PROPOSTA DE MÀSTERS PRESENTATS A LA 3a CONVOCATÒRIA ERASMUS-MUNDUS UNDERWATER ACOUSTIC TECHNOLOGY AND REMOTE SENSING

Acord núm. 147/2005 pel qual es ratifica la proposta de Underwater Acoustic Technology and Remote Sensing

- Document aprovat per la Comissió de Docència del Consell de Govern del dia 17/05/2005
- Document aprovat pel Consell de Govern del dia 27/05/2005

DOCUMENT CG 11/05 2005

Vicerectorat d'Ordenació Acadèmica
Comissionat de l'Espai Europeu d'Educació Superior
Maig 2005

"UNDERWATER ACOUSTIC TECHNOLOGY AND REMOTE SENSING"

EUROPEAN MASTER

Escola Politècnica Superior
d'Enginyeria de Vilanova i la Geltrú
UNIVERSITAT POLITÈCNICA DE CATALUNYA

MAS, EUROPEAN MASTER ON

"UNDERWATER ACOUSTIC TECHNOLOGY AND REMOTE SENSING"

INDEX

EUROPEAN MASTER ON: **"UNDERWATER ACOUSTIC TECHNOLOGY AND REMOTE SENSING" (MAS)**

Technical University of Catalonia (UPC, http://www.upc.edu), École Nationale Supérieure des Ingénieurs des Études et Techniques d'Armement (ENSIETA, http://www.ensieta.fr/), University of Wales, Bangor (http://www.sos.bangor.ac.uk/pgrad/msc.htm)
.

Introduction

This Master will be of interest to students willing to be involved in engineering development and application of underwater acoustics research, including sonar equipment, oceanography technologies, bioacoustics and underwater communication for scientific, industrial and environmental purposes. It will be also extremely relevant to students with backgrounds in Fisheries, Environmental Sciences and Marine Biology involved in the field use of advanced acoustics underwater technologies. It is specially designed to lead to Doctoral Dissertations on Underwater Acoustic Technologies.

1. Co-ordination and partnership

The MAS will be coordinated by the UPC (EPSEVG) with the partnership of the University of Wales, Bangor (UWB) and the ENSIETA, Brest, France.

UPC Professors:
Andreu Català (EPSEVG, Director, GREC Director)
Antoni Mánuel (EPSEVG, SARTI Director)
Cecilio Angulo (EPSEVG)
Xavier Parra (EPSEVG)
Vicente Parisi (EPSEVG)
Michel André (EPSEVG, LAB Director, MAS Coordination)

2. Programme overview

The master will be divided in four semesters

- Semester 1: Introduction and Fundamental Sciences

    - Introduction to the MAS Application Domains (industry/research)
    - Scientific Basics (maths, physics, informatics)
    - Introduction to Oceanography, Geophysics, Bioacoustics and Remote Sensing
    - Foreign Language, Technical Language

- Semester 2: The Acoustic Systems

    - Geophysics and modelling
    - Instrumentation
    - Signal Processing
    - Array signal Processing
    - Sonar Systems

- Semester 3: Advanced Applications

    - Advanced signal processing
    - Bioacoustics
    - Non-Acoustics Methods: Remote Sensing
    - State of the art

- Semester 4: Master Final Project

3. Outline Semester Schedule

Year	Semester	Start	End	Programme Delivery
1	1	September	January	Taught Modules (UWB)
1	2	February	June	Taught Modules (UPC)
2	3	September	January	Taught Modules (UPC)
2	4	February	June	Research Project (UPC, UWB & ENSIETA)

4. Course Content

SEMESTER 1 – Introduction & Fundamental Sciences			
Module	**Campus Location**	**UWB Credits**	**ECTS Credits**
1. Key Skills	UWB	5	
2. Physical Oceanography	UWB	5	
3. Sedimentary Processes	UWB	10	
4. Marine Acoustics	UWB	5	
5. Geoacoustics & Survey	UWB	5	
6. Geophysical Surveying	UWB	10	
7. Remote Sensing	UWB	5	
8. Geoscience Field Practice	UWB	10	
9. Biogeochem Ocean	UWB	5	
TOTAL			30
Foreign Language / Scientific Writing	*UWB*		
TOTAL CREDITS (UWB PG Certificate)		60	30
SEMESTER 2 – Acoustic Systems			
		UPC Credits	
1. Geophysics and modeling	UPC	9	
2. Instrumentation	UPC	14	
3. Signal processing	UPC/ENSIETA	9	
4. Array signal processing	UPC/ENSIETA	9	
5. Imaging sonar technologies	UPC/ENSIETA	11	
Foreign Language, Technical Communication	UPC		
TOTAL CREDITS		52	30
SEMESTER 3 – Advanced Applications			
		UPC Credits	
1. Advanced Signal Processing	UPC	18	
2. Bioacoustics	UPC	17	
3. Non acoustic methods	UPC/ENSIETA	12	
4. State of the art	UPC/ENSIETA	3	
Social Activity	UPC		
TOTAL CREDITS		50	30
SEMESTER 4 – Research Project			
		UPC/UWB/ENSIETA Credits	
Research Project	UPC/UWB/ENSIETA	45	30
TOTAL CREDITS		45	30
TOTAL CREDITS		N/A	120

5. Description of teaching modules

5.1. SEMESTER 1: INTRODUCTION AND FUNDAMENTAL SCIENCES

Module Code:	*Credits Available:* 5 credits
Module Title: **KEY SKILLS AND BIOGEOCHEM. OCEAN.**	
Module Organiser: Prof Alan Davies	*Module Staff:* Alan Davies, Vanesa Magar, Sarah Jones, Dafydd Roberts
Module Aim: To establish a common foundation in mathematical methods and computer programming for use in subsequent modules.	
Module Objectives: The module has three components involving the study of: 1. Mathematical methods: Here a range of mathematical topics will be addressed with a view to giving students adequate preparation for the later module material. 2. Computer programming in Fortran: An introduction will be given to programming in Fortran90, which is used in many operational/commercial marine modelling systems. 3. Introduction to Matlab: This course provides an introduction to the scientific data analysis package MATLAB, which is increasingly being used in research and industry for instrumentation interfaces, data processing, statistical analysis and graphical representation.	
Learning Outcomes: On successful completion of this module, the student should have: • General knowledge of a range of mathematical methods at an appropriate level for the purposes of subsequent modules. • Understanding of what is meant by a computer programming language. • Basic skill in programming in Fortran90. • Basic skill in use of Matlab. • Ability to process and present data sets obtained using marine instrumentation. • Ability to use a computer contouring package both for simple map generation and for more advanced map analysis.	
Module Syllabus: 1. Mathematical Methods: An initial overview will be given of logarithms and exponential functions, trigonometric and hyperbolic functions, and calculus (differentiation and integration methods). The topics then covered in greater detail will include: vector algebra and vector calculus, complex variable, matrices, solution of ordinary differential equations, solution of partial differential equations, Fourier series. 2. Programming in Fortran 90 3. Programming in Matlab A series of practicals cover input/output of data, array handling, programming using script files, 2-D graphics and computer contouring.	
Subject Skills: Mathematical and Computing skills.	*Transferable Skills:* • Use of mathematical methods in a range of

• General knowledge and understanding of relevant mathematical methods. • Knowledge of scientific computer programming languages (Fortran 90, Matlab). • Appreciating issues of sample selection, accuracy, precision and uncertainty during collection, recording and analysis of data in the field and laboratory. • Preparing, processing, interpreting and presenting data using appropriate qualitative and quantitative techniques and packages • Solving numerical problems using computer based techniques	applications. • Ability to use scientific computer programming languages (Fortran 90, Matlab) in a range of applications. • Communication skills: receiving and responding to a variety of information sources • Self management and professional development skills: working independently, time management and organisation skills.
Total Lecture Hours: 10 for Maths section 18 Fortran, 4 Matlab practicals	*Suggested Study Hours:* 16
Teaching Format: Lectures & computing sessions	*Facilities & Locations Used:* DC Seminar room, Westbury Mount Computing Room
Form of Assessment: Continual Assessment only in Part A of the module (corresponding to 50% of full module OXP4009).	*Deadline for Assignment* TBA
Assignment Description: Problem sheet on mathematical methods (10%), Fortran 90 assignments (20%), Matlab assignments (20%)	
Suggested Reading: Mathematical Methods for Science Students, G. Stephenson, Longmans, 19**. (or any other text on general mathematical methods).	

Module Code:	*Credits Available:* 10
Module Title: **PHYSICAL OCEANOGRAPHY**	
Module Organiser: Dr David Bowers	*Module Staff:* David Bowers & Gay Mitchelson-Jacob
Module Aim: To introduce physical oceanography	

Module Objectives & Learning Outcomes:

Objectives:

(1) to introduce basic concepts and principles of physical oceanography.
(2) to overview the dynamical features seen in the oceans and shelf seas.
(3) to consider the air-sea interactions and their influence on the surface layers of the ocean.
(4) to become familiar with the commonly used equipment and basic measurements made at sea.
(5) To learn to work with these measurements in a practical way.

Learner Outcomes:

1. Understand the concepts and principles which determine thermohaline circulation
2. Understand the physical controls that determine the formation of water masses.
3. Understand the physical conditions that control waves and tides.
4. Understand the physical controls that determine the formation of fronts and eddies.
5. Understand the role of the air/sea interface in forcing surface oceanography.
6. Understand how to process oceanographic data and to use it to make predictions.

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Module Syllabus:

- An introduction to physical oceanography, temperature, salinity, density and pressure in the oceans leading to thermohaline oceanography, the formation of dynamical features – water masses, currents, eddies, gyres, fronts, tides, waves; why these features form; where they form; when they form and their time & length scales; their occurrence in the deep seas, shelf seas and coastal regions. The interactions of the air/sea interface with dynamical features will also be covered. The learning of these concepts is reinforced by a series of data processing exercises in which students learn how to work with data from the sea and to use it to make predictions.

Practical

Introductory oceanography at sea, looking at basic measurements, e.g. salinity, temperature, density, turbidity, fluorescence and current speed and direction.

Subject Skills: • Subject specific skills relating to the scientific aims of the module. • Practical skills in the use of oceanographic equipment	• *Transferable Skills:* • Data analysis skills • Report writing skills
Total Lecture Hours: 14 x lectures 4 x practicals	*Suggested Study Hours:* 82
Teaching Format: Lectures & ship-based practicals	*Facilities & Locations Used:* MSc Seminar room; Prince Madog

Form of Assessment: Problem sheet Examination	*Deadline for Assignment*:
Assignment Description: Problem sheet covering applications of all aspects of the taught course	

Suggested Reading:

The Open University (1989). Seawater: its composition, properties and behaviour.

The Open University (1989). Ocean circulation.

The Open University (1989). Waves, Tides and shallow water processes.

Pinet, P.R. (2003). Invitation to Oceanography. Jones & Bartlett publishers, London.

