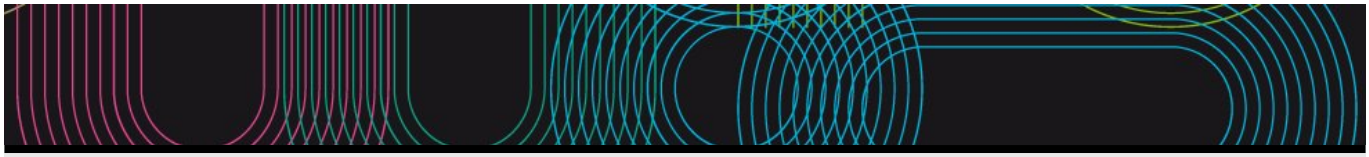

IDENTIFYING DATA				
Observation systems				
Subject	Observation systems			
Code	O07M189V01104			
Study programme	Máster Universitario en Sistemas Aéreos no Tripulados			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	6	Mandatory	1st	1st
Teaching language	#EnglishFriendly Spanish			
Department				
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.			

Training and Learning Results	
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.

Expected results from this subject	
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	A series of exercises along the teaching period will be proposed, to be done by students and submitted before a dead line. They will contribute to the global note in the same proportion and will totally represent a 30% of the total score of the subject. These proofs will be recoverable, just submitting the problems before the day of the official examination.	30	A1 B4 C2 D2 A2 B5 C4 D6 A3 D7 A5 D8 D9
Practices through ICT	This part will be evaluated by means of different proofs. The laboratory work will represent a 40% of the total score for the subject. On the other hand, a report or work related to the laboratory activities to be submitted by the students before a dead line will represent a 30% of the score. The laboratory work will not be recoverable. Reports will be recovery just submitting them before the date of the official examination.	70	A1 B4 C2 D2 A2 B5 C4 D6 A3 D7 A5 D8 D9

Other comments on the Evaluation

The student has the right to opt for the global assessment according to the procedure and the deadline established by the centre for each call. In this case the student will make an examination containing problems, exercises and questions related to the different parts of the subject, including questions related with the laboratory part.

The student submitting neither of the exercises nor any laboratory report will obtain the mark "not pressented".

Second call evaluation and end-of- evaluation will be done in the same way as in the first call: students will have to submit the problems and the laboratory reports. The students who have skipped the laboratory sessions will also undertake an additional proof with questions and problems related to the experimental work, which will represent a 40% of the whole subject.

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

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

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

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Born M., Wolf E., **Principles of optics: electromagnetic theory of propagation, interference and difraction of light**, Cabridge University Press, 1999

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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