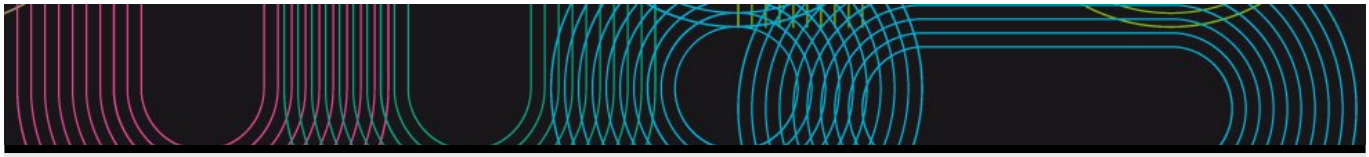

IDENTIFYING DATA				
Observation systems				
Subject	Observation systems			
Code	O07M189V01104			
Study programme	Máster Universitario en Sistemas Aéreos no Tripulados			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	6	Mandatory	1st	1st
Teaching language	#EnglishFriendly Spanish			
Department				
Coordinator	Salgueiro Piñeiro, Jose Ramon			
Lecturers	González Jorge, Higinio Salgueiro Piñeiro, Jose Ramon			
E-mail	jrs@uvigo.es			
Web	http://www.galiciadrones.es/			
General description	This subject presents an overview of drone observation systems based on both active and passive sensors.			

Skills	
Code	
A1	Possess and understand knowledge that provides a basis or opportunity to be original in the development and/or application of ideas, often in a research context
A2	That students know how to apply their acquired knowledge and problem-solving skills in new or unfamiliar environments within broader (or multidisciplinary) contexts related to their area of study.
A3	That students are able to integrate knowledge and face the complexity of making judgments based on information that, being incomplete or limited, includes reflections on the social and ethical responsibilities linked to the application of their knowledge and judgments.
A5	That students possess the learning skills that will enable them to continue studying in a manner that will be largely self-directed or autonomous.
B4	That students acquire the knowledge to develop unmanned aerial systems and plan specific operations, depending on the existing needs and apply the existing technological tools.
B5	That students are able to apply, in the field of unmanned aerial systems, the principles and methodologies of research such as literature searches, data collection, data analysis and interpretation, as well as the presentation of conclusions, in a clear, concise and rigorous manner.
C2	Knowledge of geomatics, photogrammetric and cartographic principles, navigation, aerotriangulation, interpretation and digital image processing necessary in the operation of unmanned aerial systems and know how to apply the regulations in force.
C4	Ability to develop a technical project in the field of unmanned aerial systems engineering.
D2	Ability to communicate orally and in writing in Galician.
D6	Ability to work as part of a team.
D7	Organizational and planning skills.
D8	Capacity for analysis and synthesis.
D9	Critical thinking skills and creativity.

Learning outcomes	
Expected results from this subject	Training and Learning Results

NewTo know the different passive and active sensors existing in aerial applications.	A1 A2 A3 A5 B4 B5 C2 C4 D2 D6 D7 D8 D9
Understand sensor calibration procedures.	A1 A2 A3 A5 B4 B5 C2 C4 D2 D6 D7 D8 D9
Algoritmos básicos de procesamiento de imagen y procesamiento de datos LiDAR	A1 A2 A3 A5 B4 B5 C2 C4 D2 D6 D7 D8 D9

Contents	
Topic	
1. Introduction to observation systems	Motivation. Applications. Basic components of a sensor. Relevant spectral regions. Integration of sensors in UAVs
2. Radiation measurement	Ways to describe radiation propagation. Electromagnetic theory. Harmonic waves. Types of waves. Propagation of electromagnetic waves. Wave energy flow. Radiometric magnitudes and units. Photometric magnitudes and units.
3. Radiation sources	Types of radiation sources. Ratiative processes: emission and reflection. Thermal sources. Kirchhoff's law. Reflection types. Lambertian sources. Source-sensor radiation transfer. Atmospheric transmission.
4. Radiation detectors	Types of radiation detectors. Photon detectors. Architectures of photon detectors. Colour detectors. Thermal detectors. Microbolometers. Noise sources.
5. Optical systems	Centered systems. Perfect system. Abbe and Herschel conditions. Paraxial optics. Cardinal elements. Coupling of optical systems. Lenses and mirrors. Aberrations. Aperture and field stops. Resolution of optical systems.
6. Image sensors	Optical systems for cameras. Transversal and angular fields. Onjective basic design: telescope and wide angle. Image plane irradiance. Image resolution and sharpness. Image acquisition from UAVs. Responsivity and detectivity. Sensor sensitivity: figures of merit. Space resolution: PSF and MTF.
7. Thermal imaging	Types of thermographic systems. Output signal. Detector's general response. Image evaluation: figures of merit. Spatial resolution. Measuring instantaneous field of view. Applications.

