Canadian Historical GIS Partnership Development Project *Version: January 17, 2017*

WORKING PAPER: Historical GIS visualization methods: Existing and emerging

This Working Paper was created as preparation for the mid-term conference of the Canadian Historical GIS Partnership Development Project, June 20, 2016, and has been edited as a result of discussion at that conference. This version is being released on the project website for public information.

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Introduction

This introduction will lay out the scope of this paper and the process which was used to produce it. The project proposal states that we will:

> "Produce and disseminate a series of White Papers on HGIS methods reviewing and synthesizing the literature and summarizing the experience of collaborators and partners in visualizing, working with, and distributing the products of HGIS research on the web; outlining alternative approaches and best practices. These will serve as the underlying base for presentations and round table sessions at the midterm conference, to build consensus on project implementation in Year 2."

The goals for the project in Year 2 include:

> "Build a pilot version of an open, accessible interactive mapping website."

In order to fulfill this mandate, this paper will focus on Historical GIS (HGIS) visualization for the web, concentrated on interactive web-mapping, although the description of the broader landscape in section 1 will include mention of other techniques. The five main parts of the paper are as follows:

1. **Brief overview of the HGIS web-visualization landscape**. This section will review some key articles found in the relevant literature, discuss a number of "landmark" websites using HGIS web-visualization and the methods and technologies behind them, and discuss the concept of best practices for HGIS web-visualization purposes.
2. **Classification of current web geo-visualization technologies** for different user needs, and discussion of which are more or less suitable to different HGIS needs. Establishment of consistent terminology to be used for this paper/project.
3. **Evaluation of selected web geo-visualization technologies deemed most suitable for HGIS**, through three methods:
    a. Standardized descriptive comparison
    b. Competitive analysis study
    c. User needs assessment survey with HGIS practitioners and web map designers and developers
4. **Results of Canadian Historical Web-mapping User Needs Survey**
    a. Section 1: Individual information
    b. Section 2: Needs and desires for Historical web-mapping technologies
    c. Section 3: Experience using Historical web-mapping technologies
    d. Section 4: Future considerations for Historical web-mapping
5. **Next steps: Developing principles of practice and for Canadian HGIS web-mapping activities, and plan to implement these in our Partnership development pilot website.** How can we help users decide what the best choices are in creating a web-mapping site for their research? What kind of functionality or tools should be included in a pilot project website to best address those needs?

The goals for the White Papers in the original proposal were rather broadly defined. We used a collaborative process to refine these goals and determine how achieving them was to be carried out. Preliminary consultation occurred among the authors and contributors to this paper, leading to groundwork research and writing being done by the project manager and research assistant in the fall of 2015. This led to a draft outline of the paper in December of 2015 being posted for the project collaborators, then the project collaborators were polled to create a working group of those willing to contribute to the development of the paper. Further consultation by email ensued, and a group meeting (online) in February 2016 discussed progress made on the paper and re-focused priorities. A draft version of the paper was circulated among collaborators a week before the project mid-term conference in June 2016. A presentation at that conference of preliminary findings stimulated debate about howthe project should follow in its remaining time and the form that the interactive mapping website should take.

As a result of this process some sections of the paper are more fully developed than others. The decision was made to concentrate on section 3c, the User Needs assessment survey, as the most valuable way of gathering information, benefitting from the experience of project collaborators, and extending the reach of the project to include additional members of the HGIS user community in Canada. The current version of this paper presents results from this survey, in Part 4.

The most important part of this paper, however, should be *Part 5: Next steps*. This section proposes some "Principles of practice for Canadian HGIS Partnership web-mapping activities". It also proposes specific plans for web-mapping activities to be implemented on the pilot website over the next year, in order to serve the HGIS community most effectively, and allow fulfillment of the project goals.

Part 1. Brief overview of the HGIS web-visualization landscape

The first question that always seems to arise in discussion of historical GIS is: what's so "historical" about it? Why does HGIS deserve a special status apart from other GIS methods? Isn't a historical map just a snapshot of a particular geographic location taken at a particular historical moment?

There is a sizeable literature on Historical GIS, which now is available to address these kinds of questions (Knowles 2008; Gregory and Ell, 2014), and in this project's proposal to SSHRC, we spent some time justifying the need for dedicating resources to specifically historical data and tools, so we need not go into detail here. (See proposal on Geohistory project website at: http://geohist.ca/wp-content/uploads/2016/06/CHGIS-SSHRC-2014-SUMMARY-AND-GOALS.pdf.) Much of the literature discusses the need to capture the changing nature of GIS "features" over time, whether these are shifting boundaries, changing climatic characteristics, migrating populations, or the narrative of a specific actor or agent. It is clear that part of the challenge for Historical GIS is to create data structures which can accommodate the temporal aspect of data. Many GIS system and data structures now specifically address this need.

However, in the specific context of geo-visualization, the question needs to be revisited. Merely accepting "time-enabled data" as a concept or structure does not address the challenge, which morphs into a series of questions, such as: What kinds of ways are there of visually representing change over time? What does a visualization need to illustrate historical context? How do we represent the vagueness or intermittent nature which often characterizes historical data? How can we effectively link hard locational or quantitative data with the more nuanced historical data we are often trying to represent, embodied in textual narratives, artifacts or images? A significant body of literature addresses these questions also, although much of it is embedded in the broader literature surrounding "Geovisualization" (See for example several edited collections of seminal articles by Dodge and colleagues: Dodge et al, 2008; Dodge, 2010; Dodge et al, 2011.)

It must also be recognized that these questions only scratch the surface of deeper concerns about representing historical events or figures, especially those related to human suffering, with lines and symbols on a map (see Knowles et al, 2015, for a further discussion.) Scholars from the "Digital

Humanities" community especially have developed the concept of "Deep mapping" to counterbalance the perceived quantitative nature of GIS with a different more "humanistic" view. (For examples see special compilation issue on "Deep mapping" in the journal *Humanities*, 2015 http://www.mdpi.com/journal/humanities/special_issues/DeepMapping).

This is not the place for an exhaustive review of these issues; rather this section will be a brief summary of trends and mention some relevant writings, especially recent ones, on topics related to geovisualization for the purposes of HGIS. Our method was to scan the literature, and troll the multitude of websites and links pages made available by HGIS writers, practitioners and bloggers.

Description of the HGIS web-visualization landscape

In a presentation at the initial start-up meeting for this project in August 2015, the authors looked at about 25 examples of interesting historical GIS visualization websites, with a few observations about general trends and practices. (See http://geohist.ca/wp-content/uploads/2016/06/August-2015-Visualization-Clifford-Moldofsky.pdf). We thought it would be fairly straightforward to summarize and write up the salient points from that presentation.

In retrospect, we underestimated the quantity, the breadth, and the diversity of historical mapping websites and applications. These come from many disparate communities of practice. A wide range of researchers, academics and non-academics, professionals or amateurs, GIS-savvy or web-savvy, artistic or utilitarian, from different backgrounds make historical maps online. Some of these are:

- historians
- geographers
- environmental historians
- librarians (usually map or archive)
- archaeologists
- "digital humanists"
- local and public historians
- computer scientists/programmers (Open visualization community)
- journalists (the media)

Many of these communities of practice have what may be called their own web-mapping "subculture." Between these groups – and often within them - there are often very significant differences in their conduct of HGIS and their making of historical webmaps. Some of these are:

- Data – types and requirements of historical data which may be very different, in the usual and some unusual ways
    - Vector vs. raster (the latter including historical scanned maps, photographs, as well as more recent historical remote sensed imagery)
    - Data quality (vague, missing, fuzzy, intermittent or episodic data very common in historical research)
- Goals and objectives - including
    - Purpose of mapping (egs. publish/disseminate research findings, do local history/public outreach, advocate for cause such as historical preservation or political/social activism, allow exploration and knowledge building, collect Volunteered Geographic Information (VGI)-based historical data, illustrate hypothesized geographic relationships, conduct spatial analysis)
    - Audience for mapping (egs. general public, students, a more focused or narrow research community, other GIS or non-GIS professionals)

