Course guide
230385 - SATCOM-NTN - Satellite Communications and Non-Terrestrial Networks

Last modified: 24/05/2024

Unit in charge: Barcelona School of Telecommunications Engineering
Teaching unit: 739 - TSC - Department of Signal Theory and Communications.

Degree: MASTER'S DEGREE IN TELECOMMUNICATIONS ENGINEERING (Syllabus 2013). (Optional subject).
MASTER'S DEGREE IN ADVANCED TELECOMMUNICATION TECHNOLOGIES (Syllabus 2019). (Optional subject).

Academic year: 2024 **ECTS Credits:** 3.0 **Languages:** English

LECTURER

Coordinating lecturer:

Others:

PRIOR SKILLS

Basic knowledge of wireless communications and network architecture and protocols

TEACHING METHODOLOGY

Lectures
Autonomous learning activities
Practical laboratory activities for modelling and simulation

LEARNING OBJECTIVES OF THE SUBJECT

The realization of a global network where terrestrial and satellite components are integrated and seamlessly managed constitutes one of the new connectivity frontiers on the path towards the sixth generation (6G) systems. Satellite have specific characteristics with respect to reach, availability, resiliency and inherent broadcast/multicast capabilities, which are key to complement terrestrial network services. Specifically, satellite networks can e.g. extend the reach of terrestrial networks to underserved areas and places that terrestrial networks cannot cover (e.g. on land, in the air, at sea), ensure robust and secure services for critical and mobile communications (incident response, public safety) and ensure global connectivity and service continuity for M2M/IoT devices. Recently, satellite communications have entered a period of renewed interest motivated by technological advances and nurtured through private investment and ventures, improving the performance of satellite services and driving down the cost of both connectivity and satellite devices. Within the next few years several thousands of Low Earth Orbit (LEO) satellites and mega LEO constellations are expected to be ready to provide global Internet services.
In parallel, significant work is ongoing at standardization level to develop the necessary features to ensure integration of satellite into the 5G/6G ecosystem and achieve this vision of an integrated global network. Aligning satellite technologies as appropriate with relevant terrestrial network standards offers significant benefits, as currently recognized and pursued by the 3rd Generation Partnership Program (3GPP) in charge of cellular technologies standardization. As a matter of fact, latest 3GPP Release 17 specifications concluded in 2022 introduce, for the first time, new features and adaptions to the cellular protocols allowing 5G NR and IoT radio access technologies to be also used from satellites.
In this context, the aim of this seminar is to present the main concepts, design principles, system architectures, standards, enabling technologies and critical technical challenges and solutions underpinning the realization of integrated satellite-terrestrial networks for the 6G era. In addition to class lectures, the seminar includes the realization of a number of laboratory activities for system characterization and link level performance simulations.

STUDY LOAD

Type	Hours	Percentage
Hours small group	8,0	10.67
Self study	51,0	68.00
Hours large group	16,0	21.33

Total learning time: 75 h

CONTENTS

Introduction

Description:
• Current satellite communications systems
• Satellite market and industry
• Standardization
• Regulation. Frequencies
• Integrated satellite and terrestrial networks (ISTN): Concept and expectations in the 6G era

Full-or-part-time: 7h
Theory classes: 2h
Self study : 5h

Satellite communications basics

Description:
• Satellite applications and scenarios
• System architectures. Space/Ground/User segments. Key subsystems
• Orbit types and parametrization
• Satellite link characteristics. Link budgets

Full-or-part-time: 18h
Theory classes: 3h
Self study : 15h

Integrated satellite-terrestrial network architectures

Description:
• Hybrid network architectures and terminals. Levels of Integration
• Constellation types. Inter-satellite links. Multi-layer connectivity
• Network management
• Systems for broadband connectivity
• Systems for IoT applications
• Future and open topics

Full-or-part-time: 20h
Theory classes: 5h
Self study : 15h

Radio access technologies for ISTN

Description:
• Non-Terrestrial Networks (NTN) 3GPP technologies
o 3GPP New Radio (NR) NTN
o 3GPP NB-IoT/eMTC NTN
• Non-3GPP technologies
• Future and open topics

Full-or-part-time: 18h
Theory classes: 6h
Self study : 12h

Laboratory sessions

Description:
• System characterization (beam layouts, SNR distributions, delay and doppler shifts)
• Satellite channel modelling
• Satellite link performance for NR and NB-IoT NTN protocols

Full-or-part-time: 12h
Laboratory classes: 8h
Self study : 4h

GRADING SYSTEM

Final exam (75%)
Laboratory work assessment (25%)

BIBLIOGRAPHY

Complementary:
- M. Giordani and M. Zorzi. "Non-Terrestrial Networks in the 6G Era: Challenges and Opportunities". IEEE Network [on line]. [Consultation: 17/06/2022]. Available on: https://arxiv.org/abs/1912.10226.- X. Lin, S. Cioni, G. Charbit, N. Chuberre, S. Hellsten and J. -F. Boutillon. "On the Path to 6G: Embracing the Next Wave of Low Earth Orbit Satellite Access". IEEE Communications Magazine [on line]. [Consultation: 17/06/2022]. Available on: https://arxiv.org/abs/2104.10533.- Maral, Gérard; Bousquet, Michel; Sun, Zhili. Satellite communications systems : systems, techniques and technology [on line]. 6th ed. Hoboken, N.J.: John Wiley & Sons, 2020 [Consultation: 21/03/2023]. Available on: https://ebookcentral-proquest-com.recursos.biblioteca.upc.edu/lib/upcatalunya-ebooks/detail.action?pq-origsite=primo&docID=6021106. ISBN 9781119673811.
- Berthou, P.; Baudoin, C.; Gayraud, T.; Gineste, M. Satellite and terrestrial hybrid networks [on line]. London, England ; Hoboken, New Jersey: ISTE : Wiley, 2015 [Consultation: 05/05/2023]. Available on: https://onlinelibrary.wiley.com/doi/book/10.1002/9781118625347. ISBN 9781118625347.
- Krishna Sharma, Shree.; Chatzinotas, Symeon.; Arapoglou, Pantelis-Daniel. Satellite communications in the 5G era [on line]. Stevenage, United Kingdom: Institution of Engineering and Technology, 2018 [Consultation: 15/09/2022]. Available on: https://ebookcentral.proquest.com/lib/upcatalunya-ebooks/detail.action?docID=5497182. ISBN 9781523119127.