Universidad de Alcalá

TEACHING GUIDE

Satellite Communications

Degree in
Telecommunication Systems Engineering (GIST)

Universidad de Alcalá

Academic Year 2023/2024

4th Year - 1st Semester (GIST)

Approved by the School Board on June 12th, 2023

TEACHING GUIDE

Course Name:	**Satellite Communications**
Code:	**390010 (GIST)**
Degree in:	**Telecommunication Systems Engineering (GIST)**
Department and area:	**Teoría de la Señal y Comunicaciones** **Signal and Communications Theory**
Type:	**Optional (Oriented) (GIST)**
ECTS Credits:	**6.0**
Year and semester:	**4th Year - 1st Semester (GIST)**
Teachers:	Check Department webpage
Tutoring schedule:	To be defined at the starting session
Language:	Spanish/ English Friendly

1. COURSE SUMMARY

The subject of Satellite Communications intends to introduce the context of satellite-based communications, and extend and apply thereon the previous knowledge about communication systems acquired in the subjects of Communication Theory, Digital Communications, and Radiation and Radiocommunication. To this end, the general aspects about satellite communications, like orbital parameters, positioning, and the characteristics of their constituting segments are introduced, including the detailed link design analysis. Additionally, the physical layer techniques specific to this context are examined, along with examples about supported services and applications.

This subject would be specially helpful for the Graduated in Engineering in Communication Systems working in the aerospace sector, because it provides an appropriate comprehension of the specific problems and trade-offs of this communication environment.

To get the best from this subject it would be necessary that the student had a sound previous knowledge about the subjects of Signal and Systems, Communication Theory, Digital Communications, Telecommunication Systems, and Radiation and Radiocommunication, acquired throughout the second and third academic years.

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/352/2009:

en_TR1 - Knowledge, understanding and ability to apply the necessary legislation during the development of the profession of Technical Engineer of Telecommunication and ease of handling specifications, regulations and mandatory rules.

en_TR2 - Knowledge of basic subjects and technologies that enables to learn new methods and technologies, as well as to provide versatility that allows adaptation to new situations.

en_TR3 - Aptitude to solve problems with initiative, decision making, creativity, and to communicate and to transmit knowledge, skills and workmanship, comprising the ethical and professional responsibility of the activity of the Technical Engineer of Telecommunication.

en_TR5 - Easy to handle specifications, regulations and mandatory standards.

en_TR6 - Ability to analyze and assess the social and environmental impact of technical solutions.

en_TR8 - Capacity of working in a multidisciplinary and multilingual team and of communicating, both in spoken and written language, knowledge, procedures, results and ideas related to telecommunications and electronics.

en_TRU1 - Capacity of analysis and synthesis.

en_TRU2 - Oral and written competencies.

en_TRU3 - Ability to manage information.

en_TRU4 - Autonomous learning skills.

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/352/2009:

en_CST2 - Ability to apply the techniques on which telecommunication networks, services and applications are based, both in fixed and mobile environments, personal, local or at a great distance, with different bandwidths, including telephony, broadcasting, television and data, from the point of view of view of the transmission systems.

en_CST3 - Ability to analyze components and their specifications for guided and non-guided communication systems.

en_CST4 - Capacity for the selection of circuits, subsystems and systems of radiofrequency, microwaves, radio broadcasting, radio links and radiodetermination.

en_CST5 - Ability to select antennas, equipment and transmission systems, propagation of guided and unguided waves, by electromagnetic means, radiofrequency or optical and the corresponding radioelectric space management and frequency assignment.

en_CST6 - Ability to analyze, encode, process and transmit multimedia information using analog and digital signal processing techniques.

Learning Outcomes

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

RA1. Identify and interpret the basic concepts and techniques in satellite based communication systems. This contributes to intensify the skills CST2 and CST5.

RA2. Recognise and apply the basic concepts and techniques for both analog and digital satellite communications: modulation process, noise, demodulation process. This contributes to intensify the skills CST2 and CST6.

RA3. Determine the fundamental parameters in a satellite communication system, and develop technical skills in the field of telecommunication technologies, emphasizing the mathematical analysis and characterization of a communication system. This contributes to intensify the skills CST2, CST3 and
CST4.