- Visualization design approaches (for users)
    - Representation design i.e effective ways to present data (egs. symbolization methods, graphic methods of representing change over time (locational, qualitative or quantitative), statistical methods of showing change over time) (see part 3b and Figure 8 below)
    - Interface design i.e ways of interacting with media (egs. static maps, point and click (i.e. WIMP: windows, icons, menus, pointer), post-WIMP touchscreen methods)
    - Interaction design i.e effective ways of interacting with data/information (egs. ways to allow data exploration, ways to illustrate narratives or "tell a story", ways to incorporate related non-map data, slider or timeline controls, animation)
- Technological design approaches (for designers)
    - Software interface (egs. Raw coding, Coding via Application Programming Interfaces (APIs), Graphic User Interfaces (GUIs))
    - Local desktop design vs. sophisticated online mapping programs, or "vertically integrated" local and online systems
    - Map-specific technology vs. integrated multi-modal data visualization technology (eg. Tableau)
    - GIS-based vs. graphics-based map design (eg. Online GIS services vs. images, Scalable Vector Graphics or Flash)

And so on. To "Describe the HGIS web-visualization landscape" would take a book-length treatise. For now, this brief laundry list of aspects of diversity will give an impression of the variety of "landforms" across that landscape. The following section on Classification of web geo-visualizations further develops this understanding of the range of options that is necessary to appreciate the context for our work.

Brief literature review

The second task we set ourselves was to conduct a "Brief review of the relevant literature…" related to historical GIS web-mapping. In taking a first cut at the subject, we found that there was very little written work specifically directed at online historical geovisualization. Rather, we found there was reference to the subject scattered through the literature on a number of related subjects:

- Historical GIS theory and practice
- Historical GIS project documentation
- Scientific visualization
- Computer-human interaction
- Cartographic design – and specifically the subset of web cartography

The references we reviewed which we found most relevant are listed in our selected bibliography. We arrived at the stage of having a number of pages filled with abstract-length descriptions of books and articles which made some reference to historical mapping online, the reading of which was instructive but which we did not think needed to be reproduced here. Rather, we will just highlight a few references that were most helpful, and informed our own approach to the subject.

Roth, R. E. (2013). **Interactive maps: What we know and what we need to know**. *Journal of Spatial Information Science*, (6), 59-115.
Defines and provides a review of the literature on cartographic interaction. Discusses the interaction process – the "stages of interaction", the value of interaction; when and for who interaction is of value, and considerations about the interfaces. Outlines "the six fundamental questions of a science of cartographic interaction and an associated research". These are:

"(1) what is cartographic interaction (e.g., digital versus analog interactions, interaction versus interfaces, stages of interaction, interactive maps versus mapping systems versus map mash-ups); (2) why provide cartographic interaction (e.g., visual thinking, geographic insight, the stages of science, the cartographic problematic); (3) when should cartographic interaction be provided (e.g., static versus interactive maps, interface complexity, the productivity paradox: flexibility versus constraint, work versus enabling interactions); (4) who should be provided with cartographic interaction (e.g., user-centered design, user ability, expertise, and motivation, adaptive cartography and geocollaboration); (5) where should cartographic interaction be provided (e.g., input capabilities, bandwidth and processing power, display capabilities, mobile mapping and location-based services); and (6) how should cartographic interaction be provided (e.g., interaction primitives, objective-based versus operator-based versus operand-based taxonomies, interface styles, interface design)?"
The method of using these six questions as a basis for further investigation into user practices is extended in Roth (2015) "Interactivity and Cartography: A contemporary perspective on UI/UX design from geospatial professionals", which is also instructive.

Roth, R.; Donohue, R.; Sack, C.; Wallace, T.; & Buckingham, T. (2014). **A process for keeping pace with evolving web mapping technologies.** *Cartographic Perspectives*, 78, 25-52.
In 2012, Roth et al set themselves the task of selecting a web mapping technology to use for the teaching of a course on the subject at the University of Wisconsin-Madison. In the process, as they state:
" …our research was designed to generate initial insight into the following four questions, ranging from practical questions approaching the current technological landscape to longer-term conceptual questions working towards a deeper understanding of web cartography:
1. What technologies currently are available for web mapping and how do they vary?
2. What are the important characteristics of web maps that should inform the selection of web mapping technologies?
3. How should web mapping be taught in higher education?
4. How can we better cope with continued evolution in web mapping technologies?" (p. 26)
Apart from number 3, these are all very similar to the questions we were interested in asking for our own Working Paper. And indeed, we have borrowed from Roth et al substantially (with permission) in designing the research into user needs that is detailed below.

Muehlenhaus, Ian. 2014. **Web cartography : map design for interactive and mobile devices**. Boca Raton, FL : CRC Press.
This modest book was written to instruct students in the principles of cartographic design for the web and mobile. It is brief, but we found it worthwhile just for that: its concise interweaving of the well-known principles of cartographic design (outlined in more depth in many a cartography textbook) with examples and qualifiers directed at their conversion to use on the web and mobile devices. For example, one section of the book provides the standard explanation of the "visual variables" available for use in cartography, and their use for qualitative or quantitative data. Subsequent chapters, however, deal with their use for thematic visualization online, and another section uses them in the context of animation. Little time is spent on coding or technologies, and much on the importance of purposeful design. If it is decided to provide design guidelines and resources on our project's website, this book and its associated web resources might be a good place to begin.

Discussion of best practices

Given what we have written here, it is clear that our intention to discuss "best practices" will need to undergo revision as well. What we have found is that many of the communities of practice doing HGIS visualization online, or subgroups within them, have already developed their own methods, which essentially comprise principles of best practice, or at least a range of established practices which seem to be "good enough" for their purposes.

Many of these groups or subgroups are interdisciplinary and project-based. A good example is one of the most successful and well-known websites highlighting historical geographic research: the Spatial History Lab at Stanford University. "The Spatial History Project at Stanford University is a place for a collaborative community of scholars to engage in creative spatial, textual and visual analysis to further research in the humanities… Our projects operate outside of normal historical practice in five ways: they are collaborative, use visualization, depend on the use of computers, are open-ended, and have a conceptual focus on space."
(See: http://web.stanford.edu/group/spatialhistory/cgi-bin/site/page.php?id=1)
This project-based research gets done by a team of researchers, supplemented by Spatial History Lab staff with specialized GIS, cartographic and web design expertise. Many examples of the results are online. The Conservation Histories of California project may be somewhat typical: it includes a number of maps, using several technologies and interaction techniques. Some are static maps, but most use animation or timeline-control approaches powered by the Adobe Flash plug-in (see more about diverse interaction techniques below.)
(See: http://web.stanford.edu/group/spatialhistory/cgi-bin/site/pub.php?id=125&project_id=)

However, what is key to all of the Spatial History examples is that the map representation and the interaction are driven by the goal of communicating the research: how to present the information on the map in a very effective way - rather than being driven by the data or being driven by the technology.

This point is well made by Muehlenhaus (2014) in his short book on web cartographic design: "Maps, or more specifically excellent maps, are designed with a communicative purpose… without a purpose or goal, maps become either visual encyclopedias or abstract art." (pp 12-13). Although he sounds rather like a throwback to the "cartographic communication" model, he makes a good point. It is stated more formally in Roth (2013):

> "Although the communication model largely has fallen out of favor due to concerns from practical/applied … and critical/social theory … perspectives, the design and use guidelines generated during this era remain the backbone of the modern cartographic curriculum … Today, many scholars frame their research as cartographic representation, continuing the Robinson-era investigation into how maps work from a perceptual and cognitive standpoint (i.e., how maps are seen and understood) while also accounting for the map user's situated experiences (i.e., how maps become imbued with meaning)."
> (Roth 2013, p. 60)

These points about cartographic representation and communication do not take into account all of the different possible goals of historical web-mapping, of course. If exploration of data and development of new insights is integral to the website's purpose, communicating a pre-determined message may be undesirable or counter-productive. When we started looking at creating a classification for the purposes of this paper, it also became clear that a theoretical descriptive model would be useful to underpin its structure. Figure 1, is Roth's re-working of MacEachren's "Cartography cube" (Roth 2013) which characterizes cartographic interaction on a continuum with "exploration" at the high end (private/high interaction/revealing unknowns) and "presentation" at the low end (public/low interaction/presenting knowns). We use this approach below in the organization of our classification scheme of web technologies.

