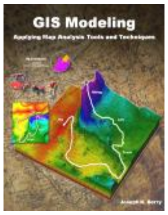
Beyond Mapping IV

Topic 6 – Education Outside the Traditional Lines


GIS Modeling book

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(*Back to the Table of Contents*)

Which Direction Are You Headed?

(GeoWorld, January 2011)

(*return to top of Topic*)

Earlier I commented on using the more generalized and palatable term *Geotechnology* to describe what some of us over time have referred to as Automated Cartography, Computer Mapping, Geographic Information Systems, Spatial Database Management, Desktop Mapping, Geospatial Technology, Geomatics, Map Analysis, Multimedia Mapping and a wealth of other terms (see Author's Note).

The discussion identified the *Spatial Triad* of Remote Sensing (RS), Geographic Information Systems (GIS) and Global Positioning Systems (GPS) as core technologies that "utilize spatial location in visualizing, measuring, storing, retrieving, mapping and analyzing features or phenomena that occur on, below or above the earth." While RS and GPS seem to have fairly succinct and universal meanings, the definition of GIS has sparked continuing debate. Most will agree on something like GIS is "a system of hardware and software used for storage, retrieval, mapping, and analysis of geographic data." But what is the interpretation the acronym itself?

My first encounter in the acrimonious acronym dispute was in the mid-1970s when the "G" in GIS was under scrutiny. The early GIS folks on the west side of the Atlantic were convinced it stood for "geographic," while those on the eastern side insisted it stood for "geographical." A quick Google search yields a boat load of discussion forums still hammering on the grammatical debate. It appears that it boils down to that the "*…ic*" in geographic means "of or pertaining to geography," whereas the "*…cal*" in geographical means "of geographic"—there seems to be more style than substance in the debate, as both terms are adjectives.

The "I" in the GIS acronym seems to be accepted by all as "meaning or pertaining to information." The important point to be made here is that data are simply facts without context. When data are processed, organized and structured within a given context to make them useful, they become information. This is a significant distinction to keep in mind as we tackle the different perspectives and interpretations of the trailing "S" in GIS.

It is the "S" that carries considerable conceptual, as well as grammatical baggage. Early debate focused on whether it meant "system (singular)" or "systems (plural)." The sides at the time seemed to align with whether one had a comprehensive turnkey commercial system, or cobbled together a bunch of public domain software packages. With the advent of today's specialized apps, mash-ups, cloud computing and the like, it seems that the "S" might be shifting back toward the plural and away from a flagship system paradigm.

Figure 1 takes the debate beyond the grammatical by outlining different substantive interpretations of the trailing "S" that greatly impacts GIS education, career planning, on-the-job skills and depth/breadth of understanding of spatial concepts, procedures and applications. The figure intentionally uses the intermediary compass positions (officially termed "intercardinal or ordinal") of NE, SE, SW and NW as a nod to astute geographers and as an indication that that the categorization blends fairly rigid "near cardinal" viewpoints.

At the birth of the discipline, the "S" unequivocally stood for the hardware, software and dataware with little or no reference to people or use—simply ***GISystems***. In this early stage (1970s) the focus was on just cobbling together a system that could handle digital maps without crashing. The dream might have been boundless utility but the practical reality was whether maps as numbers was a viable concept and could be shoehorned into the tinkertoy computing environments of the day.

Today, the GISystems perspective still holds that the GIS enabling mechanisms are paramount. Like the pit crew in a NASCAR race, GIS can't go anywhere without a finely tuned and fueled computing environment. However, over the years the "systems" interpretation has expanded to GISpecialist, GIScience, and GISolutions that primarily respond to differing perspectives on the data versus information distinction.

The idea that the trailing "S" defines ***GISpecialist*** took hold in the 1990s as the result of two major forces—uniqueness and utility. As GIS shifted from the "Eureka, it's alive" perspective of the early GIS innovators to an operational systems outlook, the uniqueness of different application environments became apparent. Enterprise systems sprung up and needed specialists who understood the unique character of an organization's spatial data and could serve as in-house experts in its care, feeding and use. By enlarge the GISpecialist's role was that of a "down the hall and to the right" resource that field, managerial and executive folks could tap when they needed maps and spatial information.

