of massive open online courses," *IEEE Signal Process. Mag.*, vol. 33, no. 4, pp. 62–83, 2016.

[3] S. Pertuz and J. Torres, "The impact of MOOCs on the performance of undergraduate students in digital signal processing," in *2016 XXI Symposium on Signal Processing, Images and Artificial Vision (STSIVA)*, 2016, pp. 1–7.

[4] L. Stuchlíková, A. Kósa, P. Benko, and D. Donoval, "Massive open online courses in microelectronics education," in *10th European Workshop on Microelectronics Education (EWME)*, 2014, pp. 31–36.

[5] "TeamUp5G – new RAN TEchniques for 5G UltrA-dense mobile networks – TeamUp5G," https://teamup5g.webs.tsc.uc3m.es/.

[6] Laporma, "Marie skłodowska-curie actions," Feb 2021. [Online]. Available: https://ec.europa.eu/programmes/horizon2020/en/h2020-section/marie-sklodowska-curie-actions

[7] "Ultra-dense networks for 5G and its evolution," https://www.edx.org/course/ultra-dense-networks-for-5g-and-its-evolution.

[8] "UC3M MOOCs." [Online]. Available: https://www.uc3m.es/uc3mdigital/moocs

[9] "Fundamentos de las comunicaciones móviles: En la palma de tu mano." [Online]. Available: https://www.edx.org/es/course/fundamentos-de-las-comunicaciones-moviles-en-la-pa