

Course guide

205097 - 205097 - Global Navigation Satellite System

Last modified: 19/04/2023

Unit in charge: Terrassa School of Industrial, Aerospace and Audiovisual Engineering
Teaching unit: 748 - FIS - Department of Physics.

Degree: MASTER'S DEGREE IN AERONAUTICAL ENGINEERING (Syllabus 2014). (Optional subject).
MASTER'S DEGREE IN SPACE AND AERONAUTICAL ENGINEERING (Syllabus 2016). (Optional subject).

Academic year: 2023 **ECTS Credits:** 3.0 **Languages:** English

LECTURER

Coordinating lecturer: Rovira Garcia, Adrià

Others:

PRIOR SKILLS

The student must have background of algebra, geometry, calculus, physics, programming, and optionally of space-related subjects such as orbital mechanics, space environment, satellite communications.

TEACHING METHODOLOGY

The course of Global Navigation Satellite System (GNSS) enters in detail in the study of the data and processing algorithms related to Galileo, GPS, GLONASS, and BeiDou constellations. The theoretical foundations are presented from a conceptual point of view and are complemented with guided exercises that conducted by a tool of software specifically designed for the processing and analysis of GNSS data known as the ESA / UPC GNSS - Lab Tool suite (gLAB). The training is intended to provide, from the first moment, operational capabilities in the use instrumental of the concepts and techniques for the treatment of data GNSS.

The course develops the contents of the GNSS Data processing book "Volume 1: Fundamentals and Algorithms" and "Volume 2: Laboratory Exercises", edited by the European Space Agency (ESA), whose authors are the instructors of the course. The materials of the course include the mentioned book (in format PDF) and one booklet with all the slides of the course in format PDF), as well as the tools software that is used in the laboratory exercises (gLAB tool suite).

LEARNING OBJECTIVES OF THE SUBJECT

Theoretical-practical study of the different navigation algorithms for Global Navigation Satellite System (GNSS) to provide the student with a rigorous knowledge about the GNSS data processing. It is promoted the acquisition of the instrumental use of concepts and techniques in GNSS-based navigation.

STUDY LOAD

Type	Hours	Percentage
Hours large group	27,0	36.00
Self study	48,0	64.00

Total learning time: 75 h

CONTENTS

MODULE 1 - INTRODUCTION TO THE GLOBAL NAVIGATION SATELLITE SYSTEM (GNSS)

Description:

GNSS concept. Historical review. GNSS segments and signals. Similarities and differences between GNSS Constellations. Precisions / accuracies that can be expected from the GNSS.

Full-or-part-time: 5h

Theory classes: 2h

Self study : 3h

MODULE 2 - INTRODUCTION TO THE GNSS POSITIONING TECHNIQUES

Description:

Introduction of the different positioning techniques by means of satellite signals. Standalone positioning with code pseudorange (i.e. Standard Positioning Service) and differential positioning with smoothed code (DGNSS). Precise positioning with code and carrier phase, Real Time Kinematics (RTK) and Precise Point Positioning (PPP). Commercial services.

Full-or-part-time: 7h

Theory classes: 2h

Self study : 5h

MODULE 3 - GNSS OBSERVABLES AND THEIR COMBINATIONS

Description:

Review of the GNSS code and carrier phase measurements. First analysis of the content of the GNSS measures by combinations of observables. Detection of jumps and discontinuities of the carrier-phase measurements (i.e. cycle-slips). Smoothing the code pseudorange with the carrier-phase (Hatch filter). Analysis of the multipath of the code.

Full-or-part-time: 9h

Theory classes: 4h

Self study : 5h

MODULE 4 - SATELLITE ORBITS AND CLOCKS

Description:

Elliptical orbits and Keplerian elements. Perturbed orbit and osculating elements. Calculation of satellites coordinates and clock drifts, characterising their associated errors. Computation algorithms from the broadcast navigation message and from the precise files (SP3 and CLK) from IGS. Calculation of satellite coordinates starting from the Almanac.

Full-or-part-time: 7h

Theory classes: 2h

Self study : 5h

MODULE 5 - PSEUDORANGE MODELING

Description:

Study of the geometric distance, relativistic effects, ionospheric delays (including study of the NeQuickG and comparison with ionospheric models used in other GNSS constellations (e.g. Klobuchar model) and from the International GNSS Service (IGS), tropospheric delays, instrumental delays, multipath, antenna phase centre corrections (from ANTEX files). Qualitative and numerical analysis of the pseudorange modelling.

