Universidad de Alcalá

TEACHING GUIDE

Remote Sensing: technologies and applications

Master in
Telecommunication Engineering

Universidad de Alcalá

Academic Year 2021/2022

2nd Year - 1st Semester

Approved by the School Board on July 6, 2021

TEACHING GUIDE

Course Name:	**Remote Sensing: technologies and applications**
Code:	**201828**
Master in:	**Telecommunication Engineering**
Department and area:	**Teoría de la Señal y Comunicaciones** **Teoría de la Señal y Comunicaciones**
Type:	**Optional (Specialized)**
ECTS Credits:	**6.0**
Year and semester:	**2nd Year, 1st Semester**
Teachers:	Por definir
Tutoring schedule:	Consultar al comienzo de la asignatura
Language:	Spanish / English Friendly

1. COURSE SUMMARY

In this course the student will learn the physical principles and the characteristics of the most important remote sensors used in Earth Observation, the technologies involved and the properties of the signals involved in transmission and reception. Different technological contexts will be covered, most particularly the European Copernicus Programme, i.e. the former GMES (*Global Monitoring for Environment and Security*). Earth Observation will be studied both for the visible and infrared spectrum regions and the microwave domain, in passive as well as in active technologies. Signals of Opportunity will be also introduced at the end of the course. In all cases, reception and transmission chains will be analysed. Future trends will be studied to include cognitive radio and software-defined radio). Different aspects of signal processing will be studied in relation to the RX and TX chains. The perspective of applications oriented towards Security and Defence will be included.

After acquiring the aforementioned knowledge, the student will have a general view of the field that will allow him/her to understand the technological developments that reach from the ground breaking missions such as Landsat to the modern Sentinel missions from ESA, the Spanish PNOTS (Programa Nacional de Observación de la Tierra por Satélite) or the large number of missions the NASA keeps active at the moment. Spain has a prominent industrial sector in volume and market growth in the Space Sector, as reported by the ProEspacio commission at TEDAE (Asociación Española de Empresas Tecnológicas de Defensa, Aeronáutica, Seguridad y Espacio).

In addition to the Space segment, the course included the study of other systems that are placed on the surface of the Earth or at airborne platforms, or those observation systems that rely on signals of opportunity provide by telecommunication systems.

Preconditions y Recommendations:

This course has a methodological connection Sistemas de radiocomunicación y Radiodeterminación (201809) and benefits from the contents of Tratamiento digital de señales en comunicaciones (201811) and all other courses related to transmitters and receivers. Nevertheless, all necessary subjects will be introduced again in the course, which make it a self-contained one.

2. SKILLS

Basic, Generic and Cross Curricular Skills.

This course contributes to acquire the following generic skills, which are defined in the Section 3 of the Annex to the Orden CIN/355/2009:

en_CGT1 - Skill of analysis and synthesis.

en_CGT2 - Skill of organization and planning.

en_CGT3 - Skill to analyze and search for information from diverse sources

en_CB6 - To have and understand knowledges that provide a basis or opportunity to be original in the development and/or application of ideas, often in a research context

en_CB7 - That students know how to apply the acquired knowledge and problem-solving abilities in new or unfamiliar environments within broader (or multidisciplinary) contexts related to their area of study.

en_CB8 - That students be able to integrate knowledge and face the complexity of making

judgements based on incomplete or limited information that includes reflections on the social and ethical responsibilities linked to the application of their knowledge and judgements.

en_CB9 - That students be able to communicate their findings and the ultimate knowledge and reasons behind them to specialized and non-specialized audiences in a clear and unambiguous manner.

en_CB10 - That students have the learning skills that will enable them to continue studying in a way that will be largely self-directed or autonomous.

en_CT1 - Troubleshooting skill

en_CT3 - Skill to work in a team

en_CT5 - Motivation for quality

en_CT6 - Ability to integrate knowledge from different scientific areas

Professional Skills

This course contributes to acquire the following professional skills, which are defined in the Section 5 of the Annex to the Orden CIN/355/2009:

en_CTecTel14 - Ability to develop electronic instrumentation, as well as transducers, actuators and sensors

Learning Outcomes

After succeeding in this subject the students will be able to:

RA1. Understand the physical principles underlying Earth remote sensing mechanisms.

RA2. Understand and take into account the main standard constraints and general aspects of design, legislation and issues associated with space engineering.

RA3. Know how to specify, design, build, verify and document the software used in aerospace systems.

