Presentation of the Unit of Geomatics of the University of Liège

Faculty of Sciences
Department of Geographical Sciences
Institute of Physics (B5)
17 Allée du 6 Août, 4000 Liège

Secretariat : +32-(0)4.366.57.42
Fax : +32(0)4.366.56.93
http://www.geo.ulg.ac.be

by Jean-Paul Donnay
jp.donnay@ulg.ac.be

Comité scientifique de l'IGN – 6 octobre 2009

Presentation of the Geomatics Unit of the ULg

Comité scientifique de l'IGN – 6 octobre 2009

- STORY
  - **1986 :** setting up of the laboratory **SURFACES** (« *Service Universitaire de Recherches Fondamentales et Appliquées en Cartographie et Études Spatiales* ») inside the Faculty of Sciences
    - In about 20 years:
      - More than 50 researchers
        - » Geographers, surveyors, engineers, computer scientists, geologists, agronomists, etc.
      - More than 120 study contracts
    - Main fields of research :
      - Remote sensing:
        - » High and very high resolution stereo (urban remote sensing…)
        - » National (TELED, TELSAT, STEREO, etc.) and international programmes (MARS, CNES, SPOT5-HRS, etc.)
      - Geographic Information Systems:
        - » Design, re-engineering, prototyping
        - » Public (IGN-B, SPW, CIRB, etc.) and private contracts (IBM, STAR-Apic, Electrabel, CILE, etc.)

Presentation of the Geomatics Unit of the ULg

Comité scientifique de l'IGN – 6 octobre 2009

- STORY
  - **1986 :** setting up of the laboratory **SURFACES**
  - **1992** : setting up of the education programme in **Surveying** ("Géométrologie")
    - To answer a ministerial request (federal) for a university education programme devoted to **expert-surveyors** for an European recognition
    - 2 « State » universities : Gent (1991) et Liège (1992)
    - 2 candidatures + 2 licences (separate options in the geographical sciences programme)

Presentation of the Geomatics Unit of the ULg

Comité scientifique de l'IGN – 6 octobre 2009

- STORY
  - **1986 :** setting up of the laboratory **SURFACES**
  - **1992** : setting up of the programme in **Surveying**
  - **1997** : **Unit of Geomatics**
    - Union of the des chairs of cartography & GIS (Donnay), surveying (Arnould), photogrammetry (Collignon) and remote sensing (Wilmet), together with the laboratory SURFACES
    - Change of the name of the programme : « Geomatics & Surveying »
      - Become with the « **Bologne reform** » :
        - » 2004 : Option « Geomatics & Surveying » of the Bachelor degree in Geographical Sciences (2^{d} et 3^{d} years)
        - » 2006 : Master degree in « Geomatics & Surveying » (authorization limited to the ULg)

Presentation of the Geomatics Unit of the ULg

Comité scientifique de l'IGN – 6 octobre 2009

- STAFF (situation September 2009)

Professors	Assistants	Grant Holders	Researchers	Administrative staff	External Collaborators
R. Billen (Professor)	1.5	2	0.5	1.5	4
A. Collignon (invited prof.)	-	-	-		-
Y. Cornet (Senior Lecturer)	-	1	1.5		-
J.P. Donnay (Ord. Prof.)	1	2	0.5		5
R. Warnant (Professor)	-	1 + 2 (IRM)	1 (+ 4 IRM)		-
Total 5	2.5	8	3.5 (+4)	1.5	9

Workforce relatively stable (15-20) but a fast turnover of the researchers and grant holders (post-docs)

Recent evolution :

New academic appointments, with a redistribution of the assistant and grant holder positions

Appreciable reduction of the number of researchers working on study contracts (by lack of free candidates… not contracts…)

Presentation of the Geomatics Unit of the ULg

Comité scientifique de l'IGN – 6 octobre 2009

- RESEARCHES IN PROGRESS

Fields	Ph.D.	Projects
GNSS	Ionospheric modelling (3) Resolution of ambiguities	PRODEX (ESA) BELSPO – Action 2
Remote sensing & photogrammetry	Extraction of road networks Dynamic modelling of vegetation LIDAR exploitation in hydraulic	MAMUD TOS
Geographical Information Science	Spatio-temporal 3D Warehouse and S-OLAP	RACE Project management
Cartographie	*Services Web (Masters)*	Atlas national
Analyse spatiale	Geographic profiling	Criminal investigations

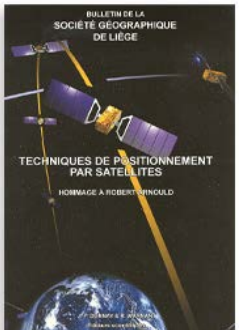
11 Ph.D. in progress, including 5 theses beginning in 2009

+ 2 Ph.D. achieved in 2009

Presentation of the Geomatics Unit of the ULg

Comité scientifique de l'IGN – 6 octobre 2009

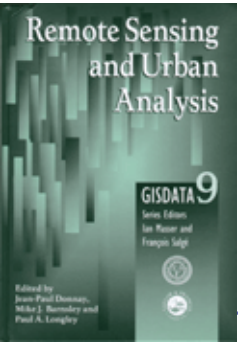
- Global Navigation Satellite Systems (GNSS)
  - **Main fields of investigation:**
    - Ionospheric modelling
    - Galileo
  - **Ph. D. in progress:**
    - Ionospheric modelling for single frequency Galileo users
    - Modelling the ionospheric errors affecting GNSS
    - Computing the Total Electronic Content (TEC) with triple frequency GNSS signals
    - A new Ph. D. begins on the resolution of ambiguities on the phase measurements (unknown cycle numbers)
  - **Research projects in progress:**
    - **Galileo** (BELSPO – Action 2)
    - **PRODEX** (ESA)
      - N.B. All projects are directly concerned with the Ph. D. in progress