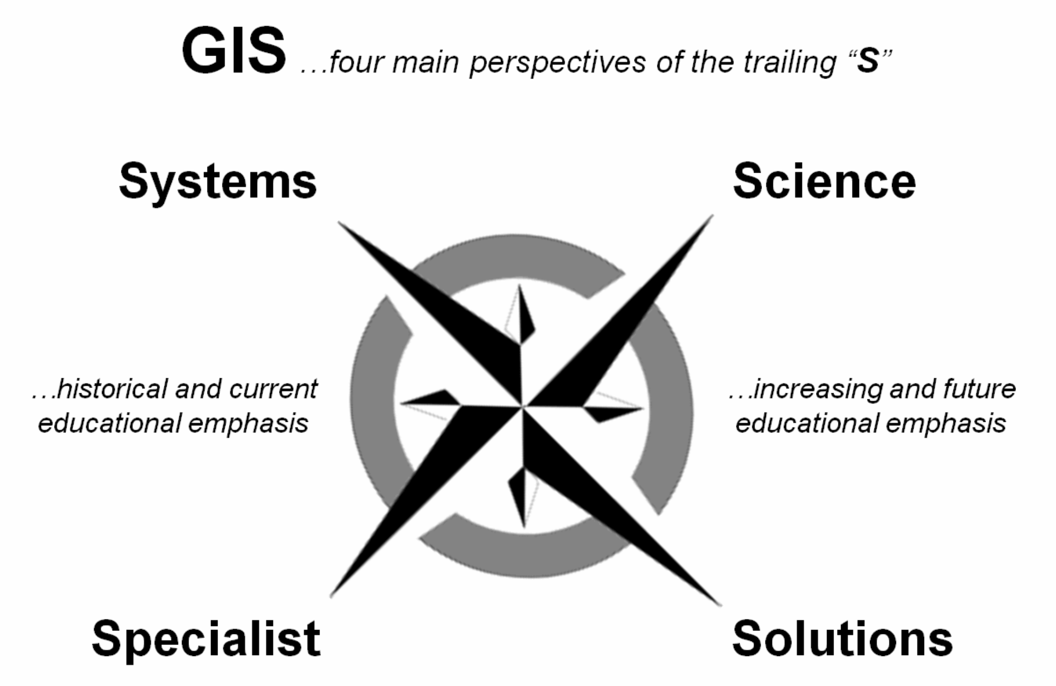


Figure 1. Four perspectives on the trailing "S" in GIS.

Numerous certificate and certification programs were designed to produce the needed specialists. At the same time a ***GIScience*** perspective took hold that recognized a more in-depth discipline was coalescing and would serve full undergraduate and graduate degrees in geotechnology. The GISpecialist has evolved into a "practitioner" role (what does it take to keep a GIS alive and how can it be used?) while the GIScience perspective tends more toward the "theoretical" (how does GIS work, how could it be improved and what else could it do?).

A fledgling ***GISolutions*** perspective has been around for some time, but seems to be capturing a lot more attention. Early GIS solutions focused on mapping and geo-query that primarily automated existing business practices. Cost and time savings in maintaining and accessing mapped data were at the heart of these highly successful applications.

However as digital mapped data became more available, interest turned to how the paper-mapbased practices might be enhanced to improve operations and decision-making. Today, the focus seems to be on entirely new GIS applications from iPhone crowdsourcing to Google Earth visualizations of real-time spatial information to advanced map-ematical models predicting wildfire behavior, customer propensity to buy a product and optimal routing of a power line.

The "GI" (Geographic Information) component seems to be a universal root, but the trailing "S" has evolved through differences in perspective of what GIS is and isn't. The GISystems and GISpecialist roles form the foundation of geotechnology's contemporary expressions whereas the GIScience and GISolutions roles determine its future directions.

Author's Note: *For a discussion on "Geotechnology" as an encompassing term, see Beyond Mapping Compilation Series book IV, Introduction, "What's In a Name?" posted at* www.innovativegis.com.

A Quick Peek Outside GIS's Disciplinary Cave

(GeoWorld, January 2010)

(**return to top of Topic**)

Over the past few months I have had the opportunity to participate in several panels discussing the future directions of geotechnology, with particular emphasis on career outlook and GIS education (see Author's Notes). One particularly intriguing "broad-brush" question setting the stage was "*What are the most radical changes that we have seen in geotechnology's evolution and that we will likely see in its future?"*

In contemplating the question I realized that it wasn't until the late 1990s that I fully realized the impact of the "perfect geotechnology storm" brought on by the convergence of four critical enabling technologies; 1) the personal computers' dramatic increase in computing power, 2) the maturation of GPS and RS (remote sensing) technologies, 3) a ubiquitous Internet and 4) the general availability of digital mapped data.

If any one of these elements were missing, the current state of geotechnology would be radically different and most certainly not as robust or generally accepted. Much of our advancement, particularly of late, has come from external forces. Now that GIS is "in the limelight" more and more of its evolution will be influenced by non-specialists' (vis., the GIS unwashed) and their perspectives on what maps are and how they might be used.

In the early years, GIS was "down the hall and to the right," sequestered in a relatively small room populated by specialists. Users would rap on the door and say "Joe sent me for some maps." Today, geotechnology is on everyone's desk and in nearly everyone's pocket. Contrary to most GIS perspectives, our contributions have been as much a reaction to enabling technologies and outside influences as it has been proactive in the wild ride to mass adoption.

Keep in mind that geotechnology is in its fourth decade—

- the 1970s saw *Computer Mapping* automate the drafting process through the introduction of the digital map;
- the 80s saw *Spatial Database Management* link digital maps to descriptive records;
- the 90s saw the maturation of *Map Analysis and Modeling* capabilities that moved mapped data to effective information by investigating spatial relationships; and finally,
- our current 2000s decade seems to be focusing on *Multimedia Mapping* emphasizing data delivery through Internet proliferation of data portals and advanced display mechanisms involving 3D visualization and virtual reality environments, such as in Google and Virtual Earths.