Figure 1. Roth's re-working of MacEachren's "Cartography cube" (Roth 2013)

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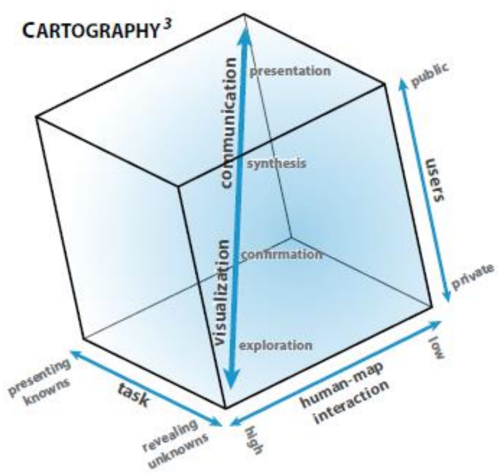


Figure 6: Cartography cube. Visual thinking is best supported through high levels of human-map interaction. Figure redrawn from MacEachren [156].

Muehlenhaus makes another useful point about technology – using the example of the use of the Adobe "Flash" plug-in, which was very popular from around 2000 to 2012. Flash is currently being "deprecated" on some browsers, and Flash is a technology which is often dismissed by the open visualization community as obsolescent. It has been declared by many as "dead." Javascript, on the other hand, is an integral part of HTML5, now heavily used. (See Roth, 2014 pp. 27-29, for a good brief description of the move away from browser plug-in technologies for animation or interaction, towards client-side open web standard technologies.) Muehlenhaus recounts his own experience, with Flash and Javascript:

> "Many years ago, while in graduate school at Penn State, I began exploring this new-fangled thing called Javascript. Everything I heard about it was largely negative. Conventional wisdom was that learning Javascript was likely a waste of time. … Programmers ridiculed Javascript for not being a "real" language… Macromedia Flash (which is now Adobe Flash) was heralded as the future of online interactivity and mapping. I subsequently sold my Javascript guidebook and bought a Macromedia Flash one. Oops."
>
> (Muehlenhaus, 2014, p. 197)

Technologies inevitably and inexorably change. Generally speaking, the technology chosen is important in the moment, and in its sustainability – but it in the long run it is less important than is fulfilling the goals and objectives of the specific project and web-mapping site. Goal-oriented and user-centred design is key to achieving this. Again, many of the basic design principles and best practices which Muehlenhaus outlines in his concise guidebook, while referencing their sources, are most important in keeping this primary principle on track.

Part 2. Classification of current web geo-visualization technologies

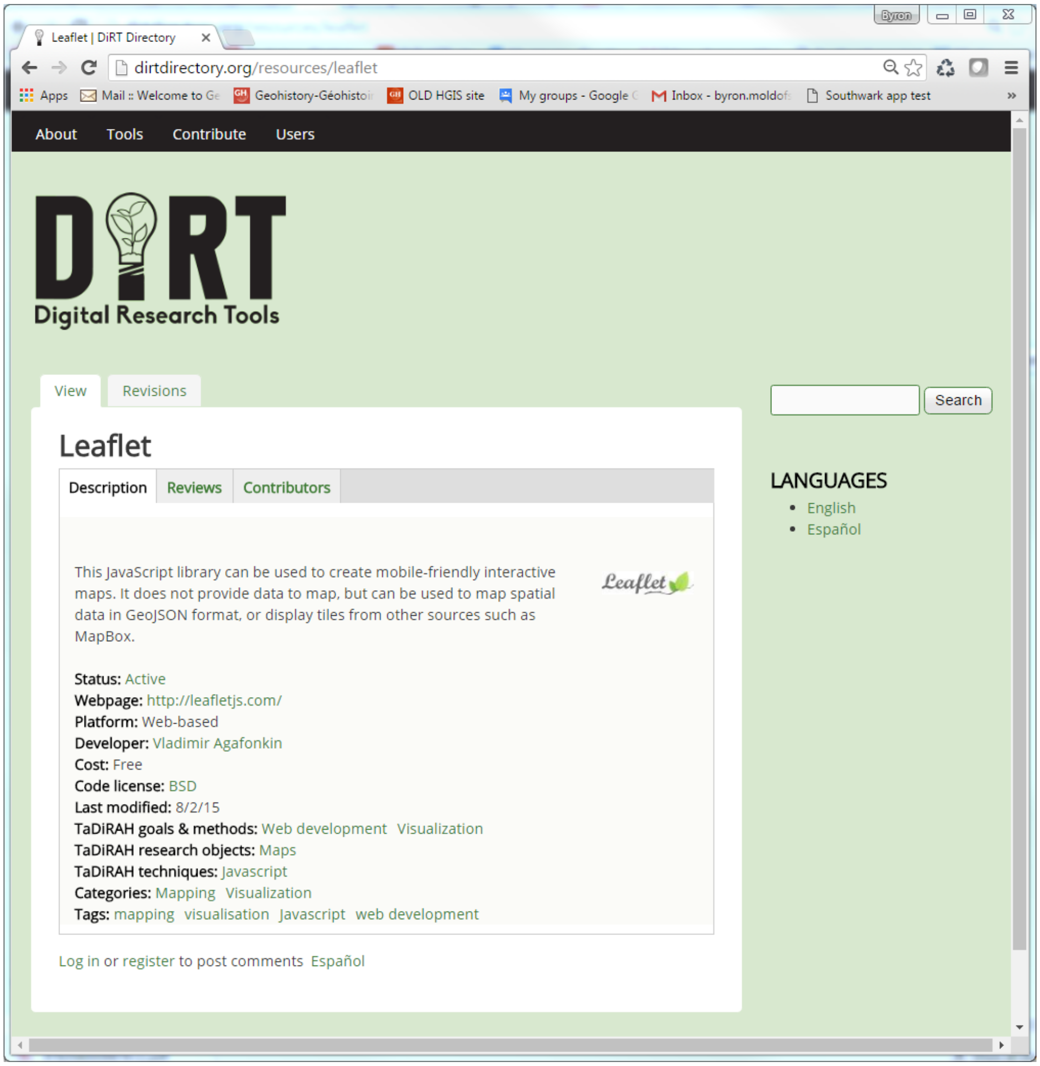
It was decided that we needed a classification of currently available web geo-visualization technologies for different user needs, so that we could establish a consistent terminology to be used for this paper/project, and differentiate among significantly different groups of technologies. This was necessary to enable a comprehensive discussion of which are more or less suitable to different HGIS needs.

As one might expect, preliminary work on this paper has shown that there are a large number of different ways of describing these technologies, and a great variety of terminology used to describe functionality and technical configuration. Perhaps unsurprisingly, we were not able to find many attempts at a comprehensive classification. One of the reasons for this may be the lightning fast pace of change within these technologies, so that any classification may quickly become out of date. Add to this the burgeoning growth in the numbers of individual tools and systems, and this becomes a somewhat daunting task (Roth et al 2014, Muehlenhaus 2014.)

One instructive approach is that taken by the Geohumanities Special Interest Group (SIG) of the Alliance of Digital Humanities, as part of the DIRT (Digital Research Tools) initiative (geohumanities.org and dirtdirectory.org) "The GeoHumanities SIG has begun developing GeoDiRT, based on a feed of geographically-related resources listed in the DiRT Directory, a web-based registry of digital research tools for scholarly use." DIRT uses a special taxonomy (Taxonomy of Digital Research Activities in the Humanities, or TaDiRAH) to break down the research lifecycle into high-level "goals", each with a subset of "methods". For example, "Analysis" is a goal and "Spatial analysis" is one method within it; "Visualization" is another. These tools are also searchable by categories: "Mapping" is one, for example. (See: http://dirtdirectory.org/categories/mapping). Each tool is then given a profile page; DIRT uses RDFa (Resource Description Framework in Attributes) as part of its standardized tool profile descriptions; RDF and RDFa are W3C recommended standards for metadata on web resources. (See: en.wikipedia.org/wiki/RDFa). See below for an example, the DIRT tool profile for Leaflet (Figure 2).

