Next Steps for the *GIS&T Body of Knowledge*

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ESRI Education User Conference

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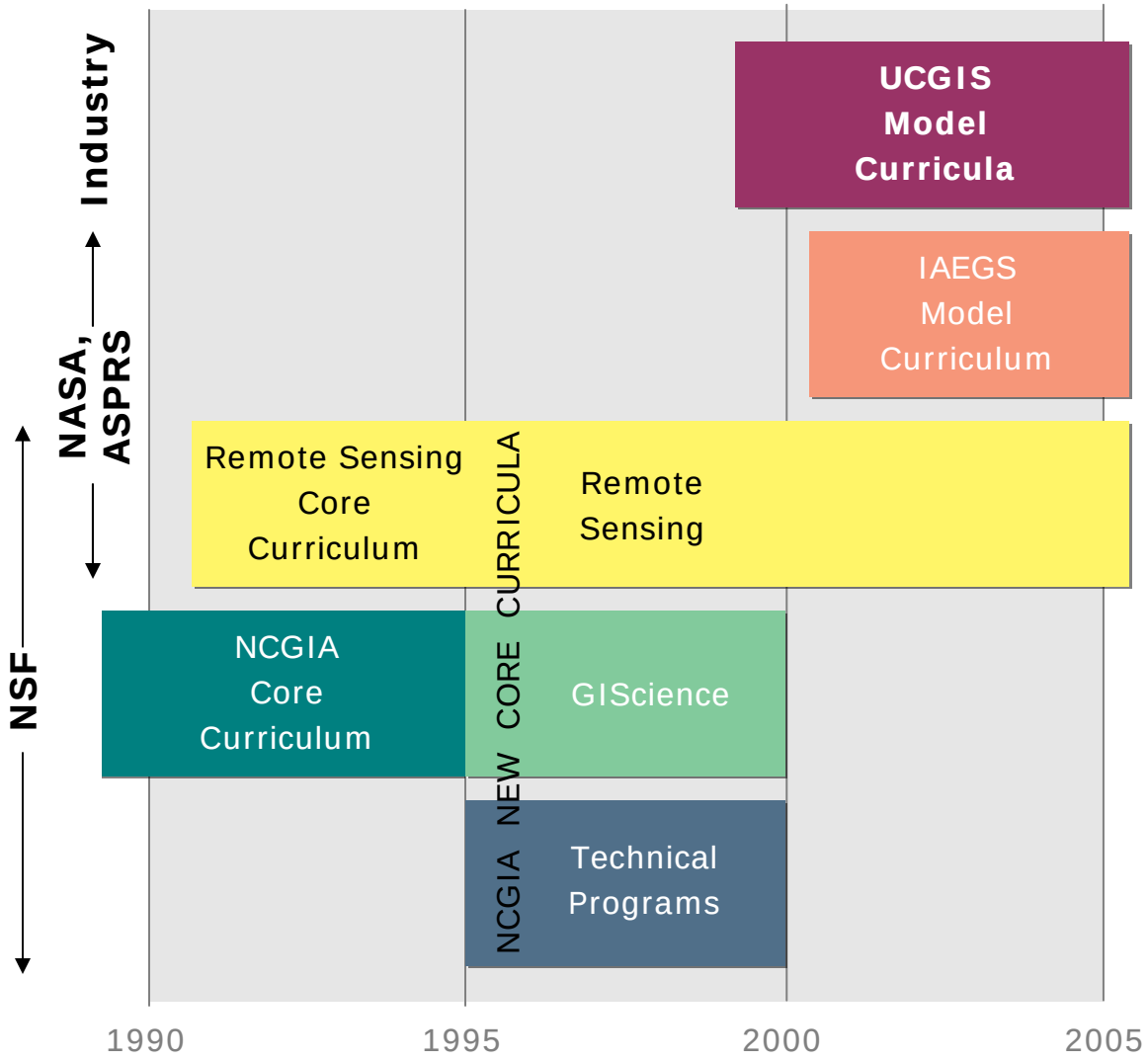
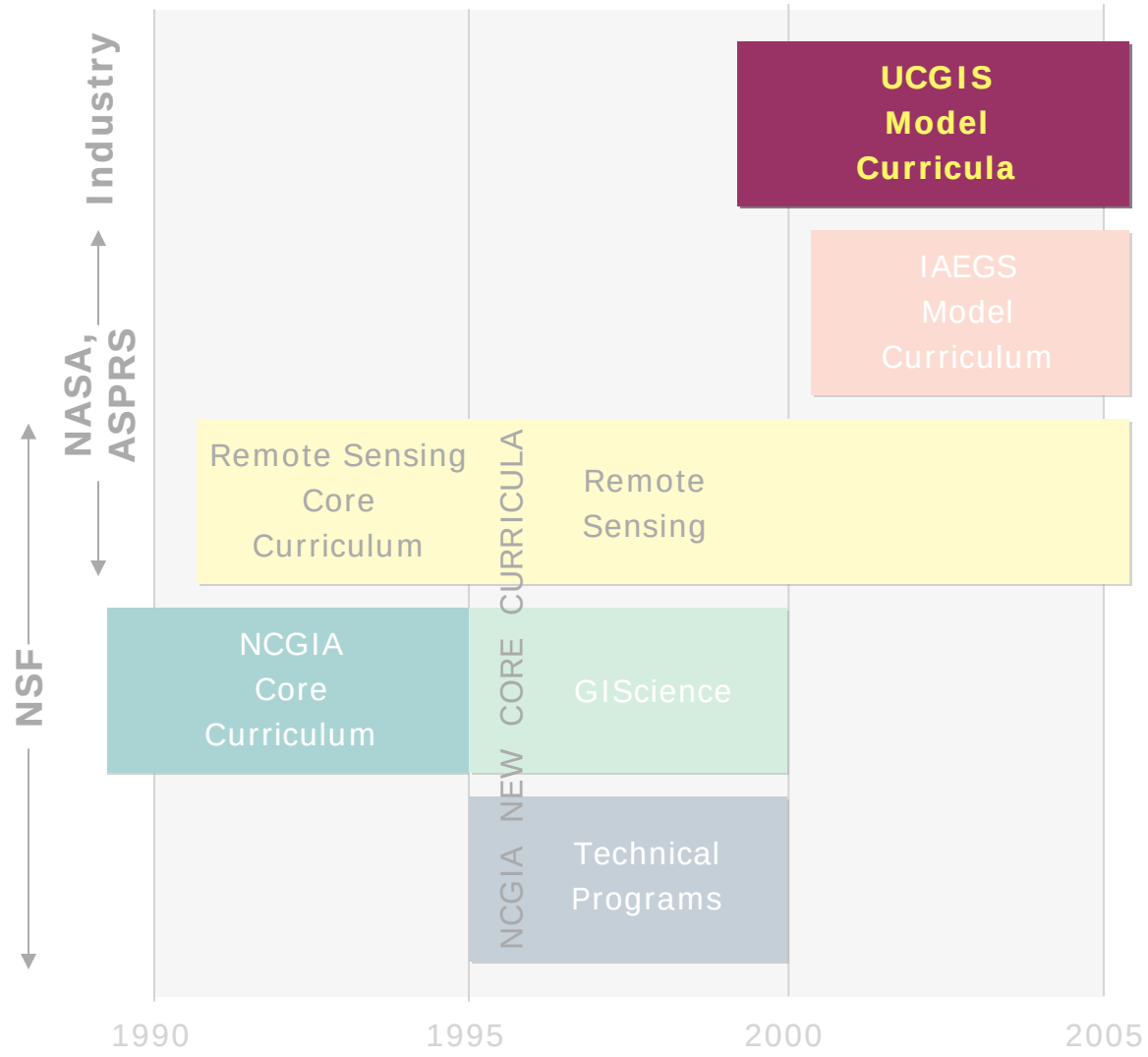
GIS&T Body of Knowledge, 1st Edition