Presentation of the Geomatics Unit of the ULg

Comité scientifique de l'IGN – 6 octobre 2009

- Remote sensing & photogrammetry
  - **Main fields of investigation:**



    - Processing of very high resolution (VHR) satellite data in 2D and 3D : urban remote sensing, digital surface models, image fusion
    - Automatic extraction of surface parameters (high and low resolution)
    - Digital photogrammetry: aerial, satellite and ground photogrammetry

  Ph. D. in progress:

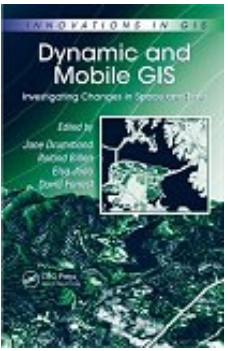
    - Automatic extraction of road networks from VHR images (new)
    - Segmentation and dynamic management of VHR LIDAR information for the simulation of extreme hydraulic events
      - Co-promotion with the Dept. of hydraulic (Fac. Applied Sc. ULg)
    - Predictive modelling of the vegetation dynamic, using low resolution satellite data and meteorological data
      - Secondment to the JRC ISPRA in March 2009

  Research projects in progress:
    - **MAMUD** (BESLPO)
    - **TOS** (SPW)

Presentation of the Geomatics Unit of the ULg

Comité scientifique de l'IGN – 6 octobre 2009

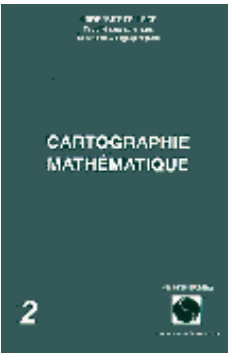
- Geographical Information Science
  - **Main fields of investigation:**
    - IS Design and data modelling
    - Qualitative reasoning and spatial ontologies
    - Description and formalization of 3D data
    - Deployment of « Open Source » solutions
  - **Ph. D. in progress:**
    - Spatio-temporal reasoning
    - Development of an ontology-based model for cables
    - A new Ph. D. begins on the spatial on-line application processes (S-OLAP) applied to data warehouses
      - Application on crime data (cf. spatial analysis)
    - A new Post-doc, in connection with the COST project SemCity, is devoted to the development of an integrated 3D urban spatial information management system
  - **Research projects in progress:**
    - **SemCity** (COST – E.U.)
    - **RACE** (A.R.C.)
    - **Project management in geomatics** (Tournesol – Currien)

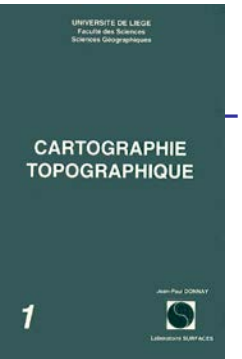


Presentation of the Geomatics Unit of the ULg

Comité scientifique de l'IGN – 6 octobre 2009

- Cartography
  - **Main fields of investigation:**
    - Development of on-line mapping solutions
    - Cartographic projections
    - Cartographic generalization
    - Spatio-cartography (cf. remote-sensing)
  - **Theses in progress:**
    - No doctorate thesis presently in progress, but master theses in geomatics & surveying dealing with Web mapping
    - Examples:
      - *On-line cartographic« Open Source » application for the management of retail locations (2008-2009)*
      - *Development of a CGI application of "assisted" thematic mapping in a 3-tiers environment (2009-2010)*
  - **Research projects in progress:**
    - **National Atlas of Belgium**

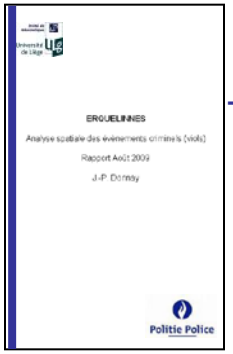




Presentation of the Geomatics Unit of the ULg

Comité scientifique de l'IGN – 6 octobre 2009

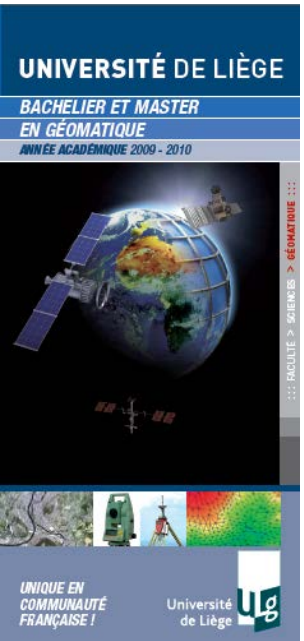
- Spatial Analysis
  - **Main fields of investigation:**
    - Geographic profiling in crime analysis
    - Modelling in geomorphology
  - **Theses in progress:**
    - Dynamic analysis of trips related to crime events (new Ph.D.)
    - *Spatio-temporal analysis of rape events in the trans-border region of Maubeuge – Erquelinnes (master thesis 2009-2010)*
  - **Research projects in progress:**
    - **Geographic profiling:** collaboration with the Belgian Criminal Police Dept., in connection with the theses in progress



Presentation of the Geomatics Unit of the ULg

Comité scientifique de l'IGN – 6 octobre 2009

- EDUCATION
  - **Original aspect in the French-speaking universities of Belgium**
    - Orientation "geomatics & surveying" as soon as the Bachelor degree in geographical sciences (2d and 3d Bac)
    - Masters degrees in "geomatics & surveying" with two orientations:
      - Orientation "surveying"
      - Orientation "applied geomatics" (Liège – Montpellier – Sherbrooke)
  - **"In charge" Unit**
    - For the subjects of cartography, photogrammetry, GIS, remote sensing and surveying
    - Concerned programmes:
      - Faculty of Sciences : geomatics & surveying, geography, climatology, geology, oceanology (+ option in biology and environment)
      - Faculty of Applied Sciences: architect engineer, civil engineer (+ option en geologist engineer)
      - Faculty of Philosophy & Arts: archaeology - archaeometry