RA4. Ability to analyse and design the radio frequency blocks of a remote sensing system in its different architectures and future trends (e.g. cognitive radio and software defined radio).

RA5. Evaluate and understand the different possibilities of remote sensing as a tool for Earth observation for environmental purposes on the one hand, and for surveillance and defence on the other.

RA6. Understand the usefulness of the different remote sensing techniques in the study of the different geophysical processes and their interaction between them (atmosphere-ocean-terrain).

RA7. Identify the capabilities of the different bands commonly used in remote sensing (optical, infrared, microwave, etc.) in the synergistic study of geophysical phenomena.

3. CONTENTS

Contents Blocks	Total number of hours
Unit 1. Introduction to Remote Sensing Interaction of electromagnetic waves with matter. Interaction mechanisms for different regions of the spectrum. Introduction to applications. Types of sensors. Signal processing and image processing. Earth maps and models. WGS-84. Cartographic projections and coordinate systems. The UTM system.	6 hours
Unit 2. Principles of Operation. Types of sensors: active and passive. Propagation through clouds and rain. Propagation through atmospheric gases. Atmospheric windows. Concepts of spatial, spectral and temporal resolution. Orbits for satellite platforms.	6 hours
Unit 3. Detectors and missions in the visible, near-infrared (VNIR) and thermal infrared (TIR) spectra Planck's law. Spectral thermal signatures. Observation of the Earth's surface, the sea and the atmosphere. Types of sensors and detectors in VNIR and TIR. Low, medium and high resolution missions. Applications of VNIR and TIR sensors. Processing techniques: pre-processing, image enhancement and classification. Data transmission and storage.	6 hours
Unit 4. Microwave Sensors Operating principles. Radiometers. Antenna noise and temperature. Types of radiometers. Calibration of radiometers. Synthetic aperture radiometers Radar sensors Scatterometers. High distance resolution radar. Synthetic Aperture Radar (SAR). SAR processing.	14 hours
Unit 5. Signals of Opportunity for Remote Sensing	4 hours

Contents Blocks (Laboratory)	Total number of hours
Block 1. Remote Sensing in VNIR and TIR.	8 hours
Block 2. Remote Sensing and image processing.	8 hours
Block 3. Microwave Remote Sensing.	6 hours

4. TEACHING - LEARNING METHODOLOGIES. FORMATIVE ACTIVITIES.

4.1. Credits Distribution

Number of on-site hours:	60 hours
Number of hours of student work:	90
Total hours	150

4.2. Methodological strategies, teaching materials and resources

Theory sessions in the classroom	The classroom work sessions, in large groups, will consist of lectures, where the main concepts of the subject under study will be presented. The aim is to introduce the student to the theoretical foundations of the subject in a guided, sequential and reflective manner. The assimilation of these concepts will culminate with the putting them into practice both in the problem groups and in the laboratory. The support with teaching materials will be fundamental to create reflective learning environments, where student and teacher can undertake a critical analysis that allows the student to relate concepts in an autonomous way. The order of presentation of the contents will evolve from the simplest to the most complex, with the aim of avoiding a high degree of abstraction that could cause the student to lack interest in the subject. In any case, it is very convenient during the classroom work sessions to establish links with other subjects in the syllabus, and to provide possible experiences on the contents, which will help to capture the student's attention and encourage their interest in the subject. Classes will be taught in hybrid mode, i.e. face-to-face but with live streaming for those students who choose to take the course in a telepresence version. This will affect all teaching-learning sessions.

Practical learning through problem solving	Students will solve exercises proposed by the teacher, putting into practice the concepts covered during the classroom learning sessions. In the problem classes, student participation is fundamental, so after solving the proposed problems, they will be corrected in the classroom and the students will present the solution methods and results obtained. The aim is to complement the student's teaching-learning process, bringing them closer to the assimilation of the concepts and their application, emphasising that the analytical techniques to be used are tools and not objectives. The strategies to be adopted in these sessions will be aimed at encouraging certain habits in the student when faced with the resolution of a problem, namely: initial study, choice of the best resolution strategy and critical evaluation of the results obtained. Information and Communication Technologies may be used to support training activities (use of the Internet, forums, wikis and e-mail, materials available on e-learning platforms, etc.).
Practical learning in the laboratory	Practices and exercises carried out in the laboratory are another learning scenario. The work sessions will be carried out in small groups, in which the student must work in teams. The objective is for the student to explore the applicability of the concepts of the theory. To this end, the methodology will be as described below: Before each session, the student must read the script of the practice or the statements of the exercises and, where appropriate, carry out the previous questions or sections that are specified. • Within the laboratory, students will carry out the corresponding practical or exercise in groups of about 3 students. • With the results obtained during the performance of the practical or exercises, students will prepare a document following the indications of the script of the practical or the corresponding statements. PC-type computers with the necessary software and all the auxiliary material required for the practical exercises are available for the practical exercises.