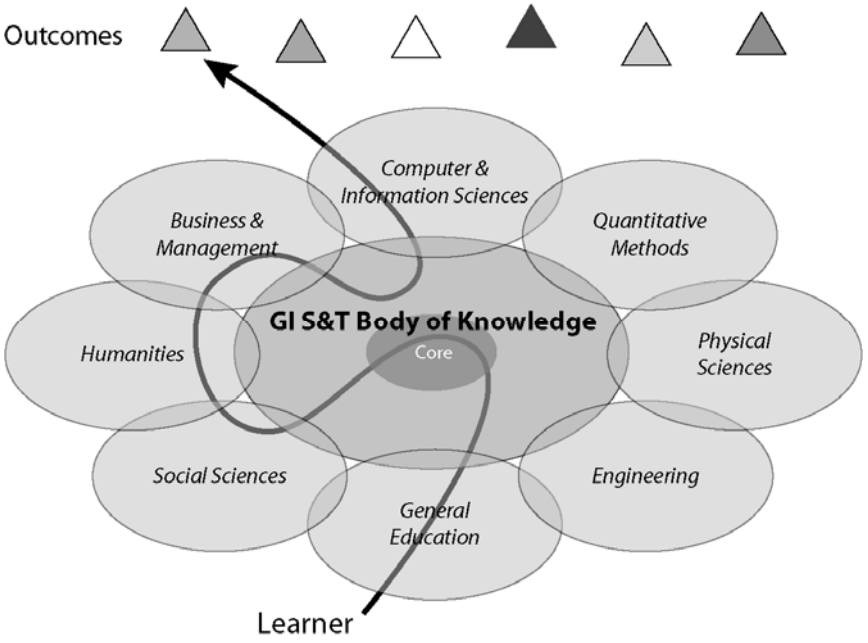
Geospatial curriculum initiatives



Geospatial curriculum initiatives



UCGIS Model Curricula project



GIS&T BoK **+ Pathways**

+ Curriculum Development Support Plan

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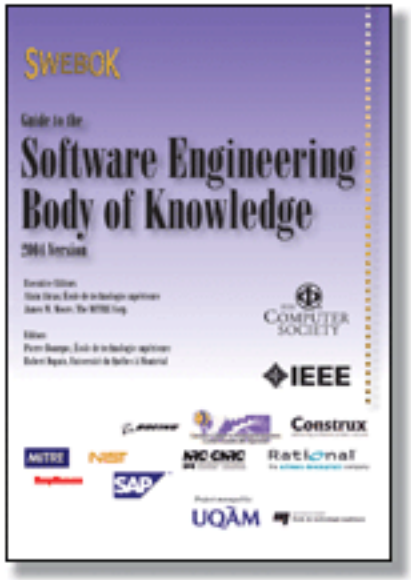
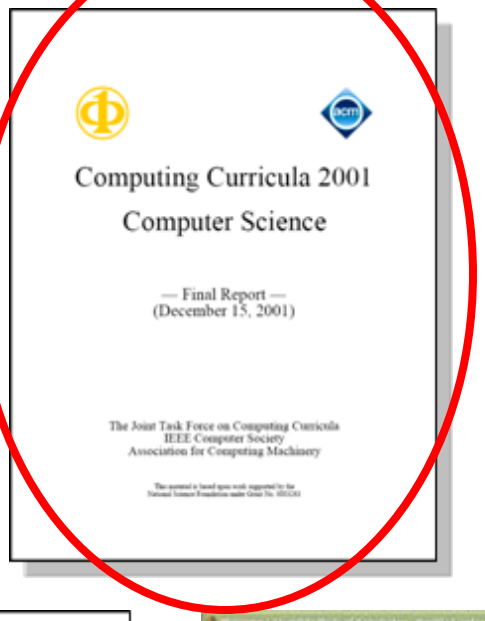
Sponsors

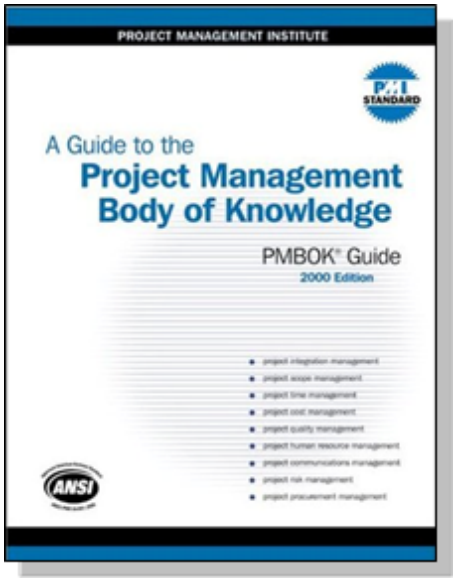
- ✓ ESRI
- ✓ Intergraph
- ✓ GE Smallworld
- ✓ National Academies of Science

