ANX-PR/CL/001-01

LEARNING GUIDE

SUBJECT

93000811 - Satellite Communications

DEGREE PROGRAMME

09AQ - Master Universitario en Ingenieria de Telecomunicacion

ACADEMIC YEAR & SEMESTER

2019/20 - Semester 1

Index

Learning guide

1. Description

1.1. Subject details

Name of the subject	93000811 - Satellite Communications
No of credits	6 ECTS
Type	Optional
Academic year ot the programme	Second year
Semester of tuition	Semester 3
Tuition period	September-January
Tuition languages	English
Degree programme	09AQ - Master Universitario en Ingenieria de Telecomunicacion
Centre	09 - Escuela Tecnica Superior de Ingenieros de Telecomunicacion
Academic year	2019-20

2. Faculty

2.1. Faculty members with subject teaching role

Name and surname	Office/Room	Email	Tutoring hours *
Miguel Alejandro Salas Natera	C-411	miguel.salas@upm.es	Sin horario. Ask for tutorships via e-mail.
Ramon Martinez Rodriguez-Osorio (Subject coordinator)	C-411	ramon.martinez@upm.es	Sin horario. Ask for tutorships via e-mail.

* The tutoring schedule is indicative and subject to possible changes. Please check tutoring times with the faculty member in charge.

3. Prior knowledge recommended to take the subject

3.1. Recommended (passed) subjects

- Sistemas De Comunicaciones

3.2. Other recommended learning outcomes

- Communication networks and systems

- Radiocommunication

- Communication electronics

4. Skills and learning outcomes *

4.1. Skills to be learned

CE1 - Capacidad para aplicar métodos de la teoría de la información, la modulación adaptativa y codificación de canal, así como técnicas avanzadas de procesado digital de señal a los sistemas de comunicaciones y audiovisuales.

CE2 - Capacidad para desarrollar sistemas de radiocomunicaciones: diseño de antenas, equipos y subsistemas, modelado de canales, cálculo de enlaces y planificación.

CE4 - Capacidad para diseñar y dimensionar redes de transporte, difusión y distribución de señales multimedia.

CG4 - Que los estudiantes sepan comunicar sus conclusiones ?y los conocimientos y razones últimas que las sustentan? a públicos especializados y no especializados de un modo claro y sin ambigüedades.

CT3 - Capacidad para adoptar soluciones creativas que satisfagan adecuadamente las diferentes necesidades planteadas.

CT4 - Capacidad para trabajar de forma efectiva como individuo, organizando y planificando su propio trabajo, de forma independiente o como miembro de un equipo.

4.2. Learning outcomes

RA285 - Trade different alternatives of a satellite communication system considering orbits, performance, feasibility and cost

RA284 - Sizing of satellite communication systems

RA283 - Know satellite communication systems, including payload, platform, ground segment and communication services

RA288 - Get familiar with existing satellite communication systems and services, and global satellite navigation systems

RA289 - Elaborate technical reports and presentations to propose a feasible solution based on satellite communications

RA286 - Understand the impact of the satellite non-linear channel on the communication system performance

* The Learning Guides should reflect the Skills and Learning Outcomes in the same way as indicated in the Degree Verification Memory. For this reason, they have not been translated into English and appear in Spanish.

5. Brief description of the subject and syllabus

5.1. Brief description of the subject

The scope of this course is to provide a complete vision of satellite communication systems, from orbital used by artificial satellites to the optimization of satellite links. Beginning with the SatCom architecture, concepts related with orbits and constellations, satellite subsystems, communication payloads will be covered. Then, design and sizing of satellite communication links will be analyzed. Students will use all the concepts to carry out the design of a satellite communication system or the implementation of a specified service. Students will deal with advanced communication concepts, interference coordination and satellite link optimization. Course will cover GEO systems, as well as Medium and Low Earth satellites and constellations.

Different practical exercises and labs will be carried out along the course to consolidate the theoretical concepts, which will be related to existing systems.

In case it is feasible, a visit to a satellite control center or similar facility related to satellite communication system will be organized.

At the end of the course, students will have a clear understanding of the aspects that influence the design of a satellite communication system and will know to evaluate the fundamental trade-offs between satellite subsystems, communication payloads, ground segment, orbits and advanced transmissions concepts.

