University of Pennsylvania, School of Design

SPEAKING OF GEODESIGN

C. Dana Tomlin

Abstract: Much attention has recently been focused on prospects for the use of geographic information systems as media for "geodesign", a term intended to imply uses for this technology that are more creative and less mechanically rational than has typically been the case in the past. This paper attempts to establish a structure for discussing these prospects in terms of more general concepts in decision making. It concludes with several recommendations, perhaps the most distinctive of which is that near-future efforts orient more toward prediction than prescription per se.

Keywords: GeoDesign, GIS, Decision making, Planning, Design

// GEDANKEN ZUM GEODESIGN

// Zusammenfassung: In jüngster Zeit fanden Perspektiven für die Nutzung von Geoinformationssystemen (GIS) als Medien für das „GeoDesign" viel Aufmerksamkeit. GeoDesign ist so zu verstehen, dass Planern eine deutlich kreativere und weniger mechanisch rationale Technologie bereitgestellt wird als dies normalerweise in der Vergangenheit der Fall war. Dieser Beitrag versucht, eine Struktur für die Erörterung dieser Perspektiven in Bezug auf die allgemeinen Konzepte bei der Entscheidungsfindung im Planungskontext zu etablieren. Er schließt mit einigen Empfehlungen, vielleicht die markanteste davon ist, dass sich in der nahen Zukunft Anstrengungen eher mehr in Richtung Auswirkungen und Vorhersagen als in Zustandsbeschreibungen per se fokussieren sollten.

Schlüsselwörter: GeoDesign, GIS, Entscheidungsfindung, Planung, Design

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1 COMING TO TERMS

Juggling, pole vaulting, making love, operating a backhoe … To be sure, there are a number of things in this life for which analytical scrutiny may be antithetical to performance at any given moment. Even in those cases, however, an appreciation for fundamentals does tend to improve performance over time.

This is certainly true of that peculiar form of decision making called "design." In academic programs that attempt to teach students how to be creative in fields such as Architecture, Landscape Architecture, Urban Design, or Regional Planning, the moment at which this actually happens is often one that ultimately remains both magical and mysterious. And perhaps this is as it should be. Nonetheless, the likelihood of achieving such moments is undoubtedly affected by a number of less magical and less mysterious but no less useful concepts, conventions, and capabilities that can indeed be taught in an academic setting and embraced in professional practice.

The term "geodesign" is one that has recently – and rightly – been promoted in reference to geographic decision making by way of that combination of rational and non-rational thought that is more typically associated with things like designing a building, sculpting a landscape, composing a song, or crafting a work of art. While the notion is certainly not a new one, the deliberate attempt to give it a name and place that name in the spotlight (both of which have been done quite successfully) presents an opportunity to articulate the notion in ways that can have real consequence.

This is particularly true in terms of the media to be employed. The current focus on geodesign is largely due to Jack Dangermond, a landscape architect by training but also founder and president of the company responsible for one of the world's most prominent geographic information systems (GIS). Indeed, much of the current discussion about geodesign has been oriented toward the ways in which it can be supported through the use of GIS and – perhaps more importantly – the ways in which GIS might be extended or refined to better assume that role.

This focus on GIS as the primary medium for geodesign has enormous implications, not only in terms of particular data-processing capabilities, but also in terms of the manner in which those capabilities are combined into more sophisticated procedures. In effect, it establishes the fundamental vocabulary by which geodesign strategies are depicted and deployed. Importantly, it also establishes the broader language through which such strategies are initially derived, gradually developed, and ultimately deliberated over time.

To appreciate just how significant that can be, consider the role of formal language in other creative fields of endeavor, from the composition of music or the choreography of movement to the engineering of materials or the forging of legislation.

The language of GIS has already affected a number of fields in which this technology has been applied. The question at hand is how this language should affect, and be affected by, efforts to articulate geodesign.

2 MAKING DECISIONS

To address that question, it may be helpful to start by stepping back. Geodesign is a form of decision making and, as such, it shares structural characteristics with other types of prescriptive activity, from optimizing delivery schedules to determining what's for dinner. It can be argued that all such activities encompass an interplay among three major types of information and two major types of information-processing activity.