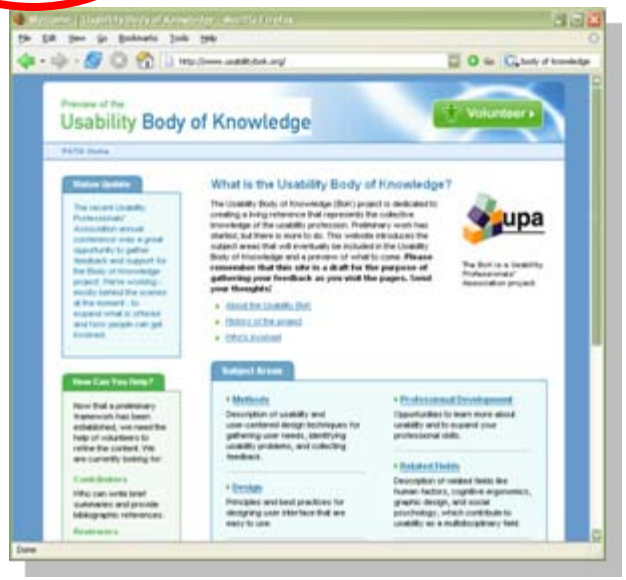
GIS&T Body of Knowledge

Bodies of Knowledge in other domains



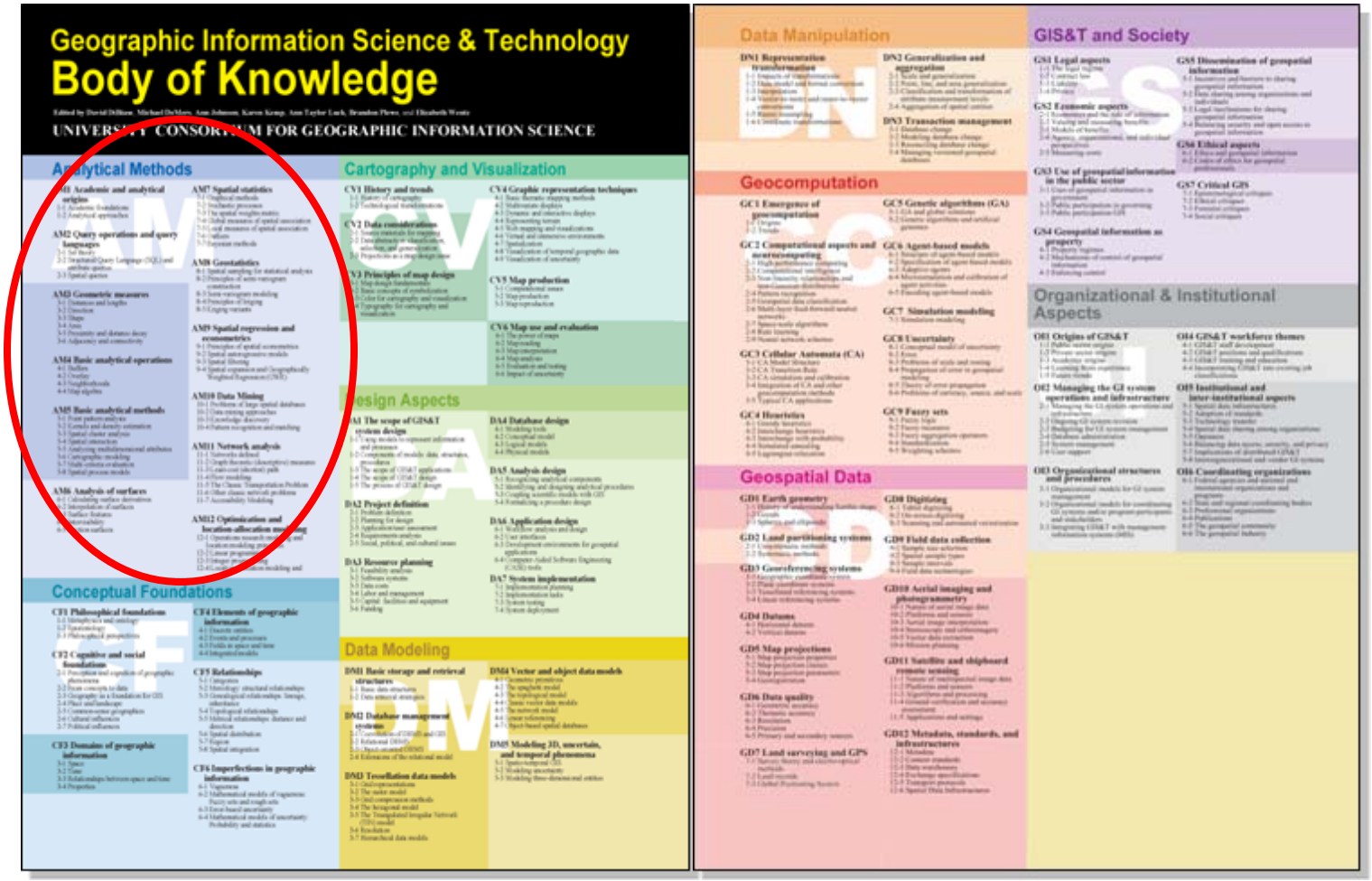






GIS&T Body of Knowledge

Knowledge Area (10)



GIS&T Body of Knowledge

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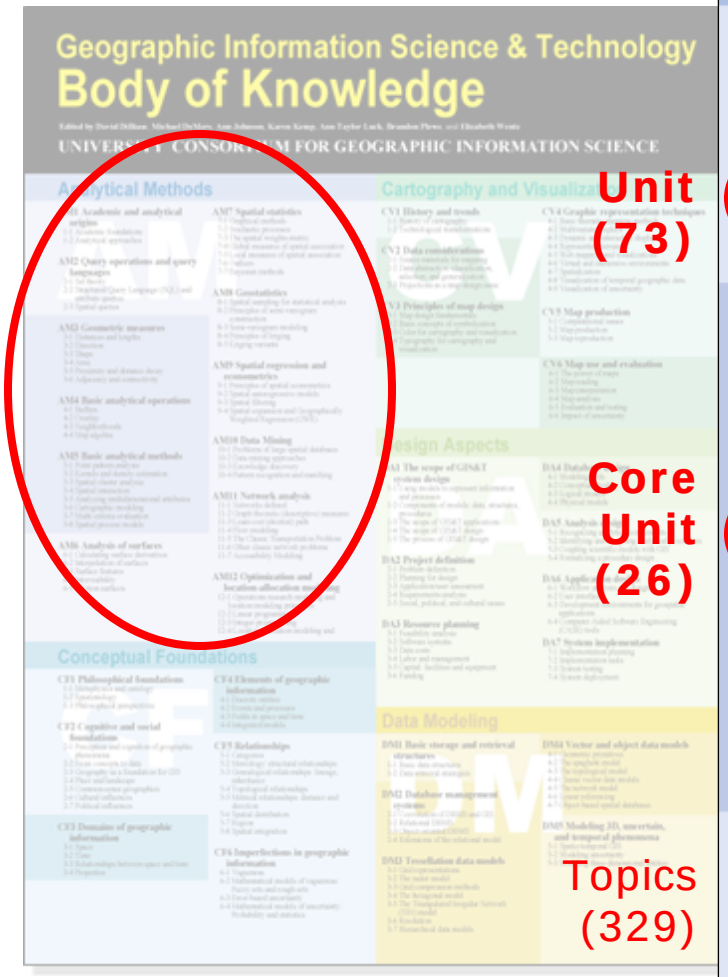