The future of our status as a "mega-technology" alongside the giants of biotechnology and nanotechnology will be in large part self-determined …that is, if we step out of the specialist's closet and fully engage other disciplines and domain experts. The "era of maps as data" (Where is What?) is rapidly giving way to the "age of spatial information" where mapped data and analytical tools directly support decision-making (Why, So What and What If?).

The direct relevance of geotechnology isn't just a wall hanging, it's an active part of the consideration of geographic space; whether it's a personal "what should we do and where should we go?" decision on a vacation, or a professional one for locating a pipeline, identifying wildlife management units or establishing a marketing plan for a new territory.

The key for developing successful solutions beyond data delivery lies in domain expertise as much, if not more, than mapping know-how. The geometrical increase in awareness and use of geotechnology by the masses will lead to entirely new and innovative applications that we haven't even dreamed of (nor can we dream of them in a geotechnology silo). The only way we could drop the ball is to retreat further into our disciplinary cave.

On a technical front, I see a radical change in geo-referencing from our 400 year reliance on Cartesian "squares" in 2-D and "cubes" in 3-D to hexagons (2-D) and dodecahedrals (3-D) that will lead to entirely new analytic capabilities and modeling applications (see Author's Notes). To conceptualize the difference, imagine a regular square grid morphing into a grid of hexagons like a tray in a bee hive. The sharp corners of the squares are knocked-off resulting the same distance from the centroid to each of the sides defining the cell …a single consistent step instead of two different types of steps (diagonal and orthogonal) when moving to an adjacent location. Now consider a three-dimensional world with 12-sided volume (dodecahedral) replacing a cube …a single consistent step instead of a series of differing steps to all of the surrounding locations.

This seemingly slight shift in spatial theory, however, will revolutionize our concept of geographic space. At a minimum, it finally will dispel the false assumption that the earth is flat …at least in our traditional map world that stacks two-dimensional map layers like pancakes. At a maximum, it will enable us to conceptualize, analyze and actualize spatial conditions within a fully three-dimensional representation of the real world. Then all that we will need to do is to figure out a way to fully account for time, as well as space, in our maps for a temporally dynamic representation of geography—but that's another story to be written by tomorrow's geo-technologists.

Another important trend reshaping geotechnology is its move toward commoditization. Commoditization implies *the transformation of goods and services into a commodity thus becoming an undifferentiated product characterized solely by its price, rather than its quality and features*. The product is perceived as the same no matter who produces it, such as petroleum, notebook paper, or wheat. Non-commodity products, such as televisions, on the other hand, have many levels of quality. And, the better a TV is perceived to be, the higher its value and the more it will cost.

So where is geotechnology along this commoditization continuum? Like the other two mega-technologies (*bio*- and *nano*-) it has a split personality with both commodity and non-commodity characteristics. In our beginning, research dominated and the mere drafting of a map by a plotter was perceived as a near miracle in the 1970s. Fast forward to today and digital maps are as commonplace as they are ubiquitous—a transformation from "knock-your-socks-off" to commodity status (and maybe "old dirty socks" that ought to be avoided in a decade or so of 3D GIS technical advancements).

But we shouldn't confuse mass adoption of a map product or service with commoditization of an entire technology. It is like the product life cycle in pharmaceuticals from trials, to unique flagship drug, to generic forms and finally to commodity status. While the products might cycle to commodity, industries don't as long as innovation keeps adding value and new product lines.

What is rapidly becoming a commodity in our field is generic mapped data and Internet delivery. However, contemporary value-added products and services are extremely differentiated; such as a propensity map for product sales, a map of wildfire risk, and a real-time helicopter routing map that avoids enemy detection. The transition is a reflection of a paradigm shift from mapped data to spatial information—less of a focus on automating traditional mapping roles and procedures, to an emphasis on new ways of integrating spatial relationships into decision-making ...*thinking with maps*.

The bottom line is that commoditization of geotechnology is neither good nor bad, nor an advantage or disadvantage. It just is a natural progression of product life cycles and renewed advancements in value-added features and services through continued innovation. If we fail to innovate, the entire industry will become commoditized and GIS specialists will hawk their gigabytes of graphics in the geotechnology commodity market next to the wheat exchange in

Chicago.

The career take-home is that an individual can't assume one brush with a four-year smart pill in education is sufficient. An individual's ability to go beyond traditional mapping is the key—from a focus on management, access, display and geo-query of spatial data (*Descriptive Mapping* that is more "data-centric") to an enlarged focus on integration of enterprise data, value-added processing and applications of spatial information (*Prescriptive Mapping* that is more "application-centric"). The discussion in the next section investigates some of the pitfalls along the geotechnology career path and education alleyways.

Author's Notes: *Summaries of the career/education panels are posted at* *www.innovativegis.com/basis/basis/cv_berry.htm#KeyNote*.