At the risk of sounding more formal than is either necessary or appropriate, those three types of information might be cast as "predictions", "descriptions", and "prescriptions". Predictions predict *what could be*. They articulate the desired result(s) of a decision-making exercise and anticipate its potential effect(s) in both positive and negative terms. As such, predictions can be equated with what might otherwise be referred to as "objectives", "goals", "purposes", "outcomes", "consequences", "effects", "results", "aspirations", "intentions", "evaluations", or "assessments". Descriptions, on the other hand, simply describe *what is*. These are what might otherwise be termed "observations", "conditions", "constraints" or "parameters". They are selected aspects of the *status quo* that must be taken into account but are not themselves seen as subject to alteration. In contrast to these are prescriptions, which deal specifically with such alterations – particularly those intended to achieve positive benefits without suffering negative consequences. Prescriptions prescribe *what should be* and, as such, are much like "solutions", "treatments", "recommendations", "suggestions", "propositions", "plans", "designs" or "decisions".

The two types of information-processing activity that relate predictions, descriptions, and prescriptions to one another can be expressed by way of the terms "proposal" and "disposal". To propose is to put forth prescriptions that attempt to perform well in regard to effects that have been predicted and conditions that have been described. To dispose is to predict the effects of given prescriptions under described conditions. As illustrated in Figure 1, the output of each of these two activities becomes input to the other to form a cycle of iterative refinement that begins and ends with predictions.

Figure 1: The Propose/Dispose Cycle

This cycle also implies that, for certain types of decision at least, prescriptive strategies can and should be informed by their predictive counterparts. After all, it only makes sense to predict how a game will be played before one attempts to prescribe a game-winning strategy. In some fields, in fact, it is possible to automatically invert the predictive statement of a problem into a prescription for its solution. A variety of mathematical optimization techniques are remarkably effecting in doing just that.

Indeed, formal optimization techniques may well have a role to play in geodesign. There is much about geodesign, however, that is likely limit that role. One such concern

is the fact that this form of decision making is inescapably *geographic* in nature.

3 MAKING GEOGRAPHIC DECISIONS

The world as seen through the eyes of a GIS is one in which geographic conditions are represented as cartographic "layers". Each layer is a bounded plane in which every cartographic position corresponds to a geographic location, and the recorded attributes of those positions represent geographic conditions at corresponding locations. These layers tend to be organized such that a typical data set might include base layers depicting things like geology, topography, hydrology, vegetation, development, and political units; derivative layers depicting general conditions like topographic slope or aspect, proximity to the nearest road, or the total amount of open space per county; and additional derivative layers depicting more specialized characteristics such as wildlife habitat vulnerability or alternative sites proposed for future development.

Such derivative layers are usually generated by way of GIS operations that perform tasks such as classifying attributes, superimposing other layers, measuring distances and directions, characterizing sizes and shapes, simulating geospatial processes, and so on. Significantly, most of these operations accept input and generate output in a common format: the cartographic layer. As such, they can easily and flexibly be combined by using the output of one as input to another. Thus, no one operation need be overly complex or highly specialized. Complexity and specialization are instead achieved as primitive operations are combined into cartographic "models".

The construction of a geographic decision-making model begins with its predictive component: a set of layer-generating operations that attempt to predict the selected effects of potential prescriptions, given a particular set of site descriptions. Consider, for example the generation of a site-suitability layer for a new land use. Since no new land use has yet been sited, the initial presumption is that this land use could be sited just about anywhere. For the moment, at least, we therefore assume (and assert) that the land use is effectively sited everywhere. That assertion makes it possible to map the predicted effects of this tentative siting and thereby indicate site suitability. Given such a site suitability layer, the next step would be to use this prediction to prescribe a siting plan that maximizes predicted benefits while minimizing predicted costs by simply selecting the most suitable sites. Once such sites have been selected, perhaps including alternatives, they might well be subjected again to the predictive component of the propose/dispose cycle in order to rank those alternatives. This elementary site-suitability mapping technique embodies methods that were popularized by landscape architect Ian McHarg in the 1960s and which are often cited for their influence on the early development of GIS.