Many thanks for your attention

Presentation of the Geomatics Unit of the ULg

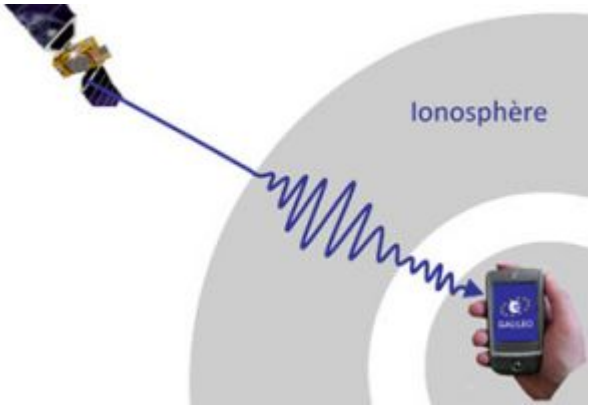
Comité scientifique de l'IGN – 6 octobre 2009

- Ph.D.: Ionospheric modelling for single frequency Galileo users
  - **Candidate:** Benoît Bidaine
  - **Promoter:** René Warnant
  - **Financing:** FNRS (grant holder)
  - **Context:**
    - An empirical model so-called **NeQuick** has been selected to assess the contribution of the ionosphere in the correction devoted to Galileo simple-frequency users
    - It generates electronic densities for various conditions of space, times and solar activities, from a minimum number of parameters. Its use combined with methods of integration permits to compute the total electronic content (TEC) required to obtain the ionospheric correction.
    - However NeQuick and its algorithm used for Galileo applications are affected by several problems resulting mainly in a TEC overestimation in the geomagnetic equator region. It is supposed to be the result of a too simplistic representation of the higher part of the ionosphere.

Presentation of the Geomatics Unit of the ULg

Comité scientifique de l'IGN – 6 octobre 2009

- **Objectives:**
  - This research project first studies the present version of NeQuick in order to underline its weaknesses and to analyse the results.
  - Then it endeavours to suggest enhancements as well for the model (particularly in the higher part of the ionosphere) as for its algorithm implemented for Galileo.
  - Finally it attempts to optimize the practical implementation of NeQuick in the Galileo receivers.



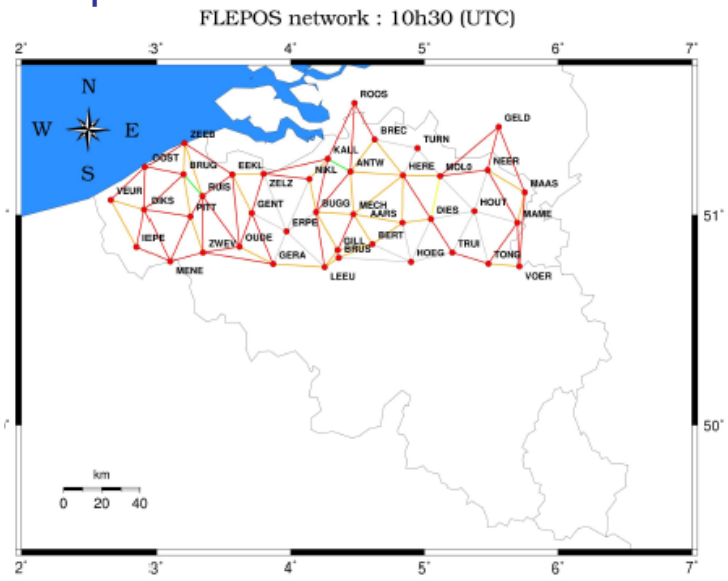
Presentation of the Geomatics Unit of the ULg

- Ph.D.: Modelling the ionospheric errors affecting GNSS
  - **Candidate:** Gilles Wautelet
  - **Promoter:** René Warnant
  - **Financing:** BELSPO – Action 2 (Meteorological Royal Institute) (grant holder)
  - **Context:**
    - Use of the very dense network in Belgium (FLEPOS + WALCORS + EUREF) to assess the ionosphere impact on the computation of the base lines
  - **Objectives:**
    - In case of relative positioning, analyse the effect of the length and the orientation of the base line on the positional error due only to the ionosphere
    - Development of a specific software for the Institute (MRI): SoDIPE/RTK
    - Web service monitoring the complete network every 15 minutes, where the influence of the ionosphere on the base line is shown by a colour code (http://swans.meteo.be)

Presentation of the Geomatics Unit of the ULg

Comité scientifique de l'IGN – 6 octobre 2009

- **Methods:**
  - Computing the residual ionospheric term in the observables of relative positioning (double differences) thanks to the combination « Geometric free »
  - Estimating the positioning error due to the ionosphere by the least square error method
- **Results:**
  - The positional error imputable to the ionosphere increases with the length of the base line
  - In organized ionospheric structures (« Travelling Ionospheric Disturbances » – TID) the base lines which are parallel to the direction of propagation of the structure present a higher positional error than the lines which are perpendicular to this direction



Presentation of the Geomatics Unit of the ULg

Comité scientifique de l'IGN – 6 octobre 2009

- Ph.D.: Computing the Total Electronic Content (TEC) with triple frequency GNSS signals
  - **Candidate:** Justine Spits
  - **Promoter:** René Warnant
  - **Financing:** BELSPO – Action 2 (Meteorological Royal Institute) (grant holder)
  - **Context:** An accurate knowledge of the TEC allows:
    - To improve models and corrections for any type of applications
    - A better understanding of the physics and the dynamics of the ionosphere
    - A 3-D reconstruction ("tomography") of the ionosphere enabling the detection of small structures

Objectives:

- Computing TEC with the help of triple frequency signals from Galileo, enhanced GPS, Glonass et Compass
- The accuracy must be better than the present GPS double-frequency precision

New Ph.D.

Presentation of the Geomatics Unit of the ULg

Comité scientifique de l'IGN – 6 octobre 2009

- Ph.D.: Automatic extraction of road networks from VHR images
  - **Candidate:** Loubna Elmansouri
  - **Promoter:** Yves Cornet
  - **Financing:** bilateral cooperation CFB – Morocco (grant holder)
  - **Context:**
    - Many algorithms devoted to linear features extraction are proposed in literature but :
      - They have limited capabilities in dense and complex environments, such as the urban milieu where a large number of objects interfere with the road network
      - They do not exploit the genuine characteristics of VHR imagery

Objective:

- To Propose a methodology :
  - Generic, self-adapting to various road geometries (width and curvature, crossroads, etc.)
  - Automatic: from the selection of initial sections, to the assessment of the extracted road features
  - Milieu-independent : rural, suburban, urban
  - Using VHR satellite imagery (<1m).

