

ERASMUS MUNDUS JOINT MASTER DEGREE IN ACOUSTICS: WAVES

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Abstract

The Erasmus Programme (**EuR**ouropean Community Action Scheme for the **Mobility** of University Students) is a European Union (EU) student exchange initiative established in 1987. Later, the EU funded Erasmus Mundus joint programme (2004). The purpose of this action is to improve the quality of higher education through the award of scholarships and academic cooperation between the EU and the rest of the world, as well as the extension of the European educational model to the whole world. One of the fundamental actions within this programme is the Joint Master's programme known as the EM Joint Master Degree (EMJMD).

Hundreds of agreements between different universities have achieved accreditation under this programme since its creation. The first of these multiple diplomas on the subject of acoustics appeared in 2019, thanks to the cooperation between the universities of Marseille, Valencia and Coimbra.

In this paper we describe this ambitious project, comment on the difficulties that have had to be overcome and finally describe the actions that will lead to its establishment as a triple diploma beyond the period of funding by the EU.

Keywords: Master degree, ERASMUS MUNDUS, teaching acoustics.

PACS n°. 43.10.Sv

1 Introduction

There is a huge number of Institutions that offer diplomas (degree and master) in the field of acoustics in the European territory (see Figure 1). They are generally targeted around a given theme, for example, vibroacoustics. Among the most representative trainings in this field are the Master in Sound and Vibration (Chalmers University, Sweden), focused in Acoustic Applications; the Master in Engineering Mechanics of the KTH Royal Institute of Technology (Stockholm, Sweden), with a strong vibroacoustics component; the MSc in Acoustical Engineering of the University of Southampton (UK), with strong components related to acoustic signal processing; the MSc in Acoustics of the Ecole Centrale Lyon (Lyon, France), with a specialization in aeroacoustics and transportation noise. At the international level, the Master in Acoustics of Penn State University (USA) offers a sound-structure interaction module and courses focused on applications. Some trainings are not dedicated to vibroacoustics, but offer modules at the frontier of this field. This is the case e.g. of the MSc in Mécanique in Paris-Saclay, in France (specialization “Modélisation et Simulation en Mécanique des Structures et Systèmes Couplés”), or the Master in Mechanical Engineering of Sherbrooke (Canada).



Figure 1. Map of the degrees and master courses in acoustics in Europe (courtesy from EAA Schola - the European Web-based University Guide [1]).

A second central subject of the existing acoustic Masters is sound insulation, which is developed in the following Masters: Métiers de la Recherche en Acoustique of the Master Acoustique de l'Université du Maine Le Mans; Environmental and Architectural Acoustics MSc (London South Bank University); MSc in Environmental Acoustics (University of Salford, Manchester, UK); MSc in Architectural Science - Audio and Acoustics - High Performance Buildings (University of Sydney, Australia); KAIST-DTU Dual Degree Master Programme in Engineering Acoustics, dedicated to Environmental, architectural and audio acoustics (International Master between the South-Korea KAIST and Technical University of Denmark); LaSalle Master in Mechanical Engineering, speciality Architectural Acoustics, University of Barcelona (Spain); Master in Acoustical Engineering, Universidad Politecnica de Madrid (Spain), specialization in building acoustics; Joint Master in Acoustical Engineering: Noise Pollution between University of Granada (Spain) and University of Cadiz (Spain).

Non-destructive testing (NDT) is a third specialization of existing master courses. It is covered in the MSc in NDT in Dresden International University (all courses taught in English); the MSc in NDT

University of Wales (UK); the MSc Ingénierie Acoustique from the Master de Mécanique de l'Université Paris-Saclay (France); the Master of Acoustics of the University of Bergen (Norway) with a significant part dedicated to ultrasound applied to the energy, oil and marine industries. In these cases, Acoustics is just one mean to characterizing the objects and media, not the core of the teaching. Finally, several Master courses are dedicated to musical acoustics, for example the ATIAM Master in Paris (France).

Up to now, none association between universities had managed to achieve the distinction within the Erasmus Mundus Joint Master Degree (EMJMD) program. The European Union (EU), through Action 1 of the Erasmus Mundus programme, supports Joint Programmes (Master Courses and Joint Doctorates) that are operated by groups of higher education institutions from the EU and, since 2009, in the whole world. They provide an integrated course and joint or multiple diplomas following studies or research in at least two higher education institutions.

