A Proposed Map of a Geodesign Research Agenda: Eleven Key Questions in an Eight-pole Space

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Abstract

The development of a robust and credible geodesign discipline will depend equally upon an ever-growing inventory of excellent real-world examples of projects embodying geodesign principles, and upon the development and pursuit of a rich and rigorous research agenda that informs geodesign theory and practice. To this end, following a consideration of several precedents from the GIS literature, a research space with eight poles is proposed. Mapping twenty or so not-quite-randomly collected examples of proposed research questions into this space yields a promising framework for an emergent research agenda, summarized by eleven key geodesign research questions.

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1 Introduction

The geodesign enterprise has gone in six short years from speculation and a small specialist meeting to annual meetings with hundreds of participants, a handful of graduate and undergraduate academic programs, journal special issues, and several notable books (MCELVANEY 2010, STEINITZ 2012, LEE 2014). Early discussions were driven by a deceptively simple question, to wit: "What is the relationship between GIS and design?" and early discussions focused on scope, definition, and intent – ranging across concerns and perspectives from cognitive psychology and computer science, to geography, landscape design, and project management. More recent publications have presented case studies, prescriptions on method, experiments with methods, and suggestions for technical system design, and have raised ethical and critical concerns (WILSON 2014). Some skeptics have questioned whether 'geodesign' is only a new term for pre-existing practices and ideas, a crassly commercial marketing 'buzz-word', or simply a passing fad.

My own definition argues that geodesign is a distinct, recognizable, and relatively new phenomenon, heavily dependent on digital technologies for measurement, representation, simulation, and communication, and characterized by distinct modes of cognition, including 'design conception' and 'systems thinking' (ERVIN 2012). The very structure of the neolo-

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gism suggests a hybridization or marriage of 'geo' (science/logic/left brain) and 'design' (art/intuition/right brain), and so entails substantial boundary-crossing and combinatorial complexity. Science has many sub-disciplines – even when limited to those inside of the 'geo' cluster, such as geography, geology, geometry, hydrology, ecology, sociology, etc. – and especially when including relevant engineering disciplines such as civil, transportation, energy and waste engineering, and others that feature prominently in case studies of geodesign. Design, similarly, has many schools and definitions, specialties, techniques, and applications ranging across a spectrum from aesthetic and formal to behavioral and functional. Distinct from science and scientific thinking in many ways, design and design thinking celebrates ambiguity and 'out-of-box' thinking, and invites self-reflective questions like "Who is the audience?" and "Is this the right question?"

Of course these diametric oppositions sometimes reflect a false duality: Scientific success may depend upon intuition; design processes may depend upon logic. Only at their extremes are these distinctions more than superficial, but the tensions between 'scientific' and 'designer-ly' worldviews, habits of mind, vocabularies, methods, and outcomes are very real. It is perhaps this is very tension – and the creative power of hybridization – that gives the geodesign project its power and appeal! It also necessarily raises the question: "What kinds of research are indicated by, and essential to the success of, the emergent discipline of geodesign?"

In science, research is well understood as a component of and foundation for the work; with design this is less well established. Scientific research seeks to establish universal principles and share-able processes; whereas design research, resistant the very idea of universal truths, and embracing individual processes, seeks only to inform individual design decisions, or perhaps families of such decisions (LAUREL, 2003). The situation today is not much changed from 20 years ago when FRAILING (1994) wrote "Where ... designers are concerned, the word 'research'– the 'r' word – sometimes seems to describe an activity which is a long way away from their ... practice." He went on to argue for a fundamental role for "design research", and characterized three major modes: research *for*, *into*, and *with* design. This seems to be a useful rubric for considering geodesign research as well.

To map out an outline agenda for research into geodesign requires asking questions about what is already known, in what categories, what is unknown, what might be learnable, and how, etc. Answers to these questions, even tentative, will help to identify possible areas for research, fruitful collaborations, avenues of inquiry, etc. A geodesign research agenda or map may look not unlike other related research agendas, but it will also surely have some unique characteristics and content.

