communication, navigation and surveillance and satellite applications for aviation

syllabus

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The International Civil Aviation Organization (ICAO) is leading research to improve air traffic control world-wide with the objective to replace different national systems with a harmonized global and cost effective system. New space telecommunication technologies will provide excellent means of achieving this goal. Until now no comprehensive training has been available to the aeronautical community to complete the technical development of CNS systems. This "Mastère Spécialisé" provides training in the various satellite technologies relevant to Communication, Navigation and Surveillance (CNS) applications. The European Strategy of the A.N.S.P (Air Navigation Service Provider) in the CNS domain is under development in the context of the SESAR (Single European Sky ATM Research) orientation. These applications are viewed from the point of Air Traffic Control but also mainly with a scientific and technical approach.

The "Ecole Nationale de l’Aviation Civile" has expertise in all aspects of this field and is able to offer a comprehensive training package. The "research and expertise" of the C.N.S/GNSS laboratory, which is fully part of the ENAC electronics systems department, allows to have a high level and permanently updated teaching staff in the field of satellite based navigation.

**Entry Requirements**

- Master of Science in Electrical Engineering, Computer Sciences, Aeronautical Engineering or equivalent.
- Bachelor’s degree in the same fields, with a least a 3 years’ professional experience.
- English proficiency: TOEFL 550 points mini or equivalent.

**Objectives**

The International Civil Aviation Organization (ICAO) is leading research to improve air traffic control world-wide with the objective to replace different national systems with a harmonized global and cost effective system. New space telecommunication technologies will provide excellent means of achieving this goal. Until now no comprehensive training has been available to the aeronautical community to complete the technical development of CNS systems. This "Mastère Spécialisé" provides training in the various satellite technologies relevant to Communication, Navigation and Surveillance (CNS) applications. The European Strategy of the A.N.S.P (Air Navigation Service Provider) in the CNS domain is under development in the context of the SESAR (Single European Sky ATM Research) orientation. These applications are viewed from the point of Air Traffic Control but also mainly with a scientific and technical approach. The "Ecole Nationale de l’Aviation Civile" has expertise in all aspects of this field and is able to offer a comprehensive training package. The "research and expertise" of the C.N.S/GNSS laboratory, which is fully part of the ENAC electronics systems department, allows to have a high level and permanently updated teaching staff in the field of satellite based navigation.

**Professional prospects and career opportunities**

- ATM systems manufacturers
- Aircraft manufacturers
- Airlines
- Aeronautical telecommunication companies
- Service providers
- Consultants
Enrolment:
Application forms are available from January 2012. Applications must be filed before 31st of May 2012.

Selection:
On the basis of the application, possibly with an interview.

Course fees:
The tuition fees for the Mastère Spécialisé “Communication, Navigation and Surveillance and Satellite Applications for Aviation” are 12,000 €.

Information and contacts:
Enrolment:
M. Michel CHAUVIN
Deputy Director Higher Education
michel.chauvin@enac.fr

Course Director:
Mr. Jean-Pierre DANIEL
jean-pierre.daniel@enac.fr
## Module

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| **Intership**                                                         | Enterprise ENAC Tutor                 | **4 to 6 months** | **30**
Presentation:
This module covers the fundamentals of data link, telecommunications networks.

Pedagogical objectives:
• To be able to understand the definition, the main environment and technical topics of a protocol concerning a local or wide area network.

Content:
• Principles of Communication Network and Formalism
• Physical Architecture
• Application on IP suite
• Overview of the Dynamic Behaviour in Network/Interconnection Theory
• Quality/Security with networking
• Quality of service
• Overview of implementation of Aeronautical networks

Methods:
• courses
• practical works

Duration:
28 hours

Intervenants:
• Experts from ENAC Electronics Systems Department

Director:
Henri DENIS (ENAC)
Presentation:
This module presents the basics in electromagnetism and antennas.

Pedagogical objectives:
- To be able to understand how to transmit the information in the frame of global positioning using satellites as well as other applications using microwave communication like surveillance, conventional navigation and voice exchange
- To be able to explain aircraft operational performances and limitations

Content:
- Propagation applied to CNS systems
- Antennas
- Microwave circuits
- Presentation of software/tools in R.F. techniques

Methods:
- courses
- practical works
Presentation:
Data transmission is one of the key elements of air transport organisation. This module explains its fundamentals.