Analytical Methods

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
3-6 Adjacency and connectivity

AM4 Basic analytical operations
4-1 Buffers
4-2 Overlay
4-3 Neighborhoods
4-4 Map algebra

AM5 Basic analytical methods
5-1 Point pattern analysis
5-2 Kernels and density estimation
5-3 Spatial cluster analysis
5-4 Spatial interaction
5-5 Analyzing multidimensional attributes
5-6 Cartographic modeling
5-7 Multi-criteria evaluation
5-8 Spatial process models

AM6 Analysis of surfaces
6-1 Calculating surface derivatives
6-2 Interpolation of surfaces
6-3 Surface features
6-4 Intervisibility
6-5 Friction surfaces

AM7 Spatial statistics
7-1 Graphical methods
7-2 Stochastic processes
7-3 The spatial weights matrix
7-4 Global measures of spatial association
7-5 Local measures of spatial association
7-6 Outliers
7-7 Bayesian methods

AM8 Geostatistics
8-1 Spatial sampling for statistical analysis
8-2 Principles of semi-variogram construction
8-3 Semi-variogram modeling
8-4 Principles of kriging
8-5 Kriging variants

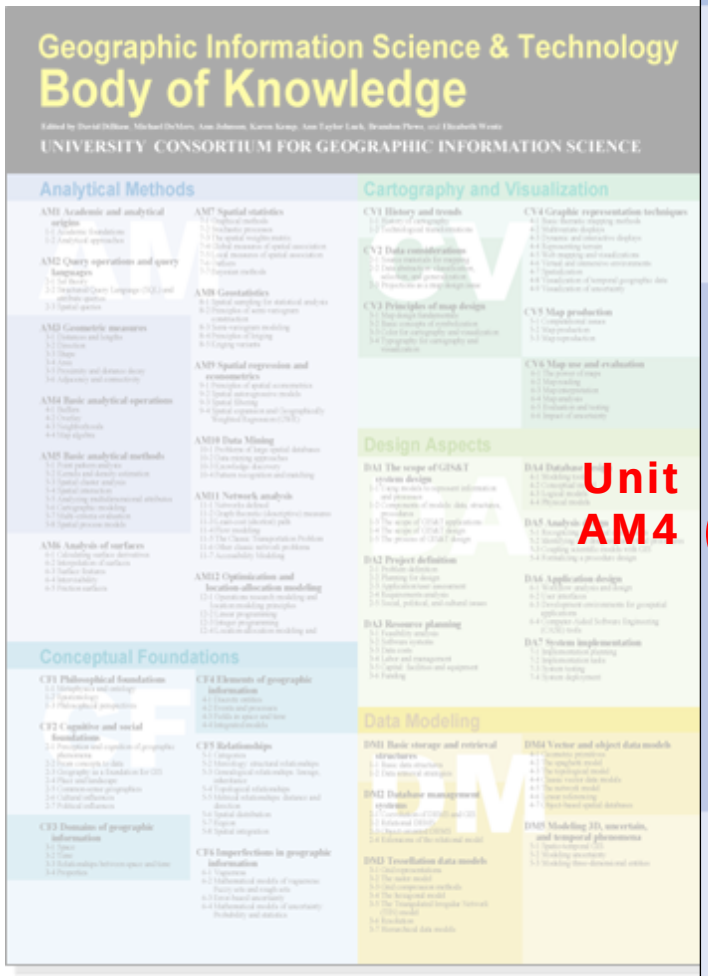
AM9 Spatial regression and econometrics
9-1 Principles of spatial econometrics
9-2 Spatial autoregressive models
9-3 Spatial filtering
9-4 Spatial expansion and Geographically Weighted Regression (GWR)

AM10 Data Mining
10-1 Problems of large spatial databases
10-2 Data mining approaches
10-3 Knowledge discovery
10-4 Pattern recognition and matching

AM11 Network analysis
11-1 Networks defined
11-2 Graph theoretic (descriptive) measures
11-3 Least-cost (shortest) path
11-4 Flow modeling
11-5 The Classic Transportation Problem
11-6 Other classic network problems
11-7 Accessibility Modeling

AM12 Optimization and location-allocation modeling
12-1 Operations research modeling and location modeling principles
12-2 Linear programming
12-3 Integer programming
12-4 Location-allocation modeling and

GIS&T Body of Knowledge



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Example Unit, Topics, and Objectives

Unit AM4 Basic analytical operations *(core unit)*

This small set of analytical operations is so commonly applied to a broad range of problems that their inclusion in software products is often used to determine if that product is a “true” GIS. Concepts on which these operations are based are addressed in Unit CF3 Domains of geographic information and Unit CF5 Relationships.