The GeoHumanities SIG is currently revising GeoDiRT, extending it with an enhanced catalog of geospatial software tools and descriptions of projects which use them, and they are moving towards mounting tutorials relating to the tools and tool reviews. They are currently seeking new resource listings, via an online form, accessible from their website (See: http://geohumanities.org/). The Canadian HGIS Partnership has now contacted this group to discuss collaboration where appropriate, in order to rationalize and standardize whatever tools we decide to offer to the Canadian HGIS community.

Figure 2: "DIRT" tool profile page for Leaftlet



However, our current interest is in a pragmatic, use-based classification of these technologies, rather than a formal one. We want to be able to slot existing tools and systems into a framework that makes sense, to understand their capabilities and potential, from a user's point of view.

One reference we found very useful for these purposes was a blog posting by German Carillo's (Carillo 2012; http://geotux.tuxfamily.org/index.php/en/geo-blogs/item/291-comparacion-clientes-web-v6) which classifies and compares open source web mapping clients . "Web mapping client comparison v.6" only deals with Open Source tools, and is now well out of date. However, it may provide a useful model for analysis. Categories of web mapping clients Carillo used are: Libraries, Wrappers, Toolkits, Frameworks and Clients. Carillo's chart showing relations between these at a given point in time (2012) is reproduced below (see Figure 3):

Figure 3. Carillo: Relation between Free and Open Source Web Mapping Clients, v.6.

What may be most instructive regarding the content of Carillo's chart is how many of these OS tools were obsolescent even at the time of writing, and how many more are non-operational today. However, it is not the content, but the use of categories of technologies that we anticipate may be useful in our current context. The design of the chart, showing dependencies between related systems, may also be useful. In addition, Carillo's tabular comparison describing the tools themselves provides some categories which may also be used as a model for our standardized description comparison (See Figure 5 several pages below.)

Robert Roth and colleagues provide another example of classification in their "competitive analysis" of Open Source client-side web mapping technologies. They use this as the first part of the process for the purpose of deciding what combination of tools to use in a course for teaching web mapping to undergraduates. (Roth et al, 2014). The authors state that: "The competitive analysis revealed a basic distinction between specialist web mapping technologies designed to support a small subset of specific functions (e.g., Cloudmade Editor, Mapnik, Modest Maps), and multi-purpose web mapping technologies designed to support numerous functions (e.g., CartoDB, D3, the Google Maps API, Leaflet, MapServer, OpenLayers/OpenScales)." Crossing over these basic distinctions, however, the authors state:

"Individual technologies generally fell into one of the following categories:
(1) frameworks… providing a full stack of client- and server-side technologies (e.g., GeoMoose, MapServer, Processing),
(2) open libraries … supporting client-side map rendering (e.g., D3, Leaflet, OpenLayers),
(3) closed APIs … exposing a subset of functionality for creation of web map mashups (e.g., the Bing Maps API, the Google Maps API, the MapQuest API), and
(4) tile rendering services … facilitating the rendering and serving of basemap tiles."
(Roth 2014, p. 34)

Using Carillo and Roth et al's concepts as the starting point, and expanding and refining these, we have created a proposed classification of web geo-visualization technologies. These previous categorizations were useful for our purposes, being based on both technical and functional characteristics. Both authors however, admit that there is some overlap between descriptive classes. This will be true by necessity when working with such diverse technologies and tools, designed for different purposes.

As mentioned above and illustrated in Figure 1, we also used the "Cartography cube" concept in developing our classification. In general, the organization of the classification scheme attempts to follow the progression laid out along the cube's vertical axis, working from "Primarily presentation" technologies at the top of the diagram to "Primarily interaction" technologies at the bottom. (See Figure 1). "Interaction" implies that a greater degree of data exploration is facilitated, as opposed to consumption of pre-digested "knowns".

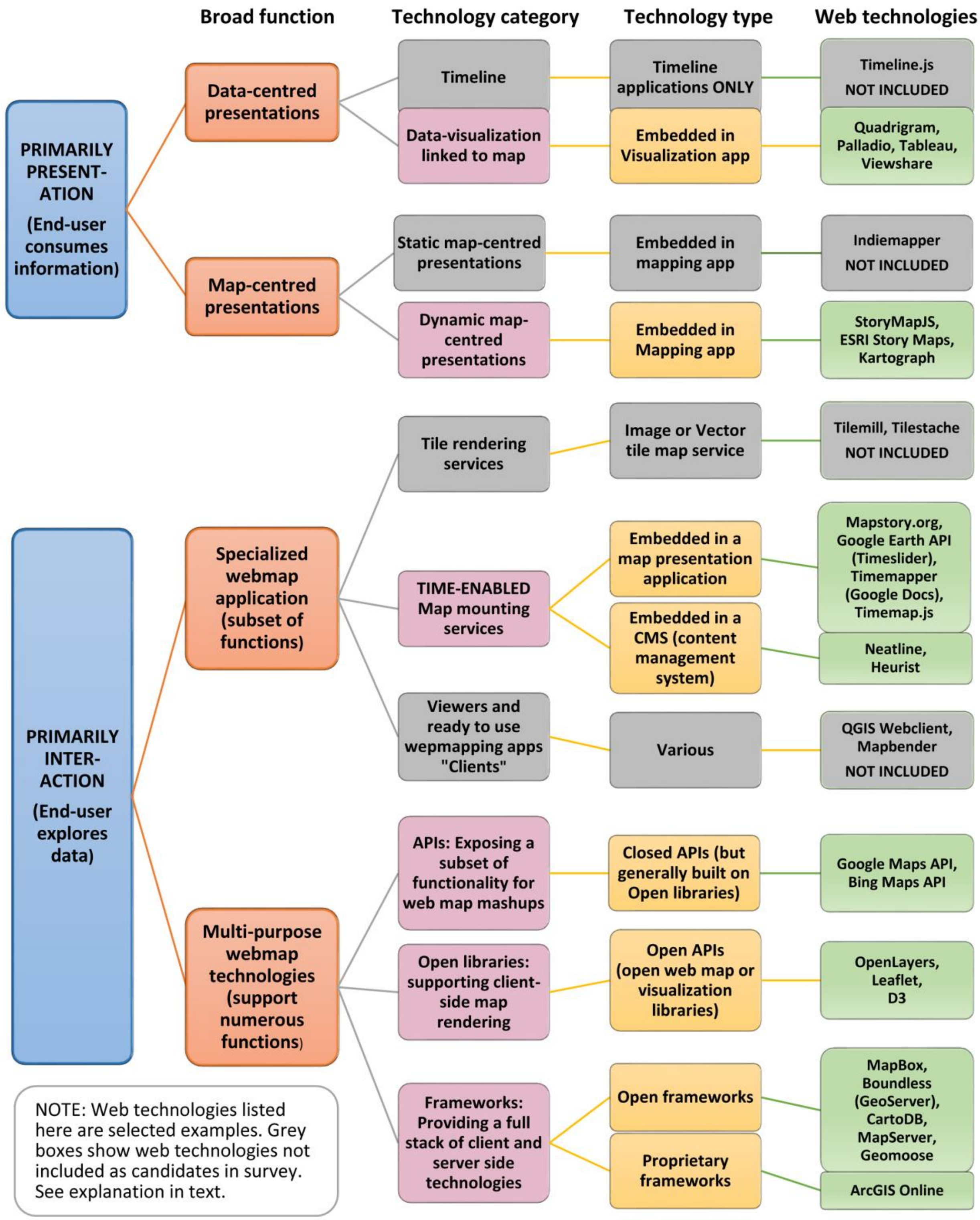
We conducted a survey of websites and technologies starting with Roth et al's list of web mapping technologies as a starting point, and adding new OS web geovisualization technologies and some proprietary ones, and incorporating some web tools and sites which are focused specifically on HGIS visualizations. (Sources for the list of included the DIRT "Mapping" directory, a list of HGIS tools prepared for the 2014 Canadian HGIS meeting "Montréal, plaque-tournante des échanges" (See: http://plaque-tournante.uqam.ca:8000/ressources/?q=outils), a collection of links from another meeting on historical geodata to the web convened at Harvard in 2014 (See: http://gis.harvard.edu/services/blog/moving-historical-geodata-web), the Open Source Geospatial Foundation project listing (See: http://www.osgeo.org), as well as our collaborators' suggestions.) We used these as a test set of technologies for populating alternative configurations of our classification attempts. (Preliminary versions were critiqued and refined by consultation with the project's geovisualization Working Group.) The resultant proposed classification of web geovisualization technologies is illustrated in the chart in Figure 4, with examples taken from this list. These examples are a small subset of all the technologies we examined for suitability for further analysis. The coloured boxes represent those which were finally selected as prime candidate technologies for HGIS web-mapping, and were included for further evaluation and as options in our user needs assessment survey (see Part 3a, b, and c).