Pedagogical objectives:
- To be able to define the main terms related to ATM
- To be able to state the air regulation and describe the air traffic services
- To be able to describe the Air Traffic Control services and explain the interaction between radar and control service.
- To be able to describe the main ATM systems and explain the architecture trends
- To be able to describe the air traffic flow management Principles
- To understand the aeronautical information service and the aeronautical information management.

Content:
- Basic Theory of Analogical Signal Processing
- Introduction to Coding
- Digital Transmission : Theory, consequences on performance

Methods:
- courses
- practical works
Presentation:
Comprehensive presentation of the Air Traffic Management organisation.

Pedagogical objectives
Provide the ATM background for further courses dealing with related CNS systems.

Content:
- Introduction to Air Traffic Management
- Air Traffic Services description and Classification
- First basics of Procedures Design
- Awareness in Operational Requirement and Risk Management in Aeronautical Environment
- Practical Demonstrations and simulations on Aerodromes and in Upper Information Region context, on the ENAC ATC simulators.

Methods:
- Courses
- practical and simulations works

Duration:
26 hours

Lecturers:
- Experts from ENAC ATM/ATC Department

Course Director:
Jean-Jacques PATACCHINI [ENAC]
**Presentation:**  
This module address the question: What is likely to be the future Communication, Navigation and Surveillance infrastructure in the next decade, in the frame of ATM context for ECAC [European Civil Aviation Conference].

**Pedagogical objectives:**  
- To be able to understand both the institutional and technical development of ATM.

**Content:**  
- The Global Context  
- The Communication Plan  
- The Navigation Plan  
- The Surveillance Plan

**Methods:**  
- Lectures

**Duration:**  
22 hours

**Lecturers:**  
- Experts from ICAO and French Civil Aviation Authority, in particular from French A.N.S.P (Air Navigation Service Provider)

**Course Director:**  
Yves BONNEFOUS (DTI)
Space Flight Dynamics and Satellite Constellations

Presentation:
This module aims to give an overview of the fundamentals of space flight dynamics.

Pedagogical objectives:
• To be able to understand the dynamics of orbital motion: flight paths, and attitudes of space vehicles; space related performances of a satellite based system.

Content:
• Fundamentals of Space Flight Dynamics
• Perturbations
• Orbital Manoeuvres
• Orbite Design
• Satellite Constellations
• Formation Flying Missions
• Introduction to Satellite Navigation Systems

Methods:
• Courses
• Workshops
• Industrial Study Case

Duration:
26 hours

Lecturers:
• Experts from Thales, Eurocontrol, Air France, Egis Avia

Course Director:
Alain LAMY (CNES)
Presentation:
The global positioning systems are presented, as well as their performances and current developments

Pedagogical objectives:
To be able to describe the main GPS systems processes

Content:
• GPS System Description
• GPS Architecture and Technique
• Differential Techniques : DGPS
• Other Satellites Constellation for Navigation
• Simulations and Lab works ,
• Illustration of the physical phenomena with the Scientific Calculus Software : Matlab

Methods:
• Courses and practical works

Duration:
50 hours

Lecturers:
• Experts from ENAC Electronics Systems Department, in particular from the "research and expertise” of the C.N.S/GNSS laboratory of this Department.

Course Director:
Christophe MACABIAU (ENAC)
Kalman Filter – Theory and Hybridation

Presentation:
Global navigation satellite systems, as well as Surveillance or Navigation applications require linear filtering techniques which are encompassed in this module.

Pedagogical objectives:
- To be able to use the tools and techniques allowing to use multi-sensors systems.

Content:
- State Space Model, Overview of Continuous and Discrete Problematic
- Reminder concerning Random Signal, Overview of the problematic of Optimum Estimation
- Notion of the “Least Mean Square Error (LMSE)” concept in Estimation Theory
- Kalman Filtering Theory and its extension
- Workshops and Simulation with the Scientific Calculus Software: Matlab.

