Building Capacity in the use of GNSS

Sergio Camacho
Regional Centre for Space Science and Technology Education for Latin America and the Caribbean

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Contents

- Background of the Regional Centres
- Objectives and programs of CRECTEALC
- CRECTEALC and INAOE activities related to GNSS

Background of the Regional Centres, affiliated to the United Nations

- Resolution 45/72 of the General Assembly of the UN, 1990: "UN should lead … establishment of Regional Centres ..."
- Regional Centres established in:
  - Asia and the Pacific (India,1995);
  - Latin America & the Caribbean (Brazil & Mexico 1997);
  - French-speaking Africa (Morocco, 1998)
  - English-speaking Africa (Nigeria, 1998)
  - Western Asia (Jordan, 2012)
  - Asia and the pacific (China, 2014)

CRECTEALC

- Created under the Programme on Space Applications, Office for Outer Space Affairs of the United Nations.
- Objectives
  - Expand knowledge in the various disciplines of space science and technology of Member States (regional and international) and thus support their scientific, economic and social development.
  - Key activities:

    - Organize programs for education, research and development of practical applications, currently oriented to remote sensing, satellite communication systems and spatial data and information.

    - Operate as a Regional Information Centre for ICG

    Dissemination of information

    Workshops for spectrum protection

INAOE-CRECTEALC
New post-graduate program

- CRECTEALC is hosted by INAOE (National Institute for Astrophysics, Optics and Electronics.

- INAOE offers M.Sc. & Ph. D. degrees in astrophysics, optics, electronics and computer science

- With CRECTEALC support, from 2014 INAOE offers

  - M. Sc. Program in Space Science and Technology;
  - Ph. D. program will be offered from 2016

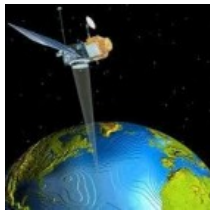
Regional Centre for Latin America and the Caribbean (CRECTEALC)

- Campuses in Brazil and Mexico
- Long-term post-graduate education programmes, 9 and 11 months
  - Remote sensing and GIS
  - Satellite Communications
  - **GNSS (2016) – initially a 4-month course**
  - **Space policy and space law workshops (2016) – look at spectrum protection**

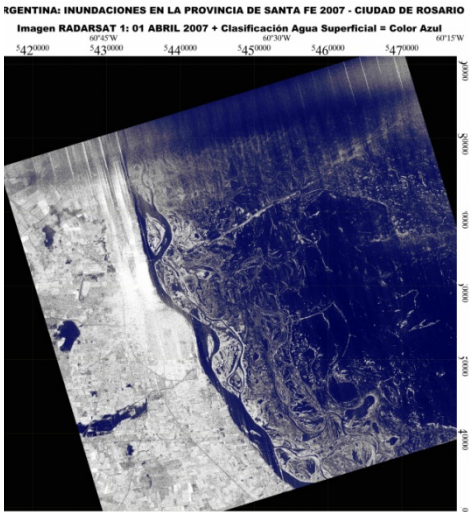
- Workshops, short courses; scientific, technical, on space policy and outreach seminars are held at the Campi Brazil and Mexico as well as in Argentina, Colombia, Chile and Ecuador.

CRECTEALC Courses in both Campi Brazil and México

Remote sensing and GIS (12 months)