Module Code:	*Credits Available:* 2.5
Module Title: **MARINE SEDIMENTARY PROCESSES** **Part a**: Properties of sediments and coastal sedimentary processes	
Module Organiser: Colin Jago	*Module Staff:* Colin Jago and Garry Reid
Module Aim: This course provides an introduction to the dynamics of entrainment, transport and deposition of cohesive and non-cohesive sediments in coastal waters with specific focus on the sedimentary processes of beach, shoreface, estuarine, deltaic, and tropical environments.	
Module Objectives & Learning Outcomes: On completion of the module, students will be able to: a) Understand the concepts and principles which govern sediment transport in coastal environments. b) Understand the primary physical controls of sediment transport and the secondary biological mediation of sediment transport. c) Understand the fundamental differences in transport of cohesive and non-cohesive sediments. d) Understand the principal observational methods used in determining sediment transport. e) Understand and manipulate the algorithms used in determining sediment transport. f) Understand the limitations inherent in observations and calculations of sediment transport. g) Understand the concepts and principles which govern coastal sedimentary environments. h) Understand physical controls of sedimentation in coastal seas. i) Understand how an interdisciplinary approach is needed to understand nature of coastal sediment deposits	
Module Syllabus: Origin and properties of marine sediments: cohesive and non-cohesive sediments. Control of sedimentation by tectonics, climate, and sea level change. Geographical distribution of coastal sediment types. Sediment dynamics: boundary layer processes, sediment transport mechanisms. Measurement and calculation of bed load and suspended load transports in coastal environments. Errors and limitations. Terrigenous coastal sediments: sedimentary processes and sediments of beach, shoreface, estuarine, and deltaic environments. Carbonate coastal systems and evaporates: tropical and non-tropical carbonate environments; reefs and lagoons.	

Subject Skills:	*Transferable Skills:* $ Subject specific skills as outlined in module aims. $ Numeracy skills: application of algorithms used in sediment transport. $ Communication skills: ability to synthesise and summarise a wide-spectrum, interdisciplinary literature.
Total Lecture Hours: 12	*Suggested Study Hours:* 13
Teaching Format: Lectures	*Facilities & Locations Used:* DC Seminar Room
Form of Assessment: Summative, problem sheet	*Deadline for Assignment*:
Assignment Description: Sediment transport problem solving exercise	
Suggested Reading: *Coastal and Estuarine Sediment Dynamics*, K R Dyer, Wiley-Interscience, 1986	

Module Code:	*Credits Available:* 7.5
Module Title: **MARINE SEDIMENTARY PROCESSES** **Part b**	
Module Organiser: Colin Jago	*Module Staff:* Colin Jago, Garry Reid and James Scourse

Module Aim:

Continental margins are important parts of the ocean since they are regions of major resource exploitation and environmental impact. The module covers the processes and products of sediment transport on continental margins with particular emphasis on the North American and North West European margins (since these are the best studied). It includes the Quaternary evolution of the NW European margin.

Module Objectives & Learning Outcomes:

On completion of the module, students will be able to:

a) Understand the concepts and principles which govern continental margin sedimentary environments.
b) Understand physical controls of sedimentation in shelf seas and on continental margins.
c) Understand the dynamics of erosion, transport and deposition of sedimentary material in continental margin environments
d) Understand the role of tidal, wave and gravitational energy, glaciations, pelagic settling and ocean circulation in continental margin environments.
e) Understand how the geological and oceanographic processes of the continental margin relate to global sedimentary processes, at present and in the past.
f) Relate the geological and oceanographic processes of the continental margin to the temporal and spatial scales over which these processes act.
g) Understand how an interdisciplinary approach is needed to understand the nature of continental margin deposition.
h) Relate an understanding of geological and oceanographic processes to the applied needs of the offshore survey industry, in particular to the importance of seabed and slope stability.
i) Undertake a critical review of the work of other scientists, demonstrating the ability to highlight the relevance of the work, its strengths and its weaknesses.
j) Review the relevant literature and write structured precis which draw together diverse elements of oceanography and geology.
k) Make an oral presentation which succinctly summarises key points from a selected item(s) in the literature.
l) Use a standardised, scientific and formal means of expression.
m) Understand the principal Quaternary events and features governing the NW European margin.

Module Syllabus:

Origin of continental shelves, wave-dominated, storm-dominated, and tide-dominated shelf regimes. Case studies: Atlantic shelf of N. America, North Sea.

Morphology, sediments and dynamic processes of the continental margins. Resedimentation process and deposits; sediment gravity flows and their deposits; contourites; submarine canyons; base of slop environments; submarine fans.

Quaternary evolution of the NW European shelf.

Subject Skills:	*Transferable Skills:* a) Subject specific skills relating to the scientific aims of the module. b) Communication skills: ability to synthesise and summarise a wide-spectrum, interdisciplinary literature in a written precis. c) Communication skills: ability to present orally a succinct summary of papers from the relevant scientific literature making use of appropriate visual aids. d) Introduce students to forms of constructive criticism of the work of other scientists and their classmates
Total Lecture Hours: 12 + student seminars	*Suggested Study Hours:* 60
Teaching Format: Lectures and seminars	*Facilities & Locations Used:* DC Seminar Room
Form of Assessment: Summative – presentation and critique Examination	*Deadline for Assignment*:
Assignment Description: The continual assessment exercise consists of the seminar presentations, the associated reading and preparation of a critique of the paper (2.5 credit) and an end of module test (5 credits)	
Suggested Reading: *Reading, H., Sedimentary Environments and Facies, Blackwell, 1978, 1986.* *Pickering, K T., et al., Deep Marine Environments, Unwin Hyman,1989.* *Kennet, J., Marine Geology, Prentice Hall, 1982.*	

<table>
<tr><td>Module Code:</td><td>Credits Available: 5</td></tr>
<tr><td colspan="2">Module Title: <u>ACOUSTICS AND REMOTE SENSING</u>
Ocean Acoustics</td></tr>
<tr><td>Module Organiser:

Sarah Jones</td><td>Module Staff:

Sarah Jones</td></tr>
<tr><td colspan="2">Module Aim:

This module provides an introduction to marine acoustics, with particular emphasis on the application of acoustic techniques in the water column. It aims to provide an understanding of the physical controls on the propagation of sound through water and an insight into the practical applications of acoustic techniques in surveying and remote sensing of the marine environment.</td></tr>
<tr><td colspan="2">Module Objectives & Learning Outcomes:

On successful completion of this module students will have an:

Understanding of physical principles of sound propagation underwater.
Appreciation of the potential of acoustic technique as an underwater remote sensing tool.
Ability to assess acoustic system capability and analyse and interpret selected acoustic data.</td></tr>
<tr><td colspan="2">Module Syllabus:

Basics and theory
Acoustic transduction
Sound propagation in the sea
Reflection and transmission at interfaces
Absorption and scattering
Noise
Applications in oceanography</td></tr>
<tr><td>Subject Skills:
Recognising and using underwater acoustic theories, concepts and principles
Recognising ethical issues of underwater acoustic techniques (environmental impacts)</td><td>Transferable Skills:
Analysing, synthesising and summarising information critically
Applying knowledge and understanding to address familiar and unfamiliar problems
Communication skills: receiving and responding to a variety of information sources
Numeracy and C & IT skills: Preparing processing interpreting and presenting data using appropriate qualitative and quantitative techniques and packages
Solving numerical problems using computer and non computer based techniques
Self management and professional development skills: working independently, time management and organisational skills.</td></tr>
</table>

Total Lecture Hours: 10	*Suggested Study Hours:* 40
Teaching Format: 10, 1 hour lectures	*Facilities & Locations Used:* DC Seminar Room
Form of Assessment: Problem sheet Examination	*Deadline for Assignment*:
Assignment Description: Marine acoustics problem sheet Examination	
Suggested Reading: *Underwater acoustic systems,* RFW Coates, MacMillan, 1990. *Principles of underwater sound,* RJM Urick, McGraw-Hill, 1975. *Acoustical Oceanography,* CS Clay and Medwin, Wiley Interscience, 1977. *Applied Underwater Acoustics,* DG Tucker & BK Gazey, Pergammon Press Ltd, 1966 *The Hunt for Red October*, Tom Clancy, Harper Collins Press, London, 1985	

<table>
<tr><td>Module Code:</td><td>Credits Available: 10 credits</td></tr>
<tr><td colspan="2">Module Title: <u>GEOACOUSTICS AND SURVEY</u></td></tr>
<tr><td>Module Organiser: Prof Jim Bennell</td><td>Module Staff: Jim Bennell</td></tr>
<tr><td colspan="2">Module Aim: This module has two aims:
- to provide an introduction to seismo-acoustic investigation of the seafloor, addressing the underpinning theory and then the practical consideration of data acquisition, processing and interpretation,
- to give the student the knowledge of how to write a geophysical method statement for inclusion into a contract tendering document, primarily using the material taught earlier in the module, but also integrating knowledge gained from other modules in the course</td></tr>
<tr><td colspan="2">Learning Outcomes: On completion of the module, students will be able to:

1. show an understanding of the fundamentals of geoacoustic propagation based on knowledge gained through the directly taught course and with reference to textual and electronic sources
2. show an understanding and have an appreciation of practical applications of marine geoacoustics
3. analyse and interpret geoacoustic and navigation datasets
4. demonstrate an ability to produce a geophysical method statement for inclusion in a site investigation tender document</td></tr>
<tr><td colspan="2">Module Syllabus:
- acoustic propagation at the seabed
- factors controlling sound transmission in marine sediments
- reflection of sound at the seabed
- the sonar equation in system design
- seismo-acoustic sources and receivers
- echo-sounders and seabed measurement
- sub-bottom profilers and subsurface investigation
- side scan sonar
- digital data: acquisition and processing
- tendering exercise</td></tr>
<tr><td>Subject Skills:
1. recognizing and using acoustic theories, concepts and principles
2. ability to interpret marine seismo-acoustic data
3. ability to analyse a specific site investigation problem and devise a field acquisition programme to address the problem as posed.
4. analyzing, synthesizing and summarizing information critically; integrating several lines of evidence to critically assess methodologies
5. receiving and responding to a variety of information sources including material from the directly taught syllabus, literature and internet sources; communicating appropriately with a potential commercial consultant or client
6. self-management and professional development</td><td>Transferable Skills
Numerical methods. Random walk methods
Modelling in Matlab</td></tr>
</table>

skils: developing skills necessary for self managed learning	
Total Lecture Hours: 20	*Suggested Study Hours:* 80
Teaching Format: Lectures, Practical, Assignment.	*Facilities & Locations Used:* MSc Class and Seminar rooms. Computer Lab.
Form of Assessment: 1. Problem sheet and interpretation exercise [15 %] LO 1,3 2. Module examination [35 %] LO 1,2,3 3. Geophysical method statement [50%] LO 2, 4	*Deadline for Assignment.*
Assignment Description: Problem sheet and computer exercise	

Suggested Reading:

Underwater acoustics, RW Coates, Macmillan, 1990
Principles of underwater sound,, RJM Urick, McGraw-Hill, 1975
Acoustical oceanography, C Clay and Medwin, Wiley, 1977
Applied underwater acoustics, DG Tucker and BK Gazey, Pergammon, 1966
The hunt for red October, T Clancy, Harper Collins, 1985

Module Code:	*Credits Available:* 10
Module Title: **GEOPHYSICAL SURVEYING**	
Module Organiser: Prof Dei Huws	*Module Staff:* Dei Huws

Module Aim: This course aims to introduce the range of geophysical techniques that a marine geoscientist would be likely to encounter as a practitioner in the field, placing particular emphasis on basic underlying theoretical considerations, the hardware used for data acquisition and also on assumptions made during interpretation and modelling of data.

