Short Name of the University/Countrycode Date (Month/Year)	AUP/4000 2019
TITLE OF THE Curricula/Module	**Code**
Global Navigation Satellite Systems (NAVSTAR, GLONASS, GALILEO, etc.)	

Teacher(s)	Department
Coordinating: **Ass. Prof. Krum HRISTOV PhD** **Others:**	Department of Economics

Study cycle	Level of the module	Type of the module
	Bachelor Master	

Form ofdelivery	Duration	Language (s)
In class presentations and discussions Practical training	15 weeks	English

Prerequisites	
Prerequisites: To know: None	**Co-requisites (if necessary):**

ECTS (Credits of the module)	Total student workload hours	Contact hours	Individual workhours
3,5	110	72	38

Aim of the module (course unit): competences foreseeen by the study programme		
For students to understand the principles underlying the use of GNSS at metre and sub-metre accuracy for applications in surveying, GIS, agriculture, asset management, and scientific studies.		
Learning outcomes of module (course unit)	**Teaching/learningmethods**	**Assessment methods**
To know: The Major Satellite Navigation Systems and how they work To point: • Global and regional navigation satellite systems;	Lectures, presentations, seminars, practical lessons, self-study	Participation in discussions, Course project development,

To explain: • What is a satellite navigation system and how do they work? To numerate: • Current and Planned Global and Regional Navigation Satellite Systems and Satellite-based Augmentations Systems To recognize: • Different forms of GNSS interference To give examplesof: • examples of accuracy and precision of gnss. To describe: • The factors that make it difficult for a GNSS receiver to calculate an exact position. Causes of GNSS denial and the methods used to mitigate them. To formulate: • The steps involved in using GNSS to determine time and position through to the end user application. To be able to: • Working with GPS Tracks and Points • Collection, processing and presentation of GNSS data; • Finding location; • Map your property with high accuracy, quickly and easily; • Find certain points in the field; Possess: • to build a map of agricultural fields; • to develop knowledge and understanding on coordinate and time systems; • to evaluate Field Survey using Low-Cost receiver for High-Accuracy positioning		Written test Verbal exam Quiz

Themes	**Contactworkhours**							**Time and tasks for individual work**	
	Lectures	Consultations	Seminars	Practiaclwork	Laboratory work	Placements	**Total contactwork**	**Individual work**	**Tasks**
GNSS Overview	2	0	0	2	0	0	**4**	**2**	Satellite navigation system and how do they work; Types of satellite navigation systems;

									Review of global and regional satellite systems; Regional Satellite-based Augmentation Systems; GNSS architecture.
Coordinate and time systems.	2	0	0	2	0	0	**4**	**2**	Introduction to coordinate system definition and realization concentrating on geometric definitions.
Basic GNSS Concepts	2	0	0	2	0	0	**4**	**2**	Steps involved in using GNSS to determine time and position through to the end user application – Satellites, Propagation, Reception, Computation, Application.
GPS (Global Positioning System, United States)	2	0	0	2	0	0	**4**	**2**	Overview of the components of the system: Space segment, Control segment, User segment; Modernization.
GLONASS (Global Navigation Satellite System, Russia)	2			2			**4**	**2**	Overview of the components of the system: Space segment, Control segment, User segment; Modernization.
Galileo and BeiDou Navigation Satellite System (China)	2			2			**4**	**2**	Overview of the components of the system: Space segment, Control segment, User

									segment; Modernization.
IRNSS (Indian Regional Navigation Satellite System, India) and QZSS (Quasi-Zenith Satellite System, Japan)	2			2			**4**	**4**	Overview of the components of the system: Space segment, Control segment, User segment; Modernization.
GNSS Error Sources. Types of errors	4			2			**6**	**2**	Techniques used to improve GNSS accuracy - Multi-Constellation and Multi-Frequency; Satellite Based Augmentation Systems; Real-Time Kinematic (RTK); Precise Point Positioning (PPP); GNSS Data Post-Processing.
GNSS and other navigation systems	2			2			**4**	**2**	GNSS+ Inertial Navigation System (INS); Odometers; Vision Aided Navigation; Sensor Fusion.
GNSS Denial	2			2			**4**	**2**	Causes of GNSS denial and the methods used to mitigate them – Interference; Anti-Jam Antennas; Multiple Navigation Sensors; Spoofing; Signal Blockage;