GIS Education's Need for "Hitchhikers"

(GeoWorld, February 2010)

(return to top of Topic)

The last section addressed a "broad-brush" panel question on "*What are the most radical changes that we have seen in geotechnology's evolution, and that we will likely see in the future?*" The discussion invoked an assessment of the four-decade trajectory of GIS, both in terms of its driving forces and incremental capabilities and utilities.

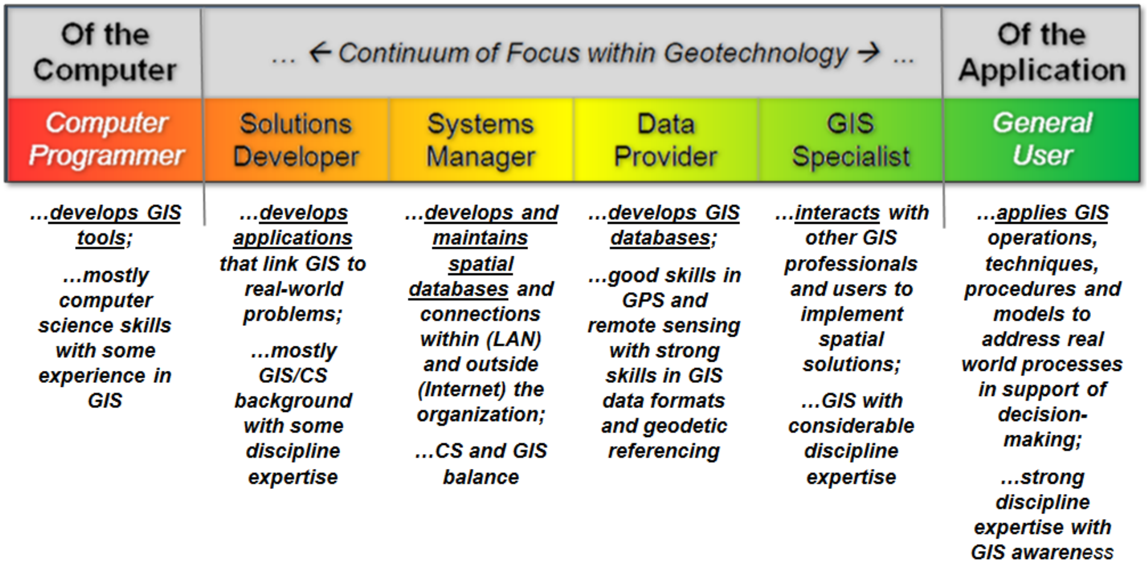
Another very basic question that seems to be making the circuit is "*Where do we go from here? …and how do we make it happen?*" As background, one needs to realize that we have established the basic means of encoding, analyzing, visualizing and storing geographic information, and have the prerequisite computer power to digest it all. In addition, we have maturing standards and a huge quantity of mapped data content in terms of vector and image data—lock and load, but what is the target?

To many, the future target is a giant leap beyond mapping and spatial record-keeping to full integration of geotechnology into real world decision-making processes— from land management to building design to retail marketing to environmental protection and a myriad of other applications.   While I am sure there are technical waypoints along the path we take from here, the human element likely will be the most critical factor of forward progress, with a revamping of the education component leading the way.

It's interesting to note that our earliest tinkering with GIS had a huge tent with zealots from all disciplines tossing something into the stone soup of an emerging technology—foresters, engineers, geographers, epidemiologists, hydrologists, farmers, geologists to mention but a few. As the field matured the big tent's diversity contracted considerably as "specialists" emerged and formal programs of study and certification surfaced.

There are many positive aspects in this maturation, but there also are some drawbacks. In many universities, a GIS Center of Excellence emerged and lodged in a disciplinary stovepipe of a single college or department. In addition, the maturation of the field resulted in a "one shoe fits all" curriculum with focus on training tomorrow's GIS'ers.

But this educational footing is far too limited for a leap from mapping to modeling. The breadth of potential applications suggests that geotechnology is ill served as the special domain of any discipline, or even coalescence into a discipline unto itself. A continuum of diverse activists have and are shaping geotechnology's future— from those "of the computer," such as *Computer Programmers*, *Solutions Developers*, and *Systems Managers*, to those more "of the application," such as *Data Providers*, *GIS Specialists*, and *General Users* (figure 1).



Of the Computer	… ← *Continuum of Focus within Geotechnology* → …				Of the Application
Computer Programmer	Solutions Developer	Systems Manager	Data Provider	GIS Specialist	*General User*
…develops GIS tools; *…mostly computer science skills with some experience in GIS*	*…develops applications that link GIS to real-world problems;* *…mostly GIS/CS background with some discipline expertise*	*…develops and maintains spatial databases and connections within (LAN) and outside (Internet) the organization;* *…CS and GIS balance*	*…develops GIS databases;* *…good skills in GPS and remote sensing with strong skills in GIS data formats and geodetic referencing*	*…interacts with other GIS professionals and users to implement spatial solutions;* *…GIS with considerable discipline expertise*	*…applies GIS operations, techniques, procedures and models to address real world processes in support of decision-making;* *…strong discipline expertise with GIS awareness*

Figure 1. The continuum of the GIS community reaches from computer science development to a mosaic of general user applications.