One place to begin is by gathering examples of geodesign practice; another is to look into research agendas in other related disciplines and undertakings; yet another is to ask practitioners, theoreticians, and scholars for their best advice, guess, or candidate research questions. All three approaches have informed this proposal.

Looking at examples self proclaimed Geo design projects, primarily through a five years of annual geo design summit meetings at ESRI from 2010 to 2050, we see a wide range of planning and design concerns. It's clear that in order to organize the knowledge and questions that will inform a research agenda, some suitable abstract and simplified organizing principle and broad categories are required. Since geodesign builds so substantially on the foundation of GIS, it seems reasonable to look at some precedents from that recent history

of research and development to guide this search. Some candidate organizing frameworks from the recent history of GIS research are explored below.

2 Some Precedents

The "Geographic Information Science and Technology" (GIS&T) community has long been driven by a sense of a pressing research agenda (UCGIS 1996) and so may present some fruitful examples. One candidate to look at is the GIS and Technology Body of Knowledge (GIS&T BOK) promulgated by University Consortium for Geographic Information Science (Fig. 1) (UCGIS 2006). This document is intended as a comprehensive resource, structured on 10 distinct knowledge areas with more than 70 units, more than 300 topics, and more than 1000 formal educational objectives. While the list is exhaustive, from basic analytical operations and methods through spatial analytics, regression, econometrics, and data mining, it is probably too large, and overwhelming, based as it is almost entirely on the science component of GIS. Indeed the 'design aspects' section has only to do with the design of databases and analytical models; with no consideration of the synthetic, interpretive, landscape, urban, and infrastructure design that geodesign must address.

A simpler foundation document may be better suited. For example, the NCGIA's original triangle that identified the three fundamental considerations for the development of Geo-Infortmation Science, as: "The Human", "The Computer", and "Society" (Fig. 2) (GOODCHILD 2010). While far fewer categories, these may be too few – and too broad – and there is little in this construction that hints at the special geo-spatial nature of the enterprise. It could just as well be a framework for Apple Computer Company! And in this formulation, too, there is no recognition of 'design'. So this, also, may not be applicable to our quest for a geodesign research framework.

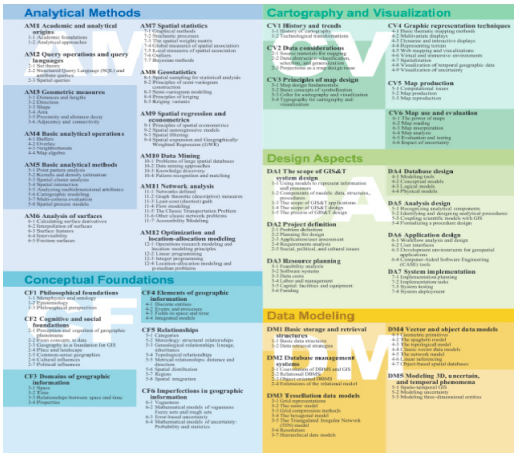

Fig. 1: GIS&T BoK

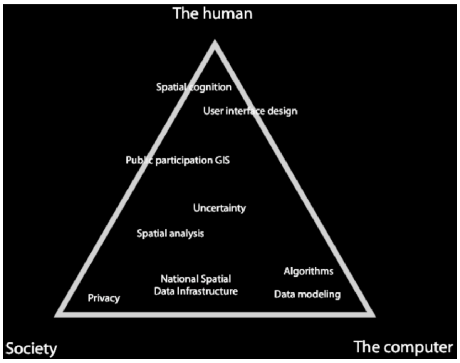

Fig. 2: NCGIA Triangle

Turning to a more recent, geodesign-specific example, in 2011 I argued for a 15-part 'toolbox' of essential operations, that would be required in a computational system to support geodesign (Fig. 3) (ERVIN 2011). These fifteen, ranging from the basic elements of object-oriented design, at one level higher than simply points, lines and polygons – that is, trees, forests, roads, buildings, lakes and dams, etc., complete with descriptive attributes – and tools for arranging them, to tools for managing collaboration and version control, as well as for using algorithms and simulations, cross a broad range of disciplinary boundaries, from cognitive psychology and computer science to geology and dynamic systems. Since this system was defined specifically for the purpose, it necessarily addresses the broad range of knowledge and disciplines required by geodesign, and so could well provide a basis for identifying research topics and questions. Each of the 'boxes' in the toolbox diagram could support a research agenda of its own. This is an attractive option – but perhaps fifteen is still too many basic concepts to support a robust general research agenda.