The kind of classification attempted here will never be absolute or exclusive, as it intermingles purpose, function, and technology. Some of these technologies are obviously limited pieces of the puzzle (limited in function, like a timeline or a tile rendering service) and not capable of or intended for hosting a full HGIS presentation. Others are frameworks which are almost unlimited in their ability to build custom applications. Despite these shortcomings, we still think the classification is useful as a broad way of looking at the range of tools and technologies available.

As a final comment on surveying and classifying web-mapping technologies, I would like to quote Muehlenhaus from his recent book on web cartography. (Muehlenhaus, 2014, pp 225-227).

> "There are several challenges when reviewing different web mapping technologies in a book. First one cannot possibly know about all of them or pay each adequate attention. Second APIs are constantly changing... Everything I have written about in this chapter is now partially out of date... Here is my advice: Do not worry about it. The main point of Web mapping is not to use the latest and greatest technologies. The point is to create maps that communicate clearly and intuitively and that people can readily access from myriad interfaces... If there is one takeaway to leave you with it is this: You do not design maps to use technology; you use technology to design better maps."

Figure 4. CHGIS Web Mapping Technology Classification scheme (Draft)



Part 3. Evaluation of selected web geo-visualization technologies deemed most suitable for HGIS

After surveying the literature for methods of evaluation, we attempted to evaluate the selected web geo-visualization technologies currently deemed most suitable for HGIS, through three methods: 3a) Standardized descriptive comparison; 3b) Competitive analysis study; 3c) User needs assessment survey. For the list of candidate technologies being considered, see Appendix 1 (including URLs; names also appear above in Figure 4.)

Part 3a. Standardized descriptive comparison

Using a standardized set of descriptors to compare technologies makes good sense, accompanied by supplementary text where necessary. This method appears in many classification efforts. The DIRT method outlined above is one approach. In his blog (Carillo 2012), Carillo used a series of three tables to compare web-mapping clients. Figure 5 (below) shows how these appear, and what "parameters of comparison" were used. The source for the information listed was the website of each client/system. These tables constituted detailed comparisons of alternative web-mapping clients.

We plan to use a similar but simplified approach in that each of the web geo-visualization technologies selected as candidates will be described using a standard description template. We decided that to implement this in a tabular format appears to be unnecessarily limiting – but it is a possibility in the long term. The source for the information listed is the website of each client/system, which was supplemented by a period of experimentation with the tools available, by a Research Assistant (RA) assigned to this task. Currently we have tested, and expect to use, a textual format to compare the candidates using the following templated descriptors:

Classification: According to classification system outlined above in Figure 4.
Description: Short textual description and analysis of the experience using technology.
Base Platform or Application:
User interface:
Programming language(s):
Base map source(s):
Level of expertise for Programming:
Level of expertise for GIS:
License/restrictions:
Cost:

For some examples of descriptive comparison entries using this format see Appendix 2.

Deciding on these descriptors was an iterative process over the course of several months. We believe they are fairly clear and avoid significant overlap, and will be helpful in covering what users "need to know" about these technologies. We propose to use them for standardize descriptions of technologies on the CHGIS partnership website. However, the eventual descriptors and the form that this will take is up for debate and decision. See Part 5b for further discussion.

Figure 5: Carillo's tabular comparison of Web mapping clients

Web Mapping Client Comparison

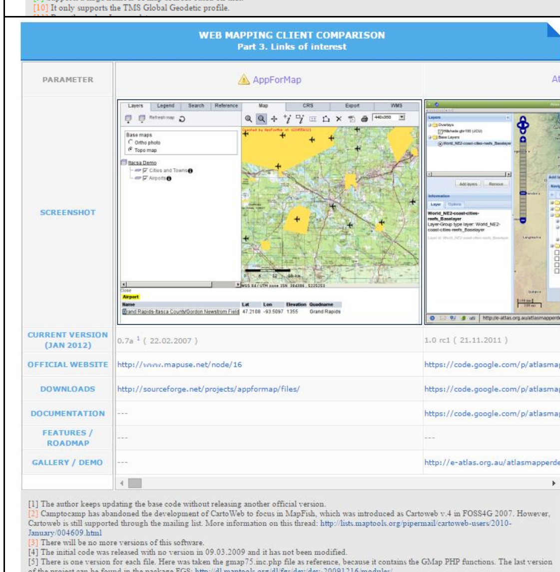
Parameters of comparison

Part 1: General description

LICENSE
ORIGIN COUNTRY
ORIGIN COMPANY OR ENTITY
DOCUMENTATION
OSGEO PROJECT?
CATEGORY
COMMENTS

Part 2 Technical features

SOURCE CODE LANGUAGE
API LANGUAGE
SUPPORTED OGC SERVICES
TILE-BASED MAPS SUPPORT
DOES IT REQUIRE PROPRIETARY PLUG-INS?
DOES IT INCLUDE META-DATA COMPONENT?
MAILING LISTS



Part 3 Links of interest

SCREENSHOT
CURRENT VERSION (JAN 2012)
OFFICIAL WEBSITE
DOWNLOADS
DOCUMENTATION
FEATURES / ROADMAP
GALLERY / DEMO

Part 3b. Competitive analysis study

This approach is modelled after Part 1 of the study of candidate Open Source web technologies for teaching as outlined in Roth et al., 2014. They conducted a "three-stage process in order to characterize and push our way into the current landscape of open source web mapping technologies." This was a "convergent" approach, with each stage building on the previous.

> "We triangulated insights across three studies in total: (1) a competitive analysis of existing web mapping technologies, (2) a needs assessment survey with web map designers and developers, and (3) a diary study tracking the implementation of the same web map using a candidate subset of technologies identified from the first two studies."
>
> Roth et al, 2014, p. 29

Perhaps it would be ideal to follow this methodology entirely, but due to time constraints it was decided to emulate study parts 1 and 2. It has been suggested that the diary component might be partially incorporated by asking RAs to keep a brief journal while using the apps to keep track of their experiences. For example, some tools may have excellent capabilities but can be frustrating or difficult to use - an important characteristic to consider when choosing a tool.

In their competitive analysis study, Roth et al. generated parameters for comparison divided into two groups of desired capabilities or "techniques" for each technology: Representation techniques, and Interaction techniques. Table 1 from their paper describing these, is reproduced below as Figure 6.

