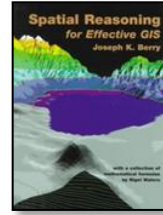


Beyond Mapping II

Topic 1 – Understanding GIS



[Spatial Reasoning](#) book

[Distinguishing Data from Information and Understanding](#) — considers the fundamental concepts behind moving mapped data to information and ultimately to understanding

[Moving Toward a Humane GIS](#) — describes an interactive link between GIS model logic and code

[Consider a GIS Modeler's Toolkit](#) — discusses an Object-Oriented Programming System approach to GIS model development

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Distinguishing Data from Information and Understanding

(GeoWorld, October 1993)

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The digital map is at the core of GIS. From that perspective, a map isn't simply a comfortable, colorful image, but an organized set of numbers. Analyzing these data involves processing thousands upon thousands of numbers to produce a set of new numbers (i.e., a new map). That is a tedious task for humans so we rely on our sickly gray, silicon friends. It isn't that we couldn't do what computers do; it's just that we have more creative things to do. We are creative (fire) while our computers are computational (ice).

As with any new technology, GIS's sharp contrast acts like a Rorschach inkblot test—in one instance it appears to be one thing (image); in the next it's another (numbers). What is needed is a blending of the two perspectives into a middle ground of creative computation. So what's holding us back? Two things come to mind— 1) the complex nature of spatial problems and 2) the inhumane nature of GIS.

Let's consider the complex nature of spatial problems. Historically, mapping was simply a matter of not getting lost and maps were used to identify the placement of features on pocket-sized abstractions of our landscapes and seascapes. Then maps evolved into graphical

inventories “linking features” to attributes describing the character, content and condition of mapped entities. Now we are enamored with the potential of a GIS to address complex spatial problems using “map-ematical modeling.” From determining the optimal route for a proposed highway to identifying the ideal habitat for spotted owls, GIS is viewed as a decision-makers salvation. But is it really?

It’s generally accepted that good data are the prerequisite of good decisions. With the advent of the computer, good data often are equated to voluminous data—the more the better. In reality, mounds of data must be sieved for a subset that’s significant and relevant to the decision at hand. The true effectiveness of any information system lies in its ability to distill *data* (all facts) into *information* (useful facts). GIS is adept at swallowing tremendous amounts of spatial data, then repackaging and presenting germane information to the user.

Yet descriptive information isn’t enough in many decisions. Consider figure 1 which is based on sociology’s enduring quandary of fact/value conflicts. The lower-right panel of the matrix identifies the ideal condition (COMPUTATIONAL) in which there is social agreement on the facts and values surrounding a decision. That is computer heaven in which efforts are focused on perfecting the computational solution. In that role, GIS is viewed as a Decision Making System (DMS) which is coupled tightly to mathematical models. Under these conditions, science and technology are indisputably paramount, with their solutions directly translating into decisions.

