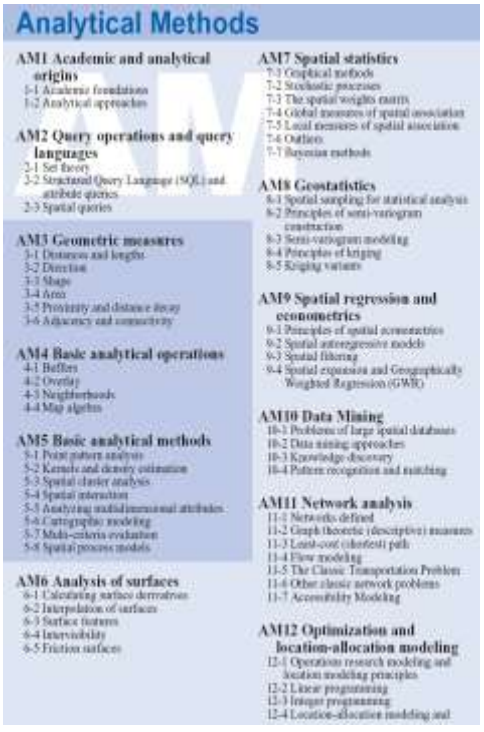


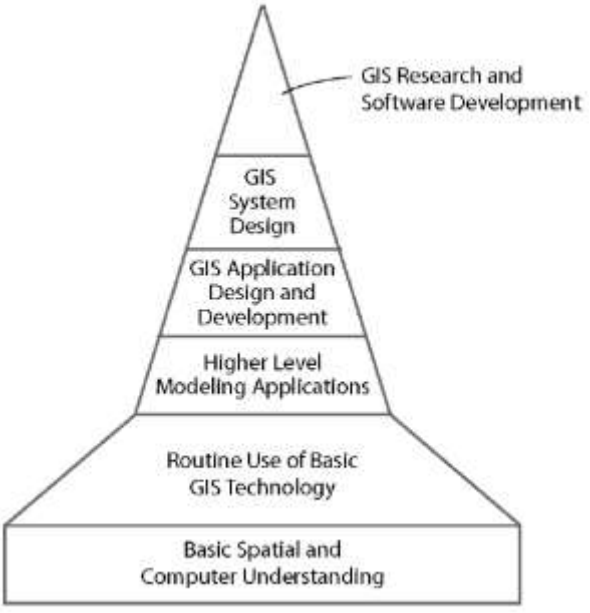

# Geographic Information Science & Technology Body of Knowledge

Edited by David DiBiase, Michael DeMers, Ann Johnson, Karen Kemp, Ann Taylor Luck, Brandon Plewe, and Elizabeth Wentz

UNIVERSITY CONSORTIUM FOR GEOGRAPHIC INFORMATION SCIENCE

The DoL estimated a $30b/year GIS industry, but where are the GIS jobs?


Figure 2: “Pyramid” of roles played by GIS&T professionals. Fewer, but more highly skilled, personnel are needed at the upper levels of the pyramid. (Marble, 1998).