Figure 6. REPRESENTATION and INTERACTION techniques Roth et al, 2014

REPRESENTATION		
1	Map vs. Imagery	load different basemap tiles, such as road map, satellite imagery,etc.
2	Basemap Styling	adjust the styling of the basemap
3	Tile Rendering	generate and serve custom maps as tiles
4	Vector Overlays	draw and overlay additional vectors, including points, lines, and polygons
5	Choropleth	generate a choropleth map
6	Proportional Symbol	generate a proportional symbol map
7	Dot Density	generate a dot density map
8	Isoline/Surface	generate an isoline or surface map
9	Flow	generate a flow map
10	Cartogram	generate a cartogram
11	Bivariate/Multivariate	depict two or more statistical variables on the map
12	Animation	animate the map over a time series
13	Graphics/Charts	add additional information graphics or charts to the map
INTERACTION		
1	Arrange/Linked Views	manipulate the layout of the map and linked views
2	Reexpress	change the displayed map type
3	Sequence	generate an ordered set of related maps or change the map from the sequence that is shown
4	Resymbolize	change the design parameters of a map without changing the map type
5	Overlay/Toggle	adjust the feature types included in the map
6	Reproject	change the map projection
7	Pan	change the geographic center of the map
8	Zoom	change the scale or resolution of the map
9	Filter	alter the map to remove map features that do not meet one or a set of user-defined conditions/constraints
10	Search	alter the map to add/indicate a particular location or map feature of interest
11	Retrieve	request specific details about a map feature of interest
12	Calculate	derive new information about a map feature of interest
13	Mobile Support	support for viewing and interacting with the map on a mobile device
14	Location Aware	support for collecting and mapping information about the user's location

Table 1. The representation and interaction codes used to compare the collected suite of open web mapping technologies.

Using information derived from the candidate technology's website, the researchers then "coded" each of these comparison parameters on a 7-step scale, according to the degree they were supported: from "Not possible" to "Requires hack" to "Known work-around" to "Supported". The results of this study was a colour coded matrix of cells, with each cell reflecting the rating given to it on the capability scale. Table 4 from their paper graphically representing this is reproduced below as Figure 7.

As stated, the matrix was intended to "provide a snapshot in time of web mapping technology that is useful for understanding general patterns and emerging trends in web mapping design." It succeeds to some degree in this goal, although it was probably more important in the research as a first cut at understanding the 35 candidate technologies, in order to winnow them down to the most promising. As a graphic representation of the web mapping technology landscape, the organization and graphic design of this matrix work contrary to this goal in a couple of ways. First, the technologies are ordered alphabetically in the matrix, despite the fact that the authors outline a categorization of them in the text. They thus randomly intermix inherently disparate types of technologies. Ordering them by major category would make it much easier to visually compare "apples to apples". Secondly, 7 steps of rating seems to be too many for a clear visual pattern to emerge. Reducing these to 4 or 5 should clarify the pattern markedly.

Figure 7. Roth et al. Results of the competitive analysis study

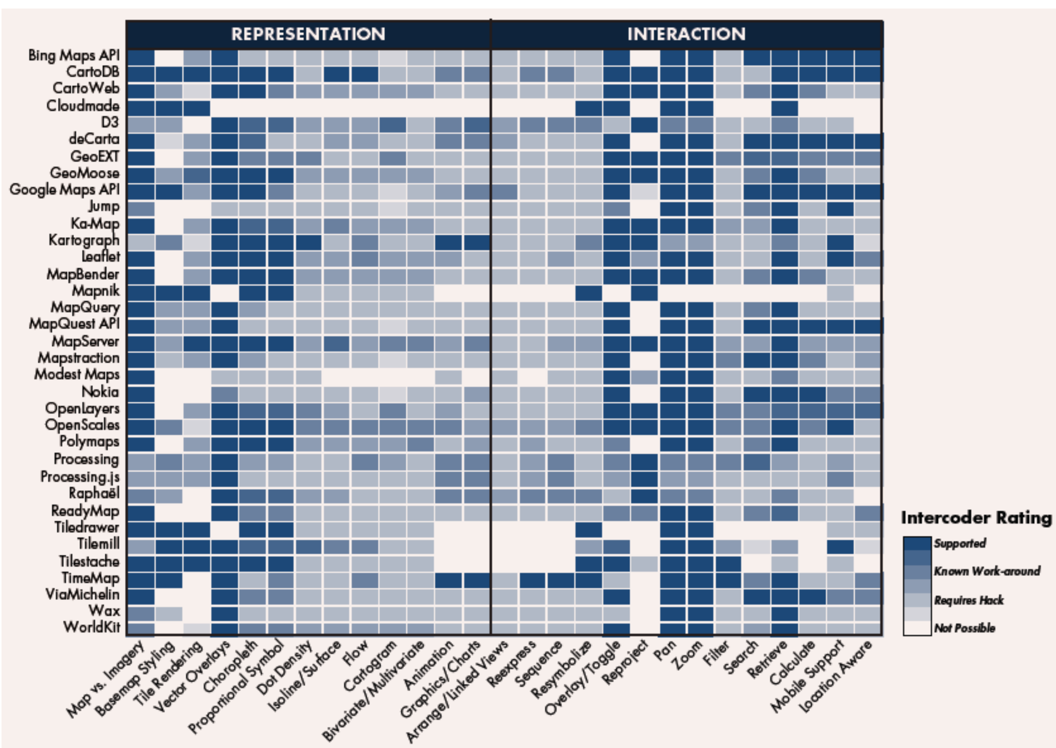


Table 4. Results of the competitive analysis study. Collection and coding was completed in the spring of 2012; therefore, the matrix is no longer complete nor accurate, although arguably it never can be, given the speed of technological advancements in web mapping. The matrix does provide a snapshot in time of web mapping technology that is useful for understanding general patterns and emerging trends in web map design.

Despite these caveats about the way the results are displayed, it is suggested that a similar method adapted specifically for Historical GIS web visualization would be very productive. Preliminary work on this method, attempting to use the parameters that Roth et al initiated has resulted in some additions, clarification, and other refinements to the list of techniques which should be most useful in this context. See Figure 8 for our suggested revised set of techniques.

For clarification, we thought it had to be made clear for whom the techniques or capabilities applied: the map designer or the user? Roth's listing of "Representation" techniques appear to refer to designer capabilities; his "Interaction" techniques refer to capabilities made available to the user. For example, the **representation techniques (for designer)** include the design and functionality it is possible to incorporate into the webmap: for example, the technique "*Choropleth*" refers to whether the designer has the capability to "*generate a choropleth map, including control over classification*". There is a similar technique for "*Proportional symbol*". On the other hand, the corresponding **interaction technique (for users)** would be "*Reexpress*", whether the user can be given the capability to "*change the displayed map type, eg. from choropleth to proportional symbol*." Another user technique would be "*Resymbolize*": whether the user can be given the capability to "*change the design parameters of a map…*", eg. the colour scheme used for the choropleth map.

In addition to native functionality, there is also an aspect of flexibility or designability to many of these techniques. In the example of "*Choropleth*" above, this refers to the ability to have "*control over classification*" as well as things like colour selection. It may seem that these would naturally be included - but in many highly automated graphic user interfaces for design, only "default" classes or colours are enabled. Amending these requires an amendment to code, if it is possible at all.

In addition, in our revised list of techniques some specific ones were amended or added that provided functionality considered extremely important for historical web-mapping. For example, a technique that we amended was *"Animation: animate the map over a time series "* – it was changed to "*Animation timeline: animate the map over a time series, including user timeline controls and a variety of types and methods"*. A new technique that we added was *"Storytelling: Provide title, supplementary text, narrative navigation tools to guide the user through the map display."*

Technologies were to be rated on a 5 point scale for their native capability to achieve the technique, combining aspects of functionality and flexibility or designability.
Rating: 0=not possible, 1=rudimentary, 2=capable, 3=very good, 4=excellent

3b. Competitive analysis study - Current status
Due to time constraints, and after consultation with the CHGIS project working group, it was decided that work on the competitive analysis study in this format should be suspended, in favour of concentrating work on part 3c, the user needs assessment survey. The usefulness of the graphic representation of these techniques in a matrix format, for the purposes of this study, was also questioned. Currently it is expected that these lists of capabilities may be used in conjunction with the Standardized Descriptive comparison approach outlined above in 3a. This is suggested in part 5b below, the proposal for online **Historical web-mapping technology profiles.** Further discussion of this approach and the value of completing among collaborators is welcomed.

