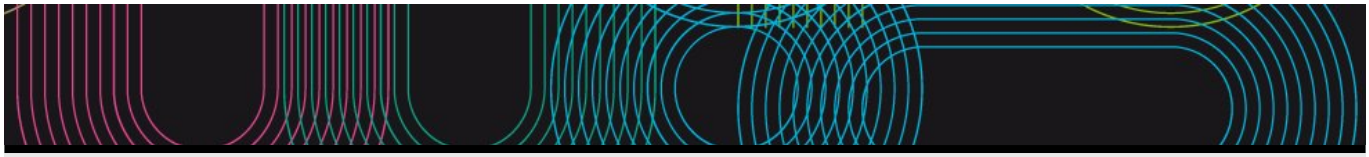

IDENTIFYING DATA				
(*)Cargas útiles baseadas en sensores pasivos				
Subject	(*)Cargas útiles baseadas en sensores pasivos			
Code	O07M174V01201			
Study programme	Máster Universitario en Operaciones e Ingeniería de Sistemas Aéreos no Tripulados			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	6	Optional	1st	2nd
Teaching language	Spanish Galician			
Department				
Coordinator				
Lecturers				
E-mail				
Web	http://aero.uvigo.es			
General description	Aims a description and basic study of sensing systems, particularly image systems, which can be installed on unmaned aerial vehicles, and their most relevant applications. International students may request from the teachers: a) materials and bibliographic references in English, b) tutoring sessions in English, c) exams and assessments in English.			

Training and Learning Results	
Code	
A3	That the students be able to integrate knowledge and face the complexity of formulating judgments from information, which being incomplete or limited, includes reflections on social and ethical responsibilities linked to the application of their knowledge and judgments
A4	That the students know how to communicate their conclusions - and the latest knowledge and reasons that support them - to specialized and non-specialized audiences in a clear and unambiguous manner
A5	That students have the learning abilities that allow them to continue studying in a way that will have to be largely self-directed and autonomous
B3	That students acquire the capabilities to analyze the needs of a company in the field of unmanned aerial systems and determine the best technological solution for the same
B4	That the students acquire the knowledge to develop unmanned aerial systems or to plan specific operations, depending on the existing needs and to apply the existing technological tools
B5	That students know and be able to apply the principles and methodologies of research, such as bibliographical searches, data collection and analysis and interpretation thereof, as well as the presentation of conclusions, in a clear, concise and rigorous way
D2	Ability to communicate orally and in writing in Galician
D6	Ability to work as a team
D7	Capacity for organization and planning
D8	Ability of analysis and synthesis
D9	Capacity for critical reasoning and creativity

Expected results from this subject	
Expected results from this subject	Training and Learning Results
Know the different passive sensors existent in aerial applications	A3 A5 B4 D2 D8

Understand the procedures to calibrate sensors	A3 A4 A5 B4 B5 D2 D8 D9
Learn to mechanically integrate sensors: implementation of boresighting and use of gimbal and synchronization	A3 A4 B3 B4 D2 D6 D7 D8 D9
Apply algorithms for aerial image processing and fotogrametry, image classification, object follow-up, filters and video processing	A3 A5 B3 B4 B5 D2 D6 D7 D8 D9
Know how to integrate images in geographic information systems	A3 A4 A5 B4 D2 D7 D8 D9