**2004 Salary Survey for the Geospatial Sciences**

| | Position | Average (Group Avg) | |
|---|---|---|---|
| Manager | Production Director/Operations Manager | 102,264 | $82,615 |
| | Sales/Marketing Manager | 100,365 | |
| | Photogrammetry Department Manager | 79,739 | |
| | Supervisory Planner | 78,650 | |
| | Human Resources/Personnel Manager | 77,580 | |
| | GIS Manager/Coordinator | 77,011 | |
| | Sales Representative | 73,038 | |
| | Technical/Production Manager | 72,275 | |
| Senior Analyst | Sr. GIS Programmer | 71,006 | $69,288 |
| | Systems Manager | 70,874 | |
| | GPS/Survey Manager | 70,262 | |
| | GIS Project Manager | 69,110 | |
| | Sr. Programmer/Analyst | 68,604 | |
| | Pilot Commercial/Instrument | 67,639 | |
| | GIS Database Manager | 67,516 | |
| Analyst | GIS Programmer | 61,452 | $57,426 |
| | Senior Image Analyst | 59,561 | |
| | Programmer/Analyst | 59,452 | |
| | Planner | 58,928 | |
| | Sr. GIS Specialist | 55,475 | |
| | Sr. Stereoplotter Operator - Analytical and Softcopy | 55,020 | |
| | Quality Assurance Analyst | 52,093 | |
| Technician | Market Analyst/Research Specialist | 48,212 | $44,023 |
| | GIS Specialist | 46,812 | |
| | Digital Ortho Image Technician | 44,929 | |
| | Aerial Photographer | 44,557 | |
| | Sr. Graphics Workstation Operator | 44,325 | |
| | Photo Lab Manager | 44,237 | |
| | Stereoplotter Operator - Analytical and Softcopy | 41,236 | |
| | GPS Surveyor/Technician | 41,145 | |
| | GIS Technician | 40,757 | |
| Jr. Technician | Raster/Vector Technician | 37,988 | $33,044 |
| | Graphics Workstation Operator | 37,040 | |
| | Computer Processing Technician | 36,252 | |
| | Jr. Stereoplotter Operator - Analytical and Softcopy | 32,054 | |
| | Photo Lab Technician | 31,084 | |
| | Jr. Graphics Workstation Operator | 23,846 | |

GeoSearch, Inc.
(www.geosearch.com)

Geospatial Technology Competency Model (Employment and Training Administration, USDL Draft 04-01-10)

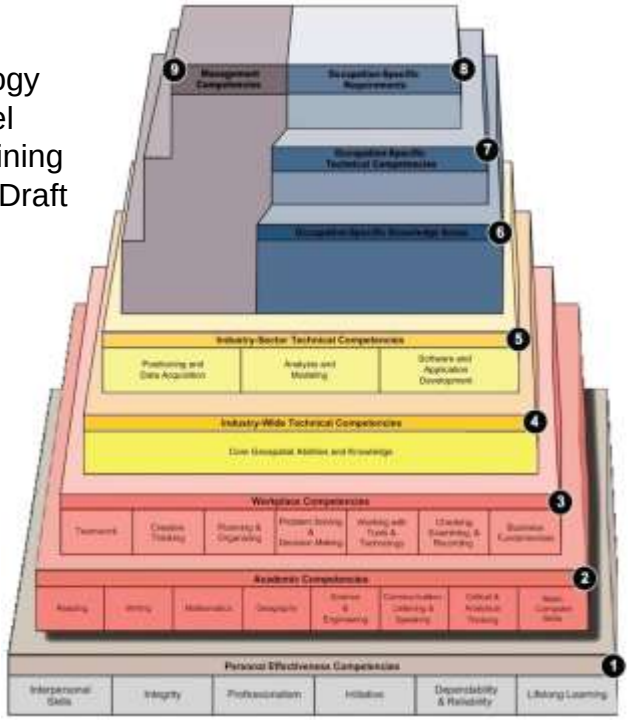


**Table 2: Twelve roles played by geospatial technology professionals (Gaudet, Annulis, & Carr, 2003).**

| Roles | Tasks | Your Status |
|---|---|---|
| Applications Development | Identify and develop tools and instruments | ? |
| Data Acquisition | Collect geospatial and related data | ☑ |
| Coordination | Interorganizational facilitation and communication | ? |
| Data Analysis & Interpretation | Process data and extract information to create products, drive conclusions, and inform decision-making | ☑ |
| Data Management | Catalog, archive, retrieve, and distribute geospatial data | ☑ |
| Management | Using financial, technical, and intellectual skills and resources to optimize the end products | ? |
| Marketing | Identify and communicate the requirements and needs of geospatial solutions | ? |
| Project Management | Oversee activity requirements to produce the desired outcomes | ? |
| Systems Analysis | Assess requirements to produce the desired outcomes on time and within budget | ? |
| Systems Management | Integrate resources and develop additional resources to support user requirements | ? |
| Training | Effective transfer of knowledge and evaluation for performance enhancement | ? |
| Visualization | Render data and information into visual geospatial representations | ☑ |

The 10 most desirable skills for someone entering the GIS, Photogrammetry, and Remote Sensing workforce
(in no particular order)