									Constellation Failure.
GNSS Applications and Equipment. Commercial applications. GNSS Equipment	2			2			**4**	**2**	Commercial applications; GNSS Equipment.
GNSS in Precision Farming and Agriculture Technology	4			4			**8**	**4**	GNSS application in Quality management; Reduced workload; Environmental Protection; Consumer Protection; Benefits.
Applications for agricultural – Mobile and computer applications	4			14			**18**	**10**	BaseCamp, DNR GPS, ExpertGPS, Locus Map, MachineryGuide, Geo Area - GPS Area Calculator, Field Navigator, AgroPilot, Soil Sampler, Farm Tracks, Tractor Guide, AgriBus-NAVI, Trimble Ag Mobile, Map Pad GPS Land Surveys & Measurements, eFarmer, etc.
Total	**32**	**0**	**0**	**40**	**0**	**0**	**72**	**38**	

Assessment strategy	**Weight in %**	**Deadlines**	**Assessment criteria**
Running control 1	15	7 week	Test and/or Quiz
Running control 2	15	13 week	Test and/or Quiz
Final exam	70	15 week	Course project development

Compulsory literature/Author	Year of issue	Title	No of periodical or volume	Place of printing. Printing house or internet link
European GNSS Agency	2018	GNSS User Technology Report	Issue 2	Luxembourg: Publications Office of the European Union, 2018 https://www.gsa.europa.eu/system/files/reports/gnss_user_tech_report_2018.pdf doi:10.2878/743965
Bernhard Hofmann-Wellenhof, Herbert Lichtenegger, Elmar Wasle	2008	GNSS - GPS, GLONASS, Galileo & more		Springer-Verlag Wien; doi:10.1007/978-3-211-73017-1
J. Sanz Subirana, J.M. Juan Zornoza and M. Hernández-Pajares	2013	GNSS DATA PROCESSING	Volume I: Fundamentals and Algorithms	https://gssc.esa.int/navipedia/GNSS_Book/ESA_GNSS-Book_TM-23_Vol_I.pdf
	2008	GLOBAL POSITIONING SYSTEM STANDARD POSITIONING SERVICE PERFORMANCE STANDARD	4th Edition,	https://www.gps.gov/technical/ps/2008-SPS-performance-standard.pdf
China Satellite Navigation Office	2019	BeiDou Navigation Satellite System Signal In Space Interface Control Document Open Service Signal B1I	Version 3.0	http://en.beidou.gov.cn/SYSTEMS/Officialdocument/201902/P020190227601370045731.pdf
Whelan, B. and J. Taylor	2013	Precision Agriculture for Grain Production Systems		
European Union	2016	Galileo - Open Service - Signal In Space Interface Control Document (OS SIS ICD V1.3)	Issue 1 rev. 3	https://www.gsc-europa.eu/system/files/galileo_documents/Galileo-OS-SIS-ICD.pdf
European Union	2019	Galileo - Open Service - Signal In Space Interface Control Document (OS SIS ICD V1.3)	Issue 1 rev. 1	https://www.gsc-europa.eu/system/files/galileo_documents/Galileo-OS-SDD.pdf
Indian Space Research Organization	2017	Indian Regional Navigational Satellite System SIGNAL IN SPACE ICD	version 1.1	BANGALORE https://www.isro.gov.in/sites/default/files/irnss_sps_icd_ver

