CREATING DEEP MAPS AND SPATIAL NARRATIVES THROUGH DESIGN

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Abstract *An interdisciplinary team of researchers were challenged to create a model of a deep map during a three-day charette at the NEH Institute on Spatial Narratives and Deep Maps. Through a reflexive process of ingesting data, probing for fruitful research questions, and considering how a deep map might be used by different audiences, we created a wireframe model of a deep map and explored how it related to spatial narratives. We explored the tension between interfaces for exploratory and structured views of data and sources, and devised a model for the intersections between spatial narratives and deep maps. The process of creating wireframes and prototype screens—and more importantly, the discussions and debates they initiated—helped us understand the complex requirements for deep maps and showed how a deep map can support a humanistic interpretation of the role of space in historical processes.*

INTRODUCTION

This article discusses the processes and discussion undertaken over a three-day charette during the NEH Institute on Spatial Narratives and Deep Maps. The challenge was to construct a deep map and to explore how digital tools and interfaces can support ambiguous, subjective, uncertain, imprecise, rich, experiential content alongside the highly structured data at which GIS systems excel. Through a reflexive process of ingesting data, probing for fruitful research questions, and considering how a deep map might be used by different audiences

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we hoped to discover what a deep map actually is and how it might relate to a spatial narrative. We used this environment to explore the contested meanings of 'neighbourhood' as it was used by religious communities in one tightly bounded late-20th century locality. In doing so, we explored the tension between interfaces for rich and structured views of data and sources, and the desire for narrative structure within a deep map. Our interdisciplinary and international team of four was made up of the authors—a cultural heritage technologist, an urban geographer, and a historian—and an additional member, historian Daniel Alves, with a range of visions for deep mapping.

APPROACHING DEFINITIONS

The title of the sponsored conference that brought us together, *Spatial Narratives and Deep Maps*, holds productive tension. This tension reflects the strain contained within many projects in the digital and spatial humanities that make material available to the public in new ways. Many projects, such as *The Valley of the Shadow*[1] or *ViHistory*,[2] seek to make widely accessible large corpora, including evidence of all kinds focused on a particular topic. They create an exploratory environment where scholars and members of the public might pursue their own questions, discover little-used documents by searching and sorting the evidence in novel ways, and even find room for interplay between their own ideas and the archival materials made accessible on the screen. At the same time, editors and curators of digital archives tag and frame their evidence in specific ways, juxtaposing particular pieces of archival material, and in so doing they create archival collections that are able to tell a story, intervene in critical literature, and contribute to particular scholarly conversations. The editorial and curatorial work of building an online archive constitutes intellectual labour in itself. Deep maps, as projects shaped by a particular scholarly vision but offering an open-ended, exploratory environment, contain the same tensions as many other projects in the digital humanities.

Deep maps must afford open-ended exploration of a particular place. This exploration could be facilitated by a system such as a desktop GIS, but we suggest that something more robust and flexible is necessary. The curator of a deep map might assign various attributes to pieces of data by identifying features—churches, businesses, or residences—counting them, and assigning them their respective places on a map. Yet counting the numbers of businesses, residences, or churches gives only a few hints about the everyday practices, beliefs, and fears of the people moving through a pristinely mapped landscape. In order to support humanistic interpretation, these deep maps must be more fully situated archives in which one might find myriad traces of evidence about a site, and from these begin to build stories and arguments. A deep map supportive of humanistic interpretation would capture more than the 'relic set,' as Michel de

Certeau put it, of pedestrians' 'intertwined paths' and trajectories. Such a map would represent the pathways that weave places together, creating urban life by their interplay and motion.[3]

The affordances of this kind of deep map places emphasis on one particular user interaction: exploration. Scholars or members of the public who approach such a map are given infinite possible paths through the map and the possibility of exploring innumerable questions. The potential for this sort of interaction is limited only by the survival of historical data, the mapmaker's ability to represent ambiguous, multivalent evidence, and the end user's analytical sophistication, creativity, and imagination in approaching such a rich and capacious map.