Module Objectives & Learning Outcomes:

On completion of the module, students will be able to:

- Understand the fundamental theory underpinning high resolution seismic approaches to sub-surface investigation
- Decide upon the most appropriate survey technique applicable to a given problem
- Analyse and interpret archive seismic refraction and reflection datasets
- Understand the use of electrical, magnetic, gravity and electromagnetic techniques of geophysical surveying on land and at sea
- Model, analyse and interpret archive datasets from electrical resistivity surveys

Module Syllabus:

This course aims to introduce the range of geophysical techniques that a marine geoscientist would be likely to encounter as a practitioner in the field, placing particular emphasis on basic underlying theoretical considerations, the hardware used for data acquisition and also on assumptions made during interpretation and modelling of data. Topics covered in the initial section of the module include: modes of propagation of seismic waves, controls on seismic velocity, interaction of seismic waves with interfaces, geometry and trigonometry of seismic refraction and reflection surveys, survey set-up and hardware, basic multichannel data processing, synthetic seismograms. The module goes on to give the student a basic idea of the theory, acquisition and interpretational techniques used in electrical resistivity techniques (e.g. vertical electrode sounding, constant separation traversing, offset techniques and pseudo depth profiling) and electro-magnetic surveying – with oceanographic techniques being described. An introduction to the use of magnetic and gravity surveying in marine sciences is also presented.

Subject Skills: • Recognising and using subject-specific theories, paradigms, concepts and principles • Interpretation and presentation of data using appropriate qualitative and quantitative techniques • Solving numerical problems using non-computer and computer based techniques • Using the internet critically as a source of information	*Transferable Skills:* • FORTRAN programming. Use of spreadsheets. Improved physical insight and mathematical skills.
Total Lecture Hours: 20 lectures	*Suggested Study Hours:* 80
Teaching Format: Lectures & practical assignments.	*Facilities & Locations Used:* MSc room
Form of Assessment: 1. Seismics exercise sheet [25%] LO 3 2. Electrical resistivity problem sheet [25%] LO 5	*Deadline for Assignments*:

3. Module examination [50%] LO 1, 2, and 4	
Assignments Description: Problem sheets covering aspects of the taught course.	
Suggested Reading: Introduction to geophysical Exploration, Kearey, Brooks and Hill, Blackwell, 2002 An introduction to applied and environmental geophysics, Reynolds LM, Wiley, 1996 Applied Geophysics (New Edition),Telford, Geldart and Sherriff Cam Uni Press, 1986.	

Module Code:

Credits Available: 5

Module Title: **REMOTE SENSING**

Module Organiser: Dr Gay Mitchelson-Jacob

Module Staff: Gay Mitchelson-Jacob

Module Aim: To introduce the use of remote sensing for marine applications

Module Objectives & Learning Outcomes:

Objectives:

(6) to introduce satellite remote sensing as a source of oceanographic data
(7) to overview the different of satellite sensors & their associated measurements
(8) to consider the major applications for each type of data
(9) to become familiar with the commonly used acronyms

Learner Outcomes:

(1) know the range of remotely-sensed measurements available for use within marine science,
(2) be able to assess which type of data is required for different applications
(3) know how to obtain the data
(4) know the basics of how the remote sensing systems work and the corrections needed to use the data
(5) be able to process the data (from some levels)
(6) be able to interpret and present the data

Module Syllabus:

The module will review the use of satellite and other remote sensing techniques in the monitoring and studying the marine environment, with emphasis on biological applications and coastal zones.

The practical sessions will

· Provide basic training in the use of the ERDAS image processing facility.

Subject Skills:

Transferable Skills: Image Processing & Analysis

Total Lecture Hours: 10 x lectures
3 x practicals

Suggested Study Hours: 37

Teaching Format:
Lectures & computer-based practicals

Facilities & Locations Used:
Craig Mair Computing Laboratory
ERDAS

Form of Assessment: Image processing

Deadline for Assignment:

Assignment Description: Report on the use of remote sensing in the Irish Sea and Malin Shelf areas for fisheries and pollution

Suggested Reading:

Clark C.D., (1993) Satellite Remote Sensing for Marine Pollution Investigations, *Marine Pollution Bulletin* **26(7)**, 357-368.

Cracknell A.P. and L.W.B. Hayes, (1991). Introduction to remote sensing. Taylor & Francis, London, 293pp.

Dalby D.B. and W.J. Wolff, (1987). Remote Sensing. Chapter 2 in Baker J M and W J Wolff (eds). Biological Surveys of Estuaries and Coasts. Cambridge University Press.

Robinson, I.S. (1985). Satellite Oceanography - An Introduction for Oceanographers and Remote-Sensing Scientists. Ellis Horwood Ltd, Chichester, UK, 455 pp.

Robinson, I.S. and T. Guymer, (1996). Observing Oceans from Space. Chapter 5 in Summerhayes, C.P. and S.A. Thorpe (eds). Oceanography, an illustrated guide. Manson Publishing.

<table>
<tr><td>Module Code:</td><td>Credits Available: 10</td></tr>
<tr><td colspan="2">Module Title: <u>GEOSCIENCE FIELD PRACTICE</u></td></tr>
<tr><td>Module Organiser Prof Dei Huws</td><td>Module Staff: Dei Huws</td></tr>
<tr><td colspan="2">Module Aim: The aim of this module is to give the participant a thorough understanding of how geophysical data are acquired in the field and how the theory taught in the lecture series modules of the course is applied to these data.</td></tr>
<tr><td colspan="2">Module Objectives & Learning Outcomes:
On completion of the module, students will be able to:
1. Conduct a range of geoscience field surveys, from the point of acquisition to the reporting stage
2. Process and interpret the datasets acquired
3. Critically analyse the underpinning models used for interpretation
4. Appreciate the uses and limitation of surface geophysical techniques for the prediction of sub-surface stratigraphy and physical property determination</td></tr>
<tr><td colspan="2">Module Syllabus:
(a) A shallow geophysical survey – incorporating seismic refraction techniques, electrical resisitivity techniques (VES, CST, Wenner and Schlumberger arrays, Offset Wenner, 2-D multielectrode pseudo depth profiling) and an electro-magnetic survey.
(b) An investigation of the magnetic and electro-magnetic signature of a buried pipeline (using proton and fluxgate magnetometers, a fluxgate gradiometer and an EM-31 device).
(c) An acoustic survey of the Menai Strait using boomer, airgun, side scan sonar and echo sounder instruments.</td></tr>
<tr><td>Subject Skills:
1. Linking geophysical signatures to geological or hydrological reality
2. Critical analysis of underpinning models used for interpretation e.g plane layer model of seismic refraction, 1-D depth model of electrical resisitivity, ‘line of dipoles’ model for magnetic data interpretation
3. Analysing and synthesizing information critically conducting, recording and analyzing data using appropriate acquisition and modeling techniques
4. Gaining ability to undertake field investigations in a responsible and safe manner, paying due attention to risk assessments, rights of access and sensitivity to the impact of investigations on the environment.
5. Appreciating issues of accuracy, precision and uncertainty during collection, recording and analysis of field data</td><td>Transferable Skills:
Image Processing & Analysis
Preparing, processing, interpreting and presenting data, using relevant qualitative and quantitative techniques and packages
Teamwork – ability to interact socially and intellectually in an effective way in the context of the aim of the practical.</td></tr>
<tr><td>Total Lecture Hours: 10 x lectures
3 x practicals</td><td>Suggested Study Hours: 37</td></tr>
<tr><td>Teaching Format:
Lectures & computer-based practicals</td><td>Facilities & Locations Used:
Craig Mair Computing Laboratory
ERDAS</td></tr>
</table>

<table>
<tr><td>Form of Assessment
1. Acoustics practical report [40 %] LO 1,2,3,4

2. Magnetic survey report [20 %] LO 1,2,3

3. Shallow subsurface investigation report [40 %] LO 1, 2, 3, 4</td><td>Deadline for Assignment:</td></tr>
<tr><td colspan="2">Assignment Description:</td></tr>
<tr><td colspan="2">Suggested Reading:
Introduction to geophysical Exploration, Kearey, Brooks and Hill, Blackwell, 2002
An introduction to applied and environmental geophysics, Reynolds LM, Wiley, 1996
Applied Geophysics (New Edition),Telford, Geldart and Sherriff, Cam Uni Press, 1997.</td></tr>
</table>

Module Code:	*Credits Available:* 5 credits
Module Title: **KEY SKILLS AND BIOGEOCHEM. OCEAN.**	
Module Organiser: Prof Alan Davies	*Module Staff:* Alan Davies, Vanesa Magar, Sarah Jones, Dafydd Roberts [I.S.]
Module Aim: To establish a common foundation in mathematical methods and computer programming for use in subsequent modules.	
Module Objectives: The module has three components involving the study of: 4. Mathematical methods: Here a range of mathematical topics will be addressed with a view to giving students adequate preparation for the later module material. 5. Computer programming in Fortran: An introduction will be given to programming in Fortran90, which is used in many operational/commercial marine modelling systems. 6. Introduction to Matlab: This course provides an introduction to the scientific data analysis package MATLAB, which is increasingly being used in research and industry for instrumentation interfaces, data processing, statistical analysis and graphical representation.	
Learning Outcomes: On successful completion of this module, the student should have: • General knowledge of a range of mathematical methods at an appropriate level for the purposes of subsequent modules. • Understanding of what is meant by a computer programming language. • Basic skill in programming in Fortran90. • Basic skill in use of Matlab. • Ability to process and present data sets obtained using marine instrumentation. • Ability to use a computer contouring package both for simple map generation and for more advanced map analysis.	
Module Syllabus: 1. Mathematical Methods: An initial overview will be given of logarithms and exponential functions, trigonometric and hyperbolic functions, and calculus (differentiation and integration methods). The topics then covered in greater detail will include: vector algebra and vector calculus, complex variable, matrices, solution of ordinary differential equations, solution of partial differential equations, Fourier series. 2. Programming in Fortran 90 3. Programming in Matlab A series of practicals cover input/output of data, array handling, programming using script files, 2-D graphics and computer contouring.	
Subject Skills: Mathematical and Computing skills. • General knowledge and understanding of relevant mathematical methods. • Knowledge of scientific computer programming languages (Fortran 90, Matlab). • Appreciating issues of sample selection, accuracy, precision and uncertainty during collection, recording and analysis of data in the field and laboratory.	*Transferable Skills:* • Use of mathematical methods in a range of applications. • Ability to use scientific computer programming languages (Fortran 90, Matlab) in a range of applications. • Communication skills: receiving and responding to a variety of information sources • Self management and professional development skills: working independently, time management

• Preparing, processing, interpreting and presenting data using appropriate qualitative and quantitative techniques and packages • Solving numerical problems using computer based techniques	and organisation skills.
Total Lecture Hours: 10 for Maths section 18 Fortran, 4 Matlab practicals	*Suggested Study Hours:* 16
Teaching Format: Lectures & computing sessions	*Facilities & Locations Used:* DC Seminar room, Westbury Mount Computing Room
Form of Assessment: Continual Assessment only in Part A of the module	*Deadline for Assignment*
Assignment Description: Problem sheet on mathematical methods (10%), Fortran 90 assignments (20%), Matlab assignments (20%)	
Suggested Reading: Mathematical Methods for Science Students, G. Stephenson, Longmans, 19**. (or any other text on general mathematical methods).	