One problem with those methods, well recognized even at the time by McHarg, relates to what were sometimes called "spatial pattern effects". These are qualities that cannot be predicted on the atomistic basis of individual locations but which instead arise only when multiple locations are considered in a holistic manner. Consider, for example, the simple requirement that a proposed land use occupy at least ten hectares. Now consider the less-simple requirement that this land use occupy *exactly* ten hectares or the decidedly-unsimple requirement that those ten hectares be in the shape of the letter "G". How about a truly complex requirement that this "G" be sited in meaningful juxtaposition to two other yet-to-be-sited land uses: one in the shape of the letter "I" and the other shaped like an "S"? In each of these cases, it would be quite possible to develop a GIS model that predicts the degree to which alternative land use plans satisfy the stated criteria. What is not so clear is whether a GIS could also be programmed to generate such plans.

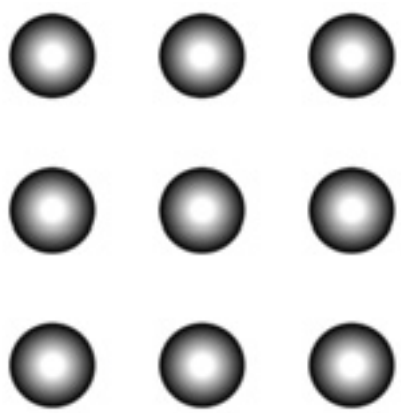


Figure 2: Connecting the Dots

And yet, we know that a human decision maker could generate such plans with ease. So how does a human decision maker actually make such decisions? Most would probably not do so by following the definitive steps of an algorithm but, rather, by following the more experimental steps of a heuristic. Whereas an algorithm is essentially a linear recipe, a heuristic is an iterative and exploratory procedure. In a typical heuristic, each iteration attempts to make progress through trial and error by

- posing an interim solution that improves on previous ones, and
- generating useful knowledge for future iterations.

Consider, for example, the kind of decision making that takes place when a group of strangers mulling about is asked to quickly "line up". What are the thought processes involved in attempting to unravel a tangle of twine? Or for that matter, what goes through your own mind as you solve the following problem in reference to Figure 2? *Without raising your pencil, draw exactly four straight lines connecting all nine dots.*

The cyclical structure of the propose/dispose cycle lends itself well to such iterative processing. Indeed, there are a number of effective heuristics for the allocation of geographic space that have gained well-deserved acceptance in fields ranging from political redistricting and retail siting to complex routing, military tactics, and timber harvest scheduling. Experience has shown, however, that both the geometric and the social dimensions of geographic problems are often such that it is well worthwhile to keep humans in the loop. In fact, it is also often a good idea to engage those humans in *design*.

4 MAKING GEOGRAPHIC DECISIONS BY DESIGN

So how does design differ from other forms of decision making like planning or engineering? It is a familiar question and one whose answer would seem to be straightforward but which is nonetheless seldom articulated. This is true even in academic and professional settings where disciplines like urban design, regional planning, and environmental engineering reside just down the hall from one another. In reference to that propose/dispose cycle, what

Figure 3: *The Optimal Path*

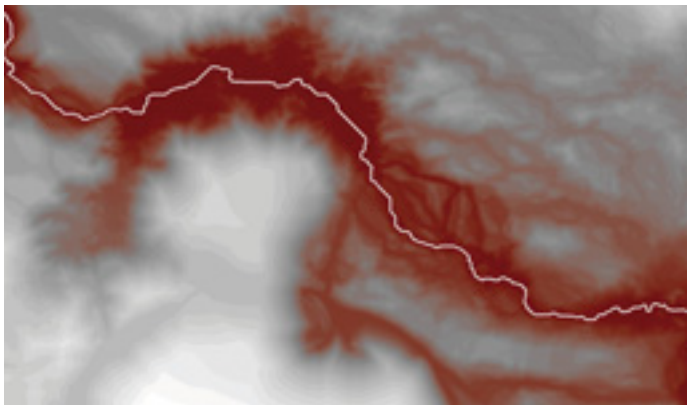


Figure 4: *Sub-optimal Paths*

seems to distinguish design-flavored variations of the cycle most is – simply and perhaps surprisingly – the fluidity of predictions. In particular, it is the choice of those selected qualities that initially motivate the design exercise and ultimately measure its success. In planning or engineering problems, these qualities tend to be well articulated from the outset and seldom subject to change. In design problems, on the other hand, they tend to be much more fluid.