A spatial narrative is designed to tell a story. If a deep map requires a commitment to open-ended exploration, a spatial narrative demands a specified point of departure, a particular pathway, and a known end point. Spatial narratives demand a plot. Like deep maps, they reflect the practices that make a place, yet these narratives cannot always remain open-ended. The deep-map-as-archive is devoid of narrative lineaments, the precise ordering and authorial voice that create a narrative. Spatial narratives require these elements.

The spatial narrative may be developed as a route through a deep map. Geographer Stuart Aitken, for example, tells the spatial story of a father's journey through time and space, joys and regrets, an 'emotive mapping' that describes the 'connections of people to other people and to places'. The story emerged as an 'ethnopoem', a co-created story that emerged out of an extended series of conversations and ethnographic interviews with Rex, a divorced father of two sons. The story proceeds chronologically, 'through a series of moves from one house to another', and is in many ways a story about 'movement, relocation, and the search for place'. Aitken's co-created story with Rex is a subtle framing of a father's turn from a desire to control the people around him. We can imagine, though, that this particular spatial story would be only one of many ways to traverse through a deep map that contained it.[4]

During our charette we began thinking about the interaction between these two, very different approaches to space, using the kinds of sources that would allow for rich interpretations of the religious spaces of Indianapolis, Indiana, USA.

OUR PROCESS AND METHODS

Each team had access to census and voting data on contemporary Indianapolis and qualitative data from the city's daily and weekly newspapers. The Indianapolis Congregations Archive (ICA) supplemented these widely available sources. The ICA is a robust dataset, containing hundreds of interviews of religious leaders, a census of religious organisations, surveys of congregants, and photographs, among other materials.

In our first team meeting we discussed the huge amounts of data available, assessed the skills and tools available to us and what we could realistically achieve in three days. We began by exploring the problem space, seeking to understand the sources provided and to determine the richness or paucity of other sources accessible within our timeframe. By the end of our first meeting we decided to focus on depth rather than breadth, focusing on questions around neighbourhoods rather than cities. Our first goal was to pull in as many rich sources as possible about one or two neighbourhoods and related congregations into what we called a 'greedy deep map' to see what issues would emerge when supporting information discovery at different temporal and geographic scales. We hoped to learn what a deep map was (and was not) through the process of devising potential research questions and spatial narratives while constructing a deep map. In short, we were creating through the process of design.

We concentrated on finding and geolocating rich contextual stories and images from historic newspapers and archives (via Google Maps markers) in parallel with importing the institute-provided datasets into ArcGIS. We then evaluated our progress and tried to find stories and interesting questions in the data collected for different neighbourhood. We devised a spatial narrative as a test of the sources we'd gathered and drew low-fidelity wireframes based on the requirements discovered through these processes.[5] The wireframes helped us clarify our design requirements and understand the 'mental models' that different groups of users brought to mapping interfaces, which then informed the process of designing prototype screens.[6] We constructed the prototype screens in Photoshop, using screenshots from Google Maps satellite and street maps, a wireframe stencil set, and snippets of screenshots from document searches, histogram and timeline viewers (Figure 1).[7]

Constructing our deep map interface was an iterative process; collaborating on content imports, storytelling or drawing diagrams required us to debate and clarify terms, which resulted in updated outputs. Much like the rest of the fortnight, this process was also about learning to find common language between our different disciplinary and cultural backgrounds. Some of the design tensions that emerged during the process of defining requirements for deep maps are discussed below, followed by a brief outline of some of the features of the prototypes created.

DEFINING INTERFACE AND USER EXPERIENCE REQUIREMENTS

We discussed the differences between our key potential audiences of historians and geographers, and decided our main potential audience was humanists who follow their curiosity or develop research questions in content-rich interfaces by exploring, bookmarking and annotating resources. The interface should also support some spatial analysis for users who are familiar with GIS techniques.