5.2. Syllabus

1. Introduction to satellite communication systems
2. Orbits and constellations used by artificial satellites
3. Architecture of satellite communication systems
   - 3.1. Platform and subsystems
   - 3.2. Communication payload. Transponder and antennas
4. Ground segment: control and user stations
   - 4.1. Ground station architecture and station types
   - 4.2. Antennas and radiofrequency elements
5. Communication techniques used in satellite communications
   - 5.1. DVB-S2 and DVB-S2x transmission systems
   - 5.2. Timing and carrier recovery techniques
   - 5.3. Techniques to improve capacity. Carrier-in-Carrier, etc.
   - 5.4. Techniques to improve availability
6. Design and optimization of satellite links
   - 6.1. Propagation
   - 6.2. Design and sizing of satelite links
   - 6.3. Interferences and coordination
   - 6.4. Optimization of satellite links
7. Satellite communication networking
8. Commercial satellite communication systems
   - 8.1. GEO systems. HTS and VHTS
   - 8.2. MEO systems and constellations

8.3. LEO systems and constellations

9. Satellite navigation systems

6. Schedule

6.1. Subject schedule*

Week	Face-to-face classroom activities	Face-to-face laboratory activities	Other face-to-face activities	Assessment activities
1	**Course presentation. Introduction to SatCom systems** Duration: 02:00 Lecture **Orbits. Kepler laws. Ephemeris. Coordinate systems.** Duration: 02:00 Lecture			
2	**Orbits. Pointing and satellite coverage. Perturbations and launch systems.** Duration: 02:00 Lecture **Orbits and constellations used by artificial satellites** Duration: 01:30 Lecture **Presentation of work in group topics** Duration: 00:30 Additional activities			
3	**Architecture of satellite communication systems** Duration: 02:00 Lecture **Architecture of satellite communication systems** Duration: 01:00 Lecture **Architecture of satellite communication systems** Duration: 01:00 Problem-solving class			
4	**Ground segment** Duration: 02:00 Lecture **Ground segment** Duration: 01:00 Lecture **Ground segment** Duration: 01:00 Problem-solving class		**Work in group organization** Duration: 00:30 Cooperative activities	

5	**Communication techniques used in satellite communications** Duration: 02:00 Lecture	**Lab: Mission anaylisis applied to a SatCom system** Duration: 03:00 Laboratory assignments		
6	**Communication techniques used in satellite communications** Duration: 01:30 Lecture **Communication techniques used in satellite communications** Duration: 01:30 Problem-solving class			**Lab manuals and/or proposed exercises** Individual work Continuous assessment Duration: 00:30
7	**Design and optimization of satellite links** Duration: 02:00 Lecture **Design and optimization of satellite links** Duration: 02:00 Lecture		**Work in groups. Progress presentation (1/2)** Duration: 00:30 Cooperative activities	
8	**Design and optimization of satellite links** Duration: 02:00 Problem-solving class		**Sizing of a satellite communication system** Duration: 02:00 Cooperative activities	
9	**Satellite communication networking** Duration: 02:00 Lecture **Satellite communication networking** Duration: 02:00 Lecture			
10	**Commercial systems. GEO. HTS and VHTS** Duration: 02:00 Lecture		**Work in groups** Duration: 02:00 Cooperative activities **Work in groups. Progress presentation (2/2)** Duration: 00:30 Cooperative activities	
11	**Commercial systems. MEO, LEO and Big LEO** Duration: 02:00 Lecture		**Work in groups** Duration: 02:00 Cooperative activities **Work in groups** Duration: 02:00 Cooperative activities	
12			**Visit to SatCom facility (if feasible)** Duration: 04:00 Additional activities **Work in groups** Duration: 02:00 Cooperative activities	**Lab manuals and/or proposed exercises** Individual work Continuous assessment Duration: 00:30 **Lab manuals and/or proposed exercises** Individual work Final examination Duration: 00:30

13	**Satellite Navigation Systems** Duration: 02:00 Lecture		**Work in groups. Preparation of oral presentation** Duration: 02:00 Additional activities	
14				**Work in Group** Group work Continuous assessment Duration: 02:00 **Work in Group** Group work Final examination Duration: 02:00
15				
16				
17				**Exam. Theory and Case study exercise** Written test Continuous assessment Duration: 03:00 **Exam. Theory and Case study exercise** Written test Final examination Duration: 03:00

The independent study hours are training activities during which students should spend time on individual study or individual assignments.

Depending on the programme study plan, total values will be calculated according to the ECTS credit unit as 26/27 hours of student face-to-face contact and independent study time.

* The subject schedule is based on a previous theorical planning of the subject plan and might go to through experience some unexpected changes along throughout the academic year.