SEMESTER 2: ACOUSTIC SYSTEMS

Module Code:	*Credits Available:* 9 credits
Module Title: **GEOPHYSICS AND MODELING**	
Module Organiser: Prof. Antoni Mánuel	*Module Staff:* Antoni Mánuel, Rafal Bartolomé, Eric Delory, Jaume Piera
Module Aim: To further study the main geophysical methods used for subseafloor imaging, focussing in those based on acoustic data (Multichannel and Wide-Angle Seismics, sidescan sonar, swath bathymetry). To present the most advanced techniques used to model and interpret geophysical acoustic data. To transfer theoretical and practical skills in geophysical exploration and prediction techniques	
Module Objectives: 1) To show the potential of seismic methods to give insights on the subseafloor structure and physical properties. 2) To identify the major applications of each type of data from both industrial and scientific viewpoints. 3) To be familiar with the most common modelling techniques. 4) To give students thorough understanding of wave propagation in a complex layered environment and the necessa skills to analyse a geophysical remote sensing problem, implement a data collection protocol and the ad-hoc mathematical methods to predict acoustic and seismic wave behaviour in the ocean and the sea-floor.	
Learning Outcomes: On successful completion of this module, the student should have: Multibeam bathymetry: objectives, experiment layout, applications, basic data processing, interpretation of data. Sidescan sonar: objectives, experiment layout, applications, advanced data processing, interpretation of data. • MCS data: objectives, experiment layout, applications, advanced data processing, interpretation of data. • Wide-angle data: objectives, experiment layout, applications, advanced data processing. • Modelling: inverse vs. direct approximations, interpretation of models. • Understanding of current methods of underwater geophysical measurements and their interpretations • Ability to design a geophysical field experiment as well as knowledge in interpreting the acquired data • Understanding of wave propagation principles in layered media • Understanding of modelling techniques for geophysical prediction	
Module Syllabus: 1. Sea-floor properties and topographic mapping 2. Theory of wave propagation in stratified media 3. Computational acoustic propagation in stratified media 4. Seismoacoustic processing and modelling 5. Inverse seismoacoustic propagation modelling	
Subject Skills: Applied Mathematics, modelling, and computational skills. The student will learn about the theoretical background of geophysical exploration and the practical implementation of acoustics and seismics in remote sensing.	*Transferable Skills:* • Ability to choose the appropriate computational tools for a specific acoustic propagation problem • Ability to program simple wave propagation models in a stratified environment • Ability to select the relevant parameters to design proper propagation models and implement them

	• Optimize computation code of current methods and software to create faster modelling techniques
Total Lecture Hours:	*Suggested Study Hours:*
Teaching Format: Lectures & computing sessions	*Facilities & Locations Used:*
Form of Assessment: Exam (50%), Practical(40%), Assignment (20%)	*Deadline for Assignment*
Assignment Description:	
Suggested Reading: Computational Ocean Acoustics, Jensen et al. Underwater Acoustics Modelling, Principles, Techniques and Applications, Etter Fundamentals of Seismic wave propagation, Chapman	

Module Code:	*Credits Available:* 14 credits
Module Title: **INSTRUMENTATION**	
Module Organiser: Prof. Dr. Antoni Mánuel	*Module Staff:* Antoni Mánuel, Carine Simon, Eric Delory, Shahram Shariat, Jaume Piera
Module Aim: To transfer the knowledge of the methods of marine parameter measurements and associated electronic technology to the students.	
Module Objectives: The students will learn how to design and build an acquisition system taking into account the specifications of the measurement. This design will also take into account the specificities of the considered marine environment.	
Learning Outcomes: On successful completion of this module, the student should have: • To train engineers in the advanced methods of electronic instrumentation with regard to the data and signals (sound, images, shapes, etc ...) acquisition , transmission, and processing of information, • Networks: (telephonic, telematic, computers, internet, ...) and transmission channels are studied both theoretically and practically. • Solid scientific knowledge of the marine environment and the relevant instrumentation technologies • To create the basis for the future observatories architecture design	

Module Syllabus:
- Introduction to the measurement chain
 	
- Marine sensors
  o Introduction to marine sensors: accelerometer, geophone, hydrophone, CTDs, etc.
  o Sensitivity
  o Working principle of marine sensors
  o Ocean current measurements
  o Calibration
  o Geophone calibration method using a vibration table.
  o Hydrophone calibration methods
  o Hydrophone design and construction (practical)
 	
- Signal conditioning
  o Signal classification
    ▪ Single ended signals
    ▪ Differential signals
    ▪ Pseudo-differential signals
    ▪ Hydrophone and geophone signal model
  o Input/Output differential circuits
  o Current to Voltage and voltage to current converters
  o Voltage amplifiers
    ▪ Operational amplifiers
    ▪ Instrumentation amplifiers
    ▪ Input/output amplifiers
    ▪ Isolation amplifiers
  o Differential filters
  o Circuit noise analysis	

- Circuit noise reduction techniques
- Design of bio-acoustic signal conditioners (practical)
- Design of seismic signal conditioners (practical)

Theory and design of acoustic transducers

- Material technologies used in acoustic transducer design. Ultrasound technologies. Piezoelectric ceramics. Acoustic transducer characterization.
- Study and design of signal conditioners, audio amplifiers and power stages in acoustic transducer design. Hybrid amplifiers for piezoelectric actuators.
- Inefficiency of traditional class A or class AB technologies. Use of commuted DC-DC amplifiers in acoustic transducer design to achieve high efficiency and smaller size in desired working range.

Analog to Digital converters

- Introduction to ADCs
  - Simple and double ramp converters
  - Successive approximation converters
  - Delta-Sigma converters
- Quantization noise
- Sampling rate, Dynamic range and Resolution
- Effective number of bits
- ADC errors

- Data Acquisition
  - Data transfer to a microcontroller (SPI, CAN, Ethernet, etc.)
  - Introduction to acquisition cards
  - Introduction to C programming (practical)
  - Design of an acquisition system program using C language (practical)
    - Design of a geophone and hydrophone data acquisition program using a datalogger.
    - Design of a seismic signal detection program.
  - Data transfer to a PC using a RS232

- Data monitoring (practical)
  - Introduction to LabVIEW programming
  - Data monitoring using serial port
  - Data monitoring using USB port
  - Introduction to GPIB communication bus
  - Instrumentation control

- Underwater sensor network and communication
  - Smart Sensors
  - Microsensors. Principles and Applications
  - Silicon sensors
    - Radiation
    - Mechanical
    - Thermal
    - Magnetic
    - Chemical
    - Sensor Technology
    - Sensor interface and bus Systems
    - IEEE P1451
  - Fibre optic sensors
  - Data acquisition for frequency-time domain smart sensors

- Observatories architecture design

- Standardisation. Mechanical, electrical and logical
- Instrumented Package. Payload. Architecture analysis
- Deployment and maintenance analysis
- Data acquisition strategy. Communication
- Acoustic networked observatory system
- Proposals for emergency response

Subject Skills: Electronic and Computing skills • General knowledge and understanding of basic electronic instrumentation. • Knowledge of scientific computer programming languages applied to electronic instrumentation design(C, C+, Labview, assembler). • Preparing, processing, interpreting and presenting instrumentation data using appropriate qualitative and quantitative techniques and packages • Solving sea technology instrumentation problems • Appreciating issues of accuracy, precision and uncertainty during collection, recording and analysis of field data	*Transferable Skills:* • Ability to use scientific microcomputer programming languages (C, C+, Labview, assembler) in a range of applications. • Use of electronic design methods in a range of applications. • Practical skills in the use of oceanographic equipment • Review of sensors required
Total Lecture Hours: lectures, seminars, practical, exercises and problem sheets (145 hours)	*Suggested Study Hours:* 50h
Teaching Format: Lectures & computing and electronic laboratory sessions	*Facilities & Locations Used:* General room, SARTI Instrumentation Laboratory , and Marine Unit Technology Research laboratories
Form of Assessment: The student evaluation is continual taking into account the exercises and project works that students perform during this course.	*Deadline for Assignment*
Assignment Description:	

Suggested Reading:

Anna Hac. Wireless Sensor Network. John Wiley&Sons,Ltd 2003
Antoni Mànuel, J.del Rio. Labview 7.1 Thomson 2005
Takuro Ikeda. Fundamentals of piezoelectricity. Oxford University Press Inc New York 1996

J. W. Gardner, Microsensors, Principles and Applications, John Wiley and Sons, 1994 Augustin, J. M., R. Le Suavé, X. Lurton, M. Voisset, S. Dugelay, and C. Satra, (1996).

Underwater electro-acoustic measurements. Robert J.Bobber. Las Altos Peninsula publishing 1988

Christoph Stiebel, Hartmund Janocha. New concept of a Hybrid Amplifier for driving piezoelectric actuadors. Proc of the 6th International Conf on New Actuators Bremen 2000 pp 189-192

Tripath Technology, Inc. 2000. Application Note 4. Parametric Measurement of Class-T Amplifiers

Urick, Robert J. "Principles of underwater sound for engineers". Mc Graw Hill 1967

Underwater acoustic modelling principles. Paul S. Etter. London Elsevier Applied Science 1991.

Kilfoyle D.B, J.C.Preig and M.Stpjanovic. The State of the art in Underwater acoustic Telemetry. IEEE Journal of Oceanic Engineering vol 25 nº1 January 2000 pp4-27
M.Ilyas, I.Mahgoub Handbook of sensor networks compact wireless and wired sensing Systems. CRC Prsss 2004.