One way to deal with this is reflected in ever-so-slightly-satirical quips like the following.

As an accomplished artist, I am certainly able to tell you precisely what it is that I am looking for. In fact, I can often do so within just a day or two of having found it.

To sculpt a masterpiece, just start with your block of stone and chip away everything that doesn't look like one.

Depending on your field of endeavor, prescription without prediction is either inspired design … or malpractice.

A more constructive way to deal with that fluidity is to acknowledge, accommodate, and take full advantage of emergent design criteria. These are sought-after qualities that are well able to be predicted but may not even have been considered at the start of a decision-making process. Rather, they come into focus and assume significance only as tentative decisions are iteratively generated, evaluated, and refined. Consider, for example, an exercise in rearranging a set of bedroom furniture. In an attempt to achieve better cross-ventilation, you move the bed to a corner between two windows. Having done so, a certain pleasing balance between the bed and the dresser begins to emerge. While this criterion was not there at the outset, it soon assumes even more importance than cross-ventilation.

The question at hand, then, is fairly straightforward. How can the job of recognizing, recording, and revising emergent geodesign criteria be accomplished *better* through the use of GIS?

5 MAKING BETTER GEOGRAPHIC DECISIONS BY DESIGN

What is it that purportedly makes the back of an envelope such an attractive medium for certain types of design? On the one hand, it is certainly quick, inexpensive, easy to use, readily available, and decidedly flexible. On the other hand, it is really not very good at evaluating or even recording – let alone generating – new ideas without relying almost entirely on the fertile imagination of that person at the other end of the pencil.

So how about GIS? Sure, it would always be nice to enjoy higher speeds, lower costs, easier operation, greater availability, and increased flexibility, but none of those niceties is particular to geodesign. What seem to be most critical to the use of this technology in a design setting are the degrees to which it is able to assist its user in doing three things: generating, recording, and evaluating refinements as part of the propose/dispose cycle.

5.1 GENERATING GEODESIGN PROPOSALS

In terms of generating new proposals, there are two conspicuous ways in which GIS might be better able to play a more constructive role in support of geodesign.

The first is not especially exotic but is nonetheless likely to have real and immediate impact. It is simply to help in cataloguing examples of previous solutions. In a world where web searching, knowledge tagging, geopositioning, aerial imaging, social networking, and mobile computing have almost instantly become routine, our ability to record geodesign precedents is already well established. What remains for GIS is to deliver those precedents to the geodesigner not just in terms of pretty pictures but, rather, in terms of things like dimensional standards, spatial templates, legal citations, price lists, and environmental impact assessments that are keyed to particular components of the design project at hand.

The second is much more exotic but also much narrower in likely impact: to improve on formal techniques for geospatial optimization. As indicated earlier, this is already an active and productive field but one whose more direct impact on geodesign may call for greater interaction between spatial allocation heuristics and the designer's intuition. In Figures 3 and 4 is an example. Given the "landscape" of site conditions depicted in Figure 3, suppose your task is to connect the upper right and lower left corners of this landscape with a path that minimizes the total amount of darkness along the way. If you will spend a few moments attempting to do so, you will soon come to appreciate the path shown in white. This path solves the same problem but does so for the other two corners. It was "designed" by way of a standard technique for generating minimum-cost routes.

To the geodesigner, however, it may not always be sufficient to simply accept such an optimal solution. Indeed, it may be much more helpful to show how that solution compares to sub-optimal alterna-

tives. Just as a negotiator might search for "wiggle room", the geodesigner might well want to know how – and where – an optimal path might be jostled just a bit in order to accommodate additional siting factors without unduly increasing its overall cost. Figure 4 responds to that concern by placing the minimum-cost path, as still shown in white, within a context of more and more costly alternatives that are represented by increasingly-lighter shades of red and then grey. The technique used to generate this output is no more recent or complex than that which was used to generate the optimal path, and yet this output may well be of much greater use to the geodesigner.