		FOR STANDARD POSITIONING SERVICE		sion1.1-2017.pdf
Manuel Perez-Ruiz and Shrini K. Upadhyaya	2012	GNSS in Precision Agricultural Operations		http://dx.doi.org/10.5772/50448
International Civil Aviation Organization	2005	Global Navigation Satellite System (GNSS) Manual	First Edition	Canada https://www.icao.int/Meetings/PBN-Symposium/Documents/9849_cons_en%5B1%5D.pdf
Additional literature				
European GNSS Agency	2017	GNSS Market Report	Issue 5	Luxembourg: Publications Office of the European Union https://www.gsa.europa.eu/system/files/reports/gnss_mr_2017.pdf doi:10.2878/0426
European GNSS Agency	2018	Report on agriculture user needs and requirements	Issue 1	Luxembourg: Publications Office of the European Union https://www.gsc-europa.eu/system/files/galileo_documents/Agri-Report-on-User-Needs-and-Requirements-v1.0.pdf
Pérez Bartolomé, Javier & Maufroid, Xavier & Fernandez-Hernandez, Ignacio & López-Salcedo, José A. & Seco-Granados, Gonzalo.	2014	Overview of Galileo System.		Springer Ltd doi:10.1007/978-94-007-1830-2_2.
International Civil Aviation Organization	2005	Global Navigation Satellite System (GNSS) Manual	First Edition	Canada https://www.icao.int/Meetings/PBN-Symposium/Documents/9849_cons_en%5B1%5D.pdf

ANOTATION /course summery

For students to understand the principles underlying the use of GNSS at metre and sub-metre accuracy for applications in surveying, GIS, agriculture, asset management, and scientific studies.

The student will learn the basics of navigation using Global Navigation Satellite Systems (GNSS), such as GPS signals, and other navigation technologies.

The student will also get a hands-on training on the GNSS receiver functionalities via a course work assignment.

List of **themes and short description**

Themes	Contact work hours
GNSS Overview History and introduction on the major GNSS systems (GPS, GLONASS, GALILEO, BEIDOU, SBAS); Physical principles that operate in GNSS;	**4**
Coordinate and time systems Introduction to coordinate system definition and realization concentrating on geometric definitions	**4**
Basic GNSS Concepts The steps involved in using GNSS to determine time and position through to the end user application. Introduction on GNSS signal structure and properties; Introduction on signal processing techniques; Introduction on GNSS receiver architectures;	**4**
GPS (Global Positioning System, United States) Overview of the components of the system – Space segment, Control segment and User segment. Modernization.	**4**
GLONASS (Global Navigation Satellite System, Russia) Overview of the components of the system – Space segment, Control segment and User segment. Modernization.	**4**
Galileo and BeiDou Navigation Satellite System (China) Overview of the components of the system – Space segment, Control segment and User segment. Modernization.	**4**
IRNSS (Indian Regional Navigation Satellite System, India) and QZSS (Quasi-Zenith Satellite System, Japan) Overview of the components of the system – Space segment, Control segment and User	**4**

segment. Modernization.	
GNSS Error Sources. Types of errors Principles associated with high accuracy differential GNSS positioning. After briefly reviewing the relevant concepts of GNSS positioning, the lecture presents the different measurements and error sources that limit positioning accuracy. The geographic and temporal variability of the errors will be addressed, as appropriate. Once the GNSS errors are understood, focus turns to mitigation of these errors through measurement differencing, linear measurement combinations, and different augmentation approaches (i.e., DGNSS, RTK, NRTK, and PPP). The motivation for these approaches will be explained in the context of trying to mitigate errors and resolve the carrier phase ambiguities. Mathematical formulations for the various augmentation approaches are introduced. Different augmentation message formats are also presented. The lecture will conclude with a discussion of the future prospects for the GNSS augmentation technique.	**6**
GNSS and other navigation systems Review of systems in which GNSS receivers work with other sensors to provide position and navigation when GNSS conditions are difficult	**4**
GNSS Denial Causes of GNSS denial and the methods used to mitigate them – Interference, Anti-Jam Antennas, Multiple Navigation Sensors, Spoofing, Signal Blockage, Constellation Failure.	**4**
GNSS Applications and Equipment. Commercial applications. GNSS Equipment Review of some of the incredible GNSS applications and equipment that are now available.	**4**
GNSS in Precision Farming and Agriculture Technology GNSS in Precision Farming and Agriculture Technology. GNSS application in Quality management, Reduced workload, Environmental Protection, Consumer Protection, Choise of GPS devices, Benefits,	**8**
Applications for agricultural – Mobile and computer applications How mobile apps and technologies help farmers.	**18**