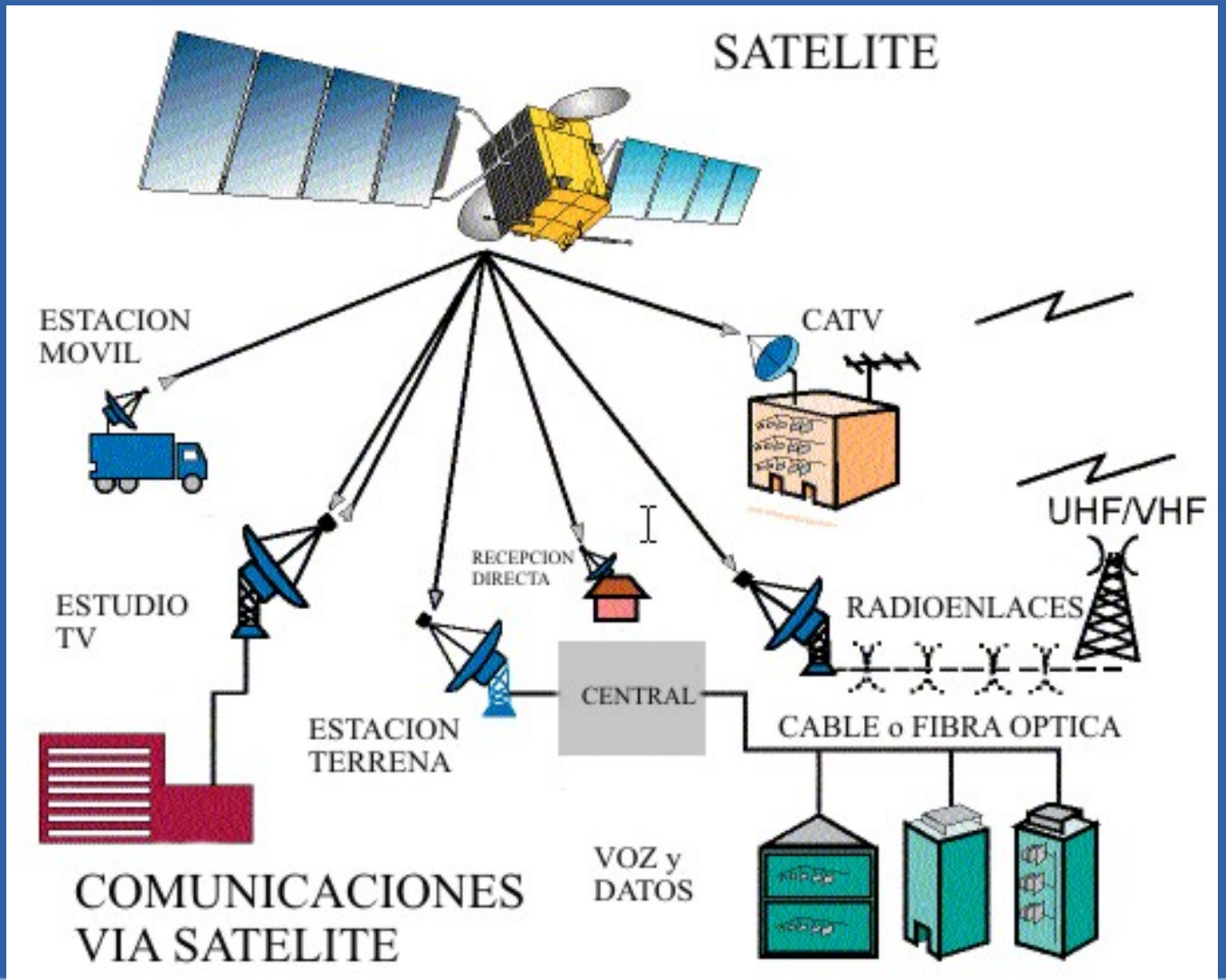
1. Remote Sensing Module
   - Tele observation
   - Interpretation and analysis of images
   - Photogrammetry



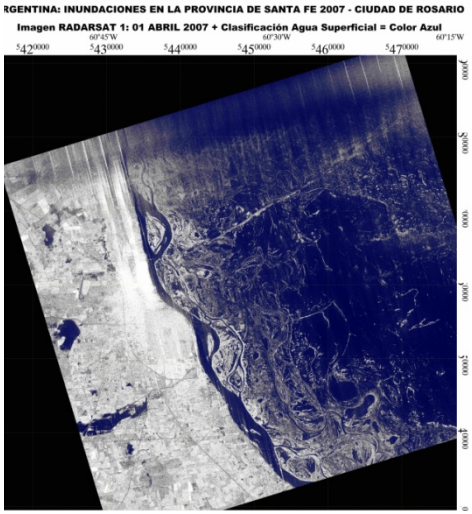
2. GIS Module
   - Geographic Information Systems
   - Photogrammetry

3. Application Project

Satellite Communications



Satellite Communications (9 months)

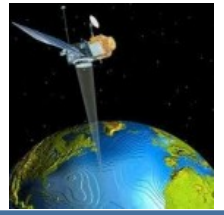


Module 1

- Communications systems theory
- Fundamentals of information theory
- Basic theory of microwave systems
- Modulation techniques and multi-channeling
- Theory of antennas and propagation

Module 2

- Satellite Communications Systems
- Elements and modules of a satellite communications system
- Satellite links and transmission techniques and satellite access
- Applications of satellite communications
- Regulation and standardization



Module 3: Application Project

CRECTEALC Programs

- Knowledge acquired in the 9- & 11-month post-graduate education programmes is strengthened by end-of-course project

- A variety of current and past projects at CRECTEALC:
  - Related with the 9 and 12 months courses
  - Construction and integration of nano satellites (Ulises I)
  - Tele-medicine and cyber health
  - Inventory system of talent and resources
  - Data mining applied to human environmental history
  - Formation flying
  - EO-POWER (European Commision)
  - NEOs observation (as member of IAWN)
  - **Future GNSS-related projects (?? TBD??)**

GNSS Calendar

Full Time
Starting on May, 2016 and ending on August, 2016 - Total 540 hours

May – July
Theoretical backgdound 180 hours: 120 hours in May, 30 hrs. in June and 30 hrs. in July

June - August
Labs 180 hours: 120 hrs in June, 30 hrs in July and 30 in August

July - August
Workshops 180 hours: 90 hours July and 90 August

Implementation:

9 Modules of 60 hours each

May 6 hrs /day, 8 clases, 45 min each
June 7.5 hrs per day, 8 clases, 55 min each
July 7.5 hrs per day
August 6 hrs per day

Module I

Fundamentals

1.1 Introduction to GNSS:

Conventional navigation, background, concepts and evolutions of GNSS (GPS, GLONASS, Galileo, BeiDou) and regional navigation satellite systems (IRNSS, QZSS). Comparison of GNSS with other navigation systems;