Topic AM4-3 Neighborhoods

- Discuss the role of Voronoi polygons as the dual graph of the Delaunay triangulation
- Explain how Voronoi polygons can be used to define neighborhoods around a set of points
- Outline methods that can be used to establish non-overlapping neighborhoods of similarity in raster datasets
- Create proximity polygons (Thiessen/Voronoi polygons) in point datasets
- Write algorithms to calculate neighborhood statistics (minimum, maximum, focal flow) using a moving window in raster datasets

Topic AM4-4 Map algebra

- Describe how map algebra performs mathematical functions on raster grids
- Describe a real modeling situation in which map algebra would be used (e.g., site selection, climate classification, least-cost path)
- Explain the categories of map algebra operations (i.e., local, focal, zonal, and global functions)
- Explain why georegistration is a precondition to map algebra
- Perform a map algebra calculation using command line, form-based, and flow charting user interfaces

Example Unit, Topics, and Objectives

Unit GS6 Ethical aspects *(core unit)*

Ethics provide frameworks that help individuals and organizations make decisions when confronted with choices that have moral implications. Most professional organizations develop codes of ethics to help their members do the right thing, preserve their good reputation in the community, and help their members develop as a community.

Topic GS6-1 Ethics and geospatial information

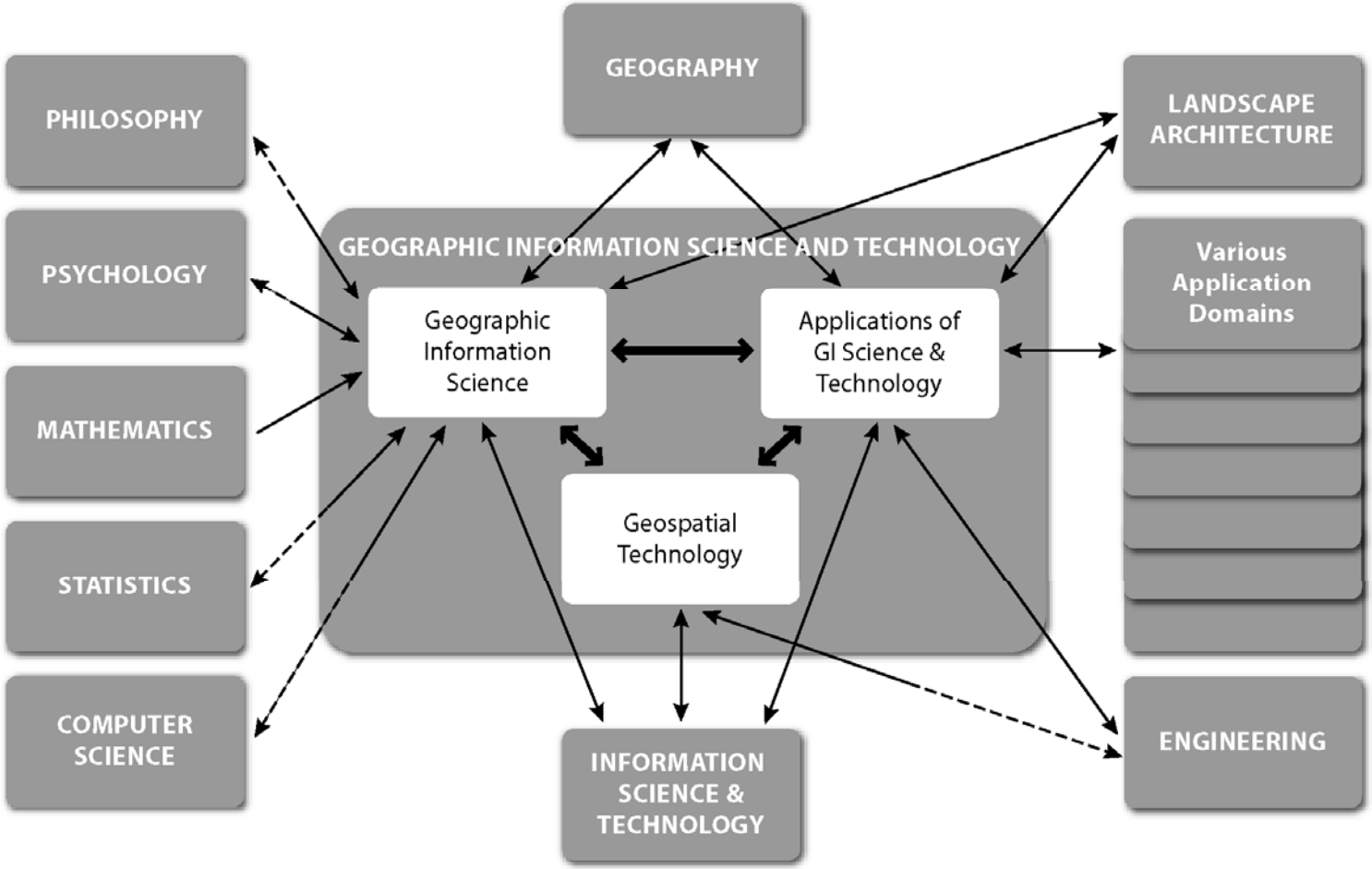
- Describe a variety of philosophical frameworks upon which codes of professional ethics may be based
- Discuss the ethical implications of a local government's decision to charge fees for its data
- Describe a scenario in which you would find it necessary to report misconduct by a colleague or friend
- Describe the individuals or groups to which GIS&T professionals have ethical obligations