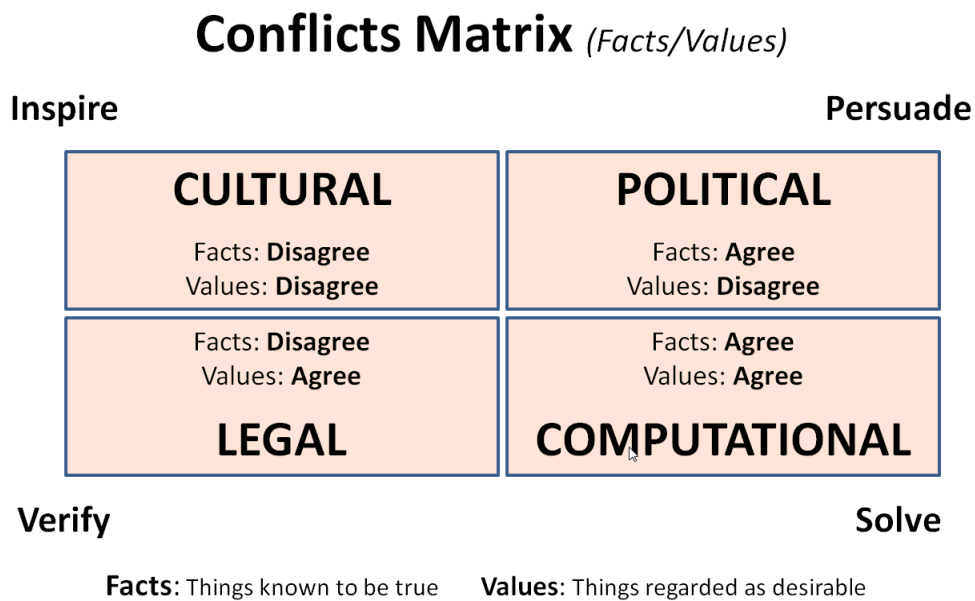


Figure 1. Only a subset of all land use issues involves computational solutions. Most use the computer as a vehicle for communicating various perspectives of an issue through spatial reasoning and dialog.

However, many of the decisions facing GIS fall outside the COMPUTATIONAL panel. Consider the LEGAL panel in the lower-left in which there is agreement on values but disagreement on facts. It's like the accused of a heinous murder claiming he was at home in bed at the time, while the prosecutor claims he was at the scene of the crime. In that role, technology is called on to "verify" the facts by viewing and comparing alternative definitions of fact. In techy-speak, that means "establishing the sidebars of the system's response."

A POLITICAL conflict (upper-right panel) is the opposite. In that decision environment there is agreement on facts, but disagreement on values. For example, we might agree on the fact that a species is endangered but disagree on the relative value we place on environmental and economic considerations. In that role, technology is used to persuade society (or at least a majority) of the logical reasoning supporting a position. The CULTURAL panel (upper-left) is the murkiest of all—disagreement on facts and values (e.g., the abortion issue). Under these conditions technology is ineffective, with their solutions having little relevance to either the discussion or a decision.

But what does all this esoteric stuff have to do with a GIS? It's just a data sponge that draws awesome graphics, right? Actually it is a Decision Support System (DSM) that transforms data into information. And if used creatively, it can transform information into *understanding* of the complex nature of spatial problems, which in turn, can lead to viable decisions. It's preposterous to assume that one more decimal place of accuracy in a spatial model could solve a complex problem in which the facts and/or values are in dispute. The computational approach only works on a limited set of spatial problems.

A view of GIS beyond data and information is in order—one as a communication tool as much as much as it is a mapping tool. A decision maker's understanding is as important to a good decision as good data. To paraphrase Professor Robert Woolsey at the Colorado School of Mines, "Managers would rather live with a problem they can't solve than apply a solution they don't understand." As problems become increasingly gray, the black-and-white approach of computational solutions becomes increasingly limited.

The next section investigates how GIS and creative computing can be used to extend data to information and, ultimately, to understanding complex spatial problems. What do you say—a pipe dream or reality?

Moving Toward a Humane GIS

(GeoWorld, November 1993)

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The previous section noted two things holding back GIS: (1) the complex nature of spatial

problems and (2) the inhumane nature of GIS. Many applications go beyond repackaging mapped data into spatial information that is presented to decision makers. Map-mathematical models relate spatial variables and, in some instances, can be used to "solve" land use issues. However, more often than not, a computational solution isn't possible because complex issues often are driven by conflicts in facts and values among individuals. In these cases words like "verify," "persuade," and "inspire" replace "solve." What is needed in these situations is a decision-making environment that promotes enlightened communication of the impacts of varying fact/value perceptions.

Or, what is needed is a kinder, gentler GIS—one that fully engages decision makers in the spatial analysis process, encourages them to try different interpretations of a spatial model and compare the outcomes, and sanctions spatial reasoning and dialogue. We have the computer, the database, the analytical operations, and even a colorful set of point-and-click icons. But we are missing a succinct expression of a model's logic and an interactive mechanism to execute the model under various interpretations.

Yet don't despair. Your vendor's GIS (Guaranteed Income stream) is addressing the situation with a humane interface. Consider figure 1, a simple model to determine areas suitable for development as being gently sloped and near roads. The upper portion of the figure is a flowchart that graphically summarizes the model's logic as a series of boxes (maps) and lines (operations). Derived maps of slope and proximity to roads are created from the base maps of Elevation and Roads, respectively. The derived maps are "calibrated" in relative terms of suitability, and then combined for an overall suitability map. The lineage, or pedigree, of the final map is succinctly expressed in the graphic.