In 2012, Bill Miller proposed a 9-point list of considerations as a foundation for geodesign (Fig. 4) (MILLER 2012). These nine, ranging from 'operational frameworks' and 'data models', collaboration and interoperability tools, intersect in many ways with the fifteen above, suggesting at least some emergent level of consensus on the definition of scope and intent of the geodesign project. Miller's list could serve as a framework for the development of a suite of research activities, but is in some ways perhaps too 'instrumental', directed at tool-builders and software development, and not quite broad or general enough.

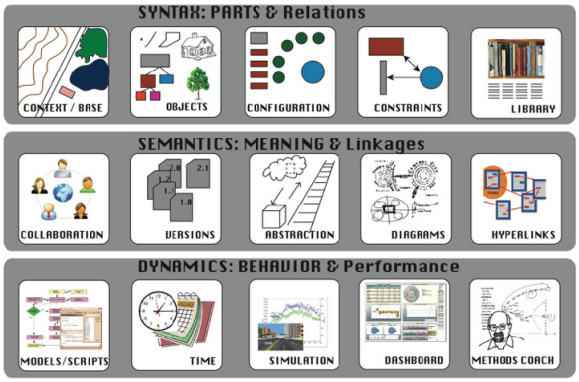

Fig. 3: Ervin's Fifteen-part Toolbox System

Fig. 4: Miller's Nine Points

Continuing to search for broader construction of key concepts and a reduced number of points, Steinitz's six-part framework presents itself as a logical candidate (STEINITZ 2012). The six elements of this framework (Fig. 5), from 'representation, process, and evaluation' models, through 'change, impact, and decision' models provide a robust and well documented framework for design enterprises, and has been widely used for a range of landscape planning, design, and 'alternative futures' studies. These six boxes, too, could easily each hold a distinct research agenda. The framework is explicit about both the science components – in 'representation' and 'process' models – and about design, in the form of 'change' models. Yet it is also, perhaps, too generic, and could as easily be applied to design of pharmaceuticals or bicycles, as to the domain of geodesign.

Steinitz's most recent publication, *'A Framework for Geodesign'*, is founded upon, and sports on its cover (STEINITZ 2012), a simple 4-part Venn diagram, (Fig. 6) asserting that geodesign is to be found at the intersection of four key components, or actors: Geographic Sciences, Information Technologies, Design Professions, and 'The People of the Place' (or, more abstractly: GIScience, design, information/technology, and sociology/psychology/politics.) This construction is explicit about the 'geo-' and 'place-based' nature of geodesign, and about design, as an essential discipline, and about humans and human interactions. With only one more component than the NCGIA triangular framework, it provides a much more specific and distinct set of areas of activity – and so, of research as well.