The European Union's Erasmus Mundus programme aims to enhance quality in higher education through scholarships and academic co-operation between the EU and the rest of the world. Scholarships cover participation costs, living expenses, and insurance for the duration of the studying period. Many students also can profit from a contribution to travel costs.

In 2018, a new consortium of institutions started working on what would be the first joint master's degree in acoustics with the approval of The Education, Audiovisual and Culture Executive Agency or EACEA. The name chosen for this joint master was WAVES (Waves, Acoustics, Vibrations, Engineering and Sound). The programme WAVES is a two-year international Master course, fully taught in English, awarding multiple national Master degrees and a Joint Diploma Supplement with the support of the Erasmus Mundus Programme of the European Union.

2 The programme EMJMD WAVES

The EMJMD WAVES will provide the students with a wide spectrum of scientific knowledge and skills in Acoustical Engineering, from advanced modelling of wave phenomena to the sustainable development of silent transport systems in urban areas. The graduates will gain an international expertise to tackle the growing challenges that will face tomorrow's acoustical engineers in industrial and academic contexts. They will contribute to reduce the environmental impact of noise, to enhance the performance of audio and sound equipment systems or to improve structural health monitoring devices. These domains are a source of highly-skilled jobs in a large number of industrial sectors such as transports (aeronautics, automotive and rail), buildings and infrastructures, energy (structural monitoring of nuclear powerplants, windfarms...), audio systems and musical instruments, oceanography and geophysics.

Four universities, associated according to their location, have been involved in this project, following previous collaborations among them (mobility partnerships and/or joint research work):

- University of Coimbra (UC);
- Polytechnic University of Valencia (UPV);
- Aix-Marseille University (AMU) United With École Centrale Marseille (ECM).

The University of **Coimbra** (UC) is one of the oldest universities in the western world and has been classified as UNESCO World Heritage since June 2013. UC constitutes a reference in higher education and scientific research in Portugal, with excellent academic reputation recognized worldwide. It includes 8 faculties and 37 research centres, providing teaching and conducting research in various scientific domains, including on science and technology related areas. One of its key specialization is Sustainable

Constructions and Acoustic Efficiency in Urban Environment, which is part of the Master WAVES programme. It is strongly linked to the Institute for Sustainability and Innovation in Structural Engineering (ISISE) that presents a considerable number of collaborations with industrial companies, mainly in the scope of consultancy works, specific partnerships or Research & Development- Innovation (R&DI) projects on topics related to building and room acoustics, noise control, vibrations and innovative acoustic solutions. Several Master and PhD Theses have been conducted with companies in the context of R&DI projects.

The city of **Valencia** is an important place of business and cultural heritage. The Polytechnic University of Valencia (UPV) is ranked first among Spanish technological universities, according to the Shanghai Ranking. With its nearly 2.000 international students per year, the UPV actively promotes intercultural exchanges. Among the three UPV campuses, the Escuela Politecnica Superior de **Gandia** stands out for its experience in various fields within Acoustics, such as architectural acoustics, simulation and ultrasound applications. Acoustics at UPV is strongly linked with the Research Institute for Integrated Management of Coastal Areas (IGIC). Moreover, a large number of companies devoted to electro-acoustics have long lasting fruitful collaboration with UPV (DAS audio, Lynx Audio, Equipson, Beyma, and so on). Furthermore, almost all of these companies have employed graduates from Master's degrees in acoustic engineering in their staffs. The same happens in the field of ultrasound applications, especially in underwater acoustics, where the last years' activities have led to the creation of a cluster research unit between IGIC and the "Spanish Institute of Oceanography" from the "Ministry of Science, Innovation and Universities".