8. Spectral imaging	Multiespectral and hyperespectral systems. Classification of hyperespectral systems. Spectral variables. Separation systems. Interference band filters. Diffraction gratings. Fourier transform spectrometers.
9. RADAR systems.	RADAR basics. Synthetic Aperture Radar (SAR). RADAR as an remote sensing system. Measurement of deformations with RADAR.
10. LiDAR systems.	Fundamentals. Time-of-flight LiDAR systems. Phase difference LiDAR systems. Solid state LiDAR systems. Calibration of LiDAR systems. Measurement procedures. Point clouds.
11. Integration of remote sensing and navigation system.	Fundamentals of navigation systems. GNSS and INS systems. Integration with passive optical systems. Integration with active optical systems
12. Data analysis and image processing	Metadata. Digital image. Image definition. Object recognition and tracking. Image processing. Photogrammetry. Point cloud processing

Planning

	Class hours	Hours outside the classroom	Total hours
Lecturing	21	21	42
Practices through ICT	21	87	108

*The information in the planning table is for guidance only and does not take into account the heterogeneity of the students.

Methodologies

	Description
Lecturing	The lecturer presents the contents of the subject using projection methods for the supporting graphic material and also attending questions formulated by the students during the presentation.
Practices through ICT	The lecturer explains the tasks to develop at the laboratory and help the students to handle the instruments and follow the necessary procedures.

Personalized assistance

Methodologies	Description
Lecturing	Mail. Videoconferencing.
Practices through ICT	Mail. Videoconferencing.

Assessment

	Description	Qualification	Training and Learning Results			
Lecturing	The theoretical contents of the subject will be evaluated by means of two partial exams.	50	A1 A2 A3 A5	B4 B5	C2 C4	D2 D6 D7 D8 D9
Practices through ICT	The practices will be evaluated on the basis of the solved exercises that the students will have to hand in to the teacher.	50	A1 A2 A3 A5	B4 B5	C2 C4	D2 D6 D7 D8 D9

Other comments on the Evaluation

Sources of information

Basic Bibliography

Complementary Bibliography

Grant, Barbara G., **Getting Started with UAV Imaging Systems**, SPIE, 2016

Holst, Gerald C., **Common Sense Approach to Thermal Imaging**, SPIE, 2000

Wolfe, William L., **Introduction to Imaging Spectrometers**, SPIE, 1997

Martínez-Corral, M., **Instrumentos ópticos y optométricos: teoría y prácticas**, Universidad de Valencia, 1998

Mejías Arias, P., Martínez Herrero, Rosario, **Óptica geométrica**, Síntesis, 1990

Hecht E., **Óptica**, Addison Wesley, 2000

Grant, Barbara G., **Field Guide to Radiometry**, SPIE, 2011

Palmer, James M. and Grant, Barbara G., **The Art of Radiometry**, SPIE, 2009

Slater, P. N., **Remote Sensing: Optics and optical systems**, Addison-Wesley, 1980

Willers, Cornelius J., **Electro-Optical System Analysis and Design: A Radiometry Perspective**, SPIE, 2013

Dereniak, Eustace L., **Optical radiation detectors**, John Wiley & Sons, 1984

Burbano de Ercilla, S., **Física General**, Mira, 1990
Born M., Wolf E., **Principles of optics: electromagnetic theory of propagation, interference and difraction of light**, Cabridge University Press, 1999
Muñoz-Rodríguez J. A., **Laser scanner technology**, InTech, 2012
Chen Z., **The application of airborne LiDAR data in the modelliing of 3D urban landscape ecology**, Cambridge Scholars Publishing, 2017
Clough D., **Earth observation systems for resource management and environmental control**, Springer, 2013
Fitch J. P., **Synthetic aperture RADAR**, Springer, 1988
Maitre H., **Processing of synthetic aperture RADAR images**, Wiley, 2008
Richards J. A., **Remote sensing with imaging RADAR**, Springer, 2009
Holvecz F., Pasquali P., **Land applications of RADAR remote sensing**, InTech, 2014

Recommendations