Topic GS6-2 Codes of ethics for geospatial professionals

- Compare and contrast the ethical guidelines promoted by the GIS Certification Institute (GISCI) and the American Society for Photogrammetry and Remote Sensing (ASPRS)
- Describe the sanctions imposed by ASPRS and GISCI on individuals whose professional actions violate the Codes of Ethics
- Explain how one or more obligations in the GIS Code of Ethics may conflict with organizations' proprietary interests
- Propose a resolution to a conflict between an obligation in the GIS Code of Ethics and organizations' proprietary interests

Questionnaire page 2

Defining the GIS&T field



Questionnaire page 3

Defining geospatial competence

TABLE 3
Geospatial Technology Core Competencies
(Note: Core competencies are shown in bold)

Technical Competencies	Business Competencies
Ability to Assess Relationships Among Geospatial Technologies Cartography Computer Programming Skills Environmental Applications **GIS Theory and Applications** Geology Applications Geospatial Data Processing Tools Photogrammetry Remote Sensing Theory and Applications Spatial Information Processing **Technical Writing** **Technological Literacy** Topology	**Ability to See the "Big Picture"** Business Understanding Buy-in/Advocacy **Change Management** **Cost Benefit Analysis/ROI** Ethics Modeling Industry Understanding Legal Understanding Organization Understanding Performance Analysis and Evaluation **Visioning**
Analytical Competencies	**Interpersonal Competencies**
Creative Thinking Knowledge Management: Model Building Skills **Problem-Solving Skills** Research Skill Systems Thinking	Coaching **Communication** Conflict Management: **Feedback Skills** Group Process Understanding **Leadership Skills** Questioning **Relationship Building Skills** **Self-Knowledge/Self-Management**

Gaudet, C., Annulis, H., & Carr, J. (2003). Building the geospatial workforce. *URISA Journal* 15(1): 21-30.

Defining geospatial competence

TABLE I Geospatial Technology Role Definitions	
Applications Development	Identify and develop tools and instruments to satisfy customer needs
Data Acquisition	Collect geospatial and related data
Coordination	Interorganizational facilitation and communication
Data Analysis and Interpretation	Process data and extract information to create products, drive conclusions, and inform decision-making reports
Data Management	Catalog, archive, retrieve, and distribute geospatial data
Management	Efficiently and effectively apply the company's mission using financial, technical, and intellectual skills and resources to optimize the end products
Marketing	Identify customer requirements and needs, and effectively communicate those needs and requirements to the organization, as well as promote geospatial solutions
Project Management	Effectively oversee activity requirements to produce the desired outcomes on time and within budget
Systems Analysis	Assess requirements for system capacities including inputs, outputs, processes, timing, and performance, as well as recommend necessary additions or adaptations
Systems Management	Integrate resources and develop additional resources to support spatial and temporal user requirements
Training	Analyze, design, and develop instructional and non-instructional interventions to provide transfer of knowledge and evaluation for performance improvement
Visualization	Render data and information into visual geospatial representations

Geospatial Technology Competency Model

Table 4
Geospatial Technology Competency Model©

			ROLES											
			Applications Development	Coordination	Data Acquisition	Data Analysis	Data Management	Management	Marketing	Project Management	Systems Analysis	Systems Management	Training	Visualization
COMPETENCIES	Technical	Ability to Assess Relationships Among Geospatial Technologies		●				●	●		●	●	●	●
		Cartography			●	●								●
		Computer Programming Skills	●		●		●				●			●
		Environmental Applications	●			●								●
		GIS Theory and Applications	●			●	●	●		●		●	●	●
		Geology Applications				●								
		Geospatial Data Processing Tools			●	●					●	●	●	●
		Photogrammetry	●		●	●								●
		Remote Sensing Theory and Applications	●		●	●						●		●
		Spatial Information Processing	●		●	●							●	●
		Technical Writing	●	●		●		●	●	●	●	●	●	●
		Technological Literacy	●		●	●	●	●		●	●	●	●	●
		Topology				●								●
	Business	Ability to see the "Big Picture"	●	●			●	●	●		●	●	●	
		Business Understanding		●				●		●				
		Buy-in/Advocacy		●				●	●		●		●	●
		Change Management	●	●		●	●	●	●	●	●	●	●	●
		Cost Benefit Analysis / ROI		●			●	●	●	●		●	●	●
		Ethics Modeling				●		●	●	●		●	●	●
		Industry Understanding	●	●				●	●				●	●
		Legal Understanding		●										
		Organization Understanding		●				●				●		
		Performance Analysis and Evaluation			●			●		●	●	●	●	
		Visioning		●				●	●	●	●	●	●	
	Analytical	Creative Thinking	●	●	●	●	●	●	●	●	●	●	●	●
		Knowledge Management		●		●		●		●		●	●	●
		Model Building Skills	●				●	●				●	●	●
		Problem-Solving Skills	●	●	●	●	●	●	●	●	●	●	●	●
		Research Skill	●			●							●	
		Systems Thinking	●					●			●	●	●	●
	Interpersonal	Coaching		●				●					●	
		Communication	●	●	●	●	●	●	●	●	●	●	●	●
		Conflict Management		●				●		●		●	●	
		Feedback Skills	●	●	●	●	●	●	●	●	●	●	●	●
		Group Process Understanding		●				●		●		●	●	
		Leadership Skills		●			●	●	●	●		●	●	●
		Questioning		●				●	●		●	●	●	
		Relationship Building Skills		●				●	●	●	●	●	●	
		Self-Knowledge/Self-Management		●				●	●		●	●	●	