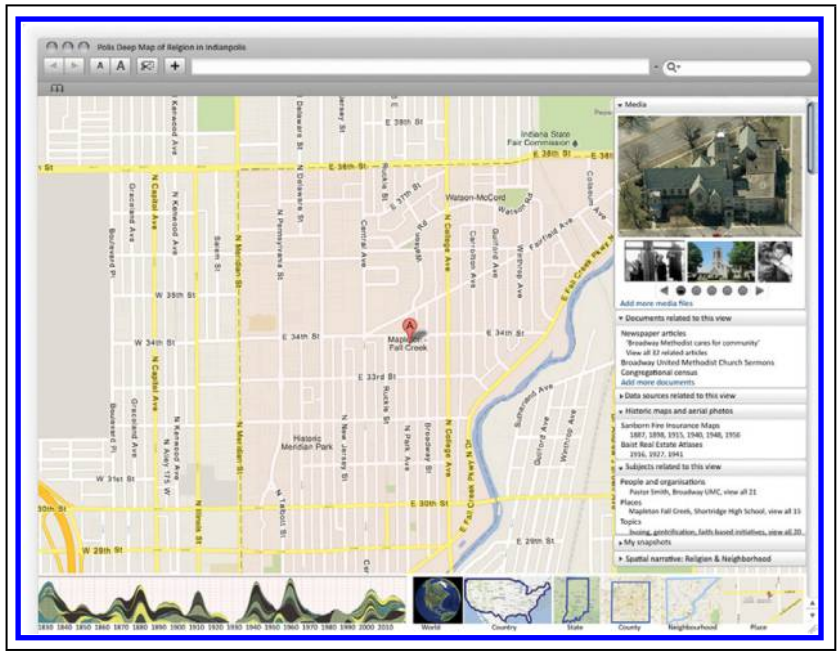

Figure 1. Sample prototype screen zoomed to a neighbourhood view.

We wanted the interface to support 'flow' (a relaxed sense of focus and immersion[8]) within the process of finding and analysing data, but discovered a tension between the requirements of the analytical data view and the desired sense of immersion in a deep map. In general a well-designed interface should 'disappear'[9]—allowing users to immerse themselves in their task—but this was complicated by our very different groups of potential users and their expectations about how one interrogates maps and mapping software. A real deep map environment would need to support both expert and casual users; those who are willing to invest time in learning how to use a tool and those who would quickly give up if it seemed difficult to get started.

Other requirements for humanities mapping emerged, including the ability to manage a wide range of temporal and geographic scales, and data with various degrees of fuzziness; to deal with combinations of bounded areas, lines and points within geocoded datasets; the ability to specify temporal ranges and to convey the context and quality of the primary and secondary sources of historical gazetteers and maps. A deep map for humanists should also be able to deal gracefully with patchy data and with datasets with geographic boundaries that

change over time. How should a deep map account for period photographs that do not include a clear spatial location, or historical sources without clear dates?

We wanted to help humanists intuitively discover the resources available rather than confront them with a blank query page, but we also wanted them to realise that a deep map is not 'just a toy'. These issues were turned into design requirements under one over-arching goal: how do we convey all the rich qualitative and quantitative information about a place contained in a deep map in such a way that users will want to dive in and keep exploring?

A PLATFORM OR AN ARGUMENT? DEEP MAPS AND SPATIAL NARRATIVES

The process of designing a deep map was complicated by the knowledge that all maps embody 'the agency of the mapmaker'- a map generated from multiple sources is therefore riddled with various 'author's prejudices and partialities'.[10] Could a deep map also convey the complex relationships between those who inhabit a space and those who speak for it? And was it possible for a deep map to also reflect the agency of the map user, who participates in the act of map-making through the choices they make when interacting with content and data in a deep map? In common with many digital humanities tool makers, we had to consider whether we were constructing a deep map as a platform for an argument or as a container for the argument.[11] And at what point does a closely curated deep map become a spatial narrative?