Methods:
- Courses
- Practical works
- Study cases

Duration:
26 hours

Lecturers:
- Experts from ENAC Electronics Systems Department, in particular from the “research and expertise” of the C.N.S/GNSS laboratory of this Department.

Course Director:
Anne-Christine ESCHER (ENAC)
Spatial Telecommunications

**Presentation:**
Communications, data transmissions and payload techniques are presented.

**Pedagogical objectives:**
To be able to understand the key drivers of space techniques and Satellite telecommunications

**Content:**
- Introduction, Definition, Budget Link, characteristics of Space System
- Space and Satellites Environment
- Communications and Access techniques for physical Layers
- Earth Stations
- Provided Service of communication
- Case study

**Methods:**
- Lectures and lab works

**Duration:**
26 hours

**Lecturers:**
- Experts from Space Industry (Thales) and Engineering School (ISAE/SUPAERO)

**Course Director:**
Christophe MACABIAU (ENAC)
**Presentation:**
Development and safety assessment methods are presented in this module.

**Pedagogical objectives:**
Provide an overall view of System Engineering process “Safety assessment process” for CNS project management, and related issues.

**Content:**
- System Engineering: bases and stakes for project management
- Safety management in the ATM domain
- Safety assessment of ATM changes

**Methods:**
- Courses
- Study cases

**Duration:**
56 hours

**Lecturers:**
- Experts from the space industry

**Course Director:**
Cécile MOURA (ENAC)
Presentation:
This formation covers the analysis of the aeronautical communication requirements (Air Traffic Management, Aircraft operation and passenger communications), the current technical solutions and their evolutions requiring new innovative technical solutions.
This course deals with in particular:

- Air/ground voice communications, the current technologies (25 kHz, 8.33 kHz, HF voice, Satellite voice) and their evolutions and the future role of voice communication in the context of a wide move toward data exchanges.
- The current Datalink technology based on ACARS (Airline Communication, Addressing and Reporting System) protocols and the key applications of the ATM domain.
- ATN (Aeronautical Telecommunication Network) that makes up the air/ground common data transport layer.
- The various sub-networks that could be inter-connected through the ATN: VDL mode 2, Satellite D/L, HF D/L.
- The main air/ground data-link services (or applications) that have been defined at ICAO level (CPDCL, ADS, ..) and their deployment foreseen in Europe (Link 2000+ programme).
- The status of the selection of new technologies to support the future needs for air/ground data communication: new terrestrial cellular system, new airport surface solution and new satellite solution.
- The evolution of the key ground/ground data communications services in the perspective of usage of native IP network service.
- The topics of “Radio Spectrum Management” will be also explored.
- Hands-on in aeronautical communications that will be covered in course, will be organised.
Content:

1. Introduction, history, context of the Aeronautical communications
2. Voice communications: case study, en route VHF coverage
   - VHF and HF physical characteristics
   - Operational constraints
3. Data communications
   - ACARS, ARINC 622/623 evolution. Description and application.
   - OSI model, X25, ISO protocols and IP Routing.
   - Aeronautical Telecommunication Network, and ATN-Subnetwork (ATN Routing)
   - VHF sub-network (VDL 2 and VDL 4) and Hands-on
   - AMSS sub-network
   - HF sub-network
   - SATCOM sub-network, future component sat-com in L Band and Hands-on
4. Ground telecommunications Services over IP
   - Deployment of Internet Protocol (IP): the future based networks in aviation
   - Data sharing information: System Wide Information Management (SWIM Concept)
5. Spectrum management
6. Overall system certification, integration onboard/ground safety and performance requirements
   - Communication function, Safety aspects
7. Data-link security techniques
   - Information security overview
   - Aeronautical data-link security basics
8. Strategy Eurolink 2000 and programme; future communication system
   - Future communication components (terrestrial, airport)

Methods:
- Lectures
CNS system-navigation: Navigation services in civil aviation: conventional navaids, GNSS(ABAS,GBAS,SBAS, GALILEO)

**Presentation:**
Analysis of the navigational needs in aeronautics and demonstration that their evolution require the implementation of global solutions with a satellite component.