RA4. Determine and discriminate the advantages and inconveniences of different technological alternatives for deployment or implementation of satellite communication systems, from the point of view of its dimensioning, signal characterization, perturbation and noise, and the usage of analog and digital modulations. This contributes to intensify the skills CST3, CST4 and CST5.

RA5. Interpret the experimental results related to the course content. It contributes to intensify the skills TRU1 and TRU4.

3. CONTENTS

Contents Blocks	Total number of hours
Block 1. General aspects of satellite communications. Introduction. Historical evolution. General characteristics.	• 4 hours
Block 2. Orbital parameters of a communication satellite. Kepler laws. Orbital equations. Satellite localization. Types of orbits.	• 4 hours
Block 3. Positioning of satellites into orbit. Launch vehicles. Satellite positioning. Space environment.	• 4 hours
Block 4. Space segment. Subsystems. Attitude control. Orbital control. Energy. Thermal control. Structure. TTC&TM. Payload. Characteristics of the most usual electronic components.	• 8 hours
Block 5. Ground segment. Functions. Integrating parts. Antenna subsystem. TX/RX subsystem. Antenna orientation.	• 8 hours
Block 6. RF satellite link design. Power balance. Atmospheric effects. Attenuation and noise. Global C/N relation. Intermodulation. Interferences.	• 10 hours
Block 7. Optical satellite communications. Optical satellite links. Application in intersatellite networks. Application in Earth-satellite links.	• 8 hours
Block 8. Satellite transmitters and receivers. Applications. Physical layer design. Multiplexing and access techniques. Services and applications.	• 10 hours

4. TEACHING - LEARNING METHODOLOGIES. FORMATIVE ACTIVITIES.

4.1. Credits Distribution

Number of on-site hours:	58 hours (56 hours on-site +2 exams hours)
Number of hours of student work:	92
Total hours	150

4.2. Methodological strategies, teaching materials and resources

The formative activities used to develop the learning process are as follows:

1. Theoretical lesson.
2. Problem solving lesson.
3. Laboratory practical lesson using didactic equipment or PC simulations and calculations. Depending on the available resources and the circumstances, it would be necessary to create working groups.
4. Individual or collective works, accompanied by their corresponding public exposition, with participation of every member of the group in the case they are elaborated collectively.
5. Individual or group tutoring.

The theoretical lessons (3 ECTS), are magistral lessons using means like the blackboard or appropriate presentations. These theoretical lessons will be complemented with examples clarifying the concepts explained.

During these theoretical lessons, the student will acquire the course specific skills, excepting those explicitly involving practical or laboratory work. It is convenient that the student contributes with his/her personal or collective work in order to complement the knowledge introduced during lesson delivery (particular cases study, or hints provided by the teacher).

For the problem solving lessons (1,5 ECTS), the teacher will provide the student with a typical problem set, from which no more than the 50% will be selected to be solved in the classroom. The teacher will inform the students about which problems from the set will be solved during the ensuing session, so that the student may try to solve them in advance. The student should guarantee that all the doubts arisen during the problem resolution are duly solved.

For a better comprehension of the mental procedure followed to solve the problems, it would be convenient that the resolution in the blackboard is faced by the students themselves under the teacher's supervision, instead the opposite case, excepting for some particular situations. This would improve the interchange of critical opinions about the resolution process, as well as the final outcome.

Laboratory practical lessons (1 ECTS), using didactic equipment or PC simulations and calculations. These practices will be done by organizing the students into small workgroups. The teacher will provide guidelines for the practices, so that the students may prepare them in advance. During these lessons, the student should compare the expected theoretical results and the real results finally obtained, so that this may spark a discussion among the members of a group in order to find possible justifications, and a common conclusion after interchanging different opinions; all of this under the timely teacher's supervision, who should guarantee that the results are conveniently justified, or that different points of view are taken into account.

It is advisable that, during these lessons, the teacher let the students work by themselves with great freedom, so that they may find their own justifications.