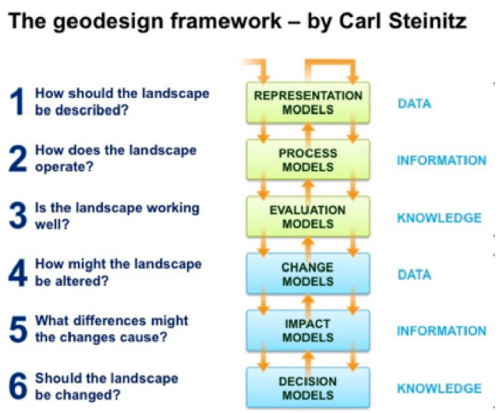

Fig. 5: Steinitz's Six-part Framework

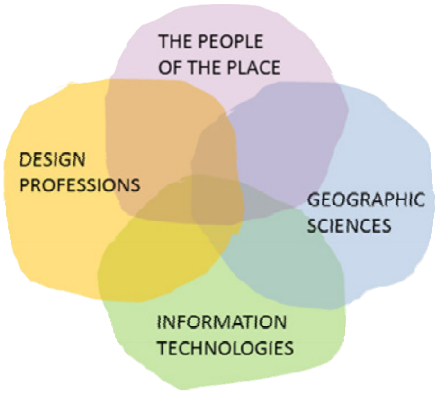

Fig. 6: Steinitz's 4-part Venn Diagram

3 A Proposed Map of Geodesign Research Space

3.1 A Proposed 4-axis, 8-pole Research Space

Steinitz's diagram identifies four major components, representing major constituents or knowledge areas for a definition of, and a prescription for the practice of, geodesign. Unlabeled, but implied in the original diagram are four intermediate components, at the pairwise intersections lying between each of the four: at the intersections of 'Design/People'; 'People/GeoSciences'; 'GeoSciences/IT'; and 'IT/Design'. These hybrid/intersection poles, more specific than their more-general parents, are further energized by their two intersecting terms, and so can serve as more specific structuring concepts that together give body and definition to geodesign. Re-labeled, in more descriptive terms, (and with a four-or-five letter abbreviation, e.g. 'CGIS', used below) they may be considered as:

Design/People = '*Participation/Collaboration*' ['P/COLL']
People/GeoSciences = '*Critical GIS*' ['CGIS']
GeoSciences/IT = '*Geographic Information Systems/Technologies*' ['GIST']
IT/Design = '*Computer Aided Design /Artificial Intelligence*' ['CAD/AI']
These four more-defined poles, together with their original parents, suggest an eight-poled space that may fruitfully structure a geodesign research agenda (Fig. 7):

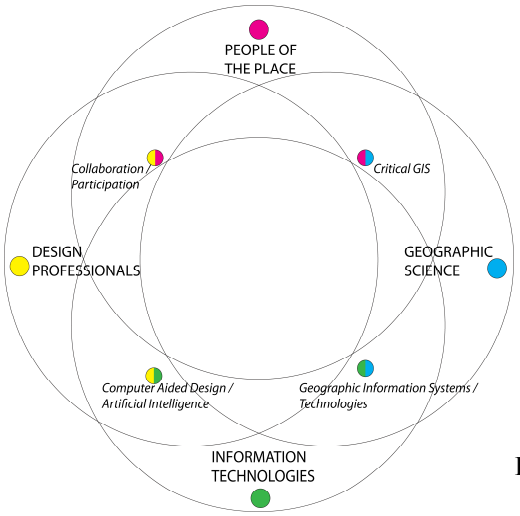

Fig. 7: Eight-Poled Geodesign Research Space

3.2 Mapping 12 Research Questions from Survey

As an exploratory test of the viability of the eight-poled map, in late fall of 2014 I approached a dozen or more colleagues who have been engaged in the geodesign enterprise in various ways, and asked each to suggest one or more possible research questions that they thought should be included in any geodesign research agenda. In all I received over 20 such questions. In all but three cases I was able to make a satisfactory mapping to the space using the 4 intermediate poles as labels. In those three cases, 'Tomlin', 'Shearer', and 'Foster', I was unable to satisfactorily locate the question in the space, and concluded that an additional central pole was required, which I have labelled 'Existential', ['EXIST'] as these are all questions that go the heart of the definition and scope – and even question the very existence – of something called 'geodesign'.

Listed below are 12+ distilled from the original 20 (and including a favorite one of my own) identified by their originator. I have added, in square brackets, my proposed identification of the nearest pole for that question, e.g. [EXIST].

A dozen (plus) not-quite-randomly suggested Geodesign Research questions:

What are some examples of projects – real or imagined – that clearly and convincingly serve to define what Geodesign is and, importantly, what it isn't? [EXIST] – Dana Tomlin

What are the relationships between "problem type/size/scale" and effective "ways of designing"? [CAD/AI] *How complex do models need to be in order to properly inform and influence geodesign decisions?* [CAD/AI] – Carl Steinitz

How can/should 2D planning tools and 3D simulation tools interact? [CAD/AI] *What are desirable attributes of 'geodesign dashboards'?* [GIST] *What tools/techniques are required for productive multi-party web-enabled collaboration in geodesign?* [PCOL] – Eric Wittner & Bill Miller