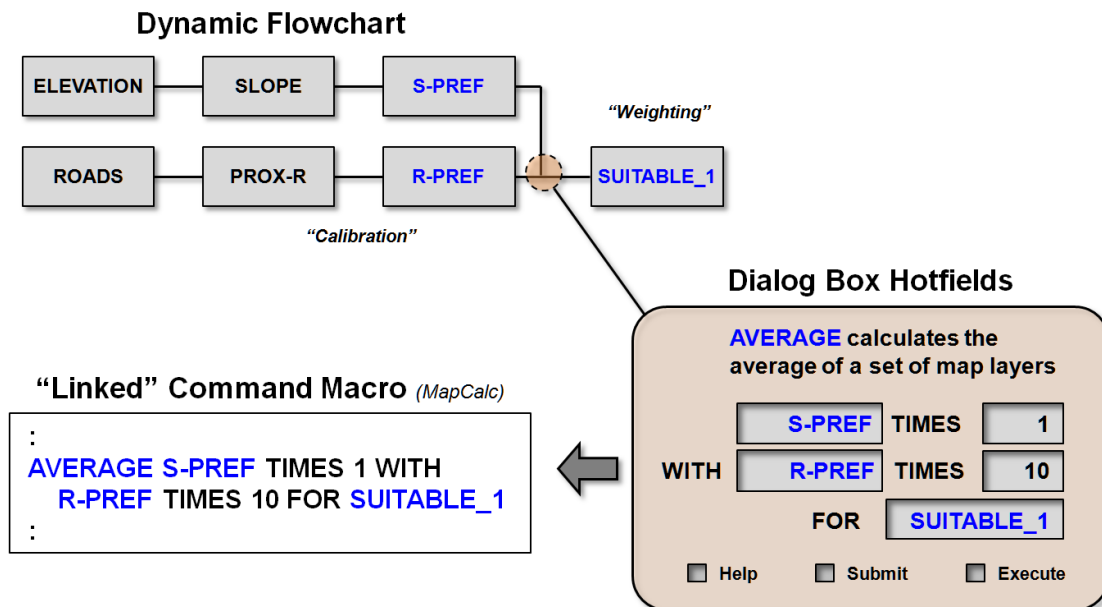


Figure 1. Clicking on a line (operation) in the dynamic flowchart pops-up a dialog box with "hotfields" that allow users to automatically edit and execute the linked command macro.

In a humane GIS interface, the flowchart is linked dynamically to the database and the command macro of the model. If you click on a box, descriptive statistics and/or an image of the map pops up. A click on a line pops up a description of the operation and its "parameterization" (lower right portion of the figure). By clicking around the flowchart, you can get a fairly good handle on the logic of the model—sort of a personalized tour of the black box. That exploratory interaction with the model develops an understanding of the spatial reasoning supporting the application. Questions, inconsistencies and gaps in logic are discussed with the model developer. That dialogue can enhance the decision maker's confidence in the model and refine the model as well.

If the user is authorized, another level of interaction can take place. When an operation's dialog box appears by clicking on a line, its specifications are contained in hotfields. For example, if the *weighting* step is clicked as shown in the figure, the AVERAGE dialog box pops up and the current weights for the slope (S-PREF) and road proximity (R-PREF) preferences are depicted. Clicking on the Help box provides a more detailed description of the operation and its options. Armed with this knowledge, you can change the weights so the average is more heavily influenced by the preference to be near roads (one to 10 times the influence, as shown). To keep things straight, edit the final map name to SUITABLE_1, as shown.

When you finish editing the hotfields and submit the dialog box, the GIS code associated with that step is edited automatically (lower left portion of the figure). You can pop-up and edit another step in the model if you choose. When you click on the Execute box, your revised command macro is run and the new SUITABLE_1 map is generated. The revised flowchart and macro form the pedigree of the new map, which in turn can be interactively explored and revised. Each time a new scenario is tried, the graphic and coded pedigree serves as the conceptual audit associated with the alternative—an objective record of its fact/value interpretations. Now we're talking.