1. College degree- Geospatial science preferred
2. GIS and CAD software familiarity- not necessarily proficiency
3. Math Skills
4. Technology literate/ Basic computer skills
5. Able to work in team and alone unsupervised
6. Able to communicate in oral and written form
7. Grasp of the world
8. Have a strong portfolio that shows your range of skills
9. Cartographic eye/skills
10. Ability to Network

http://www.psuasprs.groups.pdx.edu/colloquium/2007/CareerLinks_2007.htm

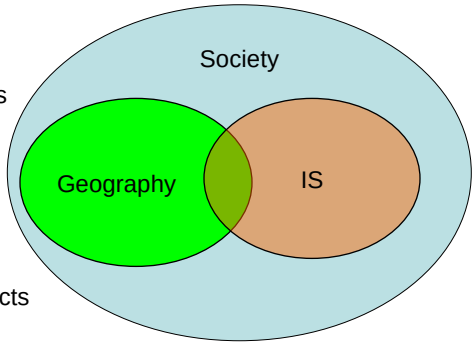
# GIS&T Body of Knowledge
# 10 Topics

- Analytical Methods
- Cartography & Visualization
- Design Aspects
- Conceptual Foundations
- Data Modeling
- Data Manipulation
- GIS&T and Society
- Geocomputation
- Organizational and Institutional Aspects
- Geospatial Data

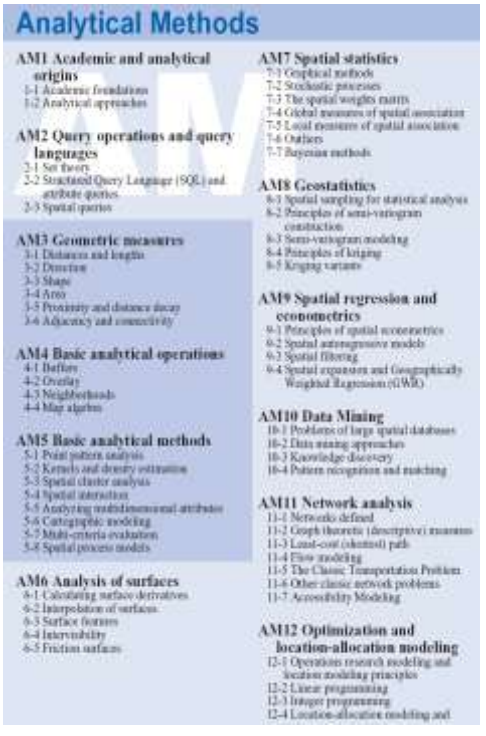
Spatial Concepts & Data
- Analytical Methods
- Cartography & Visualization
- Conceptual Foundations
- Data Manipulation
- Geospatial Data

Information & Computation Technologies
- Design Aspects
- Data Modeling
- Geocomputation

Human & Computer Interfaces
- GIS&T and Society
- Organizational and Institutional Aspects



# Spatial Concepts & Data



# Cartography and Visualization

**CV1 History and trends**
- 1-1 History of cartography
- 1-2 Technological transformations

**CV2 Data considerations**
- 2-1 Source materials for mapping
- 2-2 Data abstraction: classification, selection, and generalization
- 2-3 Projections as a map design issue

**CV3 Principles of map design**
- 3-1 Map design fundamentals
- 3-2 Basic concepts of symbolization
- 3-3 Color for cartography and visualization
- 3-4 Typography for cartography and visualization

**CV4 Graphic representation techniques**
- 4-1 Basic thematic mapping methods
- 4-2 Multivariate displays
- 4-3 Dynamic and interactive displays
- 4-4 Representing terrain
- 4-5 Web mapping and visualizations
- 4-6 Virtual and immersive environments
- 4-7 Spatialization
- 4-8 Visualization of temporal geographic data
- 4-9 Visualization of uncertainty

**CV5 Map production**
- 5-1 Computational issues
- 5-2 Map production
- 5-3 Map reproduction

**CV6 Map use and evaluation**
- 6-1 The power of maps
- 6-2 Map reading
- 6-3 Map interpretation
- 6-4 Map analysis
- 6-5 Evaluation and testing
- 6-6 Impact of uncertainty