The process of ingesting data for a 'greedy deep map' caused us to question whether one needs to pull in all the available information (or as much as one can) before deciding which data and questions are the most interesting, which in turned caused us to question the extent or boundaries of deep map. A deep map 'attempts to record and represent the grain and patina of . . . everything you might ever want to say about a place'[12] but display screens are limited in their size and resolution. Deep maps should be able to model aggregate quantitative data and help reveal spatial patterns, and also represent rich qualitative data while conveying its uniqueness, nuance, ambiguity and contingency. We had to consider the interface and architectural implications of spatial and temporal scale for 'information scent' and resource discovery.[13] How would a deep map support both close and distant 'reading'?[14]

SOME WORK TOWARDS DESIGN SOLUTIONS

Our goal was to create a universe in which a curious historian might work; an immersive experience that supported deep analysis yet would fit on a computer screen. To support these almost contradictory requirements, we designed tool bar widgets (small blocks of related functions or content) for time, location, documents and datasets, maps and aerial photos (Figure 1). Different modes

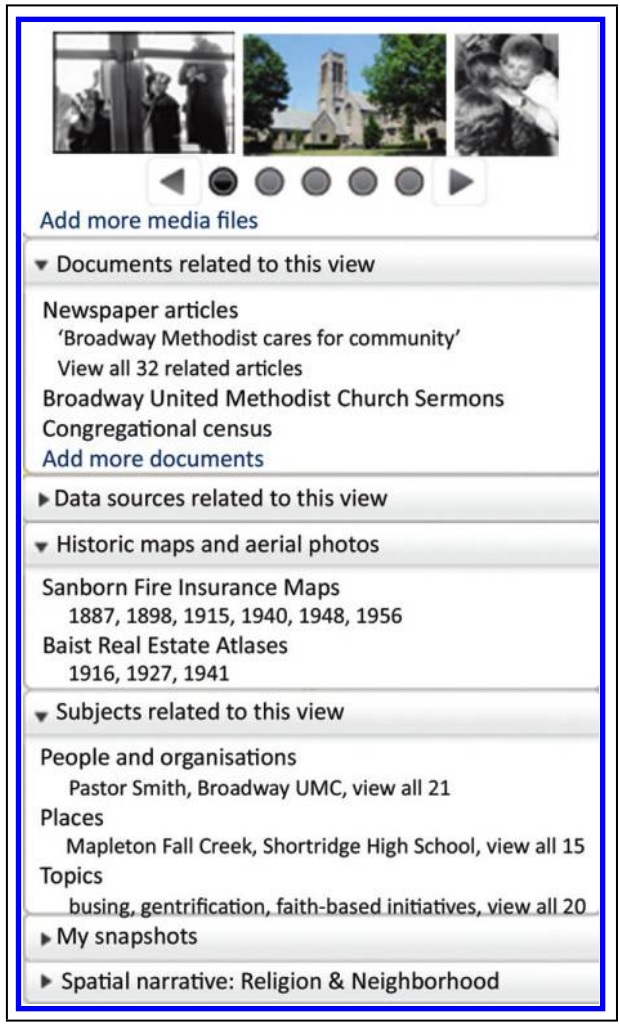

Figure 2. Detail view of our prototype 'content bar' in compact mode.

of interaction are accessed through and indicated by the state of the tool bar. Widgets could be minimised to a slim, unobtrusive toolbar, opened to a compact preview (as in Figure 2) or highlight view, or into a full overlay 'working' mode that could be used to query GIS and other datasets and view or import items. The working view provides access to the source material and supports the usual scholarly processes of comparison, review, annotation of resources, as well as the management of sources such as documents, images, audio, video, datasets,

maps and advanced search functions. This view would support the user viewing the multiple locations, times and entities related to the one resource, and enable the multivocality so vital to deep maps. Widgets would update themselves with content relevant to the time, place and scale as the user moved through the map.

The interface is designed to immediately give the user a sense of the richness and depth of data available. It uses faceted browsing rather than complicated search forms to construct queries and lead audiences to the data.[15] You can also navigate through the content sources and their multiple relations to time, place and other sources. The timeline and place sliders are always present at the bottom of the screen for easy and intuitive navigation. The timeline includes a histogram that shows the density of different types of documents and resources over time to help people get a sense of the scope of the content and to help alleviate the patchiness and messiness of humanities data. The spatial zoom includes 'spatial bookmarks' that not only expose the administrative structures relevant to that location but also help the user jump quickly between scales or locate themselves precisely within space. We included 'snapshots', a function that saves search or view parameters as a shareable link which could be useful for open peer review or simply work as shortcuts to different aspects of a deep map, supporting movement between close and distant readings over space and time and between sources.