Full-or-part-time: 9h

Laboratory classes: 4h

Self study : 5h

MODULE 6 - NAVIGATION EQUATIONS AND ITS RESOLUTION

Description:

Understanding the system of equations used for determining the coordinates and time from code pseudorange measurements (Standard Point Positioning). Resolution by least squares. Conceptual view of the Kalman filter.

Full-or-part-time: 14h

Laboratory classes: 4h

Self study : 10h

MODULE 7 - HIGH ACCURACY NAVIGATION

Description:

Understanding the Precise Point Positioning (PPP) technique. Modelling needs of the observables, both code and carrier phase. Resolution of the carrier-phase ambiguity: floating versus fixing ambiguities. State of the art: PPP with Integer Ambiguity Resolution and the use of the ionosphere to accelerate the convergence of the navigation filter (Fast-PPP).

Full-or-part-time: 9h

Laboratory classes: 4h

Self study : 5h

MODULE 8 - DIFFERENTIAL POSITIONING

Description:

Understanding of the differential positioning and errors in the GNSS signal. Concept of differential positioning and differential corrections. Mitigation of the differential error.

Full-or-part-time: 8h

Laboratory classes: 3h

Self study : 5h

MODULE 9 - AUGMENTATION SYSTEMS

Description:

Introduction to Ground Based Augmentation Systems (GBAS). Introduction to the Satellite Based Augmentation Systems (SBAS). The European Geostationary Navigation Overlay Service (EGNOS).

Full-or-part-time: 7h

Laboratory classes: 2h

Self study : 5h

ACTIVITIES

ACTIVITY 1 - THEORY LECTURES

Description:

Theory lectures

Material:

Lecture notes and course slides

Full-or-part-time: 30h

Theory classes: 10h

Self study: 20h

ACTIVITY 2 - PRACTICAL CLASSES

Description:

Guided exercises

Material:

The software associated with the practices of laboratory, including the package gLAB

Full-or-part-time: 30h

Theory classes: 10h

Self study: 20h

ACTIVITY 3 - FINAL EXAM

Description:

The final exam consists in questions and theoretical/practical exercises concerning the contents of the course.

Full-or-part-time: 2h

Theory classes: 2h

GRADING SYSTEM

The evaluations to be carried out will be of the following type:

- Final exam in the form of written test: 40%
- Laboratory exercises, including a written report: 30%
- Course project: 30%

All those students who have failed the final exam will have the option of recovering it by taking a global test that will be held on the day set in the calendar of the final exam period for the renewal of optional subjects. The qualification of this reconduction test will be between 0 and 5 and will replace that of the written test of the final exam, as long as it is higher.

BIBLIOGRAPHY

Basic:

- Sanz Subirana, Jaume; Juan Zornoza, J. Miguel; Hernández Pajares, Manuel. GNSS data processing. Noordwijk: ESA Publications Division, cop. 2013. ISBN 9789292218867.
- Hofmann-Wellenhof, B; Lichtenegger, H; Collins, J. Global positioning system: theory and practice. 5th, rev. ed. Wien [etc.]: Springer, cop. 2001. ISBN 9783211835340.
- Misra, Pratap; Enge, Per. Global positioning system: signals, measurements and performance. 2nd ed. Lincoln: Ganga-Jamuna, cop. 2006. ISBN 9780970954411.
- Xu, Guochang. GPS: theory, algorithms, and applications. 2nd ed. Berlin [etc.]: Springer, cop. 2007. ISBN 9783540727149.

Complementary:

- Hernández Pajares, Manuel; Juan Zornoza, J. Miguel; Sanz Subirana, Jaume. GPS data processing: code and phase: algorithms, techniques and recipes [on line]. 1st ed. (English). Barcelona: Centre de Publicacions del Campus Nord, UPC, DL 2005 [Consultation: 14/01/2021]. Available on : https://gagc.upc.edu/sites/default/files/TEACHING_MATERIAL/GPS_BOOK/ENGLISH/PDGPS/BOOK_PDGPS_gAGE_NAV_08.pdf. ISBN 8493223050.

RESOURCES

Other resources:

Course Slides (theory & laboratory).

The GNSS-Lab Tool suite (gLAB): an interactive educational multipurpose package to process and analyse GNSS data.