Module Code:	*Credits Available:* 9 credits
Module Title: **ACOUSTIC DATA PROCESSING**	
Module Organiser: Prof Cédric Gervaise	*Module Staff:* Cédric Gervaise, Eric Delory, Carine Simon
Module Aim: The goal of this module is to focus on digital signal processing tools dedicated to acoustic underwater data analysis and to apply them to real world data	
Module Objectives: Of principal interest is the design of algorithms to extract from the acoustic measurements its main features such as: - frequency content to separate useful signal from noise, - frequency content to asses kinetic of sources by Doppler effect, - detection and classification of signals to asses sources distribution, - estimation of time of arrival to asses geometric properties of underwater channel - estimation of signal magnitude to asses emission level and target strength.	
Learning Outcomes: On successful completion of this module students will be able to: - design basic algorithms based on Digital Signal Processing to understand the contents of measurements produce by hydrophones and to filter them to suppress nuisance components, - design algorithms to estimate major features (time delay, target strength, signal bandwidth, direction of arrival, detection) from measurements produce by a underwater acoustic system, - be aware of accuracies and robustness of these algorithms, - link the quantities to be estimated with some needs of underwater channel characterization (bathymetry, tomography…), - apply theses tools to real data and develop criticism analysis of performances.	
Module Syllabus: A) Mathematical foundation lectures : Probability and statistics, Fast Fourier Transform, Digital filtering Practicals: Matlab, Statistical analysis of real word data, Fast Fourier Transform, Digital filtering B) Signal detection for underwater acoustic Lectures : Detection theory, Active detection : Matched filter, Passive detection of narrow and broadband signals Practicals : Detection in active tomography systems, Passive detection of narrow and broadband signals (Ship noise and Marine mammals vocalizes) C) Estimation Theory applied to underwater acoustic Lecture: Estimation Theory, Measurement of times of arrival and signal strength: Matched filtering, Spectral estimation of random, Introduction to Time Frequency analysis Practicals : estimation of impulse response channels in active tomography, spectral analysis of ship noise, Time-Frequency analysis of marines mammals vocalizes, Doppler estimation	
Subject Skills: - data content analysis in the best adapted	*Transferable Skills:* - data processing is a stage of any sonar or

representation space (time, frequency, time-frequency, angular) - data processing for noise removal - data processing for detection and estimation of the main features of a measurement	acoustical system, - understanding an algorithm and evaluation of its performances and limitation, - applications on a large panel of common real world data from underwater acoustics.
Total Lecture Hours: 75 h	*Suggested Study Hours:* 25 h
Teaching Format: Lectures & computing sessions	*Facilities & Locations Used:*
Form of Assessment: Written module exam + practical reports	*Deadline for Assignment*
Assignment Description: Module exam (part A, B and C below, 1/3 total credits) + practical reports (part A, B and C below, 2/3 total credits)	
Suggested Reading:	

Module Code:	*Credits Available:* 9 credits
Module Title: **ARRAY SIGNAL PROCESSING**	
Module Organiser: Prof M. Legris	*Module Staff:* Michel Legris, Cédric Gervaise, Rafael Bartolomé

Module Aim:

The goal of this module is to focus on array signal processing tools dedicated to acoustic underwater data analysis.

Module Objectives:

As soon as underwater acoustic applications are concerned, it may be important to be able to focus an emitter or a receiver in some preferential direction to :

- maximise signal to noise ratio in this direction,
- be able to image the under sea bottom by scanning a range of emission and reception angles in active sonar application
- be able to estimate the bearing to locate source in passive or active sonar applications.

Because of wavelength values in underwater acoustic applications, focussing (at emission and reception) is mainly obtained using an array of transceivers.

Under the scope of this course will be :

- active array signal processing in imaging sonar,
- passive array signal processing apply to goniometry and beamforming application,
- data acquisition and processing techniques most commonly used in geophysical prospecting.
- distinction between reflection and refraction seismic data.
- knowledge of most common industrial and academic processing software.

Learning Outcomes:

On successful completion of this module students will be able to:

- design basic algorithms based on array of transducers in active and passive context to locate target, receive signals from emitter and image underwater medium,
- apply them on real word data using digital electronics,
- be aware of accuracies and robustness of these algorithms.
- understand the mathematical background and objectives of the main processing sequences.
- be able to apply standard Multichannel Seismic Data processing sequences using industrial (PROMAX) and academic (SU) software packages.
- be able to decide which is the most suitable processing protocol for a given data set and target.
- be able to apply standard processing sequences for wide-angle seismic data.

Module Syllabus:

A] Basis (Lecture 2h)
Lecture: Scope of the course, Near field and far field, Plane waves

B] Active array signal processing (Lecture 10 h – Practical 10h)
Lecture : Green functions, Directivity pattern of a vibrating plane, Directivity pattern of an array, Directivity index and array gain definition, Weighting functions, Imaging lobes / Grating lobes, Beamforming/focussing
Practicals: Antenna pattern analysis and prediction, Matlab simulation of a sonar beamforming

C] Passive array signal processing (Lectures 8 h – practical 10 h)

Lecture : Data model, Array gain, Goniometry (Narrowband Maximum Likelihood Estimators, High resolution Subspace techniques), Beamforming (Narrowband Maximum Likelihood Estimators, CAPON), Broadband applications, Matched Field Processing Practicals : Narrowband applications – goniometry and beamforming using an uniform linear array, Broadband applications – goniometry and beamforming using an uniform linear array, Matched field processing in shallow water environments D] Seismic array processing (Lecture 10h Practical 10h) Processing of Multichannel Seismic Data: Objectives, standard sequences: statics, sorting, filtering, velocity analysis, multiple suppression, post-sack and pre-stack depth migration. Processing of Wide-Angle seismic data: Objectives, standard sequences: plotting record sections, butterworth filtering and automatic gain correction, noise suppression: polarisation filtering, coherency filtering, f-k filtering, picking of seismic phases.	
Subject Skills: - instrumentation and electronics architecture in acoustical antenna conception, - passive and active algorithms, - underwater and seismic applications	*Transferable Skills:* - data processing is a stage of any sonar or acoustical system, - understanding an algorithm and evaluation of its performances and limitation,
Total Lecture Hours: 60 h	*Suggested Study Hours:* 15 h
Teaching Format: Lectures & computing sessions	*Facilities & Locations Used:*
Form of Assessment: Written module exam + practical reports	*Deadline for Assignment*
Assignment Description: Module exam (part A, B, C and D below, 1/3 total credits) + practical reports (part A, B, C and D below, 2/3 total credits)	
Suggested Reading: Glangeaud, J.L. & Coppens, F., 1997. Traitement du signal pour géologues et géophysiciens, Editions TECHNIP. Yilmaz, O., 2001, Seismic data analysis: Processing, inversion, and interpretation of seismic data, Edited by: Society of Exploration Geophysicists.	

Module Code:	*Credits Available:* 11 credits
Module Title: **IMAGING SONAR TECHNOLOGY AND PROCESSING**	
Module Organiser: Prof. M. Legris	*Module Staff:* Michel Legris, Mike van der Schaar, Eric Delory

Module Aim:

The goal of this module is to have a broadview on current and emerging technologies in active and multi-static passive sonar imaging and also to know how to interpret and process data from such systems.

Module Objectives:

The objective is three folds :

- first we will introduce the different design choices available and usable in imaging, presenting also advanced concepts such as synthetic aperture sonar or interferometric sonars
- then we will have a thorough investigation on how such data is usually processed,
- in a last part passive multi-static imaging sonar systems are introduced

Learning Outcomes:

On successful completion of this module students will be able to:

- to understand principles and theories behind each sonar systems;
- to determine the key points in sonar design and which parameters will impact sonar performances;
- to interpret sonar images and artifacts on real data;
- to realize the feasibility study of an acoustic imaging system.

Module Syllabus:

A] Sonar generalities and sounding techniques (lecture 2h/ practical 1h)
Lectures : Sonar general presentation, Key sonar performances, Imaging sonar types
Practicals : General knowledge of sonar systems

B] Imaging sonar design (lecture 6h/practical 11h)
Lectures : Sonar equation applied on imaging sonar, Side Scan Sonar processing and design, Multibeam sonar processing and design
Practicals: Matlab coding of sonar equation

C] Fast beamforming algorithms (lecture 4h/practical 6h)
Lectures :Temporal focusing and beamforming, Stolt Migration, Chirp Scaling algorithm
Practicals : Matlab processing of side scan sonar data

D] Advanced sonar techniques (lecture 4h/practical 4h)
Lectures : Synthetic aperture sonar, Parametric sonar, Interferometric sonar, Acoustic camera
Practicals : Matlab processing of interferometric sonar

E] Signal and image characteristics (lecture 3h/ practical 2h)
Lectures : Backscattering modeling , Spatial and temporal coherency (Van Cittert Zernike theorem), Speckle property and image statistics, Artifacts analysis (sonar stability, multiple returns, …)

Practicals : Sonar image interpretation

<table>
<tr><td colspan="2">F] Basic signal and image processing (lecture 3h/ practical 6h)
Lectures: Basics of image processing, Sonar image preprocessing (TVG compensation, Speckle filtering), Introduction of bottom detection and classification , Sonar image registration and mosaicking, Depth Data filtering and geocoding, DEM construction
Practicals: Sonar image processing

G] Passive Multi-static sonar system (lecture 10 h/ practical 10 h)

To be completed by LAB</td></tr>
<tr><td>Subject Skills:
- Basic sonar architectures
- Advanced sonar architectures
- Sonar image features and processing</td><td>Transferable Skills:
- Method for system design,
- Fields of application of sonar system,
- Image Processing</td></tr>
<tr><td>Total Lecture Hours: 70 h</td><td>Suggested Study Hours: 25 h</td></tr>
<tr><td>Teaching Format:
Lectures & computing sessions</td><td>Facilities & Locations Used:</td></tr>
<tr><td>Form of Assessment:
Written module exam + practical reports</td><td>Deadline for Assignment</td></tr>
<tr><td colspan="2">Assignment Description:
Module exam (part A, B, C, D, E, F and G below, 1/2 total credits) + practical reports (part A, B, C, D, E, F and G below, 1/2 total credits)</td></tr>
<tr><td colspan="2">Suggested Reading:</td></tr>
</table>

5.3. SEMESTER 3: ADVANCED APPLICATIONS

Module Code:	*Credits Available:* 18 credits
Module Title: **ADVANCED SIGNAL PROCESSING**	
Module Organiser: Dr. Rafael Bartolomé	*Module Staff:* Rafael Bartolomé, Carine Simon, Mike van der Schaar, Vicent Parisi
Module Aim: to teach advanced signal processing protocols used for most common marine data acquisition systems	
Module Objectives: The objective of the module is to provide the student with the necessary expertise to analyse signals in different time-frequency representations, perform feature extraction and search for patterns. Discrete-time signal processing is a field with a wide range of applications including speech and data communication, acoustic, radar, sonar, seismology, remote sensing, instrumentation and many others.	
Learning Outcomes: On successful completion of this module, the student should have: • Theory and Application of Digital Signal Processing • A selection of the most used signal processing operations in a general industrial setting, including data acquisition and real-time applications • Understand and use DSP algorithms and special-purpose DSP hardware ICs • Expertise in signal analysis (2 credits) • Knowledge of pattern classification (3 credits)	
Module Syllabus: a) signal analysis Signal Description. Continuous and discrete signals The system response. Convolution Frequency Response Methods Digital Signal Processing in Telecommunications Filterering of signals. Filter design software Analog Filter Implementation using active filters Discrete Fourier Transform Routines Delta sigma modulation Infinite Impulse Response Digital Filter Design Finite Impulse Response Digital Filter Design Digital Filter Implementation Using C. Matlab-Simulink The Fast Fourier Transform and its Applications Discrete Fourier Transform Computation of Discrete Fourier Transform Ramdom Signals Characteristics of Random Data	

Fourier series and transformations
Probability Functions and Amplitude Measures
Correlation and Spectral Density Functions
System Identification and Response
Propagation-Path Identification

Practical DSP hardware design issues
Procedures for Digital Signal Processing Hardware
Encoding of waveforms. Increasing the channel Bandwidth
DSP system design flow
The bridge to VLSI. Real DSP hardware
Texas Instruments DSPs
Applications to Radar.