# Conceptual Foundations

**CF1 Philosophical foundations**
- 1-1 Metaphysics and ontology
- 1-2 Epistemology
- 1-3 Philosophical perspectives

**CF2 Cognitive and social foundations**
- 2-1 Perception and cognition of geographic phenomena
- 2-2 From concepts to data
- 2-3 Geography as a foundation for GIS
- 2-4 Place and landscape
- 2-5 Common-sense geographies
- 2-6 Cultural influences
- 2-7 Political influences

**CF3 Domains of geographic information**
- 3-1 Space
- 3-2 Time
- 3-3 Relationships between space and time
- 3-4 Properties

**CF4 Elements of geographic information**
- 4-1 Discrete entities
- 4-2 Events and processes
- 4-3 Fields in space and time
- 4-4 Integrated models

**CF5 Relationships**
- 5-1 Categories
- 5-2 Mereology: structural relationships
- 5-3 Genealogical relationships: lineage, inheritance
- 5-4 Topological relationships
- 5-5 Metrical relationships: distance and direction
- 5-6 Spatial distribution
- 5-7 Region
- 5-8 Spatial integration

**CF6 Imperfections in geographic information**
- 6-1 Vagueness
- 6-2 Mathematical models of vagueness: Fuzzy sets and rough sets
- 6-3 Error-based uncertainty
- 6-4 Mathematical models of uncertainty: Probability and statistics

# Data Manipulation

## DN1 Representation transformation
1-1 Impacts of transformations
1-2 Data model and format conversion
1-3 Interpolation
1-4 Vector-to-raster and raster-to-vector conversions
1-5 Raster resampling
1-6 Coordinate transformations

## DN2 Generalization and aggregation
2-1 Scale and generalization
2-2 Point, line, and area generalization
2-3 Classification and transformation of attribute measurement levels
2-4 Aggregation of spatial entities

## DN3 Transaction management
3-1 Database change
3-2 Modeling database change
3-3 Reconciling database change
3-4 Managing versioned geospatial databases

# Geospatial Data

## GD1 Earth geometry
1-1 History of understanding Earth's shape
1-2 Geoids
1-3 Spheres and ellipsoids

## GD2 Land partitioning systems
2-1 Unsystematic methods
2-2 Systematic methods

## GD3 Georeferencing systems
3-1 Geographic coordinate system
3-2 Plane coordinate systems
3-3 Tessellated referencing systems
3-4 Linear referencing systems

## GD4 Datums
4-1 Horizontal datums
4-2 Vertical datums

## GD5 Map projections
5-1 Map projection properties
5-2 Map projection classes
5-3 Map projection parameters
5-4 Georegistration

## GD6 Data quality
6-1 Geometric accuracy
6-2 Thematic accuracy
6-3 Resolution
6-4 Precision
6-5 Primary and secondary sources

## GD7 Land surveying and GPS
7-1 Survey theory and electro-optical methods
7-2 Land records
7-3 Global Positioning System

## GD8 Digitizing
8-1 Tablet digitizing
8-2 On-screen digitizing
8-3 Scanning and automated vectorization

## GD9 Field data collection
9-1 Sample size selection
9-2 Spatial sample types
9-3 Sample intervals
9-4 Field data technologies

## GD10 Aerial imaging and photogrammetry
10-1 Nature of aerial image data
10-2 Platforms and sensors
10-3 Aerial image interpretation
10-4 Stereoscopy and orthoimagery
10-5 Vector data extraction
10-6 Mission planning

## GD11 Satellite and shipboard remote sensing
11-1 Nature of multispectral image data
11-2 Platforms and sensors
11-3 Algorithms and processing
11-4 Ground verification and accuracy assessment
11-5 Applications and settings

## GD12 Metadata, standards, and infrastructures
12-1 Metadata
12-2 Content standards
12-3 Data warehouses
12-4 Exchange specifications
12-5 Transport protocols
12-6 Spatial Data Infrastructures