Marseille is nowadays France's largest city on the Mediterranean coast and the largest port for commerce, freight and cruise ships. It is also well known for its national park of sublime coves called Calanques. The city was the European Capital of Culture in 2013 and the European Capital of Sport in 2017. Aix-Marseille University (AMU), the Coordinating Institution of the Master WAVES, is the largest French University in terms of number of students (78.000 students). It has been one of the three French universities labeled Excellence Initiative (IDEX A*Midex), in 2012, in the framework of the French "Investment for the Future" Program, and permanently granted this label after 2016. The Ecole Centrale Marseille (ECM) - or Central Graduate School - which belongs to the prestigious group of French Central Schools, is more focused on engineering. It trains generalist engineers with strong scientific and management skills. Several AMU and ECM partner laboratories are internationally recognized in Acoustics. They constitute the Federation of Research Fabri de Peiresc in Marseille, which regroups four engineering laboratories: the Laboratory of Mechanics and Acoustics (LMA), the Institute for Research on Non-Equilibrium Phenomena (IRPHE), specialized on turbulence and aero-acoustics, the Laboratory of Mechanics, Modeling and Green Processes (M2P2), the University Institute of Industrial Thermal Systems (IUSTI) and the Fresnel Institute which has strong expertise on meta-materials. An example of excellent relationships between industry and labs concerns the case of musical instruments. The LMA has worked for several years with Yamaha (world leader in musical instruments) and Buffet- Crampon (world leader in wind instruments). A joint laboratory, LIAMFI, has been recently created with these companies which now provides master internships, PhD theses and post-doctoral positions.



Figure 2: Laboratories involved in WAVES. Left: ISISE (at DEC, UC, Coimbra); center: IGIC (UPV-Gandia-Valencia), right: LMA (Marseille).

2.1 The EMJMD WAVES curriculum

The WAVES study plan is built as a two-year program, along 4 semesters, each validated by 30 ECTS, enabling the students to become proficient in the main applications: urban noise, acoustic insulation, structural control, health monitoring, non-destructive testing and nonlinear acoustical systems. These subjects represent an important part of the market of Acoustics and the research activities in this field throughout the world.

The main objective of the Master WAVES is to provide the students expertise in experimental methodology, numerical modelling and theoretical knowledge in order to be able to design, characterize, model and understand acoustical systems and devices. To this end, it should prepare students to develop creative approaches to solve problems related to identification, application and production of acoustical systems, using fundamental and transdisciplinary knowledge in Acoustics and being able to mobilize various multidisciplinary parties and abilities.

Built on its international nature and on the broad spectrum of Acoustics, the Master WAVES aims to train highly qualified and creative graduates that will become the next-generation scientific executives, with a strong capacity to adapt themselves to new professional contexts, to address ethical, environmental and societal challenges related to Acoustics, and to get involved in the creation of high-technology companies. The teaching of academic subjects imply both fundamental sciences (mechanics, mathematics) and applied topics (electroacoustic, experimental techniques). These subjects have been well identified to give students the core skills required to be an innovative engineer in acoustics. The educational programme is designed to ensure that the WAVES graduates have acquired a triple proficiency in theory, numerical modeling and experimental techniques. The detailed programme is reported here. The syllabus splits into 5 main groups:

- Fundamentals of Acoustics (16 ECTS);
- Methods for acoustical engineering (14.5 ECTS);
- Applications of Acoustics (26 ECTS);
- Advanced topics on Acoustics (25 ECTS);
- Additional key competencies (8.5 ECTS).

The mobility scheme during the this Programme can be summarized as follows:

- Semester 1, hosted by the **University of Coimbra (Portugal)**:
 - oriented towards engineering applications, along with the teaching of fundamentals and methods of acoustics that allows to tackle problems arising in practical common situations;
 - emphasis will be put during this semester on structural dynamics and building acoustics.
- Semester 2, hosted by the **Polytechnic University of Valencia, campus of Gandia (Spain)**:
 - strengthening of fundamental knowledge and introduction to a wider range of numerical and experimental methods;
 - the variety of acoustic fields will also be addressed: psycho-acoustics, electro-acoustics, room acoustics, ultrasounds, musical acoustics and underwater acoustics.
- Semester 3, jointly hosted by **Aix-Marseille University and the Ecole Centrale Marseille (France)**:
 - devoted to specialization in tomorrow's acoustical engineering: environmental engineering acoustics, complex media, nonlinear systems, etc...

- Semester 4: worldwide!
 - 20 Associated Partners and 21 Industrial Partners all over the world offering internship opportunities to prepare the Master Thesis.

Figure 3 illustrates in more detail the curriculum of the program.