For the purposes of the charette we assumed that content and data imported into the map would have good metadata, and ideally, extended descriptions or transcriptions to allow techniques such as entity recognition and topic modelling. This would also enable content discovery through automatically generated places, subjects and events, which could be ordered by density or weighted according to the user's research interests.

The content bar changes to show content relevant to the points in time and space shown on the screen. It is designed to hint at the content and functions available in the deep map while letting the user stay immersed in the spatial experience.

THE EMERGENCE OF A NEW MODEL

The act of labelling one of the interface elements on the second day of the charette triggered the discussion that subsequently crystallised into the two different types of the 'deep map' shown in Figure 3 below. We uncovered ambiguous definitions of a 'deep map' at the intersection between the individual research question and the wider or shared deep mapping environment. We represented our subsequent understanding of the relationship between spatial narratives, deep maps and the available pool of data as a pyramid.

The base layer of our pyramid is the universe of potential data that could be included in a deep map for a particular place. At the time we used the term

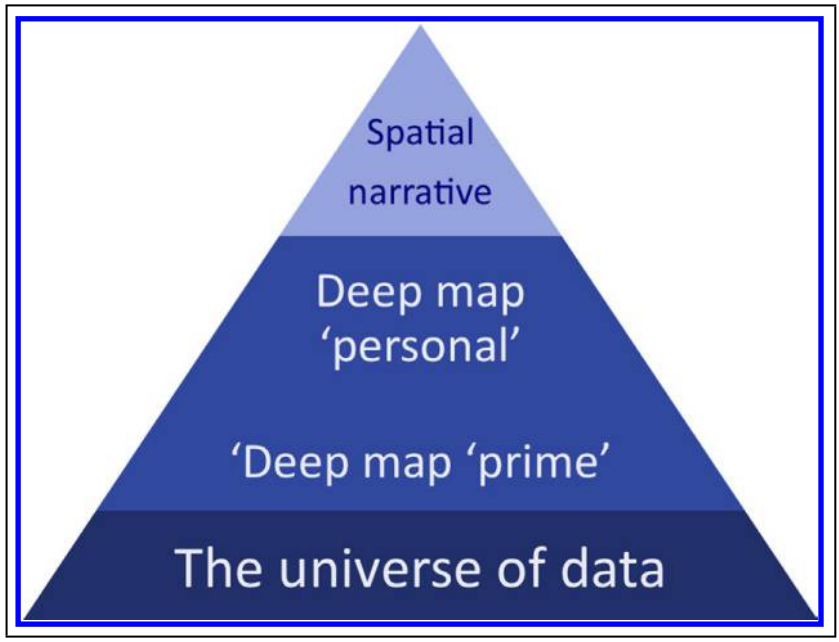

Figure 3. Conceptual model of the relationship between deep maps and spatial narratives.

'chorography' (defined in the antiquarian sense that draws from the classical tradition[16]) but 'greedy deep maps' might equally apply to describe the universe of potential data that could be considered for inclusion in a 'deep map prime'. In a way this is a view that can only exist in the imagination as a precursor to the creation of a real deep map, not least because it also necessarily includes data and content that did not survive, is not easily discoverable or is not available in digital form. Prime deep maps are constructed through a series of choices based around the research interests of a group or series of related investigations, and in turn, 'personal deep maps' are built from the research projects or questions of their creator. Spatial narratives are layered on top of 'personal deep maps'.

A deep map is a space in which a near limitless range and quantity of sources can be included, interrogated, manipulated, archived, analysed, and read. Sources can be pushed from the prime into the personal deep map as specific research questions are explored. Therefore, as one moves up the pyramid, the level of curation of sources increases; as one moves down, the amount of data available increases. The boundaries between each stage are permeable; content and relationships in the personal and prime deep maps are iteratively updated as research questions are refined.