Figure 8: Revised set of Representation and Interaction techniques proposed for this study.
(Changes and additions to Roth et al's parameters are highlighted in green text, suggested omissions are highlighted in blue.)
Technologies are to be rated on a 5 point scale for their native capability to achieve the technique, combining aspects of functionality and flexibility or designability.
Rating: 0=not possible, 1=rudimentary, 2=capable, 3=very good, 4=excellent

	Description of capability
REPRESENTATION techniques -	**for MAP DESIGNER**
Basemap related	
Map vs. Imagery	load different basemap tiles, such as road map, satellite imagery, etc.
Basemap Styling	adjust the styling of the basemap for visual hierarchy
Image tile rendering	generate and serve custom maps as image tile
Vector tile Rendering	generate and serve custom maps as vector tiles
Projection and reprojection support	Allow data in different projections to be used and allow representation in different projections to be used
Thematic related	
Import vector files	import and overlay vector layers, pts lines and polygons
Vector Overlays	draw and overlay additional vectors, including points, lines, and polygons
Coordinate/address geocoding	import of point files with anything from lat long to street addresses
Overlay styling	design the styling of overlays, for visual hierarchy
Clustering for generalization	point aggregation representation by graduated symbol
Heat maps for generalization	point aggregation representation by heat surface
Choropleth	generate a choropleth map, including control over classification
Proportional Symbol	generate a proportional symbol map, including control over sizing
Dot Density	generate a dot density map, including control over method of placement
Isoline/Surface	generate an isoline or surface map, including variety of types and methods
Flow	generate a flow map, including variety of types and methods
Cartogram	generate a cartogram, including variety of types and methods
Bivariate/Multivariate	depict two or more statistical variables, including variety of types and methods
Animation timeline	animate the map over a time series, including user timeline controls and a variety of types and methods
Graphics/Charts	add additional information graphics or charts to the map, including variety of types and methods
Legend	generate legend and control contents and display
Storytelling	Provide title, supplementary text, narrative navigation tools to guide the user through the map display
	continued on next page...

INTERACTION techniques	**for MAP USER**
Reexpress	change the displayed map type, eg. from choropleth to proportional symbol
Sequence	generate an ordered set of related maps or change the map from the sequence shown
Resymbolize	change the design parameters of a map without changing the map type
Overlay/Toggle	adjust the feature type layers included in the map
Reproject	change the map projection eg. to equidistant for distance buffers, to equal area for choropleth
Pan	change the geographic center of the map
Zoom	change the scale or resolution of the map
Filter	alter the map to remove map features that do not meet one or a set of user-defined conditions/constraints
Search	alter the map to add/indicate a particular location or map feature of interest
Retrieve	request specific details about a map feature of interest
Calculate	derive new information about a map feature of interest
Linked views maps w. info. Graphics	coordinate retrieve on the map with the line graph to show the selected feature on both graphics
Arrange/Layout	manipulate the layout of the map and other graphics or linked views
Interface design aesthetics	customize the look and feel of the interface to the map to fit the scenario
Data Reusability	Apply or export data to another map in the same or another technology or site
Legend control	control legend interaction eg. turn layers on or off
Mobile	Support for viewing and interacting with the map on a mobile device
Location Aware	support for collecting and mapping information about the user's location
TECHNICAL/ PRACTICAL considerations	**For MAP DESIGNER**
Need for programming expertise	0=none, 4=programmer
Need for GIS expertise	0=none, 4=professional
Restrictions: OS, Proprietory, Licensing	0=completely open FOSS, 4=completely restricted proprietory and closed
Cost	0=Free, 4=Expensive with no free components
TECHNICAL/ PRACTICAL considerations	**For MAP USER**
General ease of use	General rating of difficulty to try to capture look and feel: 0=very easy, 4=very hard
Commitment needed	0=anonymous, 4=subscription required for anything

Part 3c. User needs assessment survey with HGIS practitioners and current or potential web map designers and developers

The second stage of the analysis in Roth et al 2014 consisted of a web mapping needs assessment survey, administered online, and filled out voluntarily by web map designers and developers.

> "We included the survey as the second step in the overall process in order to acquire rapid feedback about technologies collected in the competitive analysis from designers and developers outside of the project team. The online survey acted as a needs assessment study, as the purpose of the survey was to elicit past experiences with the collected technologies as well as to identify future or currently unmet web mapping needs…"
>
> Roth et al, 2014, p. 30

The survey in Roth et al consisted of 21 participants, had a short biographical section and then 12 evaluation questions, and was designed to take no longer than 15 minutes to complete. Their survey covered:

> "(1) current use of the web mapping technologies identified in the competitive analysis
> (2) important qualities of web mapping technologies we should consider when selecting a technology, and
> (3) approaches to keeping pace with evolving web mapping technologies"
>
> Roth et al, 2014, p. 30

We believe this overall approach is adaptable and suitable for the needs of this project. It serves the dual goals of gathering valuable feedback from the community we are attempting to serve, as well as providing a conduit for participation and a means of engaging that community in our partnership building and web development efforts.

We decided our survey should be similar to Roth et al's in parts (1) and (2), but that it should cover respondents' past utilization of web technologies as well as their current use (i.e. with which of the selected candidate web-mapping technologies have users had experience, and did they find that experience positive or negative?) We replaced part (3) with some questions asking about future needs, rather than "keeping pace."

Regarding target audience for our survey, we decided to solicit feedback from our own partnership project collaborators, and from the larger HGIS research and web-mapping community in Canada. We decided not to limit it to individuals who have had direct hands-on experience with the candidate HGIS web mapping technologies, but extend it to anyone who has done or has an interest in doing historical web-mapping in the future. Some questions were made optional to accommodate this.

Regarding the number of participants in the survey, by nature and necessity, the survey will have a relatively small number of participants. Since it is more in the nature of an self-selected opinion poll than a randomly selected representative sample of a target population, no minimum or maximum number was set. The survey needed to be fairly short in length and simple to complete, in order to encourage participation.

We would like to acknowledge and thank Robert Roth, who was extremely helpful and collegial in providing the original text of his group's study survey questions. We designed and implemented our own survey as an online web form, and were required to undergo Research Ethics Board Review at the University of Toronto, as we decided to ask for personal information (name, email, organization) for validation and follow-up purposes, and therefore we had to ensure confidentiality to respondents.

We invited all members of the CHGIS Partnership development project and those on our email contact list to complete the survey. We also distributed the invitation to selected related email lists (eg. Canadian Association of Geographers Historical Geography Study Group, Canadian Cartographic Association) and to selected university faculty to solicit responses from students who had taken web-mapping courses. The survey was mounted online on May 2, 2016, and closed to responses on June 15, 2016. A transcript of the survey "Introduction" and the text of all questions is included in this document as Appendix 3.

The invitation and introduction is also available online at:
http://geohist.ca/invitation-user-survey/

The results of the survey are presented below in Part 4.

Part 4. Results of Canadian Historical Web-mapping User Needs Survey

Section 1: Individual information: To identify interest in Historical web-mapping

The survey was completed by 50 respondents. To facilitate analysis we classified these into 5 types of users: Professors/teacher, Student, Librarian, Researcher/analyst, and Commercial.