Wavelets
1. introduction to wavelets, wavelet vs fourier analysis
2. multiresolution analysis, wavelet and dilation equations
3. orthogonal and biorthogonal bases
4. wavelet filter banks
5. wavelet packets, redundant signal representations
6. applications, eg. denoising, compression

b) Communication systems
The state of the art in underwater acoustic Telemetry
Modulation of digitally encoded data
Frequency Shif Keying (FSK). PSK,QPSK, MPSK
Quadrature Amplitude Modulation (QAM), QPM, QAPM, OFDM
Receiver Structure. Incoherent Digital Receivers
Underwater Acoustic Networks

c) pattern recognition basics

Subject Skills: • Data analyzed in the form of correlation and spectral density functions to solve engineering problems • Discrete-time linear systems theoretical material • Applications of the FFT based on the property to rapidly compute the Fourier, inverse Fourier transforms • Use of DSP hardware ICs • The analysis and design of both analog and digital communications systems	*Transferable Skills:* • DSP algorithms and technology have made it possible for digital techniques to be used for accurate,stable real-time processing of signals originating in the analog realm, • Provide a comprehensible set of digital processing modules • The mathematical framework for communication theory and signal processing
Total Lecture Hours: lectures, seminars, practical, exercises and problem sheets (180 hours)	*Suggested Study Hours:* 90h
Teaching Format: Lectures & computing sessions	*Facilities & Locations Used:* General room, SARTI Instrumentation Laboratory , and

	Marine Unity Technology Research laboratories
Form of Assessment: The student evaluation is continual taking into account the exercises and project works that students perform during this course.	*Deadline for Assignment*
Assignment Description:	

Suggested Reading:
E.Oran Brigham (1988). The Fast Fourier Transform. Prentice Hall
A.Oppenheim, R.W.Schafer (1989).Discrete-Time Signal Processing. Prentice Hall
J.S.Bendat, A.G.Piersol (1993). Engineering Applications of Correlation and Spectral Analysis. Wiley&Sons
R.J.Higgins (1990)Digital Signal Processing in VLSI. Analog Devices-Prentice Hall
E.W.Kamen, B.S.Heck (1997). Fundamentals of Signals and Systems. Using Matlab. Prentice Hall
C.Sidney et al (1994) Computer-Based Exercises for Signal Processing using Matlab Prentice Hall
J.G.Proakis, D.G.Manolakis (1996). Digital Signal Processing. Prentice Hall
D.B.Kilfoyle. Underwater Acoustic Telemetry. Oceanic Engineering January 2000 vol 25 IEEE
I. Daubechies (1992), “Ten Lectures on Wavelets”, SIAM Society for Industrial & Applied Mathematics
G. Strang and T. Nguyen (1996), “Wavelets and Filter Banks”, Wellesley-Cambridge Press
S. Mallat (1999), “A Wavelet Tour of Signal Processing”, Academic Press
R.O. Duda, P.E. Hart, D.G. Stork (2001), “Pattern Classification”, Wiley-Interscience
C.M. Bishop (1995), “Neural Networks for Pattern Recognition”, Oxford University Press

Module Code:	*Credits Available:* 17 credits
Module Title: **BIOACOUSTICS**	
Module Organiser: Prof. Michel André	*Module Staff:* Michel André, Eric Delory, Mike van der Schaar

Module Aim: Part I: To understand how marine mammals sense and perceive the marine environment (sensory systems including sound production and reception)

Part II: a.) Optimality of biosonar signals and b.) auditory computation

Module Objectives: The part I includes 5 components which involve the study of:

1. Marine mammal morpho-physiological adaptations to the marine environment: A comparative approach.
2. Marine mammal sound production. The phonation apparatus and sound characteristics
3. Marine mammal sound reception. Cetacean acoustic pathways and processing
4. Biosonar and communication function of acoustic signals: theoretical and experimental approach
5. Acoustic signal capture and interpretation. Effect of noise pollution: modelling a virtual ocean.

The part II presents two objectives:

a.) Provides an introduction to the current knowledge on how marine vertebrates modulate their acoustic signals in order to efficiently sense their environment. Basics of information theory applied to cetacean signals time-frequency characteristics are presented and the students will learn about the natural time-frequency trade-offs that animals are faced with in their search for preys and in long-range communication.

b.) Provides an introduction to the computational approach for understanding auditory information processing. Psychoacoustic results will be introduced for cetaceans and compared to humans, accounting for the adaptation to the aquatic medium.

Learning Outcomes:

On successful completion of this module, the student should have:

- Understanding of the marine environment perception from a non-human perspective
- General knowledge of cetacean sound repertoire and functions
- Ability to predict the effects of noise pollution in the marine environment under simple scenarios
- Understanding of biosonar signals specificity in terms of environmental sensing and information extraction
- Ability to provide quantitative time-frequency cues of modulated pulsed signals
- Ability to apply basic mathematical and physical principles to extract relevant information from an emitted acoustic signal
- Understanding of the basics of mammalian auditory computation
- Understanding of the neural bioprocesses involved in hearing
- Model simple hearing systems, from monoaural to binaural
- Decompose an auditory scene analysis problem and implement basic auditory biomimetic tasks with a computer

Module Syllabus:

1. Morpho-physiology of the marine mammal adaptation to an aquatic environment
2. Marine mammal sensory abilities: vision vs acoustics
3. Integrating marine mammal acoustic processes in the marine habitat
4. Basics of signal information theory applied to biosonar signals
5. Cetacean signal interspecificity
6. Activity-driven signal adaptivity
7. Biosonar signal optimality and the sonar equation
8. Auditory Computation: an overview of feature extraction and integration
9. Cetacean neuroanatomy and electrophysiology

Practicals:

- Dissection of cetacean phonation apparatus and acoustic pathways
- Application of the sonar equations to the cetacean signals, time-frequency content analysis with Matlab, problem solving, quantitative interpretation of bioacoustic data:

1. Cetacean Acoustic Pulse modelling and comparison

2. The Heisenberg box and the biosonar pulse: Time Bandwidth products calculations
3. Optimal filtering of cetacean signals

Subject Skills: • General knowledge and understanding of the morphology and physiology of the marine mammal sound production and reception • Appreciating the importance of a better level of understanding of the cetacean biosonar functionality for industrial applications • Non-stationary bioacoustic signal exploration through time-frequency techniques • Quantitative measurement of signal cues related to cetacean acoustic signals • Basics of Information theory and in particular the Heisenberg principle, applied to a real world problem • Concepts of narrowband and broadband signals and their respective utilities in bioacoustics • Introduction to Matlab signal processing tools for underwater signal off-line analysis	*Transferable Skills:* • Ability to apply sound bioprocesses to perform and optimize oceanographic exploration • Integrated approach to design and develop acoustic tools • Algorithm development of automated signal time-frequency analysis • Self management and professional development skills: working independently, time management and organisation skills. • Practical skills: Implement a perceptual model-based approach to acoustic scene data • Interpretation and presentation of data using appropriate qualitative and quantitative techniques
Total Lecture Hours: lectures, seminars, praticals, exercices and problem sheets (170 hours)	*Suggested Study Hours:* 30
Teaching Format: lectures, seminars + lab practicals and computing sessions	*Facilities & Locations Used:* General room and Laboratory of Applied Bioacoustics (UPC)
Form of Assessment: Module exam + practical reports, exercises & problem sheets	*Deadline for Assignment*

Assignment Description: Problem sheet covering applications of all aspects of the taught course

Suggested Reading:

Au, W.W.L. (1993). The Sonar of Dolphins. Springer Verlag.
Au W.W.L., Popper A.N. and R.R. Fay. (2000). Hearing by whales and dolphins. Springer handbook of auditory research, vol.12. ISBN 0-387-94906-2.
Richardson, W.J., C.R. Greene, Jr., C.I. Malme, and D.H. Thomson. (1995) Marine Mammals and Noise. Academic Press, San Diego.
Part II:
Bouvet. Traitements des signaux pour les systèmes sonar
Pierce : An Introduction to Information Theory: Symbols, Signals and Noise
Mallat : Awavelet tour of signal processing
Animal sonar processes and performance (Ed: Nachtigall and Moore)
Kamminga: Research on Dolphin Sounds
Popper and Fay: The mammalian auditory pathway: Neurophysiology
Popper and Fay: The mammalian auditory pathway: Neuroanatomy
Hawkins, Mc Mullen et al Auditory Computation
Zwicker : Psychoacoustics
Guérit : Les potentials évoqués

Development of the auditory system (Rubel, Popper and Fay)

*Module Code***:**	*Credits Available:* 12 credits
*Module Title***: NON ACOUSTIC SENSING**	
Module Organiser: Prof A. Coatanhay	*Module Staff* A. Coatanhay, N. Seube, I. Probst, Andreu Català, Cecilio Angulo, Xavier Parra, Jaume Piera

Module Aim:

The purpose of this module is to provide students a wide view of non acoustic (electromagnetic) approaches for maritime monitoring:
- remote sensing : micro-wave, optic, infrared,…
- design and control of oceanographic mobile sensor : To present key technologies of underwater floats and gliders.
- neural network learning
- artificial intelligence techniques for process control

Module Objectives:

Remote sensing: this course has to describe physical phenomena due to the interaction between electromagnetic waves and sea. Then, different sensing devices are presented: radar system, optic sensors, satellites. Finally, electromagnetic measurement are shown to be related to ocean data (biology, sea surface characteristics, pollution, …). Indeed, this module could be fruitfully associated with various subjects:
Sea wave modelling, Oceanography, Sea biology, Climatology