While constructing our prototype we discovered that the line between 'deep maps' and 'spatial narratives' is itself fuzzy, as both are interpretive and use sources selectively. We came up with a 'hop-on, hop-off' tourist bus metaphor to clarify the difference between deep maps and spatial narratives – like a tourist bus, a spatial narrative takes you to pre-selected locations and evidence, while a deep map experience begins when you step off the 'bus' and begin to explore data more deeply. As a tool, deep maps both help construct the argument contained in the spatial narrative and provide a platform for presenting it.

THE VALUE OF THINKING-THROUGH-MAKING AND THE POTENTIAL OF OUR APPROACH

> 'to make is to unpack what exactly you mean and to perform meaning for others. . . . The production of meaning becomes a negotiation with objects, what they restrict and accommodate. . . . To make is to morph, not only stuff but also subjectivities.' Jentery Sayers, 'Making Things in the Digital Humanities'.[17]

Wireframes are a useful tool for clarifying indistinct requirements and for surfacing ambiguities or questions that may not have emerged during discussion.[18] The process of developing the wireframes around a particular case study or research question helped us develop a shared language to articulate questions about the conceptual models and modes of interaction underlying the functionality and user interface elements visible on the prototype screen. As Ellis and Callahan (2012) say, prototypes 'take proposals out of the abstract'.[19]

Prototyping also forced us to tackle interdisciplinary differences. We may be in an era of 'post-disciplinary mapping'[20] but maps are still viewed through a disciplinary lens. Through discussion of the sketches we produced while sharing ideas, we uncovered a serious question: is the meaning of a line or an arrow on a page different for historians and geographers? Do disciplines represent contingency and uncertainty in contradicting ways? The resulting discussion showed the value of walking through the detail of a particular story or research question early in the prototyping process.

Finally, the potential of prototypes derives from their contributions to knowledge and their ability to function both as a process of critical interpretation and an artefact.[21] As 'boundary objects' that enable the understanding and exchange of design ideas by bridging links between specialisms, prototypes are also valuable communication aids among interdisciplinary team members and part of the digital humanities tradition of 'thinking-through-making'[22,23,24].

THE RESULTS AND CHALLENGES OF OUR CHARETTE

As we turn to evaluate our group's efforts one year later, did we accomplish what we had set out to do? It was clear from the outset of not only our group project, but of the Institute as a whole, that coming to a consensus of what a deep map is—what it does, who uses it, and what they take out of it—would be challenging. As we set out to develop a prototype of a deep map we came to agree that the requirement for a deep map to be 'greedy' was central to our approach. It needed to be greedy not only in what we ask of its capabilities as a tool and its insightfulness as an epistemology, but also in the scope of data and sources that can be incorporated into the space of a deep map.

What resulted was our envisaging of a deep map as an archival workspace that would appeal to both a casual user and a specialist. The interface should create a digital environment where a qualitative-minded user felt comfortable but a quantitative one did not feel restricted. A deep map should enable spatial analytics, hermeneutics, and discourse analysis to co-exist in relative harmony.

Given the challenges associated with the charette-style conceptualisation and implementation, the necessity of establishing a common language between disciplines and cultures, and the complex world of big data and interface design, a reflective glance at the interface we created suggests that we were generally successful. However, as we cautioned in the introduction, this is very much a first attempt and our model leaves room for further advancement.

Where we have been particularly successful is in creating a deep map interface that emphasises exploration. Users are able to explore, on their own terms, the type of sources available at any given combination of spatial and temporal extents. That is, as you move through space and time the sources made available to you are those that are applicable to the time and space determined. Although this allows rapid access to 'applicable' sources, if not carefully designed it could exclude potential sources that may provide insight into the research question but happen to fall beyond the bounding boxes set by the researcher.