#	S1: Coimbra	S2: Valencia	S3: Marseille
Fundamentals	Acoustics and Vibrations in buildings and their envelopes (6 ECTS)	Musical acoustics (2 ECTS) Psychoacoustics (2 ECTS) Audio synthesis (2 ECTS) Ultrasounds (2 ECTS) Underwater acoustics (2 ECTS)	
Methods	Computational modelling (3 ECTS) Instrumentation and acoustic & vibration measurements (4.5 ECTS)	Computer Aided Design in acoustic engineering (3 ECTS) Programmable instrumentation (2 ECTS) Simulation models in acoustics (2 ECTS)	
Applications	Strategies for acoustic and thermal rehabilitation (6 ECTS) Sustainable constructions and materials (6 ECTS)	Room acoustics (3 ECTS) Sound system design (3 ECTS)	Environmental engineering acoustics (4 ECTS) Imaging and Non-Destructive Evaluation (4 ECTS)
Advanced	Advanced strategies for sound insulation and noise and vibration control (4.5 ECTS)	Electroacoustic systems (4.5 ECTS)	Vibroacoustics and structural acoustics (4 ECTS) Nonlinear systems in acoustics (4 ECTS) Wave propagation (4 ECTS) Metamaterials (4 ECTS)
Additional competencies		Research seminars (2.5 ECTS)	Projects (4 ECTS) Project Management (2 ECTS)

Figure 3. Programme at a glance

Further details can be found at [3].

Two additional initiatives should also be referred: the initial welcome integration week in Coimbra, playing an important role to start the integration process of the students on the arrival to the first University being visited, and the summer school, taking place at UPV, in the transition from the first to the second year, stimulating an effective integration within a professional environment.

3 Difficulties encountered during the design period

The approval of the WAVES master by the EACEA was far from being a straightforward path and many difficulties have had to be overcome as we got along. We understand that it is of interest to other universities that want to follow our steps that we briefly indicate what these difficulties have been.

One of the first problems was to find teachers from among the staff of each university involved, with a satisfactory level of English to teach the courses. Unfortunately, not all university teachers have an adequate level to teach a subject at a master's level. It should be noted that of the three partner countries only Portugal is among the countries with the best English proficiency according to the EF English Proficiency Index. In contrast, Spain is ranked 35th. Invited scholars will also be involved along the Master WAVES, coming mainly from the Associated Partner institutions but also from non-educational institutions. They will provide the current state-of-the-art knowledge in Acoustics and applications.

Probably the main problem we have faced is the different internal rules among the universities involved. Also, the differences between the times needed to get, for example, the signature of official documentation has come to compromise the implementation of the program.

Similarly, the national institutions (ministries) governing education in the three countries participating in the EMJMD WAVES, apply very different rules and laws. Unfortunately, more than 20 years after the declaration of Bologna, different schemes of combination of Bachelor and Master degrees are coexisting throughout the European territory. In particular, the three previously existing accredited Masters had different durations and teaching loads. Thus, the Coimbra Master's consisted of 90 ECTS, the Gandía Master's of 60 ECTS and the Marseille Master's of 120 ECTS. All of this has forced the restructuring (several changes of semester) of some subjects in the existing Master's which, depending on the country, have been more or less complicated.

Additionally, establishing tuition fees were one of the most complicated issues. Each of the countries involved has different prices that also depend on the nationality of the students in different ways. In this proposal a flat rate has been decided, in order to simplify the process.

4 Future of the proposal

One of the most challenging aspects of an EMJMD is the future, after the end of the funding of the programme by the European Union. Each Full Partner should make what is necessary to enable the programme to continue with a valid national accreditation. Other financial supports will be actively sought by a dedicated person of the Consortium Committee in charge of this mission in the coming years. This person may be helped by the representatives of the 21 Industrial Partners. He/she can rely on dedicated people working in this sector at each partner University. The progress in the funding of the WAVES programme will be regularly reviewed, e.g. during the annual meeting of the Consortium Committee. The sources of funding fall into two categories:

- Direct Scholarships: At national level, it should be requested to concede scholarships to students from the 3 Programme Countries (Portugal, Spain and France) who want to study in the WAVES Master;
- General funding: We plan to have self-funded students during the whole period of the program. These students will be asked to pay tuition fees (2 k€/year for Erasmus Programme Country students and 4.5 k€/year for Partner Country students). During the EU funding period, we plan to increase from 4 self-funded students (at the first intake) to 8 self-funded students (at the last intake). It is reasonable to anticipate 10 self-funded students/intake after the EU funding period, especially after the graduation of the first cohort which can contribute to the successful promotion of the program. Apart from this we will try to get a relevant contribution from local authorities or funding companies/institutions which can give financial support on a regular basis or a single donation.

Acknowledgements

Authors acknowledge the financial support from the ERASMUS+ programme from the European Union.

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