Historically, digital mapping tilted toward the right side of the continuum as GIS specialists established and nurtured vast databases that automated existing business practices. Then map analysis and modeling shifted focus toward the left side with Solution Developers doing the heavy lifting by providing new capabilities, models and turnkey solutions.

However, the "bookends" of this continuum are the current drivers. Increasingly, computer science and technological advancements in visualization and access are at the frontier. With the full embrace of RS, GPS and GIS by Google, Oracle and other "big-hitters" in the computer industry, geotechnology's applications are becoming ubiquitous.

It is hard to pick up a magazine, watch TV or attend a conference that new and powerful ways of accessing and interacting with mapped data aren't being ballyhooed—my grandmother would be proud. For first time society comprehends a paperless map and marvels at its uses, from saving lives with OnStar to finding a store across town to zooming in to a beach in Belize. While geotechnology is at the foundation, it has been applied computer industries that hit the ball out of the park.

It is widely purported that eighty percent of all data has a spatial component but simply "mapping to visualize" these data is rarely sufficient in many decision-making arenas. Geotechnology's next leap forward will be lead by the other bookend group—involving the active participation of domain experts in development of entirely new applications addressing complex spatial relationships. The old adage that "those with the problems have the solutions" apply applies.

As long as the questions involved "*how do I map that?*" or "*where is what?*" GIS'ers at the core of the continuum could take the lead. But as questions progress to "*why and so what?*" and "*do what where?*" the solutions move well beyond mapping—to spatial reasoning, dialog and problem solving.

Within a modeling context, disciplinary knowledge of underlying concepts, assumptions, state variables, driving variables, processes, rates and limits becomes paramount. In most fields, understanding of these relationships has been developed through years of non-spatial science. The idea that spatial considerations could be "addressed spatially" is foreign—"shouldn't all that data be collapsed to a mean and standard deviation?" The notion that there are tools for characterizing geographic distributions and relationships within and among mapped data has been outside their experience base, and all too often outside their comfort zone.

But domain expertise is the key ingredient for innovative solutions of complex spatial problems. The direct engagement of bright minds with a practical understanding of the dimensions and complexities of a potential application has been the "missing link." In large part, a "campus chasm" that is too onerous for most students to cross proves to be the barrier.

Contributing to the divide is that the preponderance of geotechnology education focuses on "discrete spatial objects" as a set map features composed of Points, Lines and Polygons (**Vector** perspective). However, most spatial models focus on "continuous spatial distributions" of geo-registered map variables expressed as gradient Surfaces (**Raster** perspective) with all of the rights, privileges and responsibilities of a true "map-*ematics*."

This requires a paradigm shift from our current thinking of what GIS is and isn't— from a mapping focus (warehousing, accessing and visualizing mapped data) to an application focus (solving spatial problems). This involves a conceptual shift, not just a structural change. For many GIS'ers the thought is a bit outside their experience but for non-GIS'ers it is a totally foreign and “off-the-wall” perspective of a map.

An earlier discussion about “*Turning GIS on Its Head*” (see Author’s Note) suggested that the traditional didactic approach of “fundamentals first, then applications” severely limits the breadth of exposure of geotechnology across campus. While a “*data-centric* mindset” that geotechnology education starts with geographic/cartographic principles and proceeds through software mechanics works for the inner core players along the GIS continuum, it effectively excludes the bulk of the bookend players.

An alternative is an introductory experience where students interact with the mapping and modeling capabilities at the onset without knowledge of mapping “details,” such as geodes, datum and projections. Within this context, the early focus is shifted to a grasp of the problem solving capabilities of geotechnology— an “*application-centric* education.” Toward the end of the experience the mapping details can be introduced within the context of accuracy and precision assessment, rather than establishing a set of working skills required in the mechanics of database development and maintenance.

Ideally, this experience aligns with students disciplinary interests. As with other aspects of campus life, geotechnology can benefit more from its diversity than from its oneness. It’s often perceived condition as a divorced discipline for specialists on the other side of campus has dramatically hindered geotechnology from reaching its full potential as a fabric of society, and spatial reasoning as a matter of fact.

To accomplish this transition we need to engage applied “domain expertise” in GIS offerings. This means that outreach across campus as important (and quite possibly more important) than honing courses for training core professionals. This perspective suggests less flagship/toolbox software systems and more custom/tailored packages solving well-defined spatial problems that stimulate “thinking with maps.” The next section will investigate approaches and procedures that can be used to move beyond the perception that GIS is a cluster of technical specialists “down the hall and to the right” to a collaborative team of domain experts and GIS specialists solving real world spatial problems.

