Canadian Board of Examiners for Professional Surveyors
Elective Syllabus Item
E 1: SPATIAL DATABASES AND LAND INFORMATION SYSTEMS

Syllabus Topics:

Database [relational, object-relational, object-oriented]; Database Management Systems (DBMS), Relational Database Management Systems (RDBMS) and universal servers;

Database architecture [centralized and distributed, web-based]; Web servers [client/server]; Multidimensional systems; Data warehouses, datamarts, On-Line Analytical Processing (OLAP) and Data Mining; interoperability; standards [WMS, WFS];

Database design and developement [system development methods and database modeling]; data modeling formalisms [UML, Entity-Relationship and relational database modeling]; visual modeling tools [CASE tools, Computer-Assisted Software Engineering]; integrity constraints; database normalization and optimization; access methods and index;

Application of Database Management to Geographical Information Systems (GIS); Geospatial Databases; spatial data types [point, line, polygon; OGC data types], spatially-extended SQL [spatial operators]; spatial data integrity constraints; spatial indexing methods [Quadtree, R-tree]; geographic information system data structures; land information systems (LIS); parcel-based LIS; standards [ISO TC/211, OGC]; metadata [ISO-19115]

Recommended Prior Knowledge and Skills:

Item C1: Mathematics

Item C2: Least-Squares Estimation and Data Analysis

Item C3: Advanced Surveying

Item C4: Coordinate Systems and Map Projections

Item C5: Geospatial Information Systems

Courses or extensive experience in geospatial data analysis using spatial operators; geospatial data structure [topological and nontopological (spaghetti)]; Geospatial Information System data types [point, line, polygon, …].

Learning Outcomes:

In order to satisfy the requirements of this syllabus item, candidates should be able to:

1. Describe these topics and be able to give examples:
    a. data, geospatial data, metadata
    b. databases, geospatial databases
    c. database management systems, relational database management system, object-oriented database management system;
    d. geographic information system (GIS), land information system (LIS)
    e. geographic information system data structures,
    f. analysis and design of spatial databases for applications
        i. modeling language: UML, E/R

ii. data model, conceptual model, implementation model

iii. CASE tool;

g. spatial database implementation and querying,

i. SQL and spatially-extended SQL;

h. architecture of database systems

i. centralized, distributed

ii. client server, web map server, web map service (WMS) <http://www.opengeospatial.org/standards/wms>, web feature service (WFS) <http://www.opengeospatial.org/standards/wfs>, geographic markup language (GML) <http://www.opengeospatial.org/standards/gml>

iii. data warehouse, datacube or multidimensional database, data mining, datamart and OLAP;

iv. interoperability

i. database optimization techniques

i. index, spatial index, cluster, partition

2. Explain the similarities and differences between categories of databases such as transactional, analytical (or datacubes), data warehouses, datamarts, centralized, distributed.

3. Describe the major phases of formal methods such as IBM Rational Unified Process (RUP), Extreme Programming (agile), OMG (MDA) and similar methods and the families of methods such as Waterfall, Incremental, Spiral and Agile, required in geospatial database development project.

4. Describe organizational and institutional issues affecting the success of geospatial database and LIS project

5. Use appropriate modeling languages (ex. E/R, UML) to design geospatial database models.

a. Design a conceptual model (CIM) from user requirements using normal forms.

b. Translate conceptual model (CIM) to normalized or denormalized logical model (PIM) for relational database.

c. Give examples of business rules, integrity constraints and spatial integrity constraints which should be implemented to insure quality and security of the spatial database.

d. Do the reverse engineering from SQL code or Map (PSM) to logical model (PIM) or conceptual model (CIM).

e. Make the mapping between modeling and implementation languages.

f. Describe what CASE tools can do to support this process.

g. Illustrate the difference between technology-independent conceptual database models (CIM) and technology-specific database implementation models (PSM).

6. Suggest improvements to a database structure to perform given queries, to optimize given queries, to increase data quality and to reduce redundancy and data inconsistency.

7. Name ISO TC/211standards and OGC standards related to topics listed in learning outcome #1.

a. Use appropriate OGC geometry data types in conceptual and logical models

8. Apply spatial database concepts in a Land Information System context.

Essential Reference Material:

a. Yeung, A. and Hall, B. [2007]. *Spatial Database Systems: Design, Implementation and Project Management*, Springer ISBN: 978-1-4020-5391-7.

All the chapters in this book are essential. See also additional materials of this book at this Web address: http://www.fes.uwaterloo.ca/research/spatial/

Note: sec. 2.3, figure 3-4, is incorrect. Because the relationship between OWNER and PARCEL is a many-to-many relationship, a new table OWN must be created having the primary key of each table in relation as foreign keys. Remove the foreign key OWNER_SIN in PARCEL table and PARCEL_ID in OWNER table. The schema should look like this one below.