The teacher will propose different works, to be done either individually or in groups (0,5 ECTS) depending on their complexity and involvement, with the intention to amplify or complement the information about the subject. The students should make a public presentation of their work for the rest of the classroom.

In the individual or collective tutoring sessions, the teacher could solve doubts, or clarify points about the subject. The students will have the possibility to establish a more personal communication, so that they can pose questions that may not be addressed practically in a larger group.

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 (Regulations for the Regulation of Teaching Learning Processes, NRPEA, 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 Regulations for the Evaluation of Apprenticeships (approved by the Governing Council on March 24, 2011 and modified in the Board of Directors). Government of May 5, 2016) 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.

1. Ordinary call:
    a. Continuous assessment: it consists in taking part in the laboratory practices, completing the final work and the final exam. The delivery of the laboratory practices and the final work will be addressed during the semester.
    b. Assessment through a final exam: it will consist in making a final exam.
2. Extraordinary call: there are two possible situations.
    a. If the student has done the work proposed during the semester, and chooses this option, the corresponding grading from the ordinary call for this part of the continuous assessment process call will be kept. The rest of the assessment will be made by means of a final exam.
    b. The student has not made the work proposed or chooses not to keep the grading obtained. The assessment will consist uniquely in a final exam.

To take part in the assessment through a final exam, the student should ask it by addressing a letter to the Dean, indicating the reasons why the student cannot follow the continuous assessment path. The Dean will inform about his/her resolution in a maximum of 15 days. In case there is no answer after this period, the pledge will be considered not accepted.

5.2. EVALUATION

EVALUATION CRITERIA

Respecting every evaluation instrument, both for the students opting to continuous assessment and for those opting to the final exam, in both the ordinary and extraordinary calls, the following criteria will be paid attention to:

CE1. The student exhibits analysis and synthesis capacity (TRU1).

CE2. The student exhibits autonomous learning capactity (TRU4).

CE3. The student is able to learn and apply the new knowledge acquired and appropriate techniques related to satellite communications (CST2, CST3).

CE4. The student is able to interpret and modify the code (corresponding to the software tools in use) related to the exercises proposed in the practical part, or similar ones (CST6).

CE5. The student is able to analyze and explain the fundamental parameters of a satellite

communication system (CST3, CST4, CST5).

CE6. The student is able to characterize the modulations, the medium access techniques and the main trade-offs of a satellite communication system (CST2, CST6).

CE7. The student applies the basic principles of satellite communications in different situations and for different environments (CST2, CST5, CST6).

GRADING TOOLS

The student has two possible calls to pass the subject, one ordinary and one extraordinary. In accordance with the norms regulating the learning evaluation processes -Consejo de Gobierno, 24th March 2011-, the evaluation will be developed continously along the semester, with the exceptions specified in the related norm, when the assessment will be made through a final exam. During the extraordinary call, the student assessment will be done through a final exam.

The continous assessment – ordinary call process will make use of the following grading tools:

- **E1. Delivery of proposed exercises (individually or in groups),** and delivery of the justified results of the laboratory practices, done individually or in groups.
- **E2. Delivery of an individual or collective final work,** together with its presentation during a public session.
- **PEF. Final written exam,** consisting in the resolution of problems and explanation of different questions related to the subject contents, as well as about its practical part.

The final assessment, both for the ordinary or extraordinary call, will make use of the following grading tools:

- **PEF. Final written exam,** consisting in the resolution of problems and explanation of different questions related to the subject contents, as well as about its practical part.

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
TRU1, TRU4, CST2, CST3, CST4, CST5	RA3, RA4, RA5	CE1, CE2, CE3, CE5, CE7	E1	30%
TRU1, TRU4, CST2, CST3, CST4, CST5	RA3, RA4, RA5	CE1, CE2, CE3, CE5, CE7	E2	30%
CST2, CST3, CST4, CST5, CST6	RA1, RA2, RA3, RA4	CE3, CE4, CE5, CE6, CE7	PEF	40%

The grade in the case of continuous assessment will be obtained by taking into account the grade of the diverse practices made during the semester. This part of the assessment acounts for 60% of the final grade. 30% of the grade corresponds to small periodic deliverables (E1) during the semester, linked to the practical part, and they could be individual or collective; an additional 30% of the grade corresponds to a major final work (E2) that will be made individually or in groups. The number, nature and periodization of these practices will be made known at the beginning of the course.