Author’s Note: *See Beyond Mapping Compilation Series, book III, Epilog, section 6, “Turning GIS Education on Its Head.”*

Fitting Square Pegs into Round GIS Educational Holes

(GeoWorld, March 2010)

(return to top of Topic)

The previous section suggested that geotechnology needs “hitchhikers” to reach beyond mapping. The technology’s first three decades capitalized on the development of the digital map, first simply for *Computer Mapping*, then for *Spatial Database Management* and then for *Map Analysis* by exploiting entirely new encoding, storage, processing and display tool sets that were radically different from our paper map legacy (figure 1).

Through the 1990’s, the new kid on the block, *Geographic Information Systems and Science*, was in the driver seat and in control of the emerging technology. However with the new millennium, geotechnology matured into a mega-technology that captured the full attention of the computer industry and its reading of the huge potential market for *Multimedia Mapping and Visualization*. The result was near commoditization of many traditional digital mapping capabilities—tremendous mass acceptance and use occurred, but innovation shifted from the GIS community core toward the computer science bookend.

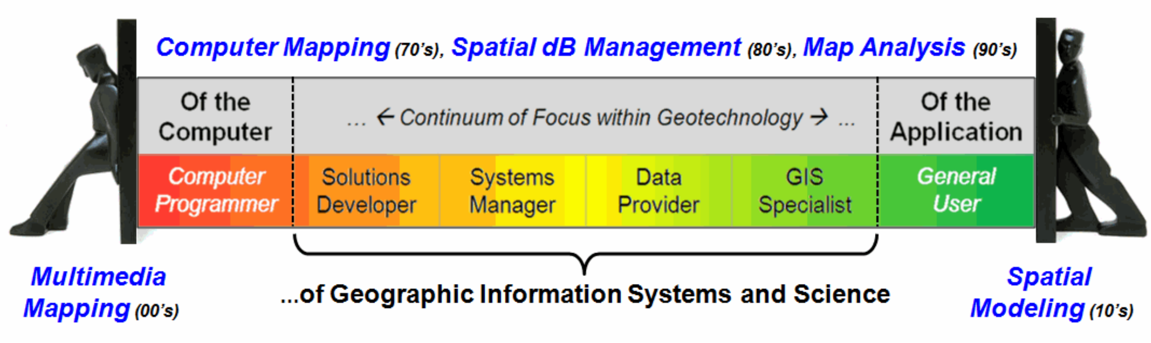
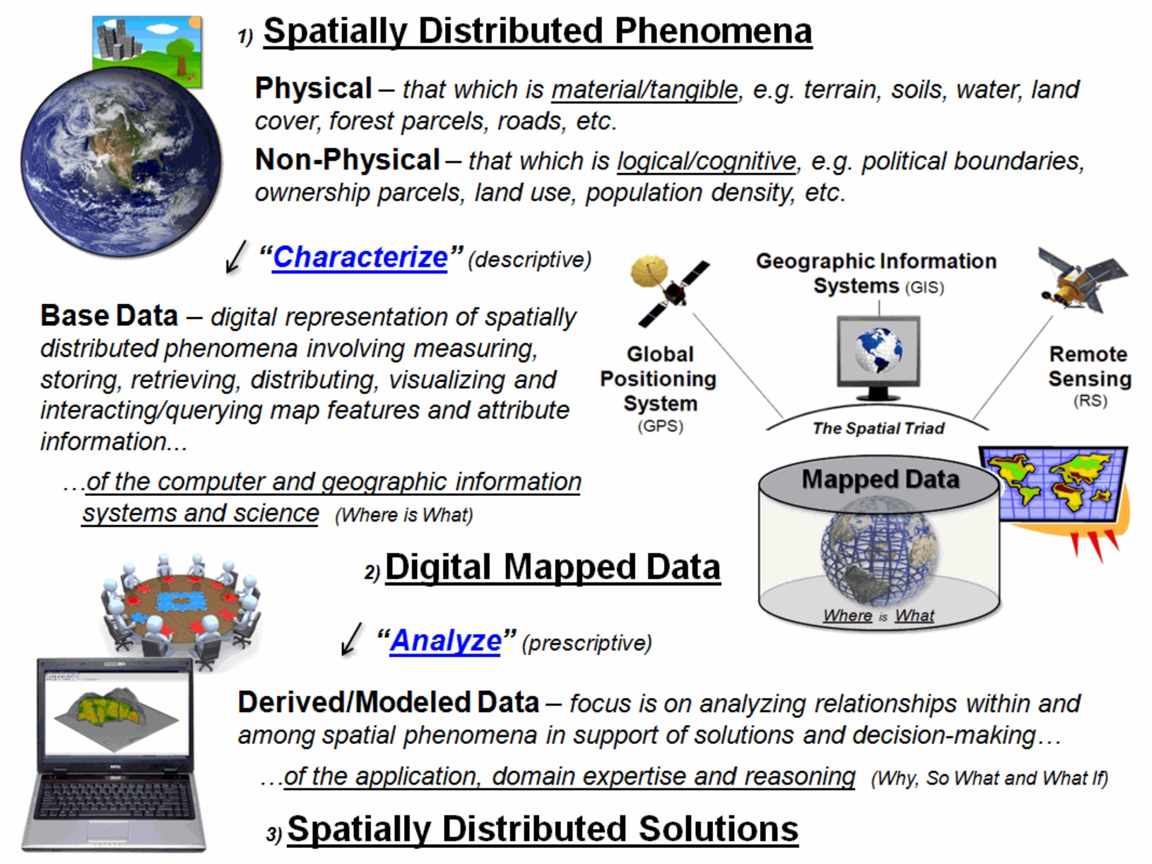


Figure 1. The bookends of the continuum of the GIS community are the current drivers of Geotechnology.