Which social and technical methods need to be developed to support routine geodesign use and updating of "best available science"? [PCOL] – Mike Flaxman

What does the doing of 'critical geodesign' mean? [CGIS] – Matt Wilson

To what extent should (or would) geodesign approaches and practices benefit from (as well as shape) innovative smart environments in order to improve or facilitate citizen engagement? [PCOL] – Stephane Roche

How is geodesign different from "traditional design" methods? [EXIST] *Does the notion of "primary generator" have relevance to (or meaning in the context of) geodesign?* [CAD/AI] *What would be the best use(s) of AI in geodesign?* [CAD/AI] – Allan Shearer

What system architecture(s) can form the basis of an end-to-end and top-to-bottom geodesign environment to address complex sustainable systems (decision) interventions that are theoretically sound and practically useful? [GIST] – Timothy Nyerges

How can GIS technology be extended to include/cover all of the elements of a geodesign ontology (including e.g. dynamics, interactions, affordances, and especially "purpose" – answers to "why?" questions)? [GIST] – Mike Goodchild

What role might geodesign play in addressing the "grand challenges" of our time and how might these tools and methods be more widely used in order to deal with those challenges? [CGIS] – Tom Fisher

What distinguishes geodesign from similar processes? [EXIST] – Kelleann Foster

What are the roles of diagrams in geodesign and how might they be digitally represented and computed with? [CADAI] – Stephen Ervin

For each of these above questions I have attempted to locate it on the map (Fig. 8) aligned with its nearest pole. Among the others, some are more centered-on, and some more adjacent-to their corresponding label. Their exact placement within the inner circle of the map is approximate, and governed by some simple rules of cartographic generalization, including legibility through non-overlapping labels.

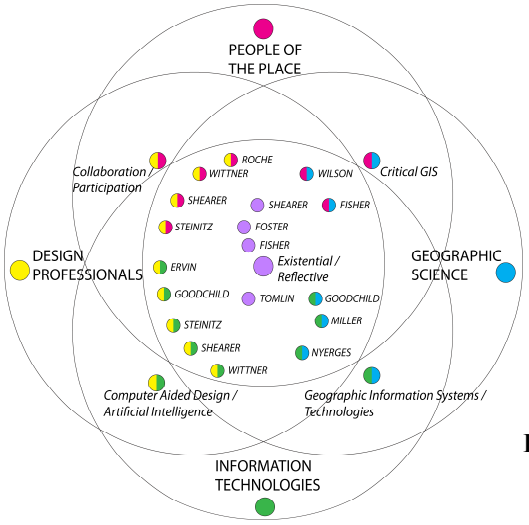

Fig. 8: Twelve (plus) questions located in eight-pole geodesign research space

4 Conclusions and Discussion

Although the sample size is small, the results of the mapping exercise do at least suggest the viability of the proposed eight-pole space, and the descriptive value of the four intermediate poles, as well as invite some generalized observations on the pattern. First, there seem to be a majority of them clustered on the 'left side', along the Design axis, between Collaboration/Participation and Computer-Aided Design/AI. This may be bias introduced by my selection of respondents, but I believe it to be something more: an indication of the simple fact that the 'design' component of geodesign is the new and complicating factor in a rich field of GIS knowledge and research. Design research, as indicated at the outset, is problematic at best.

Second, there is an obvious scarcity of questions on the 'Critical GIS' pole. Again, aside from whatever bias introduced by my selections, I suspect that has to do with the fact the questions are difficult, and the research area not well-defined. I take this as an encouragement to the community to dig more deeply into this area, in hopes of adding some depth and breadth to such research.

A final point: there are two additional intermediate poles, beyond the four presented, that come from the combinatorial intersections of the original 4 poles: from the intersection of the 'opposite' poles, in addition to the 'adjacent'. That is, the intersection of 'People of the Place' with 'Information Technologies' – we might call this 'Social Networks / Crowdsourcing' [SNCS]; and the intersection of 'Design Professionals' with 'Geographic Science' – we might call this 'Geodesign'! [GEOD]. As this realization followed the survey and classification process described above, and since the graphic formalism adopted of intersecting circles is not easily extended to include these two additional poles (they mess up the adjacency property of the diagram!) I have not gone back to refine the classifications by including these two poles, but it is likely that they should play a role in an emergent geodesign research agenda, and in any comprehensive map thereof. They are included in the next section, with suggested key questions.