Presentation of the Geomatics Unit of the ULg

Comité scientifique de l'IGN – 6 octobre 2009

- Ph.D.: Spatio-temporal reasoning
  - **Candidate:** Pierre Hallot
  - **Promoter:** Roland Billen
  - **Financing:** ULg (assistant)
  - **Context:**
    - Due to the multiplication of real time positioning techniques, the amount of spatio-temporal data constantly increases. In order to extract the whole information contained in those data, it is necessary to develop genuine models based on qualitative reasoning.
    - Present models of spatio-temporal relationship are often limited to period of co-existence, co-occurrence or common visibility between the objects under study and they only describe the disjointure phase between objects.

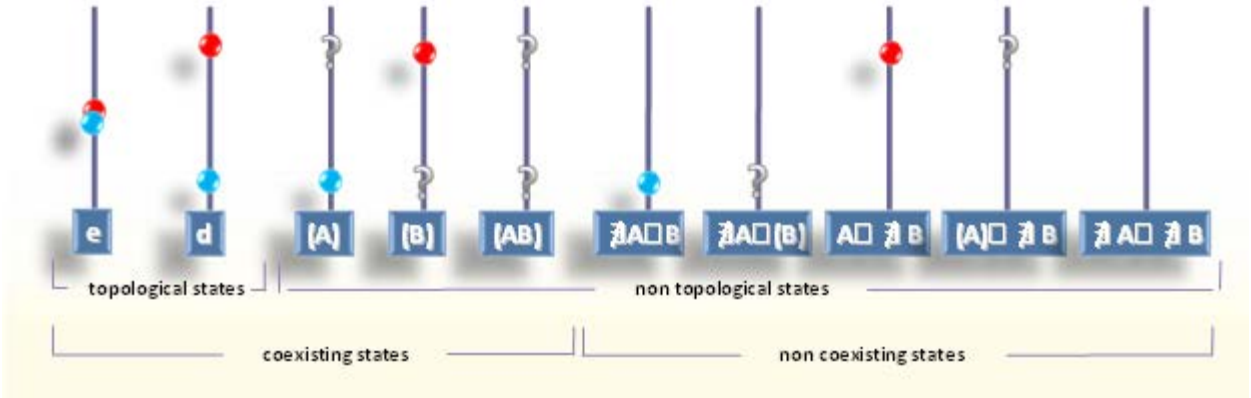
Objective:

- A generalised model of spatio-temporal relations based on the concept of "spatio-temporal states » permitting to formalize "spatio-temporal stories".

Presentation of the Geomatics Unit of the ULg

Comité scientifique de l'IGN – 6 octobre 2009

- **Method:**
  - First a generalization of spatio-temporal stories – based on topological relationship in a primitive time-space – has been developed. This allow the use of standard spatial operators implemented in DBMS to achieve spatio-temporal requests and reasoning.
  - An interpretation of the relations in natural language is also proposed in order to develop requests which are closer to human perception e.g. : « *selection of objects which already met themselves* », « *selection of all objects being in touch with the object "A"* », etc.
  - A prototype capable of fully exploiting the proposed model is in progress.



New Ph.D.

Presentation of the Geomatics Unit of the ULg

- Ph.D.: Development of an ontology-based model for cables
  - **Candidate:** Ivana Sainovic
  - **Promoter:** Roland Billen
  - **Financing:** ULg (grant holder)
  - **Context:** the improvement of the management of underground infrastructures requires:
    - Identifying the needs of the different professions involved in underground structures construction (relevant information to be modelled)
    - Improvement of communication between professionals (engineers, land surveyors, designers, etc.) is a key issue
    - Sustainability and safety is prerogative in this model

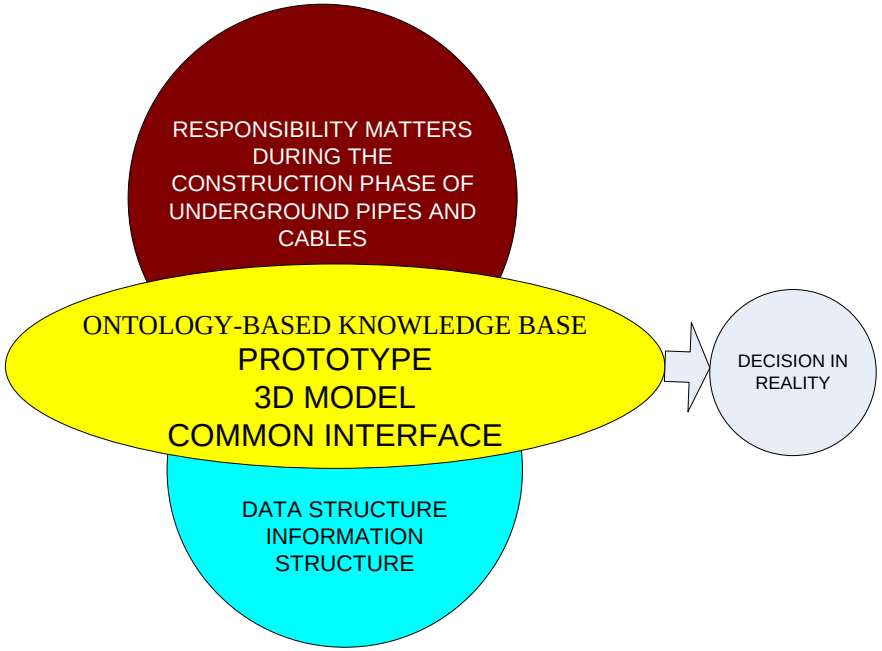
Objectives:

- Avoidance of duplication of data and widening of the spatial perception
- Improvement of the performance of the utilities during their full life cycle
- Planning and better decision making during construction phase and afterwards for emergency planning, urban planning and response
- Single interactive model supporting 3d visualisation and communication capability of 3D simulations

Presentation of the Geomatics Unit of the ULg

Comité scientifique de l'IGN – 6 octobre 2009

- Methods:
  - Development of an ontology-based model allowing sharing of information between « users »
  - Such model would not be only based on underground structures precise geometry, but would include other types of information, e.g. semantics or relative spatial positioning
  - Management tool and a way to improve the interoperability of multidisciplinary approach toward practical challenges

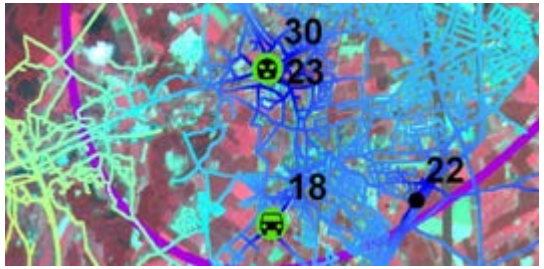


New Ph.D.

Presentation of the Geomatics Unit of the ULg

Comité scientifique de l'IGN – 6 octobre 2009

- Ph.D.: Dynamic analysis of trips related to crime events
  - **Candidate:** Marie Trotta
  - **Promoter:** Jean-Paul Donnay
  - **Financing:** ULg (grant holder)
  - **Context:**
    - Criminal events can be described by temporal and spatial attributes
    - The present analyses forming geographic profiling are essentially descriptive and static, applying "recipes" issued from standard quantitative geography



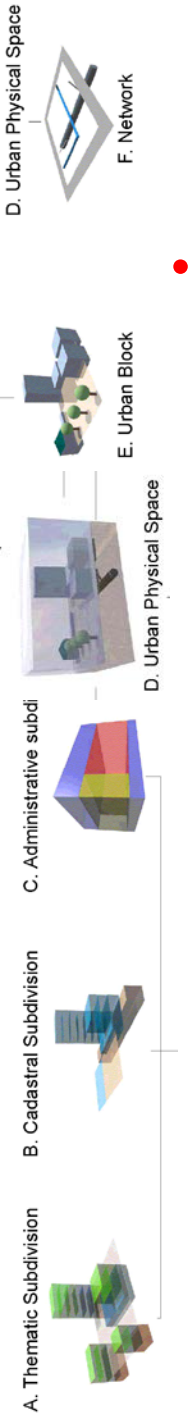
  - **Objective:**
    - Development of a method aiming at supporting decision (elaboration of scenarios) based on spatial and temporal characteristics of criminal data featuring trips

Method:

- Reconstitution of trips and research of trip origins related to crime event series, making use of spatial and temporal propagation on various kind of networks

Presentation of the Geomatics Unit of the ULg

Comité scientifique de l'IGN – 6 octobre 2009

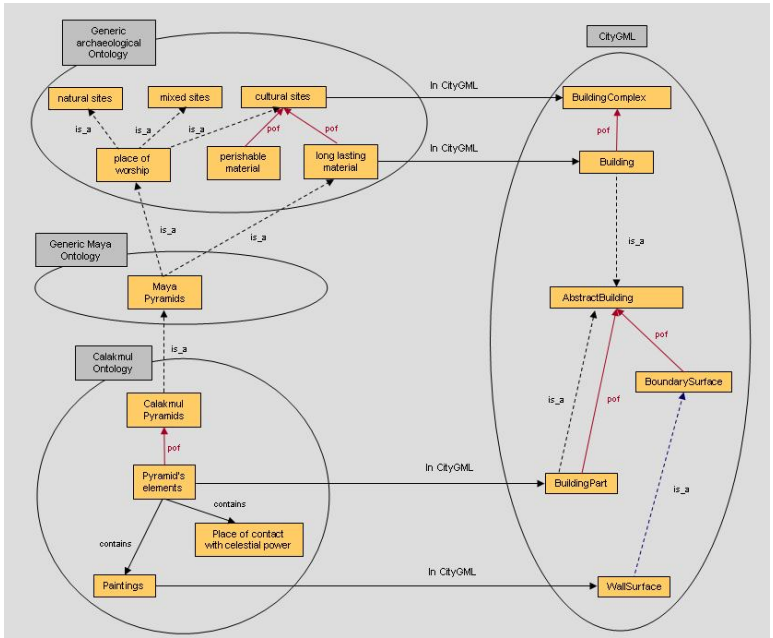


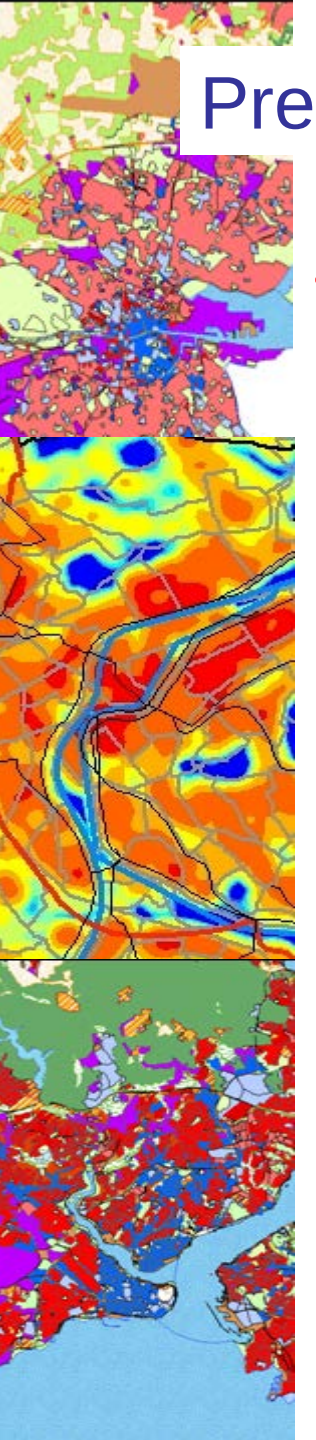
- Post-Doc & Project: Integrated 3D urban spatial information management system
  - **Candidate:** Vitor Silva (Dr. EPFL)
  - **Promoter:** Roland Billen
  - **Financing:** ULg (grant holder) + COST project **SemCity** (E.U.)
  - **Context:**
    - 3D geodata are more and more available as well as realtime visualization possibilities with free three-dimensional viewers. This implies a growing demand of 3D city models, which are 3D representations at the scale of the city. Despite their intended wide range of applications, such models cannot be used for many urban tasks as they cannot represent the urban information associated with these tasks.
    - On the contrary, ontologies have proven their capacity and usability in the representation of information and knowledge of various domains. Besides, interoperability is a crucial problem for urban information systems. Transferring information between different systems or models requires the ability to set up correspondences between concepts from one system to concepts in the other one. The use of ontologies can greatly facilitate this mechanism of concept matching.