5.2 RECORDING GEODESIGN PROPOSALS

In terms of recording new proposals, it can be said that trying to sketch with a GIS is no more difficult and no less effective than trying to console a crying baby … by issuing instructions to its baby sitter … over a phone line … via text messages … while driving … a backhoe … in heavy traffic. It is clear that GIS could benefit enormously from the kind of intuitive input gestures that the SketchUp application has introduced to the world of architectural modeling. In contrast to those of SketchUp, however, each gesture here should be guided not so much by what has already been drawn as by the landscape beneath that drawing. One should be able to reposition, reorient, resize, and reshape in ways that immediately and automatically interact with geographic conditions. A point drawn on a topographic surface, for example, should be able to initiate a downstream path, to follow a contour, to grow its upstream watershed, or to delineate its viewshed. And ideally, each of these should be immediately updated as that point is repositioned.

In order to be effective in the particular context of geodesign, it is also (and perhaps even more) important that the GIS user be able to record proposals at varying degrees of both spatial and thematic precision. Spatially, this would suggest that proposals be cast not in terms of crisply-bounded features (or at least not necessarily so) but as continuous fields of presence/absence on which transitions may be either gradual or abrupt. Thematically, it would suggest that proposals be cast not in terms of crisply-articulated conditions (or at least not necessarily so) but as qualities defined at higher levels of abstraction. Consider, for example, a back-of-the-envelope scribble. The degree to which this is to be taken as literal or figurative is entirely a matter of its scribbler's intent. And very importantly, that intent must be allowed to change again and again as certain portions of the scribble are anchored while others are permitted (and indeed encouraged) to float in a sea of additional opportunities and constraints. In short, what is needed is something akin to the blob diagrams that have long been employed in traditional landscape design. Note how the map layer shown in Figure 5, for example, depicts three different

Figure 5: Blob Diagrams

spatial phenomena: the specific location of an uppercase "G", the more general location of an "I-like" form, and the vague notion of some sort of squiggle.

5.3 EVALUATING GEODESIGN PROPOSALS

Arguably, the greatest opportunities to empower geodesign through GIS lie not in the generation or the recording of design proposals but, rather, in their evaluation: the ability to dispose of such proposals in a manner that leads to their subsequent evolution.

Perhaps the most straightforward way in which GIS can assist here is to enable geodesign proposals to be taken, quite literally, into the field. While we have done well over the past several decades in bringing more reality into the lab, we have only recently begun to establish the technology necessary to move in the other direction and effectively take more of our virtual worlds back into the real one. As we consider how best to deliver pertinent information to that geodesigner who is currently standing in a very-real world of sights and sounds, temperature and humidity, sunlight, winds, risks, recollections, and so on, it is clear that GIS has much to offer in effectively organizing and presenting stored information.

The second most straightforward way in which GIS can assist in the evaluation of geodesign proposals may be to make them more readily available to the public. The same digital media that hold such promise for placing precedents within reach of the geodesigner have also spawned interests and expectations in online rating mechanisms that portend a fundamental shift in the geodesigner's role. At the risk of endorsing "design by committee" in any traditional sense, suffice it to say this. While individuals are still just as likely to be better at proposing, disposing will still almost always be better handled by committee – particularly when something like GIS is available to present options, compile reactions, and return results to the public in meaningful terms.

Closely related to this is the prospect of making design-evaluation models available and easy to invoke. Recent developments geographic data access, model sharing, and web-service computing make it easy to envision a time when off-the-shelf capabilities will make it possible to routinely upload ones data and plans in order to assess anticipated impacts. Even more encouraging along these lines are developments in what has come to be referred to as "parametric design." The fundamental notion here is that the component elements of a design proposal can be made sufficiently sensitive to their proposed environments (and each other) that they can self-adjust in order to achieve a better fit. Not only can that proposed pine say "Ouch!" but it can also walk away if necessary or even metamorphose into a hemlock. Though good geospatial examples of this are not yet common beyond the worlds of infrastructural networks, an ability to combine the geometric capabilities of GIS with the bookkeeping magic of relational database management systems holds enormous promise for the construction of such "smart" digital landscapes.