Design and control of oceanographic mobile sensor : The module has three components involving the study of Key technologies for floats and gliders, Floats and Glider dynamics and control. Design of in-board control system, Routing and distributed control of multiple floats and gliders

Describe the differences between traditional Artificial Intelligence and soft-computing methods
Design and apply a suitable neural network to control a non-linear system
Describe and differentiate the main neurocontrol schemes
Design and apply a fuzzy inference system to control a non-lineal system
Identification and description of other basic soft-computing methodologies applied to process control: expert systems and evolutive methods

Learning Outcomes:

On successful completion of this module students will be able to:

- Understand physical phenomena involved in non-acoustic sensing.
- Know different technologies and systems dedicated to sea monitoring using an electromagnetic approach.
- Know of which ocean characteristics can be detected by electromagnetic devices.
- Analyze the data collected by a non acoustical remote sensing system.
- General knowledge of technologies that are used in advanced oceanographic sensors such as floats and gliders (mechanical design, sensors, energy sources, actuators, computing resources)
- A good knowledge of dynamics and control of floats and gliders,
- A good knowledge of in board control system integration techniques
- Ability to design a float and glider simulator, and routing system
- Expertise on learning system

Module Syllabus:

A] Remote sensing
A-1) Preliminaries (Lecture 7 h – Practical 5 h)
Lectures : Basic electromagnetism, Polarization (Jones & Stokes parameters), Antenna & emission diagram, Cross section, Laser & interferometry
Practicals :Polarization, Antenna, Interferometry
A-2) Scattering by the sea surface (Lecture 7 h – Practical 6 h)
Lectures: Electromagnetic scattering by a rough surface, Sea wave modeling, Electromagnetic scattering by sea surface
Practicals : Scattering of a coastal surveillance radar by the sea surface, Refraction of the light

A-3) Scattering in the sea (Lectures 10 h– Practical 14 h)
Lectures : Scattering by a small particle: Rayleigh, Rayleigh-Gans, Mie, Scattering by particles: attenuation, radiative transfer, Fluorescence, Brillouin, Raman
Practicals : Scattering by a sphere, Laser beam attenuation in the sea, Radiative transfer: Chandrasekhar and Monte Carlo approaches, n isotropic particles
A-4) Radiance-Irradiance (Lectures 4 h– Practical 6 h)
Lecture : Thermal emission, radiance & irradiance
Practicals : Temperature of the sea, Color of the sea, Pollution detection
A-5) Remote sensing systems
Lecture : Satellite, airborne and other systems
Practicals/ Problems : Remote sensing analysis
A-5) Micellaneous
Lecture : Video, Ultra Low frequency methods
Practicals : Sea wave dynamo phenomenon, Wreckage detection

B] design and control of oceanographic mobile sensor
B-1) Key technologies: Mechanical design, volume actuators, motion sensors, volume sensors.
B-2) Dynamics and control of floats and gliders: The dynamics of flight, hydrodynamics modelling, equation of motion, non linear control and observation methods.
B-3) Real-time software integration
B-4) Optimal routing in the presence of currents.

C] Neural Network Learning
C-1) Learning basics.
C-2) Architecture and techniques.
C-3) Supervised learning sytems.
C-4) Self-learning.
C-5) Reinforcement learning..
C-6) Dynamic information treatment.
C-7) On line learning.
C-8) Extraction and insertion of expert knowledge.

D] Artificial Intelligence
D1) Introduction to Artificial Intelligence
1.1 Definitions
1.2 IA Basics. Intelligent Action
1.3 Classic IA Techniques:
1.3.1 Representations
1.3.2 Search
1.3.3 Planning
D2) Artificial Neural Networks
2.1 Biologic Motivation Parallel Processing
2.2 Multi-Layer Perception. Backpropagation Learning
2.3 New Techniques of Machine Learning
2.3.1 Rbf Neural Nets
2.3.2 Support Vector Machines (Svm)
D3) Introduction to Learning Based Identification and Control
D4) Identification Using Neural Networks
D5) Control Using Neural Networks
5.1 Control by Operator Mimic
5.2 Model-Based Control:
5.2.1 Direct Control
5.2.2 Inverse Control
5.3 Internal Model Control
5.4 Bp-Through-Time
D6) Fuzzy Logic and its Applications

6.1 Introduction 6.2 Basic Element of a Fuzzy Inference System (Fis) 6.3 Case Study 6.4 Classification of Fuzzy Logic Controllers 6.5 Fis Design 6.6 Working on a Real Process D7) Expert Systems 7.1 Features 7.2 Knowledge Representation 7.3 Reasoning Methods 7.4 Aplications and Examples D8) Evolutive Methods 8.1 Stochastic Methods 8.2 Evolutive Methods 8.3 Genetic Algorithms 8.4 Genetic Programming E] Bio-optical oceanography E1) Radiation and radiometry E2) Inherent Optical Properties (IOPs) & Apparent Optical Properties (AOPs): definition, relationships; overview of E3) Radiative Transfer Equation (RTE) E4) IOPs1. Absorption: units, identity of absorbers measurement of absorption coefficients pigments and photoadaptation E5) IOPs 2. Scattering: scattering physics, phase function, volume scattering function particle size and shape, size-frequency distribution, refractive index measurement and modeling efficiency factors E6) AOPs : measurement, mean cosine, reflectance, K E7) Flow cytometry and single-cell scattering E7) Introduction to remote sensing reflectance Remote sensing of sea floor from ocean surface Satellite remote sensing Models for IOPs and AOPs Fluorescence: mechanism, remote sensing Aircraft remote sensing E8) Backscattering instruments Primary production: measurement and parameters Primary production: models for derivation from in-water and remotely-sensed optical measurements E9) Underwater visibility and imaging Lidar bathymetry Bioluminescence	
Subject Skills: - Physics Bases - Electromagnetic remote sensing of sea surface and water, - Basics to design underwater robotics - Algorithms to automatically command and use underwater robotics - Dynamics of mechanical systems, flight dynamics. - Modeling of environmental disturbances (density	*Transferable Skills:* - Electromagnetic waves physics, - autonomous robotics design, - Artificial Intelligence - General and detailed design of systems devoted to oceanographic observation. - Ability to setup a methodology for control system design, simulation and real-time validation. - Design of embedded systems

fronts, currents, dynamic pressure). - Control system and observers synthesis. - Optimal control for routing problems - Numerical methods for simulation	
Total Lecture Hours: 120 h	*Suggested Study Hours:* 40 h
Teaching Format: Lectures & computing sessions	*Facilities & Locations Used:* General room, SARTI Laboratories
Form of Assessment: Written module exam + practical reports	*Deadline for Assignment*
Assignment Description: Module exam (part A, B, and C below, 2/3 total credits) + practical reports (part A, B, and C below, 1/3 total credits)	

Suggested Reading:

Beale, D.M; Demuth, H.B; Hagan, M.T. (1996). Neural network design. Boston: PWS Pub. Co.
Hertz, J. Krogh, A. Palmer R. G. (1998). Introduction to the theory of neural computation. Redwood City: Addison Wesley.
Keckman, V. (2001). Learning and soft computing. Cambridge: MIT Press.
Ripley B. D. (1996). Pattern recognition and neural networks. Cambridge: Cambridge University Press.
Suykens, J.A.K; Vandewalle, J. P; De Moor, B. L. R. (1996). Artificial neural networks for modelling and control of non-linear systems. Boston: Kluwer Academic Publishers
Copeland, J. (1996). Inteligencia artificial. Madrid: Alianza Editorial.
Hilera, J.R; Martínez, V.J. (1995). Redes neuronales artificiales. Madrid: Ra-Ma.
Mobley, C. D. (1994). *LIGHT AND WATER: Radiative Transfer in Natural Waters*, Academic Press.
Kirk, J. T. O. (1994). *LIGHT & PHOTOSYNTHESIS IN AQUATIC ECOSYSTEMS*, 2nd ed., Cambridge University Press.
Spinrad, R. W., K. L. Carder, and M. J. Perry (1994). *OCEAN OPTICS*, Oxford University Press.
Shifrin, K. S. (1988). *PHYSICAL OPTICS OF OCEAN WATER*, American Institute of Physics.

Module Code:	*Credits Available:* 3 credits
Module Title: **STATE OF THE ART**	
Module Organiser: All professors	*Module Staff:* All professors
Module Aim: Bibliography research on specific topics to be developed in final projects	
Module Objectives: At the end of semester 2, the students will have chosen their specific final project hosted by the three institutions. In parallel with the taught units in the three first semester, students undertake a review of the literature	

on their selected research topic, chosen in consultation with the teaching staff. The Review should consist of a critical appraisal of published work and should be structured and produced to a professional standard. The content should be summarized concisely in an abstract; there should be an introduction to define the context of the topic; and there should be a concluding section to emphasize important points and to indicate possible areas where future work (including the student's own research) should be directed. The length should be about 5000-8000 words, and the completed work should be handed in with a deadline to be specified.
Learning Outcomes: On successful completion of this module, the student should have: • ability to access and create data base (endnotes software) • critical review of published work • ability to synthesize data base research results

5.4. SEMESTER 4: RESEARCH PROJECT

*Module Code***:**	*Credits Available:* 45 credits
*Module Title***: <u>FINAL RESEARCH PROJECT</u>**	
Module Organiser: All partners	*Module Staff:* All partners
Module Aim: Students will devote themselves entirely to their individual project during the last semester of the course.	

Module Objectives: The project is worth 45 Credits. The subject of the research should be agreed as early as possible with the staff supervisor and will normally be related to that chosen for the literature review (state of the art). Students' own ideas for research topics are welcome, and where appropriate, students are encouraged to select topics relevant to the work they have been or expect to be doing in their home institute. The possibility of incorporating projects actually being undertaken in the students' institute will be considered. Supervisors will in any case offer several possible topics that make use of the wide range of modern equipment available in the different institutions laboratories.

Ideally, discussions on the outline of the project should be completed by the end of the second semester, in order to assemble any necessary equipment, and define the literature review subject appropriately. Particular urgency for early planning exists for projects involving work on research vessels. The pattern of research projects varies widely, with opportunities to acquire a variety of skills in using the many research tools available. In addition, students are required to pursue programming courses given Information Services in preparation for the data reduction phase of their projects. The dissertation, submitted at the end of the project, should contain a clear and concise account of the experimental programme as well as a full discussion of the results and their relation to existing knowledge. The assessment of the written account (together in some cases, with a viva voce examination) constitutes 33% of the total for the course. Students are advised to give the fullest attention to its preparation and presentation.

6. Estimated Budget Description

The two year Master programme on Underwater Acoustic Technology and Remote Sensing (MAS) requires the expertise of researchers and professors actively involved in the field. The UPC Campus of Vilanova I la Geltrú include two research laboratories (SARTI and LAB) fully dedicated to marine technologies as well as a research group (GREC) whose expertise on Artificial Intelligence and Robotics efficiently complete the UPC offer within the frame of this Master. However, due to the master very high level proposed, professors will have to be contracted mainly part-time contracts, to cover the different fields.