Presentation of the Geomatics Unit of the ULg

Comité scientifique de l'IGN – 6 octobre 2009

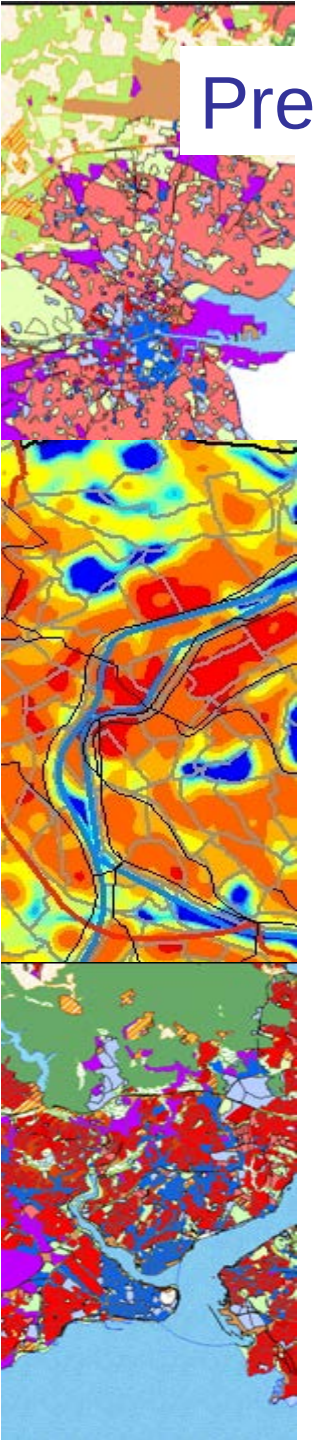
- **Objective:**
  - The project aims to develop, in an Open Source environment, an integrated 3D urban spatial information management system. The system is conceptually built on a geomatics-based ontology, which follows current geographical information standards. The system will offer several modules, especially a 3D spatial database-modelling interface.
  - In this project ontologies will be used to overstep the semantic limitation of 3D city models and to inter-connect urban models in order to improve their interoperability.
- **Collaboration:**
  - University of Delft (TU Delft)
    University of Berlin (TU Berlin)





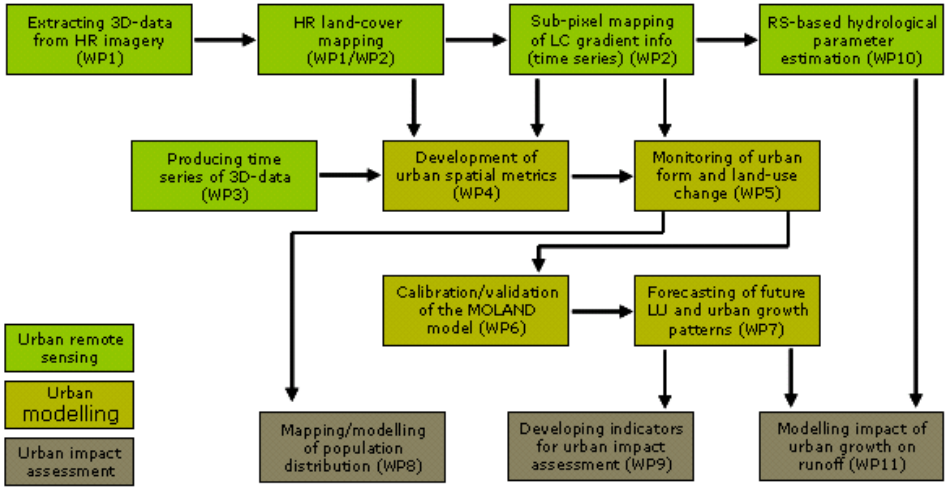
Presentation of the Geomatics Unit of the ULg

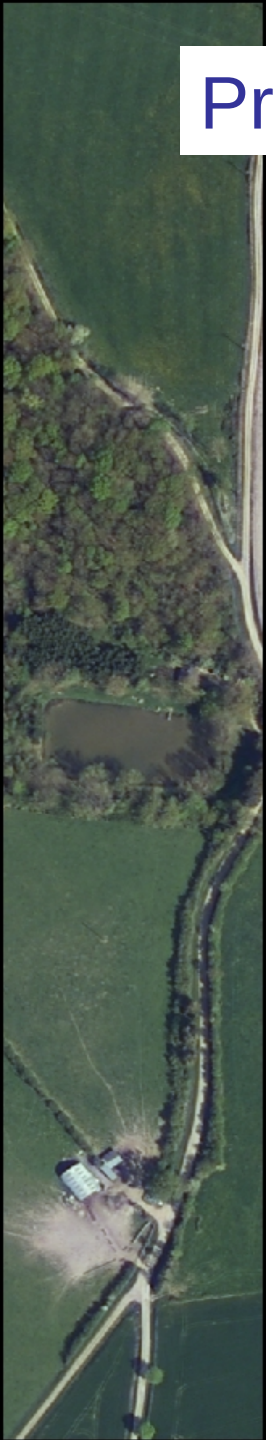
- Project MAMUD: Measuring And Modeling Urban Dynamics: impact on quality of life and hydrology
  - **Objectives:**
    - To investigate how earth observation data can contribute to a better monitoring, modeling and understanding of urban dynamics and its impact on the urban and suburban environment
    - To examine how spatial metrics, derived from remotely sensed imagery (high and low resolution), may lead to more objective descriptions of urban form that may be used for intra-urban and inter-urban comparison, as well as for urban change analysis
  - **Financing:** Belgian Science Policy Office (BELSPO)
    - **Collaborations** : VUB (CGIS & HYDR), UG (Geography), VITO, JRC (Land Management and Natural Hazards Unit)