Comparing the results of your tinkering (successive SUITABLE_xxx maps) provides insight into the model's sensitivity and plenty of material for discussion. "Huh, you mean when road proximity is considered 10 times more important, it doesn't change suitability much? And that limited change is concentrated in the southwest portion of the project area? Heck, it doesn't affect my property. I thought it would affect every square inch." That direct interaction fully engages stakeholders and decision makers in the analytical process. As they see the effects of their "what if" questions, they develop a better understanding of the issue and its ramifications.

"Naïve you say. Pollyannaish. Detached ramblings of a demented soul who never has been in the decision-making trenches. It never will work." These may be a few of the thoughts that cross your mind. Yet consider the alternative: a detached GIS producing an increasing deluge of colorful, yet indecipherable, mapped gibberish. The humane GIS modeling structure provides a

user-friendly means for interacting with the GIS that goes beyond map viewing. So what's in it for the GIS specialist? That's for the next section to tackle.

Consider a GIS Modeler's Toolkit

(GeoWorld, December 1993)

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So what does the future have in store for the GIS specialist's bag of tricks? The previous section proposed a graphical entry mechanism into GIS application models for users, based on a dynamic flowchart of the final map's pedigree. Such a system allows decision makers to interactively tinker with a model and gain valuable insight into its application-sort of a point-and-click tour of the black box's logical reasoning. If the user is authorized, that tinkering can expand to modifying the weights and calibrations (model parameterization) to generate maps of alternative scenarios. How the final map changes under different interpretations becomes the real spatial information for decision making. The maps themselves are colorful products, but how they change leads to colorful dialogue.

OK, but what does all that have to do with GIS modelers? The techy crowd merely codes, right? Yes, but the link between the command macro and the dynamic flowchart is essential. So why not have the modeler work with the same graphical interface to build the model? Yep, that's it—a graphical, object-oriented, GIS modeler's toolkit. At that level, construction and model structure editing is provided for the modeler, as well as the simple viewing and parameter editing granted to the users.

To get a feel for how it might work, consider figure 1. Keep in mind that this approach is somewhere between "scareware" and "vaporware," but it's a probable future for GIS. The top portion contains a set of processing widgets that are tied to data and operations. The lower portion is a graphical workspace. A model developer uses the widgets to construct a flowchart of an application. As the flowchart is completed, the dynamically linked command macro is written automatically.