OWNER	NAME	ADDRESS	OWNER_SIN		
PARCEL	LOCATION	AREA	PARCEL_ID	ZONING	ASS_VAL
OWN	PARCEL_ID	OWNER_SIN			
REGISTER	PARCEL_ID	DATE			

b. Jewett, T. [2006]. *Database design with UML and SQL*, 3rd edition. Available via <*www.tomjewett.com/dbdesign/dbdesign.php*> or web-search "Tom Jewett database design"

Good overview on how to implement UML models in relational databases.

c. [2009]. *Introduction to UML*. SmartDraw Tutorials. Available via <*www.smartdraw.com/resources/tutorials/Introduction-to-UML*>.

Explore rapidly the 10 UML diagrams and learn in more detail Class diagrams.

d. Boehm, B. and Turner, R. [2003]. *Observations on Balancing Discipline and Agility*. Available via <*agile2003.agilealliance.org/files/P4Paper.pdf*>

Very good comparison of agile development methodologies and plan-driven approaches.

e. Hurst, J. [2007]. *Comparing Software Development Life Cycles*, Available via <*www.giac.org/resources/whitepaper/application/257.php*>

Overview of software development life cycle (synonym as software development methodology)

f. [2006] *OpenGIS Implementation Specification for Geographic information - Simple feature access - Part 1: Common architecture*. Version 1.2.0.Open Geospatial Consortium. Available via <*www.opengeospatial.org/standards/sfa*>

Supplementary Reference Material:

a. [2009] *OMG Model Driven Architecture*. Object Management Group. Available via <*www.omg.org/mda/specs.htm*>

b. [2003] *Using Spatial PVL for spatial database modeling*. Available via <*sirs.scg.ulaval.ca/perceptory/english/pvl_e.asp*>

c. Bell, D. [2004]. *UML basics: The class diagram*. IBM. Available via <www.ibm.com/developerworks/rational/library/content/RationalEdge/sep04/bell/>

d. [2000]. *The UML and Data Modeling*, Rational Software Whitepaper. Rational Sotware Corporation. Available via <www.uml.org.cn/oobject/Tp180.pdf>

e. [2009]. *Unified Modeling Language (UML), Version 2.2*. Object Management Group. Available via <www.omg.org/technology/documents/formal/uml.htm >

f. [2008]. OpenGIS Reference Model (ORM). Version 2.0. Open Geospatial Consortium. Available via <www.opengeospatial.org/standards/orm>

Read this article to better understand OGC standards. A very good overview!

g. Ventura, S. J. [1997]. "Land Information Systems and Cadastral Applications", NCGIA Core Curriculum in GIScience, posted October 23, 1998. Available via www.ncgia.ucsb.edu/giscc/units/u164/u164.html

This article can be useful for LO #8

h. Natural Resources Canada [1996]. National Topographic Database Data dictionary. Available via <ftp2.cits.rncan.gc.ca/pub/bndt/doc/dictntd3_en.pdf>

This reference is useful for spatial data integrity constraints.

Glossary, dictionary and encyclopaedia:

These supplementary reference materials can be useful for LO #1

i. GeoConnections Glossary. Available via <www.geoconnections.org/publications/training_manual/e/glossary/glossary.htm>

j. Free On-line Dictionary of Computing. Editor Denis Howe. Available via <foldoc.org/contents/database.html>

k. High-Tech Dictionary. Available via <www.computeruser.com/resources/dictionary/index.html>

LIS Geospatial database projects:

These supplementary reference materials give examples of LIS database project using UML. They can be useful for LO #8.

l. Oosterom, P. and C. Lemmen [2006]. The core Cadastral Domain Model: A tool for the development of distributed and interoperable Cadastral Systems. International Federation of Surveyors, commission 7. Available via <www.fig.net/commission7/india_2006/papers/ts04_01_lemmen.pdf>

m. [2008]. Geographic Information Framework Data Content Standard - Part 1: Cadastral. Federal Geographic Data Committee, USA. Available via <www.fgdc.gov/standards/projects/FGDC-standards-projects/framework-data-standard/GI_FrameworkDataStandard_Part1_Cadastral.pdf>

n. Mutambo, L. S. [2003]. The Unified Modelling Language (UML) in Cadastral System Development. Master degree Thesis. International Institute for Geo-information Science and Earth Observation (ITC), Netherlands. Available via <www.itc.nl/library/Papers_2003/msc/gim/levi.pdf>

o. Kaufmann, J. [2004]. ArcGIS Cadastre 2014 Data Model Vision. ESRI, USA. Available via <www.esri.com/industries/cadastre/pdf/nc_2014.pdf>

p. Paasch .J. [2005]. “Legal Cadastral domain Model – An Object-oriented Approach”, Nordic Journal of Surveying and Real Estate Research, vol 2, n.1, February, 117-136. Available via <*mts.fgi.fi/njsr/issues/2005/njsrv2n12005_paasch.pdf*>