Our deep-map-as-archive model prioritizes exploration of a nearly limitless array of sources over curation, precise ordering, and the authorial voice that creates a predetermined narrative. Recognising the needs of humanists to create their own narratives, we have built a number of capabilities into the interface that allow for the creation of spatial stories. Through the use of spatial and temporal bookmarking, image and text extraction, dynamic note-taking, and the importation of personal data or sources, a humanities researcher can begin to develop their own spatial narrative for export and further development outside of the deep map.

The model outlined here illustrates the need of a fully functioning deep map to be 'greedy'. However, as discussed above, we took an idealised view

of the availability of machine-readable sources. We recognise that significant issues surround record linkages, place-name recognition by gazetteers, and that digitisation processing errors abound.[25] Non-tabular data such as letters, artwork, and photographs need complete metadata to be created, or must at least be editable by users to meet their unpredictable and varying needs. For example, in a photograph of a local prominent church, do you elect to include every individual who may be walking in the foreground, or the dilapidated home on the photographs edge? They are not the central theme of the sources, but researchers often value tangential or serendipitous elements.

We have left open the question of who imports and spatialises traditionally non-spatial sources. If local or expert knowledge would afford placement at a more precise spatial resolution, do we allow users to shift items in space and time through Wikipedia-style edits? And we have not overcome the perpetual dilemma of a spatially-minded researcher—the modifiable areal unit problem.[26] These issues of source harmonisation, data fuzziness, and open-source capabilities challenge all digital humanities researchers.

Although we had wanted to accommodate the quantitative researcher's need to have the full spatial toolsets that they are familiar with in environments such as GIS, we recognised early that this would serve as a limitation to our prototype. Instead, we established that those demands are best served by the capabilities built by the major GIS software suites and instead we would facilitate a streamlined import/export function between the deep map interface and a desktop GIS.

CONCLUSION

Perhaps surprisingly, after a period of rapid inter-disciplinary collaboration in a somewhat arbitrary situation, and having begun without a shared working definition of deep maps or spatial narratives, we feel our prototypes have some potential.

The charette also afforded us an interdisciplinary 'blank slate' to work through problems and develop solutions to deep map interface design. Creating a particular spatial narrative through the deep map helped us navigate past larger unresolvable definitional and practical issues.

The process of creating wireframes and prototype screens—and more importantly, the discussions and debates they initiated—helped us understand the complexity of the requirements for deep maps, the design tensions they would have to accommodate, and the importance of descriptive language in interdisciplinary platforms. Our prototyping process lead us to devise a conceptual model that helped clarify relationships between spatial narratives and deep maps and encompass the different definitions of deep maps encountered at the Institute.

The prototype screen designs discussed above are visible artefacts of our discussions. As products, they can foment further discussion, but they also merely mark one of many possible moments and paths in the design process. Ultimately, we were able to meet our goals of outlining a shared deep map concept through a tiered system of maps and interfaces. Firstly, we constructed a deep map-as-prime where research questions and interests can be explored in a flexible, interactive, digital platform. Secondly, through the creation of an experimental spatial narrative about the religious communities of one neighbourhood in Indianapolis, we showed how a deep map can support a humanistic interpretation of the role of space in historical processes. Finally, we have suggested a new research framework for all, academics and public alike, to explore the expanding array of digital sources and media in a spatially-rich environment.

END NOTES

[1] The Valley of the Shadow Project is a digital archive of newspapers, letters, census and church records from two American communities during the American Civil War: http://valley.lib.virginia.edu, last accessed 2 June 2013.

[2] ViHistory is a digital repository of a wide range of sources documenting the evolving social and economic history of Vancouver Island, British Columbia: www.vihistory.ca, last accessed 2 June 2013. For a review of how the repository can be used for a myriad of historical inquires see J. Lutz, P. Dunae, J. Gilliland, D. Lafreniere, and M. Harvey, 'Turning Space Inside Out: Spatial History and Race in Victorian Victoria' in J. Bonnell and Marcel Fortin, eds., *Historical GIS Research in Canada* (Calgary: University of Calgary Press, 2013).