Looking forward into the next decade two dominant thrusts seem to be surfacing. While the bulk of the GIS community will continue to develop and expand the digital map repository, a small group of innovators will work with computer scientists to radically revolutionize our current data and processing structures. A somewhat larger contingency will engage general and innovative users in developing *Spatial Models* that integrate domain expertise, spatial reasoning and map analysis tools in support of solutions and decision-making.

Figure 2 depicts the major components involved in spatial modeling. Historically, maps focused on precise placement of physical features (material/tangible) primarily for navigation. As mapping evolved more non-physical information (logical/cognitive) found its way into map form. In the past few decades both types of descriptive characterizations of spatial phenomena have been incorporated into huge digital mapped data repositories identifying “Where is What” with sophisticated tools for interacting with the data.

The step from digital map data to spatially distributed solutions involves a paradigm shift from descriptive “Where is What” mapping to prescriptive “Why, So What and What If” modeling. This transition in emphasis involves the other bookend (users) as much, or more, than it involves the core GIS community.



1) Spatially Distributed Phenomena

Physical – *that which is material/tangible, e.g. terrain, soils, water, land cover, forest parcels, roads, etc.*

Non-Physical – *that which is logical/cognitive, e.g. political boundaries, ownership parcels, land use, population density, etc.*

“Characterize” (descriptive)

Base Data – *digital representation of spatially distributed phenomena involving measuring, storing, retrieving, distributing, visualizing and interacting/querying map features and attribute information…*

…of the computer and geographic information systems and science (Where is What)

2) Digital Mapped Data

“Analyze” (prescriptive)

Derived/Modeled Data – *focus is on analyzing relationships within and among spatial phenomena in support of solutions and decision-making…*

…of the application, domain expertise and reasoning (Why, So What and What If)

3) Spatially Distributed Solutions

Figure 2. Map analysis and modeling extend mapped data to spatial solutions.

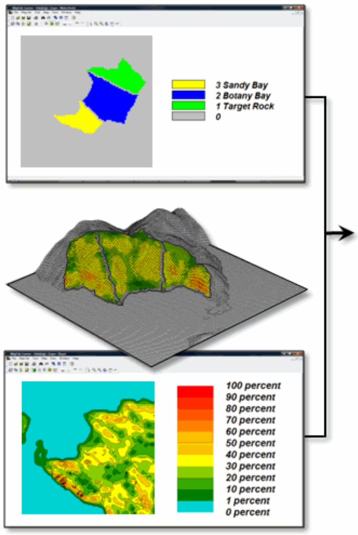
It suggests that spatial reasoning needed for the transition lies outside the usual knowledge, skill sets and experience of GIS’ers. However, most GIS curricula are designed to service the core community with minimal attention to reaching other disciplines—they can take our established courses, but targeted courses for non-GIS’ers focusing on spatial problem identification and solving are rare indeed.

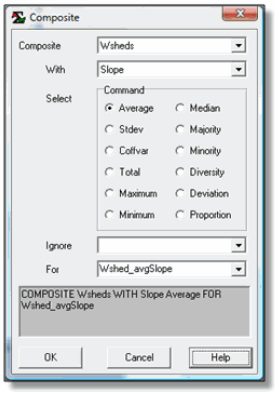
Yet the development of curricula and courses for the “unwashed” likely will determine geotechnology’s future. If we are to reclaim a share of driver’s seat we need to instill closer and active relationships with the bookends of the GIS community. The small group of technology innovators seems well along the way through research initiatives and industry investments.

The knurly problem lies in engaging a dispersed set of applied disciplines to develop awareness and skills in spatial reasoning. The old adage “they don’t know what they don’t know” applies and over-stuffed disciplinary curricula keeps most students at bay. What elective “holes” are available are usually tied-up by concentration tracks that delve even deeper into their discipline. This, coupled with a university administrative structure that struggles with inter-disciplinary efforts, effectively limits exposure of most students to spatial reasoning and problem solving.

Two potential remedies to this disciplinary stovepipe “standoff” seem viable—both requiring the initiative of the geotechnology academic community. First, a concerted “outreach” program needs to be developed where GIS students are encouraged to develop a secondary disciplinary thrust that focuses on spatial problem solving instead of the usual database compilation concentration. In addition, faculty needs to develop secondary ties across campus that actively contribute to teaching and research involving spatial reasoning within applied disciplines.

An important step in this outreach is recognizing that the GIS tool isn’t the focus and “training” outside students/faculty in the nuances and fine distinctions of database construction and GIS software isn’t relevant. The objective becomes developing an awareness of the capabilities of GIS through instructive case studies coupled with simple hands-on exercises.