7. Activities and assessment criteria

7.1. Assessment activities

7.1.1. Continuous assessment

Week	Description	Modality	Type	Duration	Weight	Minimum grade	Evaluated skills
6	Lab manuals and/or proposed exercises	Individual work	No Presential	00:30	10%	3 / 10	CT4 CE2
12	Lab manuals and/or proposed exercises	Individual work	No Presential	00:30	10%	3 / 10	CT4 CE2
14	Work in Group	Group work	Face-to-face	02:00	50%	3 / 10	CG4 CT4
17	Exam. Theory and Case study exercise	Written test	Face-to-face	03:00	30%	3 / 10	CE1 CE2 CE4

7.1.2. Final examination

Week	Description	Modality	Type	Duration	Weight	Minimum grade	Evaluated skills
12	Lab manuals and/or proposed exercises	Individual work	No Presential	00:30	20%	3 / 10	CT4 CE2
14	Work in Group	Group work	Face-to-face	02:00	50%	3 / 10	CG4 CT4
17	Exam. Theory and Case study exercise	Written test	Face-to-face	03:00	30%	3 / 10	CE1 CE2 CE4

7.1.3. Referred (re-sit) examination

Description	Modality	Type	Duration	Weight	Minimum grade	Evaluated skills
Exam	Written test	Face-to-face	03:00	50%	3 / 10	CE1 CE2 CE4
Work in Group/Individual homeworks	Group work	Face-to-face	00:00	50%	0 / 10	CG4 CT4

7.2. Assessment criteria

Students will be qualified through continuous evaluation by default. According to the Normativa de Evaluación del Aprendizaje de la Universidad Politécnica de Madrid, students willing to renounce to continuous evaluation must complete the Moodle task entitled "Renounce to continuous evaluation" before week number 6 (deadline will be announced in Moodle).

Evaluation will assess if students have acquired all the competences of the subject. Thus, evaluation through final assessment will be carried out considering all the evaluation techniques used in continuous evaluation (EX, TI, and TG). EX will be celebrated in the exam period approved by Junta de Escuela for the current academic semester and year. Evaluation activities that assess learning outcomes that cannot be evaluated through a single exam as TI and TG will be carried out along the semester.

Extraordinary examination will be carried out exclusively by the final assessment method.

ORDINARY EXAMINATION

Evaluation in the ordinary period (both continuous and by final examination) will consist of the following items:

1. Individual homework. Subsmission of homeworks along the course and completion of the laboratory manuals. Attendance to the laboratory sessions and sumission of the lab manual in mandatory. (20%)
2. Work in group. Intermediate reviews will be performed along the course with presentations in class (in English). Each group will carry out a final presentation in class. Organization, oral presentation, technical documentation and results will be evaluated. (50%)
3. Exam. Theory and case study exercise. (30%)

Work in group will consist in the analysis and/or design of a particular satellite communication system to provide a specific communication service (e.g. broadband access in Europe, application of big LEO constellations for low latency Internet service, in-flight connectivity) or a particular process (e.g. evaluation of ACM strategies in DVB-S2 systems, impact of intermodulation in channel quality). Progress meetings will be held along the course or when required by students. Work in group will include the realization of simulations, submission of technical report and oral presentation.

EXTRAORDINARY EXAMINATION

Final qualification in the extraordinary examination will be composed of the same items than in the ordinary examination. The student has to re-take the items that have not been passed in the ordinary examination, and the qualifications of the passed items will be conserved. In case the work in group has not been passed, an oral exam will be performed to check the understanding of the project. In case needed, a technical report summarizing the work perfomed by the student shall be ordered.

8. Teaching resources

8.1. Teaching resources for the subject

Name	Type	Notes
Satellite Communications Systems: Systems, Techniques and Technology, 5th Edition, Gerard Maral, Michel Bousquet, Zhili Sun, Wiley, 2009.	Bibliography	SatCom book
Comunicaciones por Satélite, Miguel Calvo, Ramón Martínez, Antonio García, ETSIT-UPM, 2005.	Bibliography	SatCom manual
Moodle site of the course	Web resource	Moodle site
Satellite Communications, 4th. Ed., Dennis Roddy, McGraw Hill, 2006.	Bibliography	SatCom book
ITU Handbook on Satellite Communications, 3rd. Ed., Wiley, 2002.	Bibliography	ITU SatCom manual
ITU recommendations for propagation calculations	Web resource	
System Toolkit	Equipment	Mission analysis software available at www.agi.com (evaluation version)
Journal papers	Others	International Journal of Satellite Communications and Networking, Via Satellite, etc.

Satellite Communications Payload and System, T. M. Braun, Wiley, 2012.	Bibliography	SatCom payload book

9. Other information

9.1. Other information about the subject

Realization of the mission analysis laboratory sessions is conditioned to the availability of System Toolkit (STK) software licenses. Thus, lab sessions might change the date, might be modified or could be substituted by individual exercises or homeworks with the same working hours.

The visit to an external facility depends on the availability of the facility and its personnel. Exact dates will be announced when confirmed.