Analytical Methods

AM1 Academic and analytical origins
- 1-1 Academic foundations
- 1-2 Analytical approaches

AM2 Query operations and query languages
- 2-1 Set theory
- 2-2 Structured Query Language (SQL) and attribute queries
- 2-3 Spatial queries

AM3 Geometric measures
- 3-1 Distances and lengths
- 3-2 Direction
- 3-3 Shape
- 3-4 Area
- 3-5 Proximity and distance decay
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- 11-7 Accessibility Modeling

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- 12-1 Operations research modeling and location modeling principles
- 12-2 Linear programming
- 12-3 Integer programming
- 12-4 Location-allocation modeling and

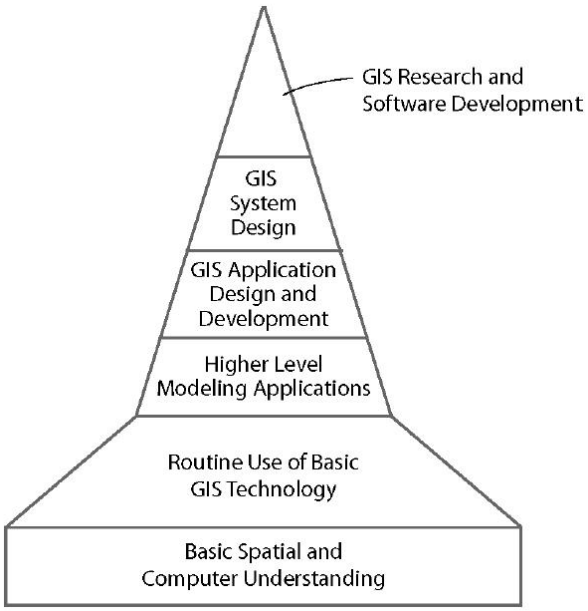
Geographic Information Science & Technology
Body of Knowledge

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)

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

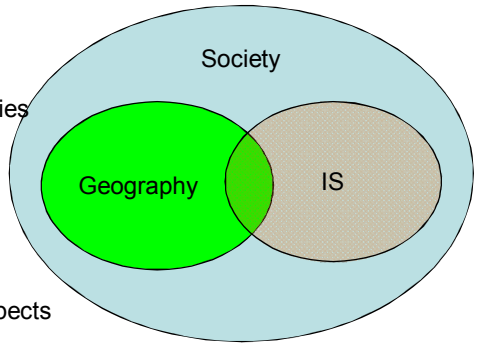
GIS&T Body of Knowledge 10 Topics

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

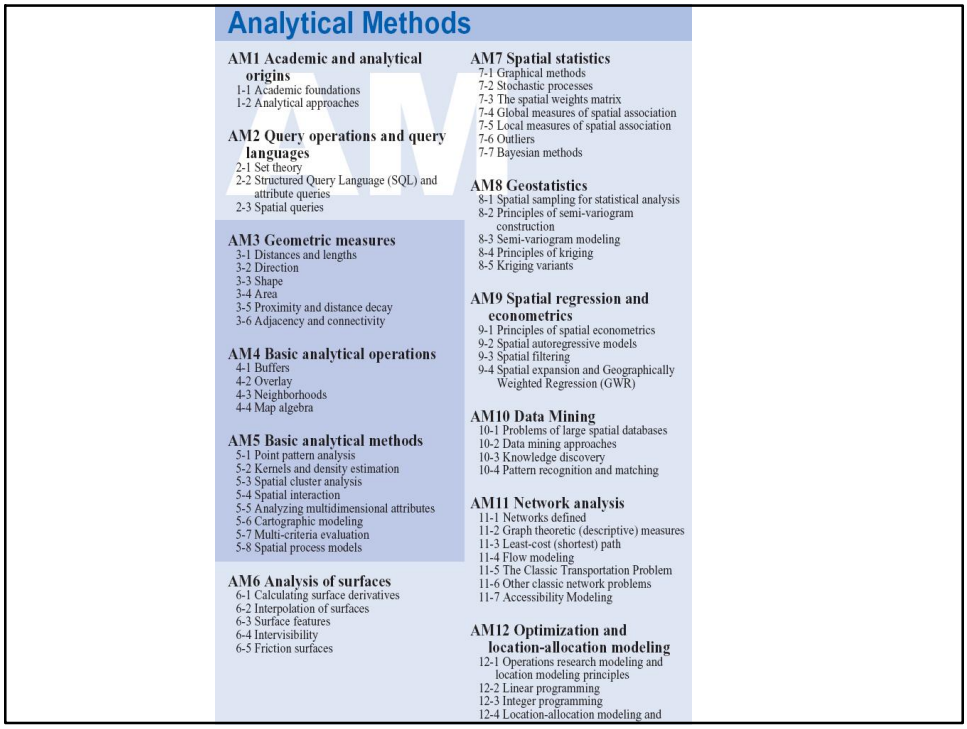
Spatial Concepts & Data
- Analytical Methods
- Cartography & Visualization
- Conceptual Foundations
- Data Manipulation
- Geospatial Data