Composite: Wsheds
With: Slope
Select — Command:
● Average ○ Median
○ Stdev ○ Majority
○ Coffvar ○ Minority
○ Total ○ Diversity
○ Maximum ○ Deviation
○ Minimum ○ Proportion
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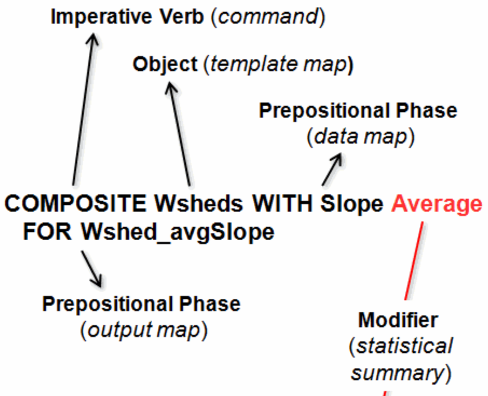
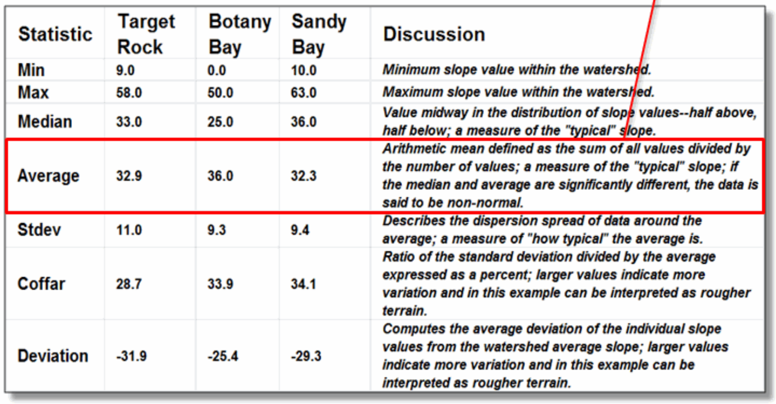
For: Wshed_avgSlope

COMPOSITE Wsheds WITH Slope Average FOR Wshed_avgSlope





Statistic	Target Rock	Botany Bay	Sandy Bay	Discussion
Min	9.0	0.0	10.0	*Minimum slope value within the watershed.*
Max	58.0	50.0	63.0	*Maximum slope value within the watershed.*
Median	33.0	25.0	36.0	*Value midway in the distribution of slope values--half above, half below; a measure of the "typical" slope.*
Average	32.9	36.0	32.3	*Arithmetic mean defined as the sum of all values divided by the number of values; a measure of the "typical" slope; if the median and average are significantly different, the data is said to be non-normal.*
Stdev	11.0	9.3	9.4	*Describes the dispersion spread of data around the average; a measure of "how typical" the average is.*
Coffar	28.7	33.9	34.1	*Ratio of the standard deviation divided by the average expressed as a percent; larger values indicate more variation and in this example can be interpreted as rougher terrain.*
Deviation	-31.9	-25.4	-29.3	*Computes the average deviation of the individual slope values from the watershed average slope; larger values indicate more variation and in this example can be interpreted as rougher terrain.*

Region-Wide Statistics Table. *The region-wide statistics indicate that the Target Rock watershed is slightly steeper (Average= 32.9) and not as rough (Coffvar= 28.7) as the other two watersheds.*

Figure 3. Effective education for non-GIS students shifts the focuses from mapped data to interacting with model logic and its spatial reasoning foundation.

Hands-on experience is critical but it can't be the same as for traditional GIS students. Flowcharts provide a mechanism for interacting with a spatial model's logic and its processing expression (e.g., ArcGIS's Model Builder). The link between step-by-step logic of a model and the sequencing of the commands becomes the objective.

For example, figure 3 uses MapCalc Learner (see Author's Note) to decipher a region-wide overlay summary that derives the average slope within three watersheds. Note that the command forms a complete grammatically correct sentence that resonates with less-technical students and that the contextual help provides information on additional summary options providing fodder for further discussion.

As GIS education moves beyond mapping the emphasis lies in full engagement of cross-campus entities. Like remora and the shark, a symbiotic relationship with applied disciplines is what will take us there.

Author's Note: *A listing of several MapCalc Learner "application exercises" used in special presentations for various applied disciplines are at www.innovativegis.com/basis/Senarios/Default.html#Application_examples. The educational software system can be downloaded for free.*

Further Online Reading: *(Chronological listing posted at **www.innovativegis.com/basis/BeyondMappingSeries/**)*

Lumpers and Splitters Propel GIS — *describes the two camps of GIS (GeoExploration and GeoScience) (December 2007)*

Melding the Minds of the "-ists" and "-ologists" — *elaborates on the two basic mindsets driving the geotechnology community (July 2009)*

Questioning GIS in Higher Education — *describes thoughts and notes from a panel discussion on "GIS in Higher Education" (June 2012)*

(return to top of Topic)

(Back to the Table of Contents)