5. ASSESSMENT: procedures, evaluation and grading criteria

Preferably, students will be offered a continuous assessment model that has characteristics of formative assessment in a way that serves as feedback in the teaching-learning process.

5.1. PROCEDURES

The evaluation must be inspired by the criteria of continuous evaluation (Learning Assesment Guidelines, LAG, art 3). However, in compliance with the regulations of the University of Alcalá, an alternative process of final evaluation is made available to the student in accordance with the Learning Assesment Guidelines as indicated in Article 10, students will have a period of fifteen days from the start of the course to request in writing to the Director of the Polytechnic School their intention to take the non-continuous evaluation model adducing the reasons that they deem convenient. The evaluation of the learning process of all students who do not apply for it or are denied it will be done, by default, according to the continuous assessment model. The student has two calls to pass the subject, one ordinary and one extraordinary.

Ordinary Call

Students will have the option of continuous assessment. In order to make use of the final assessment, students must apply in writing to the dean or director of the faculty within the first two weeks of the course, explaining the reasons that prevent them from following the continuous assessment system. In the case of students who, for justified reasons, have not formalised their enrolment on the starting date of the academic year or of the period in which the subject is taught, the period indicated will begin to run from the date of their incorporation to the degree course. The dean or director of the faculty or school must assess the circumstances put forward by the student and make a reasoned decision. If 15 working days have passed without the student having received an express written response to their request, it will be understood that the request has been accepted.

Continous Assessment:

The content and timing of the Continuous Assessment will be detailed at the beginning of each course in the Work Plan of the subject, which will include:

1. Production of laboratory practicals and exercises, and delivery of the corresponding documents with their resolution. The evaluation will consider systematic observation, where the teacher will record the main difficulties and skills observed in each student. Students must attend 100% of the laboratory sessions and hand in the corresponding reports for all laboratory practices and exercises. Recovery sessions will be available for those students who have not attended any of the sessions and justify it with documents. Students, in groups, will hand in the reports of the practicals and laboratory exercises following the calendar established in the subject's Work Plan.

2. Work will be carried out and presented in small groups. Each group will be responsible for the realization and presentation of one or two works: one on remote sensing with optical systems or on thermal infrared, and/or another on microwaves.

Assessment through final exam:

In the case of assessment by final exam, the assessment elements to be used will be the following:

1. Practical laboratory test.

2. Theoretical-practical written test.

Students are recommended to carry out the practical laboratory work and exercises during the four-month period. In this case, they will have the option of substituting the practical laboratory exam for the evaluation of the reports corresponding to the different practicals and exercises.

Extraordinary Call

The procedure will be the same as that described for assessment by final examination in the ordinary exam.

5.2. EVALUATION

EVALUATION CRITERIA

The assessment criteria measure the level in which the competences have been acquired by the student. For that purpose, the following are defined::

CE1. Understand the physical principles underlying Earth remote sensing mechanisms.

CE2. Ability to understand and take into account the main standard restrictions and general aspects of design, legislation and problems associated with space engineering.

CE3. Ability to specify, design, build, verify and document the software used in Earth observation systems, especially those involved in the ground segment.

CE4. Be able to solve quantitative problems.

CE5. Be able to communicate and transmit knowledge, skills and abilities, both in writing and orally.

GRADING TOOLS

Students must achieve the minimum pass mark independently in the laboratory and in the set of activities and tests related to the theoretical part of the subject (problem solving, completion of assignments and final exam). In the case of continuous assessment, the grade will be awarded taking into account the following percentages and considerations:The work of the student is graded in terms of the assessment criteria above, through the following tools:

1. Resolution of exercises and practical exercises (PL): 45%.
   Optical and infrared systems: 30%. Microwaves: 15%.

2. Completion of 1 or 2 small group assignments (TGR1): 40%. If there are 2:
   Optical and infrared systems: 20%. Microwaves: 20%.