Presentation of the Geomatics Unit of the ULg

- **Methods:**
  - Development of new urban metrics (e.g. land-cover gradients) obtained through sub-pixel classification of medium-resolution imagery or aggregation of high-resolution land-cover classifications
  - Use of stereoscopic and multi-scopic imagery to extract information on the vertical structure of urban areas
  - Developed metrics are used to complement detailed land-use maps in the historic calibration of a spatially-dynamic land-use model of the type cellular automata

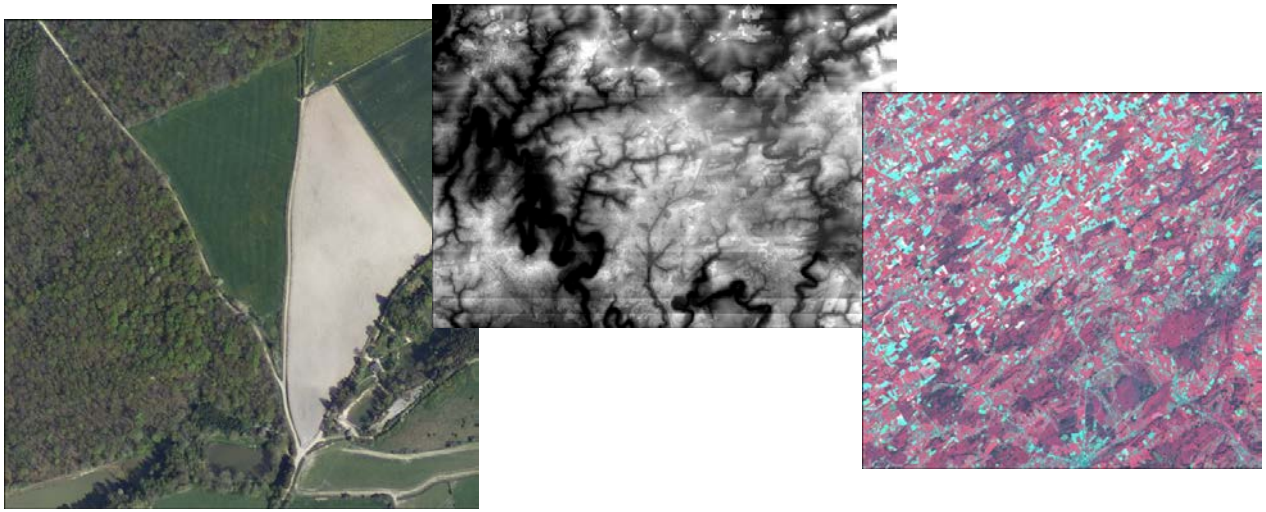




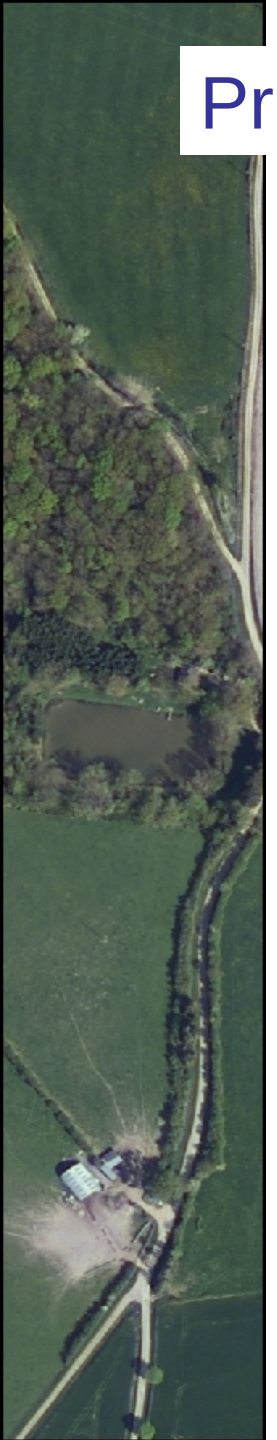
Presentation of the Geomatics Unit of the ULg

Comité scientifique de l'IGN – 6 octobre 2009

- Project TOS: Télédétection de l'Occupation du Sol en Wallonie
  - **Objective :** to assess the possibilities given by the ortho-image cover and its attached digital surface model produced by the Walloon Region, in order to improve the classification processes of not urbanized land uses.



  - **Financing :** Direction Générale de l'Agriculture des Services Publics de Wallonie
    - Collaboration**:** Faculty of Agronomy (Gembloux – ULg): Unité de Gestion des Ressources forestières et des Milieux naturels



Presentation of the Geomatics Unit of the ULg

Comité scientifique de l'IGN – 6 octobre 2009

- **Data sources:**
  - Walloon cover of aerial digital ortho-images
    - Flights 2006-2007, spatial resolution: 50 cm
    - 4 spectral channels: B, G, R, NIR
  - Digital surface model of the Walloon region
    - Made from the digital aerial images
    - Spatial resolution: 5 m
  - Satellite images SPOT (various dates)
    - Spatial resolution: 10 m
    - 4 spectral channels: G, R, NIR, MIR
- **Methods:**
  - Digital aerial images are segmented in groups of pixels sharing similar spectral behaviours ("objects")
  - "Object – classification" (not "pixel – classification")
  - Assessment of the object height from the DSM
  - Thematic classification – diachronic and pyramidal – of the SPOT images