1.2 Reference systems:

Terrestrial, celestial and orbit coordinate reference system. Height Systems. Geoid. Time systems, synchronization and data conversion. Transformations between coordinate reference systems. Contribution of the International GNSS Service (IGS) to providing access to the International Terrestrial Reference Frame (ITRF);

1.3 Satellite orbits:

Orbital parameters. Orbital motion, representation (Keplerian elements, etc) Determination of satellite position, visibility and ground tracks;

1.4 Basic techniques of communications:

Propagation of electromagnetic waves. Antennas and propagation

Module III

Technologies: augmented systems

3.1 Errors in GNSS measurements:

functional model and fundamental error equation, effect of GDOP, classes of ranging errors and biases;

3.2 Effects of errors:

error budget, user equivalent range error, position accuracy with one sigma and three sigma errors;

3.3 Error mitigation techniques:

real time kinematic (RTK), differential GNSS (DGGNSS), local and wide area DGNSS

3.4 Augmented systems:

Wide Area Augmentation System (WAAS), European Geostationary Navigation Overlay Service (EGNOS), System of Differential Correction and Monitoring (SDCM), Multi-functional Transport Satellite (MTSAT) Satellite-based Augmentation System (MSAS), GPS Aided Geo Augmented Navigation (GAGAN), etc.;

3.5 GNSS networks:

Global, regional and local GNSS Permanent Networks and geodetic infrastructure for real positioning services;

3.6 GNSS impact factors and mitigation techniques:

Orbit errors, clock errors, multipath, troposphere, ionosphere including higher order

Module IV

Sensors and embedded system design

4.1 Sensors and transducers:

Introduction, Sensor classification, characteristics and compensation, classification of transducers. Transducer descriptions, parameters, definitions and terminology;

4.2 Embedded systems:

Cell phones, pagers, PDAs, answering machines, microwave ovens, televisions, VCRs, CD/DVD players, video game consoles, GNSS devices,

network routers, fax machines, cameras, music synthesizers, planes, spacecraft, boats, and cars all contain embedded processors

Module V

GNSS receivers

5.1 Receiver architecture:

Technology, radio-frequency front end, signal processing system hardware and software techniques, software defined radio;

5.2 Signal tracking:

Maximum likelihood estimate of delay and position, delay lock tracking of signal, coherent and non coherent delay lock tracking of pseudo noise

sequences, mean square error estimation, vector delay lock loop, receiver noise performance, maximum likelihood estimate, early late gating;

5.3 Navigation algorithm:

Measurement of pseudo range, Doppler, decoding and using of navigation data, single point solution, precise point positioning, dynamics of user,

Kalman filter, least-squares adjustment, and other alternatives

Module VI

GNSS/INS integrated navigation

6.1. Inertial navigation systems.

Accelerometer, Gyroscopes, Inertial platforms, Navigation equation, Integration of modelling equations in e-frame;

6.2. INS error dynamics:

Simplified analysis, Error dynamics equations in e-frame, INS initialization and alignment;

6.3. GNSS/INS integration:

Integration mode, Mathematical model of supported INS navigation, Observation procedures for inertial surveying;

6.4. General sensor fusion concepts

Module VII

GNSS applications

7.1. Geospatial databases:

Geo extensions for Open Source Databases, POSTGRES, MySQL etc.;

7.2. GNSS navigation:

Professional and personal, GIS/mapping, Surveying, Natural Hazards management, Earth sciences, Natural resources, Infrastructure;

7.3. Navigation and communication:

Integrated application;

7.4. Communication, navigation and surveillance:

Integrated application;

7.5. GNSS applications for remote sensing of the atmosphere and space weather:

Radio occultation technique for monitoring terrestrial weather (temperature and water vapour) and monitoring ionospheric weather (electron density and total electron content);

7.5. Revenue model for value added services;

7.6. Management, team work, intellectual property, business in GNSS.

Module VIII

Space weather and GNSS

8.1. Sources of space weather and related background physics:

Sun, galactic cosmic rays, magnetosphere, thermosphere, ionosphere coupling;

8.2. Impact of space weather events on GNSS;

8.3. Satellites, interference with solar radio emission, radio wave propagation;

8.4. Different view in precise (geodesy, DGPS) and safety of life (aviation) applications;

8.5. Ionospheric scintillations and their impact, monitoring and modeling;

8.6. GNSS-based monitoring of the ionosphere by ground and space based measurements;

8.7. Ionospheric correction and threat models

Module IX

9.1.Coordinate and time conversion, and reference system transformations;

9.2.GNSS/INS equipment;

9.3.GNSS data formats:

Receiver Independent Exchange Format (RINEX), Real-Time

GNSS Data Transmission Standard (RTCM), United States National Marine

Electronics Association (NMEA);

9.4.Single point positioning solution;

9.5.High precision postprocessed GNSS;

THANK YOU!

Secretariat
Luis Enrique Erro No. 1
Santa María Tonantzintla
San Andrés Cholula, Puebla
C.P. 72840, México
Tel: + (52 222) 266 3100 Ext. 2317
Fax: + (52 222) 266 3100 Ext. 8302
Web: http://www.crectealc.org/