# Information & Computation Technologies

## Design Aspects

**DA1 The scope of GIS&T system design**
- 1-1 Using models to represent information and processes
- 1-2 Components of models: data, structures, procedures
- 1-3 The scope of GIS&T applications
- 1-4 The scope of GIS&T design
- 1-5 The process of GIS&T design

**DA2 Project definition**
- 2-1 Problem definition
- 2-2 Planning for design
- 2-3 Application/user assessment
- 2-4 Requirements analysis
- 2-5 Social, political, and cultural issues

**DA3 Resource planning**
- 3-1 Feasibility analysis
- 3-2 Software systems
- 3-3 Data costs
- 3-4 Labor and management
- 3-5 Capital: facilities and equipment
- 3-6 Funding

**DA4 Database design**
- 4-1 Modeling tools
- 4-2 Conceptual model
- 4-3 Logical models
- 4-4 Physical models

**DA5 Analysis design**
- 5-1 Recognizing analytical components
- 5-2 Identifying and designing analytical procedures
- 5-3 Coupling scientific models with GIS
- 5-4 Formalizing a procedure design

**DA6 Application design**
- 6-1 Workflow analysis and design
- 6-2 User interfaces
- 6-3 Development environments for geospatial applications
- 6-4 Computer-Aided Software Engineering (CASE) tools

**DA7 System implementation**
- 7-1 Implementation planning
- 7-2 Implementation tasks
- 7-3 System testing
- 7-4 System deployment

# Data Modeling

**DM1 Basic storage and retrieval structures**
- 1-1 Basic data structures
- 1-2 Data retrieval strategies

**DM2 Database management systems**
- 2-1 Coevolution of DBMS and GIS
- 2-2 Relational DBMS
- 2-3 Object-oriented DBMS
- 2-4 Extensions of the relational model

**DM3 Tessellation data models**
- 3-1 Grid representations
- 3-2 The raster model
- 3-3 Grid compression methods
- 3-4 The hexagonal model
- 3-5 The Triangulated Irregular Network (TIN) model
- 3-6 Resolution
- 3-7 Hierarchical data models

**DM4 Vector and object data models**
- 4-1 Geometric primitives
- 4-2 The spaghetti model
- 4-3 The topological model
- 4-4 Classic vector data models
- 4-5 The network model
- 4-6 Linear referencing
- 4-7 Object-based spatial databases

**DM5 Modeling 3D, uncertain, and temporal phenomena**
- 5-1 Spatio-temporal GIS
- 5-2 Modeling uncertainty
- 5-3 Modeling three-dimensional entities

# Geocomputation

**GC1 Emergence of geocomputation**
- 1-1 Origins
- 1-2 Trends

**GC2 Computational aspects and neurocomputing**
- 2-1 High performance computing
- 2-2 Computational intelligence
- 2-3 Non-linearity relationships and non-Gaussian distributions
- 2-4 Pattern recognition
- 2-5 Geospatial data classification
- 2-6 Multi-layer feed-forward neutral networks
- 2-7 Space-scale algorithms
- 2-8 Rule learning
- 2-9 Neural network schemes

**GC3 Cellular Automata (CA)**
- 3-1 CA Model Structure
- 3-2 CA Transition Rule
- 3-3 CA simulation and calibration
- 3-4 Integration of CA and other geocomputation methods
- 3-5 Typical CA applications

**GC4 Heuristics**
- 4-1 Greedy heuristics
- 4-2 Interchange heuristics
- 4-3 Interchange with probability
- 4-4 Simulated annealing
- 4-5 Lagrangian relaxation