**Pedagogical objectives:**
Give a broad understanding of navigation techniques from conventional navaids to future ones.

**Content:**
- General consideration on navigation and operational requirements
- Conventional navigation systems
- ICAO and the GNSS concept
- On-board augmentation technique (ABAS)
- Augmentation based on satellites (SBAS)
- Augmentation based on ground stations (GBAS)
- Navigation and interference
- International terrestrial reference systems: needs and principles
- GNSS: description of the next constellation for positioning and other services: GALILEO
- Demos and workshops on GNSS system

**Methods:**
- Courses
- Practical Work

**Duration:**
50 hours

**Lecturers:**
- Experts from DGAC from French A.N.S.P (Air Navigation Service Provider) and from Space industry

**Course Director:**
Benoît ROTURIER (DTI)
Presentation:
Overview of all the sensors of surveillance which are used and spread in ATM context of surveillance.

Pedagogical objectives
To be able to understand the surveillance needs and requirements of the civil aeronautics, as well as the global integration in a more comprehensive ATM/CNS surveillance strategy.

Content:
- Operational requirements
- Radar based surveillance techniques
- Multilateration: LAM-WAM
- Automatic Dependent Surveillance
- Surveillance processing and application
- European normalized digital format of messages for Surveillance (ASTERIX)
- European Standard radar assessments and radar processing assessment (SACC)
- Anti-collision system

Methods:
- Lectures
- Study cases
- Practical works

Duration:
50 hours

Lecturers:
- Experts from DGAC, Air France and Airbus

Course Director:
Bruno COLLARD
(ENAC)
Architectures of CNS avionics system

Presentation:
Systems integrator’s industrial point of view on the avionics architecture systems, which is connected with CNS concepts.

Pedagogical objectives
To be able to understand the avionics architecture, computers and telecom buses and the current trends

Content:
- Engineering, standardization, qualification, certification for avionics
- Systems design
- Conventional CNS avionics
- Evolution of conventional avionics
- Integrated Modular avionics and CNS
- On-board databases and integrity
- Airbus avionics architecture
- Visit of ENAC avionics lab. Visit of Airbus Industrial Center.

Methods:
- Courses
- Industrial examples
- Visits
- Flight simulations

Duration:
26 hours

Lecturers:
- Experts from the ENAC Air Transport Department.

Course Director:
Thierry MIQUEL (ENAC)
Non - Aeronautical Satellite Positioning Applications

Presentation:
Existing and potential needs for positioning, navigation and dating, and survey in fields that are not directly linked with aeronautical ATM/CNS.

Pedagogical objectives
Have a comprehensive view on non-aeronautical Satellite positioning applications.

Content:
- Oral presentation Basis
- Use of satellite in transport
- Terrestrial and civil applications
- Applications in the field of agriculture
- Geodesic applications
- Military applications
- Data bases and maps

Methods:
- Courses
- Study cases
- Demonstrations

Duration:
34 hours

Lecturers:
Experts from the French laboratory involved in Satellite Positioning (Ponts et Chaussées, IGN, DGA, Thales)

Course Director:
François PEYRET (LCPC)
Presentation:
This 3 month activity (from January to March) will be centered on a case study led by small groups of students with experts support on a regular basis.

Pedagogical objectives
To be able to understand and go in depth into one of a particular technical topics of the present Mastère and situate it in the complex global systems of the CNS/ATM Deployment.

Content:
• Oral presentation Basis
• Application of the project on one of the three essential domain (Communications or Navigation or Surveillance)
• Realization of a part of numeric simulation on the targeted issue.
• Introduction to system engineering and functional analysis
• Progress meetings
• Case study presentation and follow up technical meetings

Methods:
• Project in groups (around 4 students)

Duration:
36 hours

Lecturers:
• Experts from ENAC and DTI/DSNA
Industrial sequence (April to September)

The course is completed with a 4 to 6-month internship in a professional environment either in France or abroad. The internship is supervised by a tutor from the host organisation and by a scholarship tutor from ENAC. The student is required to produce a professional thesis which he/she defends before a combined jury made of professors and professionals.
Syllabus