Critiquing the GTCM

62% of survey respondents agreed that Technical Competencies specified in the GTCM are inadequate.

Recommendations for Modifications to the Geospatial Competency Model

- The University of Southern Mississippi's Geospatial Workforce Competency Model should be refined and updated.
- It would be helpful to clarify the differences between the terms "roles," "competencies," "occupations," and "job titles."
- A fifth group of competencies may be added to include discipline-specific application competencies such as "environmental applications," "geological applications," "demographic applications," or "sociological applications."
- "Standards" and "interoperability" may be added to the existing technical competencies.
- The level of competency may also be incorporated into the model in conjunction with the type of competency.

Applications of *GIS&T BoK*

- Curriculum planning
- Program accreditation
- Program evaluation and assessment
- Program articulation
- Professional certification
- Employee screening
- Defining the GIS&T field

Questionnaire page 4

Analytical Methods

Unit AM1 Academic and analytical origins
Unit AM2 Query operations and query languages
Unit AM3 Geometric measures
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Unit AM5 Basic analytical methods
Unit AM6 Analysis of surfaces
Unit AM7 Spatial statistics
Unit AM8 Geostatistics
Unit AM9 Spatial regression and econometrics
Unit AM10 Data mining
Unit AM11 Network analysis
Unit AM12 Optimization and location-allocation modeling

Conceptual Foundations

Unit CF1 Philosophical foundations
Unit CF2 Cognitive and social foundations
Unit CF3 Domains of geographic information
Unit CF4 Elements of geographic information
Unit CF5 Relationships
Unit CF6 Imperfections in geographic information

Cartography and Visualization

Unit CV1 History and trends
Unit CV2 Data considerations
Unit CV3 Principles of map design
Unit CV4 Graphic representation techniques
Unit CV5 Map production
Unit CV6 Map use and evaluation

Design Aspects

Unit DA1 The scope of GIS&T system design
Unit DA2 Project definition
Unit DA3 Resource planning
Unit DA4 Database design
Unit DA5 Analysis design
Unit DA6 Application design
Unit DA7 System implementation

Data Modeling

Unit DM1 Basic storage and retrieval structures
Unit DM2 Database management systems
Unit DM3 Tessellation data models
Unit DM4 Vector and object data models
Unit DM5 Modeling 3D, temporal, and uncertain phenomena

Data Manipulation

Unit DN1 Representation transformation
Unit DN2 Generalization and aggregation
Unit DN3 Transaction management of geospatial data

Geocomputation

Unit GC1 Emergence of geocomputation
Unit GC2 Computational aspects and neurocomputing
Unit GC3 Cellular Automata (CA) models
Unit GC4 Heuristics
Unit GC5 Genetic algorithms (GA)
Unit GC6 Agent-based models
Unit GC7 Simulation modeling
Unit GC8 Uncertainty
Unit GC9 Fuzzy sets

Geospatial Data

Unit GD1 Earth geometry
Unit GD2 Land partitioning systems
Unit GD3 Georeferencing systems
Unit GD4 Datums
Unit GD5 Map projections
Unit GD6 Data quality
Unit GD7 Land surveying and GPS
Unit GD8 Digitizing
Unit GD9 Field data collection
Unit GD10 Aerial imaging and photogrammetry
Unit GD11 Satellite and shipboard remote sensing
Unit GD12 Metadata, standards, and infrastructures

GIS&T and Society

Unit GS1 Legal aspects
Unit GS2 Economic aspects
Unit GS3 Use of geospatial information in the public sector
Unit GS4 Geospatial information as property
Unit GS5 Dissemination of geospatial information
Unit GS6 Ethical aspects of geospatial information and technology
Unit GS7 Critical GIS

Organizational and Institutional Aspects

Unit OI1 Origins of GIS&T
Unit O2 Managing the GI system operations and infrastructure
Unit OI3 Organizational structures and procedures
Unit OI4 GI S&T workforce themes
Unit OI5 Institutional and inter-institutional aspects
Unit OI6 Coordinating organizations (national and international)

Questionnaire page 5

Next steps for UCGIS Model Curricula

1. Priorities for future development
2. Staffing of future *GIS&T BoK*
3. Format of future *GIS&T BoK*

Next steps for UCGIS Model Curricula

Thanks for your contribution!