3. Presentation of 1 or 2 of the work carried out (TGR2): 15%.

A grade of "Not presented" will be awarded to a student who, having opted for the continuous assessment procedure, fulfils any of the following requirements:

1. When the student has failed to attend at least 70% of the problem classes or laboratory practicals.
2. When the student has not handed in at least 70% of the work requested.

GRADING CRITERIA

In the ordinary call-continuous assessment the relationship between the competences, learning outcomes, criteria and evaluation instruments is as follows.

Skill	Learning Outcomes	Evaluation criteria	Grading Tool	Contribution to the final mark
CB7- CB10, CGT1-CGT3, CT1, CT3, CT5, CT6, CTecTel14	RA1, RA2, RA5, RA6, RA7	CE1, CE2, CE3, CE4, CE5	PL	45%
CB6, CB8, CB10, CG1, CGT2, CGT3, CT1, CT3, CT5, CT6, CTecTel14	RA1, RA2, RA5, RA6, RA7	CE1, CE2, CE4, CE5	TGR1-TGR2	55%

In the ordinary call-final evaluation, the relationship between the competences, learning outcomes, criteria and evaluation instruments is as follows.

Skill	Learning Outcomes	Evaluation criteria	Grading Tool	Contribution to the final mark
CB7-CB9, CGT1-CGT3, CT1, CT5, CT6, CTecTel14	RA3, RA4	CE1, CE3	EPL	30%
CB6, CB7, CB9, CB10, CGT1, CGT2, CT1, CT5, CT6, CTecTel14	RA1, RA2, RA5, RA6, RA7	CE1, CE2, CE4, CE5	ETP	70%

Extraordinary call

In the case of the extraordinary exams, the same percentages will be maintained as those established in the case of assessment by final exam, giving the option of taking the practical laboratory exam or maintaining the mark obtained in the laboratory practicals (continuous assessment) or in the practical exam (final assessment), depending on the student's decision. In any case, the practical exam will be taken by those students who have not taken it in the final exam option in the ordinary exam.

Students must achieve the minimum pass mark independently in the practical laboratory exam and in the written theoretical-practical exam.

Skill	Learning Outcomes	Evaluation criteria	Grading Tool	Contribution to the final mark
CB7, CB8, CB9, CGT1-CGT3, CT1, CT5, CT6, CTecTel14	RA3, RA4	CE1, CE3	EPL	30%
CB6, CB7, CB9, CB10, CGT1, CGT2, CT1, CT5, CT6, CTecTel14	RA1, RA2, RA5, RA6, RA7	CE1, CE2, CE4, CE5	ETP	70%

6. BIBLIOGRAPHY

6.1. Basic Bibliography

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- Elachi, C, van Zyl, J. - “Introduction to the Physics and Techniques of Remote Sensing”. John Wiley & Sons. Segunda Edición. 2006.
- Sabins, F. S., Ellis, J. M., "Remote Sensing. Principles, Interpretation, and Applications". Waveland Press, Inc. Cuarta Edición. 2020.
- Richards, J. A., "Remote Sensing Digital Image Analysis". Springer Verlag. Quinta Edición. 2013.
- Liang S., Wuang, J., "Advanced Remote Sensing. Terrestrial Information Extraction and Applications". Academic Press. Segunda Edición. 2020.
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- Cumming, I.G, Wong, F.H., “Digital Processing of Synthetic Aperture Radar Data: Algorithms and Implementation”, Artech House, 2004.

6.2. Additional Bibliography

- Landgrebe, D.A., “Signal Theory Methods in Multispectral Remote Sensing”, John Wiley & Sons, 2003.
- Ulaby, F.T., Moore, R.K., Fung, A.K. “Microwave Remote Sensing”. Artech House. Tres tomos. 1986.
- Ulaby, F.T, Dobson, M.C., Alvarez-Perez, J.L, "Handbook of Radar Scattering Statistics for Terrain", Artech House, 2019.
- Martin, S. “An Introduction to Ocean Remote Sensing”, Cambridge University Press, 2014.
- García Soto, C. (Ed.), “Oceanografía y Satélites”, Editorial Tébar, 2009.
- Revistas:
    - IEEE Transactions on Geoscience and Remote Sensing.
    - Remote Sensing of Environment
    - International Journal of Remote Sensing

Disclosure Note

The University of Alcalá guarantees to its students that, if due to health requirements the competent authorities do not allow the total or partial attendance of the teaching activities, the teaching plans will achieve their objectives through a teaching-learning and evaluation methodology in online format, which will return to the face-to-face mode as soon as these impediments cease.