[3] J. Corrigan, 'Qualitative GIS and Emergent Semantics' in D. Bodenhamer, J. Corrigan, and T. Harris, eds., *The Spatial Humanities: GIS and the Future of Humanities Scholarship* (Bloomington: Indiana University Press, 2010), 76–88; M. de Certeau, *The Practice of Everyday Life*, trans. S. Rendall (Berkeley: University of California Press, 1984), 97.

[4] S. Aitken, 'Deep emotional mappings and the ethnopoetics of space' in D. Bodenhamer, J. Corrigan, and T. Harris, eds., *Spatial Narratives and Deep Mapping* (forthcoming).

[5] Wireframes define the structure, content and functionality of a web page but do not include any graphic design. For an overview of the benefits and drawbacks of high- and low-fidelity prototypes see M. Hughes, *Wireframes: from Bar Napkins to Prototypes*, http://blog.usabilla.com/wireframes-from-bar-napkins-to-prototypes, last accessed 2 June 2013, and, H. Sharp, Y. Rogers, and J. Preece, *Interaction Design: Beyond Human-Computer Interaction* (Chichester, Wiley, 2007), 535.

[6] Mental models are internal models people form about an object or technology as they interact with it. See D. A. Norman, 'Some Observations on Mental Models,' in *Mental Models*, ed. D. and A. L. Stevens (Hillsdale, NJ: Lawrence Erlbaum Associates, 1983).

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[10] M. Fitzjohn, 'The Use of GIS in Landscape Heritage and Attitudes to Place: Digital Deep Maps' in *Heritage Studies: Methods and Approaches*, ed. M. Sorensen and J. Carman (London: Routledge, 2009).

[11] See for example discussion of frameworks as 'applications that make it possible to create things, as opposed to applications that make it possible to accomplish tasks' in D. McClure, *Neatline and the Framework Challenge*, http://www.scholarslab.org/geospatial-and-temporal/neatline-and-the-framework-challenge, last accessed 2 June 2013.

[12] M. Pearson and M. Shanks, *Theatre/archaeology* (London: Routledge, 2001).

[13] P. Pirolli and S. Card, 'Information foraging,' *Psychological Review* 106, no.4 (1999): 643–75.

[14] F. Moretti, *Graphs, Maps, Trees: Abstract Models for a Literary History* (London: Verso, 2005).

[15] Faceted browsing allows users to navigate a site by applying filters based on the properties of the content. They can construct complex custom queries by selecting attributes that are relevant to their needs. See for example S. Lemieux, Designing for Faceted Search, https://www.uie.com/articles/faceted_search, last accessed 2 June 2013.

[16] See for example S. Mendyk, 'Early British Chorography,' *The Sixteenth Century Journal*, 17, no. 4 (1986): 459–81; or D. Rohl, 'The Chorographic Tradition and Seventeenth- and Eighteenth-Century Scottish Antiquaries,' *Journal of Art Historiography*, 5 (2011).

[17] J. Sayers, *Making Things in the Digital Humanities*, http://projectroomseattle.org/2012/03/making-things, last accessed 2 June 2013.

[18] Sharp, Rogers, and Preece, *Interaction Design: Beyond Human-Computer Interaction*, 531.

[19] S. Ellis and M. Callahan, *The Code4Lib Journal – Prototyping as a Process for Improved User Experience with Library and Archives Websites*, http://journal.code4lib.org/articles/7394, last accessed 2 June 2013.

[20] J. Pickles, *A History of Spaces: Cartographic Reason, Mapping, and the Geo-Coded World* (London: Routledge, 2004), 24.

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[22] H. Rhinow, E. Köppen, and C. Meinel, 'Prototypes as boundary objects in innovation processes,' *Proceedings of the 2012 International Conference on Design Research Society, Bangkok, Thailand* (July 2012).

[23] Sharp, Rogers, and Preece, *Interaction design: beyond human-computer interaction*, 530.

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[26] The modifiable areal unit problem (MAUP) is concerned with the aggregation of non-modifiable entities (e.g. census households) into modifiable areal units (e.g. districts, neighbourhoods, wards etc) or the change of the areal units over time. See S. Openshaw, *The Modifiable Areal Unit Problem* (Norwich: Geo Books, 1984).