Contents	
Topic	
Sensors for UAVs	Motivation. Applications. Specific aspects of sensing using UAVs. Technologies for sensors in UAVs. Sensor basic components. Spectral regions of interest. UAV platforms for sensing. Integration of sensors in UAVs: gimbal systems. Image sensing in UAVs
Radiation: measurement and detection	Propagation of electromagnetic radiation. Light rays and wavefronts. Power flux. Radiometric magnitudes and units. Radiation sources: emission and reflection. Kirchoff's law. Lambertian sources. Atmospheric transmission. Photon detectors: CCD and CMOS sensors. Thermal detectors. Sources of noise.
Optical systems	Centered system. Conjugate points. Perfect system. Abbe and Herschel conditions. Paraxial optics. Cardinal elements. Optical system coupling. Lenses. Mirrors. Aberrations. Aperture and field stops. Resolving power of optical systems.
Sensors of image	Optical systems for cameras. Transversal and angular field. Basic design of lenses: teleobjetive and wide-angular lenses. Image plane irradiancie. Horizontal and vertical view fields. Instantaneous field of view. Image systems for UAVs. Signal to noise ratio. Noise equivalente power, radiance and irradiancie. Noise equivalente differential reflectance. Spatial resolution: PSF and MTF.
Thermografic image	Thermal detectors. Emittance and atmospheric transmission. Thermal contrast. Noise equivalent temperature difference. Thermal resolution. Thermographic systems for UAVs. Applications.
Multispectral image	Multispectral and Hyperspectral systems. Spectral image. Image at the focal plane. Spectral systems for UAVs. Band filters. Prism separation. Interferometers. Fourier transform spectrometers. Diffraction grating spectrometers.
8. Analysis of data and image processing	Metadata. Digital image. Motion video. Image definition. Object recognition and tracking. Image quality scale (NIIRS). Probability discrimination. Atmospheric correction. Image processing. Photogrammetry.

Planning

	Class hours	Hours outside the classroom	Total hours
Lecturing	10	0	10
ICT suppoted practices (Repeated, Dont Use)	22	22	44
Mentored work	7	63	70
Report of practices, practicum and external practices	0	10	10
Problem and/or exercise solving	3	13	16

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

Methodologies

	Description
Lecturing	Content presentation in the classroom
ICT suppoted practices (Repeated, Dont Use)	Use of specific sensing equipment (RGB cameras, thermograhic cameras, espectral cameras, etc) on UAV platforms and realization of proofs in flights.
Mentored work	Proposal of problems, activities or projects related to the contents of the subject that the students should develop by means of design, calculation and/or simulación.

Personalized assistance

Methodologies	Description
ICT suppoted practices (Repeated, Dont Use)	Personal interviews and remote attention by means of the email
Mentored work	Personal interviews and remote attention by means of the email

Assessment

	Description	Qualification	Training and Learning Results		
ICT suppoted practices (Repeated, Dont Use)	The students will owe to deliver a report on each experience or proposed activity.	50	A3 A4 A5	B3 B4 B5	D2 D6 D7 D8 D9
Mentored work	The students will owe to solve propossed problems.	50	A3 A4 A5	B3 B4 B5	D2 D6 D7 D8 D9

Other comments on the Evaluation

Sources of information

Basic Bibliography

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

Grant, Barbara, **Field Guide to Radiometry**, SPIE, 2009

Holst, Gerald C., **Common sense approach to thermal imaging**, SPIE, 2000

Wolfe, William L., **Introduction to imaging spectrometers**, SPIE, 1997

Complementary Bibliography

Slater, P. N., **Remote sensing: optics and optical systems**, Addison Wesley, 1980

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

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

Willers, Cornelius J., **Electro-optical system analysis and design: aradiometry perspective**, SPIE, 2013

Chuvieco, Emilio, **Fundamentos de teledetección espacial**, segunda ed., Ediciones Rialp, 1995

Hays, James, **Computer Vision**,

Shenk, T., **Introduction to Photogrammetry**,

A Brief Introduction to Photogrammetry and Remote Sensing,

Introducción a la fotogrametría,

Olaya, Victor, **Sistemas de información geográfica**, 2014

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

Mejías Arias, P. et al., **Óptica geométrica**, Síntesis, 1999

Hetch, E., **Óptica**, tercera ed., Adison Wesley, 2000

Recommendations

Subjects that continue the syllabus

External internships/O07M174V01205
Final Dissertation/O07M174V01206

Subjects that it is recommended to have taken before

Fundamentals of unmanned aerial systems/O07M174V01101
Unmanned aerial systems operations/O07M174V01102
On-board sensors/O07M174V01104
Radio communication and navigation systems/O07M174V01103
Sistemas de control/O07M174V01105