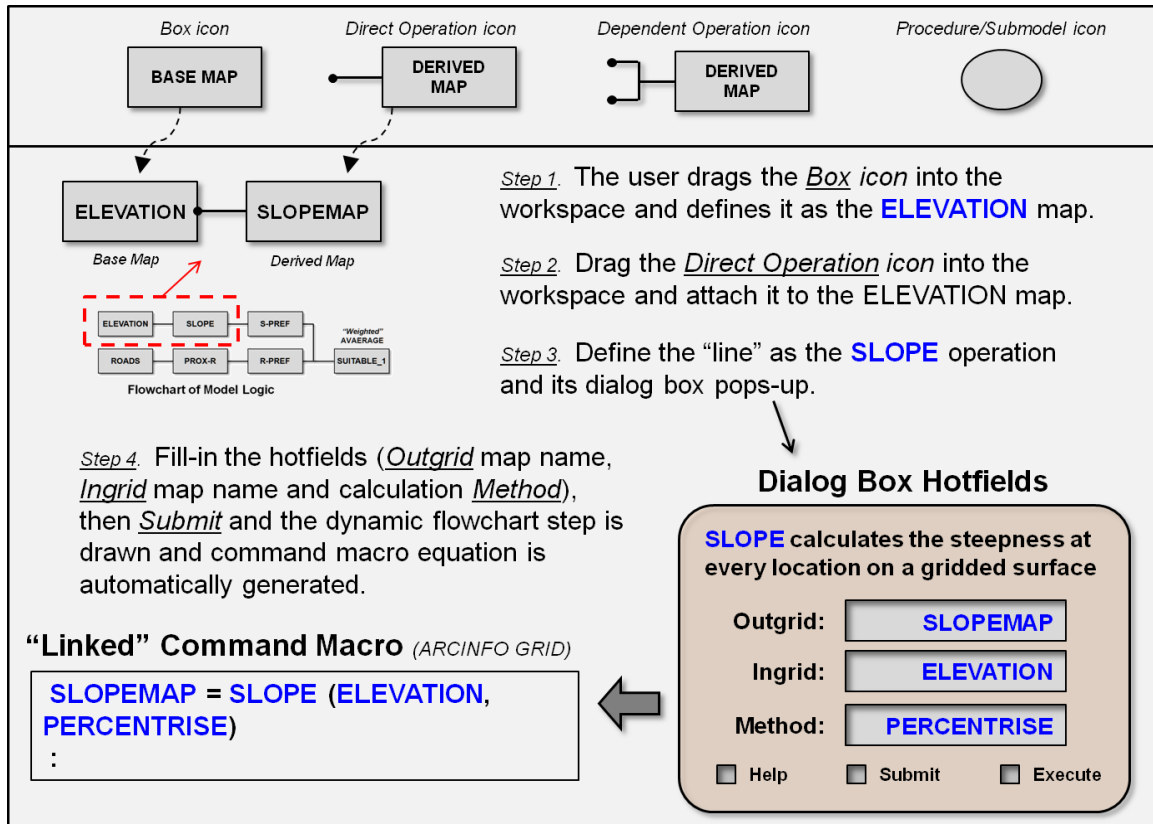


Figure 1. The GIS toolkit of the future may allow the modeler to generate fully indexed macros by simply constructing an application's flowchart.

For example, the modeler might click and drag the box icon, representing a base map, into the work space. Once positioned, the box is defined as the Elevation map. The system searches the database and associates the mapped data with that element of the flowchart (Step 1). Clicking on the box at any time pops-up a description and/or display of the map. To continue flowchart construction, the modeler drags the Direct Operation icon and attaches it to the Elevation map (Step 2). At that point, the system knows a new map is desired, but it doesn't know what operation to use.

The modeler defines the line as the SLOPE command, which causes the system to draw an empty output map box and pop up SLOPE's dialog box (step 3). The example indicates the options for Environmental Systems Research Institute Inc.'s ARC/INFO GRID command. The hotfields are specified for "out-grid" and "method." It already knows the "ingrid," unless you want to change it. The completed dialog box is submitted, which causes the command line to be written to the macro and the out-grid name placed in the flowchart (Step 4). The process is repeated to construct subsequent parts of the model.

Note that not all widgets are the same. Some are related to data (maps), some to methods (GIS

commands) and their properties (command options), while others can identify procedures (frequently used submodels). These terms are in the realm of what computer scientists call *object-oriented programming*. It suffices to say that the basic structure for a humane GIS is in place, but there is a lot of work and discussion before it arrives on your desk.

Continuing with the example model's construction, a modeler might attach and identify the RECLASS operation to the SLOPE map. Complete its hotfields by assigning preferences to various slope classes and designate S-PREF as the outgrid. In GRID syntax, a "remap" table is generated and linked to the RECLASS command line. Other systems will write the reclassification assignments as part of the command line.

That trivial point, however, raises a more important point. The GIS industry has made great strides in establishing standards for data exchange. It wasn't too many years ago that maps in one system couldn't be fed to another. If your temples aren't gray, you probably can't imagine such a silly state of affairs. A database Tower of Bable severely limited GIS's potential.

But what about system-specific application models? It's part of the GIS mystique, isn't it? Part of the insider knowledge that makes your GIS union card so valuable. Part of the product differentiation strategy that ensures system loyalty. It's also part of the evolutionary progression toward open systems. Just as database management systems evolved Standard Query Language (SQL) to give a similar look and feel to their users, a GIS Analysis Language (GAL) is the next step in GIS technology.

Because GIS is graphical anyway, why not use a dynamic flowchart i a map's pedigree as the entry point? To users and modelers alike, the flowchart entry would be similar among systems, even if the attached command lines were radically different. That will require an extraordinary effort, similar to the development of geographic standards for the paper map and the exchange standards for the digital map. Yet the payoff is huge. Tackling GIS at the command line level is a superhuman effort. Keep in mind that the millions of potential GIS'ers are real people who simply need a humane GIS.

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