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

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



Spatial Concepts & Data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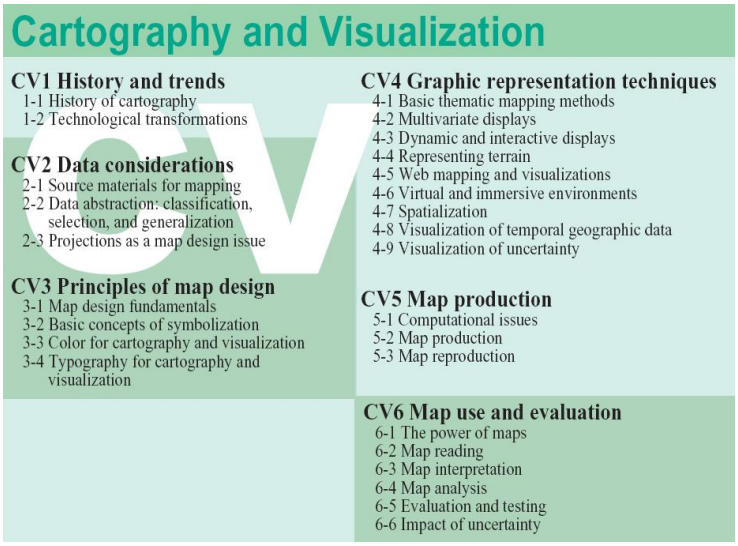
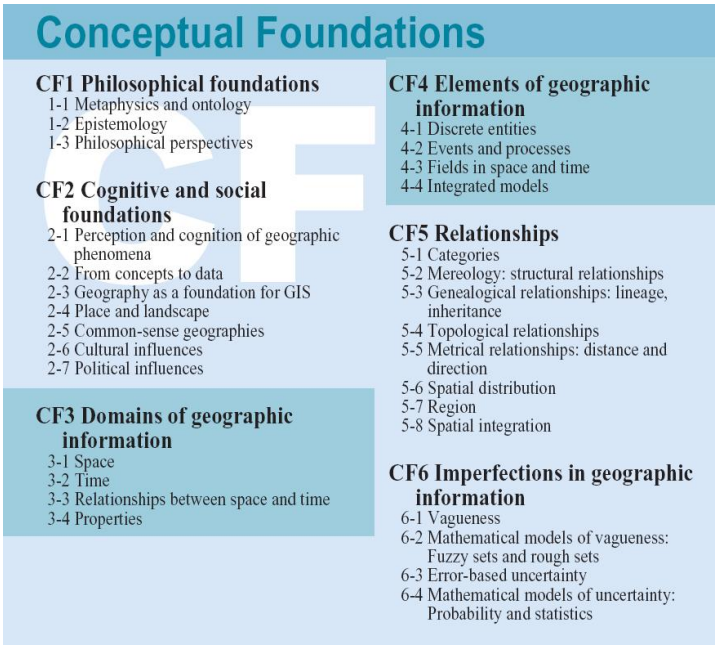
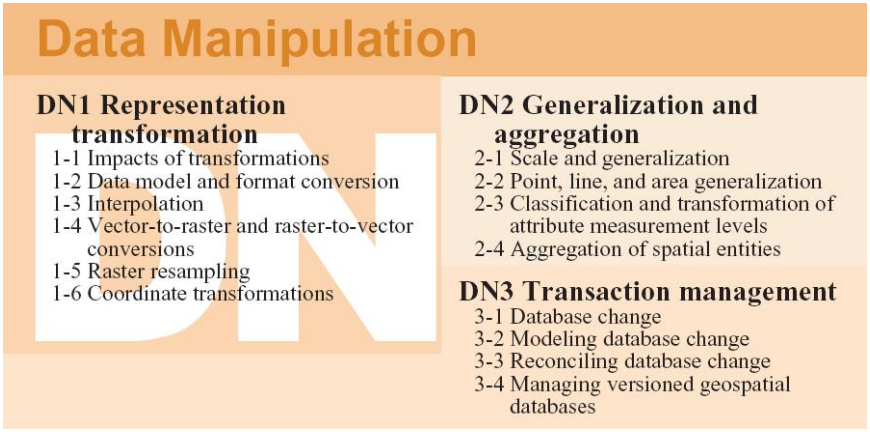

Cartography and Visualization
CV1 History and trends
1-1 History of cartography
1-2 Technological transformations
CV2 Data considerations
2-1 Source materials for mapping
2-2 Data abstraction: classification, selection, and generalization
2-3 Projections as a map design issue
CV3 Principles of map design
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 Earthis 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

GIS&T and Society

GS1 Legal aspects
- 1-1 The legal regime
- 1-2 Contract law
- 1-3 Liability
- 1-4 Privacy

GS2 Economic aspects
- 2-1 Economics and the role of information
- 2-2 Valuing and measuring benefits
- 2-3 Models of benefits
- 2-4 Agency, organizational, and individual perspectives
- 2-5 Measuring costs

GS3 Use of geospatial information in the public sector
- 3-1 Uses of geospatial information in government
- 3-2 Public participation in governing
- 3-3 Public participation GIS

GS4 Geospatial information as property
- 4-1 Property regimes
- 4-2 Mechanisms of control of geospatial information
- 4-3 Enforcing control

GS5 Dissemination of geospatial information
- 5-1 Incentives and barriers to sharing geospatial information
- 5-2 Data sharing among organizations and individuals
- 5-3 Legal mechanisms for sharing geospatial information
- 5-4 Balancing security and open access to geospatial information

GS6 Ethical aspects
- 6-1 Ethics and geospatial information
- 6-2 Codes of ethics for geospatial professionals

GS7 Critical GIS
- 7-1 Epistemological critiques
- 7-2 Ethical critiques
- 7-3 Feminist critiques
- 7-4 Social critiques

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