**GC5 Genetic algorithms (GA)**
- 5-1 GA and global solutions
- 5-2 Genetic algorithms and artificial genomes

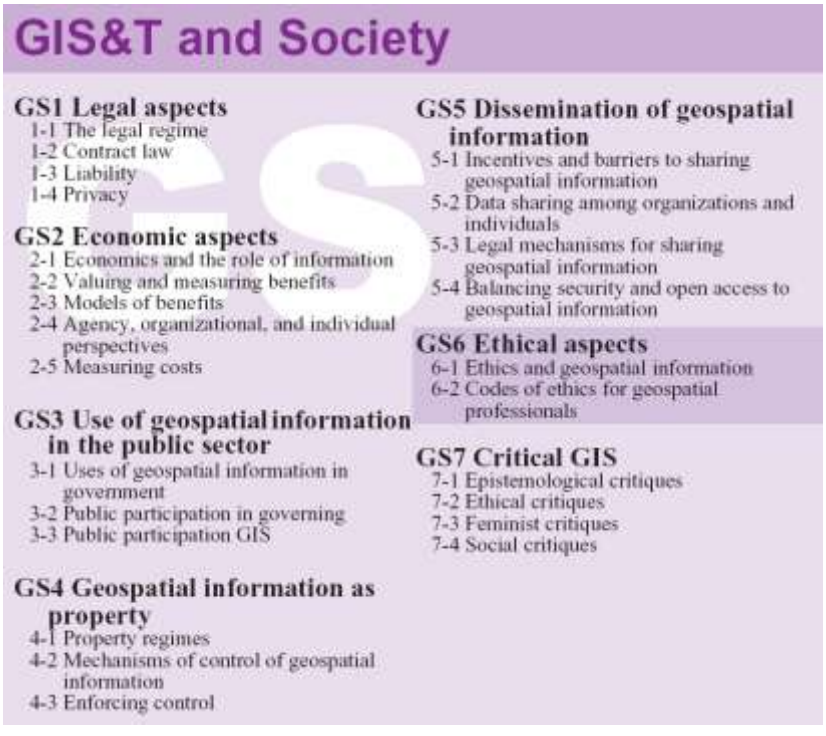
**GC6 Agent-based models**
- 6-1 Structure of agent-based models
- 6-2 Specification of agent-based models
- 6-3 Adaptive agents
- 6-4 Microsimulation and calibration of agent activities
- 6-5 Encoding agent-based models

**GC7 Simulation modeling**
- 7-1 Simulation modeling

**GC8 Uncertainty**
- 8-1 Conceptual model of uncertainty
- 8-2 Error
- 8-3 Problems of scale and zoning
- 8-4 Propagation of error in geospatial modeling
- 8-5 Theory of error propagation
- 8-6 Problems of currency, source, and scale

**GC9 Fuzzy sets**
- 9-1 Fuzzy logic
- 9-2 Fuzzy measures
- 9-3 Fuzzy aggregation operators
- 9-4 Standardization
- 9-5 Weighting schemes

# Human & Computer Interfaces



# Organizational & Institutional Aspects

**OI1 Origins of GIS&T**
- 1-1 Public sector origins
- 1-2 Private sector origins
- 1-3 Academic origins
- 1-4 Learning from experience
- 1-5 Future trends

**OI2 Managing the GI system operations and infrastructure**
- 2-1 Managing the GI system operations and infrastructure
- 2-2 Ongoing GI system revision
- 2-3 Budgeting for GI system management
- 2-4 Database administration
- 2-5 System management
- 2-6 User support

**OI3 Organizational structures and procedures**
- 3-1 Organizational models for GI system management
- 3-2 Organizational models for coordinating GI systems and/or program participants and stakeholders
- 3-3 Integrating GIS&T with management information systems (MIS)

**OI4 GIS&T workforce themes**
- 4-1 GIS&T staff development
- 4-2 GIS&T positions and qualifications
- 4-3 GIS&T training and education
- 4-4 Incorporating GIS&T into existing job classifications

**OI5 Institutional and inter-institutional aspects**
- 5-1 Spatial data infrastructures
- 5-2 Adoption of standards
- 5-3 Technology transfer
- 5-4 Spatial data sharing among organizations
- 5-5 Openness
- 5-6 Balancing data access, security, and privacy
- 5-7 Implications of distributed GIS&T
- 5-8 Interorganizational and vendor GI systems

**OI6 Coordinating organizations**
- 6-1 Federal agencies and national and international organizations and programs
- 6-2 State and regional coordinating bodies
- 6-3 Professional organizations
- 6-4 Publications
- 6-5 The geospatial community
- 6-6 The geospatial Industry