Presentation of the Geomatics Unit of the ULg

- Project RACE : Rapid Assessment of marine Coastal Environment
  - **Specific tasks:**
    - Design, implementation and diffusion (via Internet) of an oceanographic database (data collected from the beginning of the '70s over the bay of Calvi (oceanographic station of the ULg – Corse)
    - Setting up of an automatic network (sensors) for updating the database and "upstream" interfacing between sensors and database
    - Database "downstream" interfacing between the database and the digital models dedicated to the dynamic modelling of the bay of Calvi
  - **Financing :**
    - Action de Recherche Concertée (A.R.C.)
    - Collaboration with 6 units of the ULg (Sciences & Applied sciences):
      - Geo-hydrodynamics, oceanology, planctonology, algology, marine ecology, mathematic methods and modelling

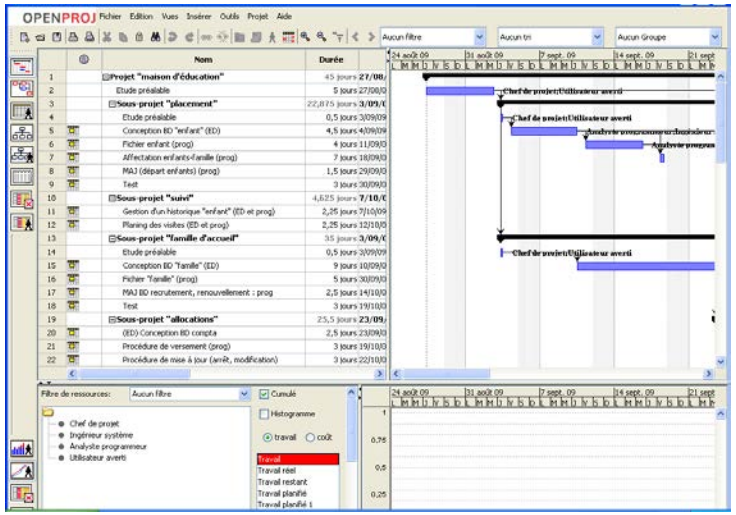
Presentation of the Geomatics Unit of the ULg

- **Present results:**
  - Design of a spatialized database with Web2GIS
  - Server implementation of the database with PostgreSQL + PostGIS
  - Storage of more than 3.10^6 measures corresponding to:
    - 100 campaigns
    - 250 temporal series
    - 600 samples
    - 125 localised stations
    - 125 parameters, built and documented
  - Interface programming for "on-line" requests according to different user categories
  - Results exportation under various formats for feeding modelling software

Presentation of the Geomatics Unit of the ULg

Comité scientifique de l'IGN – 6 octobre 2009

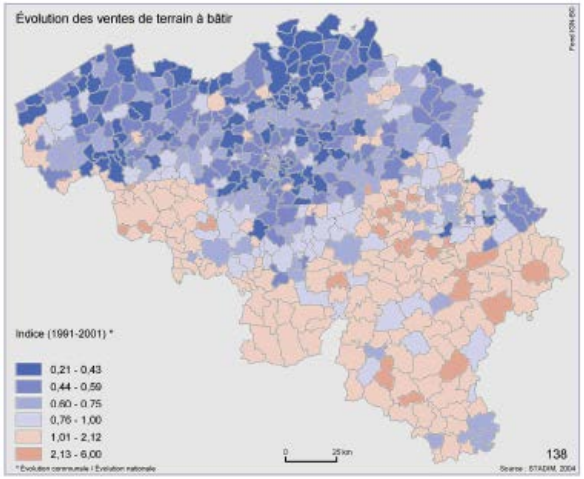
- Project: Project management in geomatics
  - **Tasks:**
    - Scientific aspect: adjustment of the project design methodology of "information systems" to new distributed architectures (data infrastructures and data warehouses)
    - Educational aspect : elaboration of a syllabus – including exercises – devoted to computer project management methods adapted to spatialized projects, e.g. terrain survey, enterprise GIS, etc.
      - Logiciel « open source » Serena OpenProj vers. 1.4
  - **Financing:** PHC Tournesol (CFB) & Fondation Joseph Currien (France)
    - Collaboration : University of Montpellier II (LIRMM)

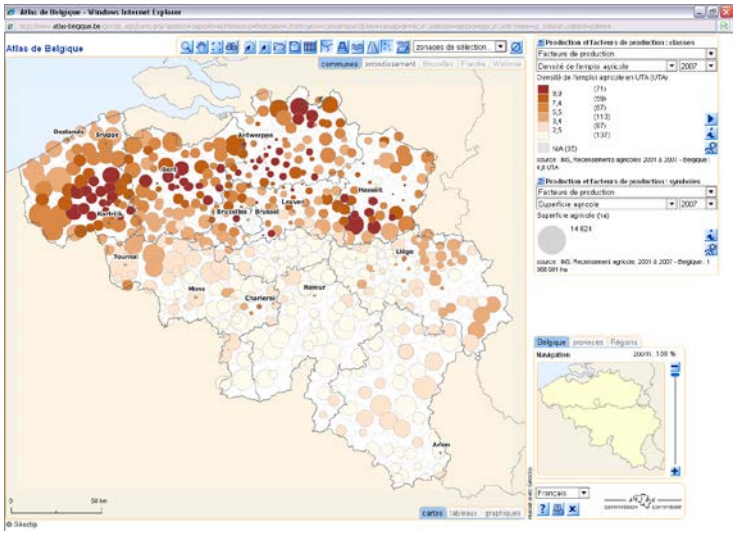


Presentation of the Geomatics Unit of the ULg

Comité scientifique de l'IGN – 6 octobre 2009

- Project National Atlas of Belgium
  - **Specific tasks:**
    - Receiving, editing and finalizing all maps published in the National Atlas series (4th volume in progress)
    - Prototyping of a digital National Atlas of Belgium
      - Software **GeoClip** – personalised version





  - **Financing:** National Committee of Geography, sub-committee for the National Atlas & Belgian Science Policy Office (BELSPO)
    - Collaboration : University of Gent