Much of this promise relates to the possibility of endowing digital trees, lakes, roads, buildings, and other elements of intelligent maps with sophisticated behaviors. Given such a set of elements, the geodesigner need not be a forester, hydrologist, transportation engineer, or an expert

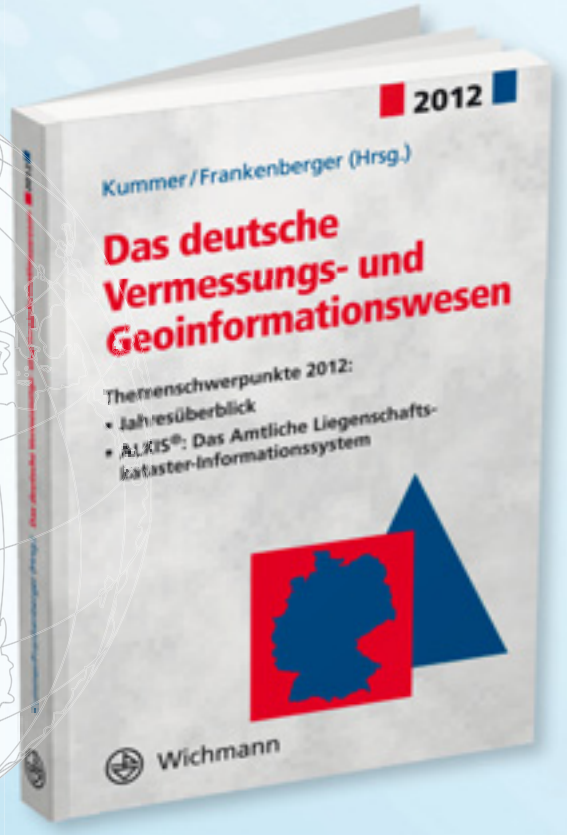
specializing in any one of their particular behaviors in order to effectively work with those elements in a game-like design environment. In fact, it may well be the game-like nature of that environment that is ultimately more important than the sophistication of those behaviors. By enabling that geodesigning gamer to tap into human powers of perception and choreography that are more visceral than cerebral, it is often possible to detect patterns, to capture opportunities, and to "cultivate serendipity" in ways that would otherwise never happen.

With or without the benefit of a game-like environment, another way in which GIS could certainly improve on its use as a design tool is simply to present its evaluations in more evocative form. How about levels of sound that rise or fall in pitch and/or volume as evaluations change? A mild electric shock might even be used to convey the implications of an ill-advised decision (a technique that actually works quite well with my dog).

The most productive critic is always one whose criticism, regardless of its content, is delivered in a format that lends itself to immediate ideation. In evaluating geographic decisions, however, this is often made difficult by the fact that causes and their effects may well occur at different locations. While it is one thing to note, for example, that a limited number of allowable units per district has just been exceeded by the last one proposed, it is quite another to determine just where that problem should be noted in order to be corrected. This is also true of visual impacts, which may well be felt in the eyes of the beholder but are often more helpfully cited at the location of whatever it is hat has been beheld. And note how solutions to hydrological problems almost always seem to lie upstream? In short, the ease with which one can damn the darkness may often belie the difficulty of turning on a light, particularly when the light switch is located elsewhere.

Less difficult but perhaps just as important is the prospect of developing evaluation models at different levels of abstraction. Half-baked ideas should be taste-tested as such, with more general criteria and greater tolerance in earlier iterations of the propose/dispose cycle. What might initially be evaluated as "open space", for example, might later be assessed "outdoor recreation" and only after that identified and judged as "a nine-hole golf course".

This idea of employing different models of evaluation at different points in the design process is also central to one final recommendation. In recognition of the fact that what most distinguishes geodesign from other forms of geographic decision making is the role of emergent criteria, what would happen if evaluation models themselves could be selected, weighted, adapted, and even reinvented as a consequence of their own earlier findings? In other words, what if the propose/dispose cycle could be cast as one in which predictions learn from prescriptions as much as the other way around? It is an engaging question and one that could prove to be fundamental to the broader issue at hand. It is also a question that will never be answered or even well posed, however, without an appreciation and an aptitude for design.



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