4.1 Eleven Foundational Geodesign Research Questions

Pursuing the implications of the eight-pole space, adding two poles as just suggested, and including the special 'Existential' pole identified above, gives us eleven poles, which can be the central Categories, or Themes for organizing a geodesign research agenda. Generalizing from the examples given above, I propose a high-level 'key question' for each of the eleven, as follows:

Key Geodesign Questions in 11 categories:

Design: *"Where do design ideas come from, and how?"*
Geographic Science: *"What do we know about the earth and natural processes, and human settlements and processes, and how can they be described ?"*
Information Technologies: *"What can (and cannot) be computed, how and why?"*
People of the Place: *"How do people perceive & value environments, both real and represented?"*
'Participatory/Collaborative Design': *"How can participatory/collaborative design best work?"*
'Critical GIS': *"What are the _real_ meanings of a map/diagram/proposed plan?"*

'Geographic Information Systems / Technologies': "*What about the earth, natural processes, human settlements, and space/place can be computed, and how?"*
'Computer Aided Design / Artificial Intelligence': *"What do we know about design thinking and processes, and how can they can be aided or automated by computation ?"*
'Social Networks': *"How do computation & telecommunications shape human society?"*
'Geodesign': *"What does GIS/T have to do with design, and vice versa?"*
'Existential': "How is geodesign like and unlike any other human or computational activity?"

Each one of these questions can of course spawn further sub-questions and side -questions; each of which can itself be a rich treasure trove or a comparatively dead-end; this is the nature of the research enterprise. The twelve or so submitted research questions itemized above are examples of this – each is a somewhat specialized variant or logical consequence of one of these key questions. Building on foundational questions, such as these, and delving into emergent and associated new questions over time, promises to keep the geodesign research enterprise alive into the indefinite future. Advances in technology writ-large, in GI science in particular, in our understanding of planetary and atmospheric chemistry, as well as human perception and cognition, and into the Grand Challenges of our time as well as fascinating byways of collaborative design technologies, all will fuel the development both of new research questions and topics, and of the practice of geodesign itself.

The idea that research can be *for, into* or *with* geodesign, mentioned earlier, can help to further delineate the emergent geodesign research agenda.

Research *for* geodesign projects is nearly unlimited, as it can be in any of the supporting sciences, or disciplines, or methods required by a particular project. Research *into* geodesign is the broadest likely category, especially in a relatively young body of practice and literature, as this can range from highly abstract definitional/existential questions (such as "What exactly is unique about geodesign?" – which may be approached from either a theoretical or empirical approach) to the descriptive (e. g. "What is the most common make-up of effective geodesign teams?") and the prescriptive (e. g. "What six questions must be asked in any geodesign project?"). As the body of geodesign work and practice grows, so does the universe of possible research questions.

Research *with* geodesign is perhaps the most interesting, and certainly the most potentially troubling, form of research. If we take geodesign to include mostly projects which affect peoples lives, usually though transformation of some geographic attributes or elements, then there are clearly ethical concerns about 'experimenting' on people's lives and landscapes. It is also true that not all experiments are malign, though, so the potential for 'experimental crop plots' at the geodesign scale is intriguing. One might also argue that much of design is essentially experimental, often 'trying something new'. We like to think that we know enough to simulate design impacts well enough to eliminate disastrous ones – a central tenet of geodesign practice – but human history proves that wrong. This is truly a designer's dilemma – when is innovation safe and justified? "When can or should geodesign activities be an essential part of a research enterprise?" is perhaps the most vexing question of all in this undertaking – a question that is not easily answer-able, but one which clearly only time & real-world experience can settle. Using research *with* geodesign to

inform research *into* geodesign, and to reveal promising areas of research *for* geodesign, would be a logical pinnacle of a geodesign research agenda.

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