Module Name: Spatial Audio (optional)
ECTS weighting: 5 Credits
Contact Hours: 22 x 1-hour lectures;
78 hours of independent study
Module Coordinator: Dr. Enda Bates

Rationale
Spatial Audio is a one-semester module which is intended for those interested in using spatial audio techniques in a variety of different contexts, including but not limited to: spatial music composition, cinema surround sound, VR and 360 Video, multimedia performance and interactive installations, audio production and recording, surround sound for gaming and mobile devices, sonification, auditory interfaces, and psychoacoustics. Students will need some prior knowledge of the fundamentals of DAW-based audio production, such as that presented in the Electroacoustic Composition 1 module in the first semester of the MMT programme, for example.

This course is intended to enable future audio engineers, composers, researchers and sound-designers to clearly determine the optimal spatialization schemes and techniques for a given application and environment, as well as motivating further innovation and artistic creativity in the field. Students are presented with a wide variety of spatial content, both in class and also in additional listening sessions/concerts of contemporary and historical works of spatial electroacoustic music. The history of spatial audio is discussed, in terms of mainstream cinema and film, popular music releases, 360 Video, and a wide variety of contemporary/ electroacoustic music and composers. Students are encouraged to critically assess the strengths and weaknesses of different techniques to enable their effective and creative use of spatial audio in different contexts.

Aims
The aim of this module is to give the student a complete understanding of all relevant aspects of current spatial audio technology. It addresses the psychoacoustic principles underlying different techniques, as well as practical production techniques for 5.1 and 7.1 surround sound using the DAW Reaper, Ambisonics, Dolby Digital Encoding, Binaural processing, and a variety spatial microphone techniques. By the end of the course, the student will have a deep understanding of the issues and creative possibilities of spatial audio and a thorough knowledge of all relevant spatial audio systems and topics. This knowledge will enable students to effectively use spatial audio in their subsequent artistic work, and/or facilitate further technical research in this area.

Learning Outcomes
On successful completion of this module, students will be able to:
• Compose, produce and design original spatial content for fixed and interactive media live performance and interactive installations.
• produce and engineer spatial recordings using binaural and surround microphone techniques.
• characterise the strengths and weaknesses of different spatialization methods.
• understand the psychoacoustic principles underlying different approaches to spatial audio.
• select an appropriate and effective spatial audio technique for a particular application.
• analyse, describe and identify techniques and methods used by spatial music composers and sound designers.
• setup and configure spatial audio software and hardware.

Module Content
History of spatial audio
Spatial hearing and psychoacoustics.
Stereophony: theory, implementation and limitations
5.1 Production in Reaper
Bass Management
Ambisonics & HOA
Surround Sound recording techniques
Spatial Music Composition
Array Calibration
Binaural recording and processing
Spatial Impulse Response Rendering
Virtual Reality and 360 Video

**Recommended Reading List**
Jens Blauert: Spatial Hearing: The Psychophysics of Human Sound Localization;
Francis Rumsey: Spatial Audio
Denis Smalley: Spectromorphology: explaining sound-shapes - (Organised Sound / Volume 2 / Issue 02 / August 1997, pp 107-126);
John M. Chowning: The Simulation of Moving Sound Sources - (Computer Music Journal, Vol. 1, No. 3. (Jun., 1977), pp. 48-52);
Enda Bates: The Composition and Performance of Spatial Music
Website: http://endabates.net/academic.html

**Methods of Teaching & Student Learning**
The teaching strategy is a combination of lectures, software and hardware tutorials, dedicated listening sessions, and critique classes on assignment work. Tutorials in Reaper and spatial audio plugins are held in the first half of the semester, while practical demonstrations of recording techniques, microphone configurations and array calibration are presented later in the semester. Dedicated listening sessions/concerts of classic and contemporary works of spatial music are presented throughout the module. In addition, conventional lecture presentations include many demonstrations of other material, in particular surround sound for film and popular music releases in 5.1 and 7.1 Surround Sound.
The initial assignment consists of a formal analysis of different spatial effects such as distance processing and the capture of spatial impulse responses.
The second, larger assignment consists of a number of options, a surround recording of a music ensemble, band, orchestra or choir, a studio-based spatial music composition, or a formal analysis of spatial audio recording and production techniques. These options reflect the wide variety of potential applications of spatial audio, and the potentially quite different interests of students taking this module. This assignment work is also presented in a class concert at the end of the semester.

**Methods of Assessment**
Assessment of this module is by practical assignment work. Students are required to submit two assignments: an initial spatial research project and a second larger assignment, worth 30% and 70%, respectively. The initial assignment is primarily research orientated, in which the students investigate a specific aspect of spatial audio in terms of different production techniques and software. This could for example involve the investigation of distance effects using different panning techniques and software, or an analysis of binaural impulse responses. Students are required to develop their own assessment strategy for this research work and to summarize their findings. Marks for this assignment are equally divided between the technical implementation and the research findings presented in the report.
The larger, second assignment consists of three options; a location spatial audio recording of a large ensemble, orchestra or choir, or a studio-based spatial music composition, or a formal piece of technical analysis. This choice is intended to reflect the potentially quite different interests of the students which could range from technical recording and production work, to artistic expression and music composition, and media engineering.