The MAS has clearly the vocation to receive the label "Erasmus Mundus" from the European Commission and has designed its programme together with two prestigious institutions: The University of Wales, Bangor and the ENSIETA, France. Due to the French legislation on Master programmes and Grandes Écoles d'Ingénieurs, the ENSIETA will not be able during the first and second cycle to teach their modules within their institutions although this will be implemented for the third. The students will nevertheless be offered the same number of final research projects to be supervised and hosted *in situ*. This leads to an intermediate situation where the ENSIETA professors will come to Vilanova i la Geltrú to teach (4 x 15 days). The ENSIETA will cover their salary but the UPC will have to pay their travel expenses estimated to be around 10.000 euros/year if accommodated or 20.000 euros/year if they have to pay their hotel

Under the Erasmus Mundus perspective, the MAS has to present an homogeneous content, same evaluation process and the same registration fees. For the time being, these fees are estimated to be 6.000€/student/master. We can expect an average student number of around 15-20 students per year, equivalent to an income of 90.000-120.000€ per master (two years) or 45.000-60.000€ per year to be divided between the three institutions involved (15.000-20.000€ per year/institution).

Regarding other expenses, the use and consumable equipment of the UPC laboratories as well as the subcontract of the UTM (Unidad de Tecnología Marina) from the CSIC for practical boat trips (Garcia del Cid) is estimated to be around 20-30.000 euros per year.

The promotion of the programme will be conducted through the design of a website whose cost is estimated to be around 3.000 euros and there will also be some administration expenses (part-time secretary).

7. UPC laboratories Description

SARTI (http://www.cdsarti.org/)

1.- Equipos para el diseño de sistemas electrónicos de instrumentación

- Sistemas de emulación para microprocesadores de 8, 16 y 32 bits.
- Sistema fabricación placas circuito impreso y circuitos electrónicos.
- Sistemas de adquisición de datos
- Instrumentación de banco de trabajo

- Sistemas portátiles de test y medida. (Osciloscopio, multimetros, etc.)

2.- Equipos calibración transductores

- Patrones de parámetros eléctricos y ambientales
- Cámaras para test y medida de temperatura y humedad
- Sismómetros terrestres y marinos. Mesa para medida de vibraciones
- Acondicionador y analizador de señal para transductores acústicos
- Hidrófonos

3.- Equipos para medidas de Radio Frecuencia y señales acústicas

- Analizadores de espectro fijo y portátil
- Generador de Radio frecuencia
- Equipos de pre-certificación EMI
- Medidas acústicas de aislamiento y ambientales. Generadores y receptores
- Sistemas de verificación de cableado. Fibra óptica

4.- Equipos electrónica de potencia

- Fuentes alimentación continua alta potencia 100A/160V
- Cargas programables alta potencia 28A/100V
- Analizadores y generadores de AC
- Amplificadores de potencia

Laboratori d'Aplicacions Bioacústiques (LAB) (http://www.lab.upc.es)

Transducers and Amplifiers

BRÜEL & KJAER Type 2713 Power Amplifier	100V RMS, 1A into Capacitive Load Frequency Range : 10Hz-200kHz Voltage Gain: 0-60dB in 10 dB steps Switchable maximum output voltage limits Circuit protection against overload	Driving the Standard Hydrophone Type 8100 as a projector Driving electrostatic actuators at high voltage levels As general purpose power amplifier for capacitive piezoelectric transducers
BRÜEL & KJAER Type 8104 Standard Measuring Hydrophone	Frequency Range : 0,1Hz to 125kHz Sensititvity calibration traceable to NBS Flat frequency response over wide range Receiving sensitivity of each hydrophone individually calibrated Maximum working pressure 40 ato. (400m ocean depth) Working temperature: -40 to 120 deg. C Omnidirectional over wide frequency range Shielded element construction Monel mounting support for corrosion resistance Absolutely waterproof moulded neoprene construction Low-noise low capacitance integral cable to MIL-C-915 A	Calibration reference standard Underwater sound measurement Laboratory measurements and gases
ITC-1080 Spherical Hydrophone	Frequency range: 1Hz – 350kHz Capacitance: 1500pF Omnidirectional +/- 2dB 6,000 ft operational	
BRÜEL & KJAER Type 8101 General Purpose Hydrophone	Frequency range 1Hz-125kHz Built-in solid-state preamplifier High sensitivity –184 dBV re 1 uPa (-84dBV re 1ubar) Each hydrophone individually calibrated Insert voltage calibration facility Inherent noise near Wenz's lowest ambient Maximum working pressure 40 ato or 400m ocean depth Working temperature -10 deg C to	General purpose underwater sound measurements Laboratory measurements in liquid and gases Educational experiments

	65 deg C Waterproof moulded neoprene construction Low-noise, low capacitance waterblocked cable to MIL-C-915A	
BRÜEL & KJAER Type 8103 Hydrophone	Very wide frequency range 0.1Hz to 200kHz Very small size (50x9.5mm) Double shielded low noise integral cable Working temperature –40 to 120 degC	Waterborne sound measurements Calibration reference standard Ultrasonic measurements in liquids Investigation of marine animal noise Laboratory and industrial measurements in liquids and gases Sound measurements in water tanks Underwater projector Educational experiments Noise measurements in humid and polluted atmospheres
Cetacean Research Technology C54 preamplified hydrophone	Frequency response 14Hz to 60kHz and 100kHz to250kHz Sensitivity : -165dBV re 1uPa Maximum depth: >1500m Omnidirectional in the horizontal plane	
Marshall Acoustics four channel towed hydrophone array	High stength 100 metre salt water and UV resistant signal and power cable Two hydrodynamic PU moulded and mechanically uncoupled modules Two high sensitivity embedded preamplified PVDF sensors per module (-160dBVre 1uPa) Omnidirectional in transverse plane 6th order 10Hz-40kHz band-pass filter Weight < 70kg Wheeled on portable stainless steel wheel 4 independant low impedance outputs 2 headphone outputs with independant volume control Battery operated	Acoustic localisation of underwater wideband sound sources Noise measurements Education and research tool for underwater sound localisation system development

Signal Conditioning

2 x BRÜEL & KJAER Type 2635 Conditioning Amplifier	Charge input 3 digit conditioning to transducer sensitivity Unified output ratings for simplified system calibration High sensitivity up to 10V/pC Built-in integrators for displacement and velicity Switchable low and high frequency limits Built-in test oscillator
LAB 8-Channel battery operated wideband preamplifier	2 amplifier stages including one submersible with 20dB gain On-board 40 and 60 dB additional gain Battery operated 8 differential inputs 4th order 1kHz high-pass filter with +/- 0.5 dB in pass-band 4th order 150kHz low-pass filter with +/- 0.5 dB in pass-band
Neurophysiological signal preamplifier	One differential channel Selectable low and high-pass filter 100dB gain low-noise
BRÜEL & KJAER Type 2606 & 2608 Measuring Amplifiers	One input , preamplified or direct Input Attenuator: 50 -150dB Output Attenuator:-50 - 0dB Gain Control adjustment knob
Low Noise BK 8101 Preamplifier	Battery operated 20-40-50-60 dB gain Max 2.6 V output

Data Acquisition and Recording

IOTECH Wavebook 516	Up to 1-MHz sampling with 12- or 16-bit resolution 8 differential inputs, expandable to 72 1-µs channel scanning of any combination of channels Up to 1-MHz streaming to RAM Up to 700-kHz continuous streaming to disk 128-location programmable channel/range sequencer DSP-based design provides real-time digital calibration on all channels Single & multichannel analog triggering with programmable level & slope Digital TTL-level and pattern triggering Pulse Trigger External Clock

	Programmable pre- & post-trigger sampling rates Eight or sixteen 1-MHz digital inputs Connects to portable PC via Parallel port and PC Card Battery powered
SONY DAT TCD-D10 PRO II	Battery powered professional portable stereo DAT recorder Balanced switchable mic/line inputs Built-in hours meter, microphone low cut filter and microphone attenuator/limiter AES/EBU digital I/O Built-in speaker Absolute time recording Hi-speed search using the ID recorded in subcode area Frequency response: 20 - 22,000Hz S/N +85dB; Dynamic range +85dB Distortion less than 0.06%
Bittware Audio PMC+ 8 channel 96kHz DAQ board	8 channels of 96 kHz audio input: 24-bit analog and/or AES digital 8 channels of 96 kHz, 24-bit audio output with AES analog and digital outputs Input sample rate converters Lock to master AES input, external word clock, or local oscillator Supports SPDIF connections RS-232 control port 4-signal TDM serial port host interface on PMC+ 16 MB SDRAM processing/delay buffer Dual embedded 60 MHz ADSP-21065L SHARC DSPs 2 MB FLASH memory with auto-boot for standalone operation SharcFIN 64-bit, 66 MHz PCI interface Drivers for Windows and Linux with additional development tools available
Racal 7DS tape recorder	7 channels IN/OUT FM and Direct Recording 300Khz max Analog bandwidth on each channel Tape speed:1 7/8, 3 3/4, 7 1/2, 15, 30 and 60 in/s Tape width: 6.25 mm (1/4 in) Max flutter 0.55% Weight 22kg
Nagra IV-SJ portable recorder	2 channels and FM 35kHz max Analog bandwidth Tape speed:1 1/2, 3 3/4, 7 1/2, 15 in/s Tape width: 6.25 mm (1/4 in) Battery autonomy: 11 hours with mic in, 26 hours direct Weight 7.3kg

Laboratory R&D Equipment

HP/Agilent 33120A Arbitrary Function Generator	High-performance synthesized function generator 100 µHz to 15 MHz operation Features sine,triangle,square,ramp,and noise waveforms

	Sin (x)/x, exponential rise/fall, heartbeat and DV volts 12-bit,40 MSa/s,16 k-deep arbitrary waveform generator Internal sweep and modulation capabilities AM, FM, FSK & Burst modulation V peak to peak, V RMS and dB outputs 50 ohm output impedance
Oscilloscope Tektronix TDS 2014	100Mhz Bandwidth 4 Channels, External trigger input 1GS/s on each channel
Khron-Hite 4030R Oscillator	Frequency Selection: 0.1 - 99.9 / 100 - 999 / 1000 - 9990 / 10 000 - 99 900 Hz Accuracy (resp.): 0.1 - 1 - 10 - 100 Hz Voltage: 10Vrms open-cicuit / 5 Vrms in 200 Ohms Current: 30 mA max Power: 125 mW max from each output simultaneously into 200 Ohms Internal Impedance: Constant 200 and 600 Ohms
Rockland Dual HI-LO Filter Model 852	0 to 10,000 Hz Hi-Low Pass switches 0 or 20dB gain Falt Amplitude or Flat Delay switch 2 channels