Respecting the grading of the practices made and handed in by the students, it will be valid what is

written in Article 34 of the Normativa de Evaluación (Consejo de Gobierno, 24th March 2011), respecting their originality and the appropriate citing and attribution policy. Any plagiarism, after identification, will have as consequence a null grade in the affected deliverable. If a student makes a delivery after a deadline, or fails to provide it altogether, he/she will get a null grade for the corresponding deliverable.

The additional 40% of the grade will be obtained by means of a final written exam (PEF), where the student would have to show an adequate knowledge about the subject, including its practical part, by means of questions related to the code or the simulation systems employed. A student not attending the final exam, in case he/she is in conditions of being considered as presented, will have a null grade in this part.

A student will be considered as presented in case he/she has provided assessment evidences amounting for more than 20% of the total grade of the subject.

In the case of final assessment – ordinary call, the relation among criteria, tools and grading is as follows.

Skill	Learning Outcomes	Evaluation criteria	Grading Tool	Contribution to the final mark
TRU1, TRU4	RA5	CE1, CE2	PEF	100%
CST2, CST5	RA1	CE3, CE5, CE6, CE7		
CST2, CST6	RA2	CE3, CE4, CE6, CE7		
CST2, CST3, CST4	RA3	CE3, CE5, CE6, CE7		
CST3, CST4, CST5	RA4			

Those students subject to the system of evaluation by means of a final exam, in the cases considered under the norms regulating the learning evaluation processes (Consejo de Gobierno, 24th March 2011), will obtain the 100% of the grade by means of a final exam (PEF), which will be equal to the final exam of the students subject to continuous assessment.

In the case of the extraordinary call – continuous assessment, the relation among criteria, tools and grading is as follows.

Skill	Learning Outcomes	Evaluation criteria	Grading Tool	Contribution to the final mark
TRU1, TRU4	RA5	CE1, CE2	PEF	100%
CST2, CST5	RA1	CE3, CE5, CE6, CE7		
CST2, CST6	RA2	CE3, CE4, CE6, CE7		
CST2, CST3, CST4	RA3	CE3, CE5, CE6, CE7		
CST3, CST4, CST5	RA4			

The students that have not passed in the ordinary call (be it through continuous assessment or through final exam) will have the right to attend the extraordinary call, consisting in a final written exam (PEF),

with the same characteristics of the final written exam of the ordinary call, by means of which the 100% of the grading will be obtained.

6. BIBLIOGRAPHY

6.1. Basic Bibliography

- **SPACE MISSION ANALYSIS AND DESIGN** Author: James R. Wertz, Publisher: Kluwer Academic Publishers
- **SATELLITE COMMUNICATIONS** Author: Denis Roddy, Publisher: McGraw Hill
- **SATELLITE COMMUNICATIONS APPLICATIONS HANDBOOK** Author: Bruce R. Elbert, Publisher: Artech House
- **SATELLITES: ORBITS AND MISSIONS** Author: S. Lyle, M. Capderou, Publisher: Springer (Available online through UAH library webpage)

6.2. Additional Bibliography

- **DIGITAL COMMUNICATIONS** Author: J.G. Proakis, Publisher: McGraw Hill
- **COMMUNICATION SYSTEMS ENGINEERING** Author: J.G. Proakis y otros, Publisher: Prentice Hall
- **COMMUNICATIONS SYSTEMS** Author: Simon Haykin Publisher: John Willie & Sons
- **DIGITAL MODULATION TECHNIQUES** Author: Fuqin Xiong, Publisher: Artech House

Disclosure Note

During the evaluation tests, the guidelines set out in the Regulations establishing the Rules of Coexistence of the University of Alcalá must be followed, as well as the possible implications of the irregularities committed during said tests, including the consequences for committing academic fraud according to the Regulation of Disciplinary Regime of the Students of the University of Alcalá.