User Type	Use GIS	Use Historical Data	Design Webmaps	Do Web Programming
Professor/ teacher	supervise	supervise	never	never
	supervise	occasionally	never	never
	supervise	occasionally	supervise	never
	occasionally	yearly	supervise	supervise
	occasionally	yearly	supervise	supervise
	monthly	monthly	occasionally	supervise
	weekly	weekly	occasionally	supervise
	weekly	weekly	yearly	supervise
	weekly	weekly	yearly	occasionally
	daily	daily	monthly	yearly
	daily	daily	weekly	monthly
	daily	daily	daily	daily
Student	occasionally	occasionally	occasionally	never
	monthly	occasionally	occasionally	never
	monthly	occasionally	occasionally	never
	weekly	monthly	occasionally	occasionally
	weekly	monthly	monthly	yearly
	weekly	weekly	monthly	monthly
	daily	daily	weekly	weekly
Librarian	supervise	occasionally	supervise	never
	occasionally	occasionally	supervise	never
	monthly	monthly	occasionally	never
	weekly	monthly	occasionally	never
	weekly	monthly	occasionally	supervise
	weekly	monthly	occasionally	supervise
	daily	monthly	yearly	supervise
	daily	monthly	yearly	occasionally
	daily	weekly	monthly	occasionally
	daily	weekly	monthly	occasionally
	daily	weekly	monthly	yearly
	daily	weekly	monthly	weekly
	daily	daily	daily	weekly
Researcher/ analyst	never	supervise	never	never
	yearly	occasionally	supervise	never
	monthly	monthly	supervise	never
	weekly	monthly	occasionally	supervise
	weekly	monthly	occasionally	supervise
	weekly	monthly	occasionally	occasionally
	weekly	weekly	occasionally	occasionally
	weekly	weekly	monthly	occasionally
	weekly	weekly	monthly	occasionally
	weekly	weekly	monthly	occasionally
	daily	daily	monthly	occasionally
	daily	daily	weekly	occasionally
	daily	daily	daily	weekly
	daily	daily	daily	daily
Commercial	daily	occasionally	occasionally	never
	daily	monthly	occasionally	never
	daily	monthly	monthly	supervise
	daily	monthly	daily	daily

Figure 9: Users sorted by type and frequency of use of historical GIS and web mapping

The respondents came from a wide range of backgrounds and experiences. This was a self-selected sample, rather than a randomly selected representative one. To gain some understanding of their background and level of expertise, we asked several multiple choice questions about the frequency of their use of GIS, of historical data, of designing webmaps, and of doing basic web programming (see Appendix 3, Section 1: Individual information). As can be seen from Table 1, the aggregated and sorted responses reflect the expected wide range of levels of use of each of these aspects of historical GIS web mapping. It appears that only a few include designing webmaps as a regular part of their job description. Even fewer do web programming on an every day or every week basis. This is consistent, however, with the population we are trying to serve: the regular user of GIS and historical data, who needs assistance in getting their data or results into a visual form via web mapping.

Section 2: Needs and desires for Historical web-mapping technologies (answering optional)

Section 2 of the survey addressed potential users' "Needs and desires for Historical web-mapping technologies." Respondents were asked to rate the importance of different aspects of web-mapping technologies to them or their teams, in three sub-sections: Design and functionality, Technical considerations, and Practical considerations. They were given three rating options: Not important, Important, or Extremely important. Many of these questions were modelled after those used by Roth and associates (Roth et al, 2014), but some were deleted, modified or added for our specific audience and our perception of special needs for historical GIS web-mapping. For example, a question about dynamically loading real-time current information was deleted; a question about incorporating a time-line with slider controls was added.

These questions were all optional, and users were asked to choose whether or not to answer them depending on their experience, and it was suggested that "If you are not technically oriented, please skip to Section 4 (Future considerations.)" Of the 50 respondents, 48 answered all or almost all of these questions.

After reviewing the raw data it was decided that for analytical purposes we would create two sets of charts. The first set are simple frequency distributions, showing the numbers of respondents answering with each rating option for each question, to get an overall idea of how respondents rated the importance of each characteristic of web-mapping technology. It was expected that all of the characteristics provided for rating would be "important" - that is to say, we did not ask about any characteristics which we thought respondents would judge to be "useless." Given our expectations, the most useful data we glean from these responses may be the outliers: which characteristics appear to be much more important than we may have expected, and which appear to be of lesser importance.

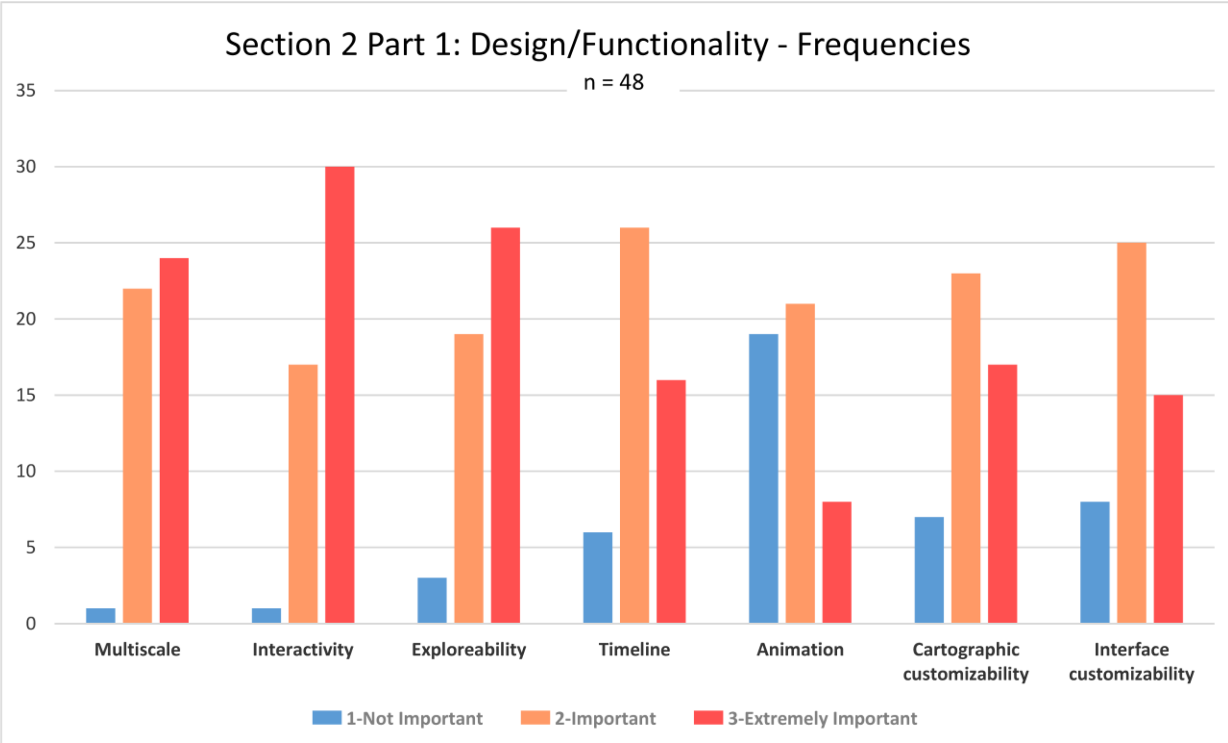
The second set of charts attempts to quantify these responses: we assign a value of 1, 2 or 3 to each response: 1 for Not important, 2 for Important, and 3 for Extremely important. The mean value of responses for each question, subdivided by user type, is shown in the chart. The intent of these charts is to visualize the differences in how each group of user types rate the importance of each characteristic. This addresses potential differences within the population of respondents. A certain characteristic may be much more important to one type of user than to others, and if so, we should be able to illustrate that difference in this way. We realize that the level of measurement for these data is inherently ordinal, as opposed to interval, and therefore assigning numerical values to them and using a mean to represent each group is open to criticism. Despite this, we still believe the method is useful to visually illustrate broad distinctions between user types. The vertical scale shown in the charts has the range of 1-3, rather than 0-3, because the mean value represents a position on the spectrum of values between 1-3, rather than a numerical mean at a ratio level of measurement. The labels or legend for each of the charts also includes the number of respondents in each user type group, as using means may tend to overemphasize the responses of smaller groups such as Commercial where n=4; these are included as a reminder to take into account this disproportionate effect.

In the charts and brief analysis that follows, we have used short forms to represent the questions, such as "Multiscale", "Interactivity", etc. These could potentially be misleading, so the reader is encouraged to refer to the full text of the questions which are available at the end of this paper (See Appendix 3, Section 2 for the questions.)

Section 2 - 1: Design and functionality

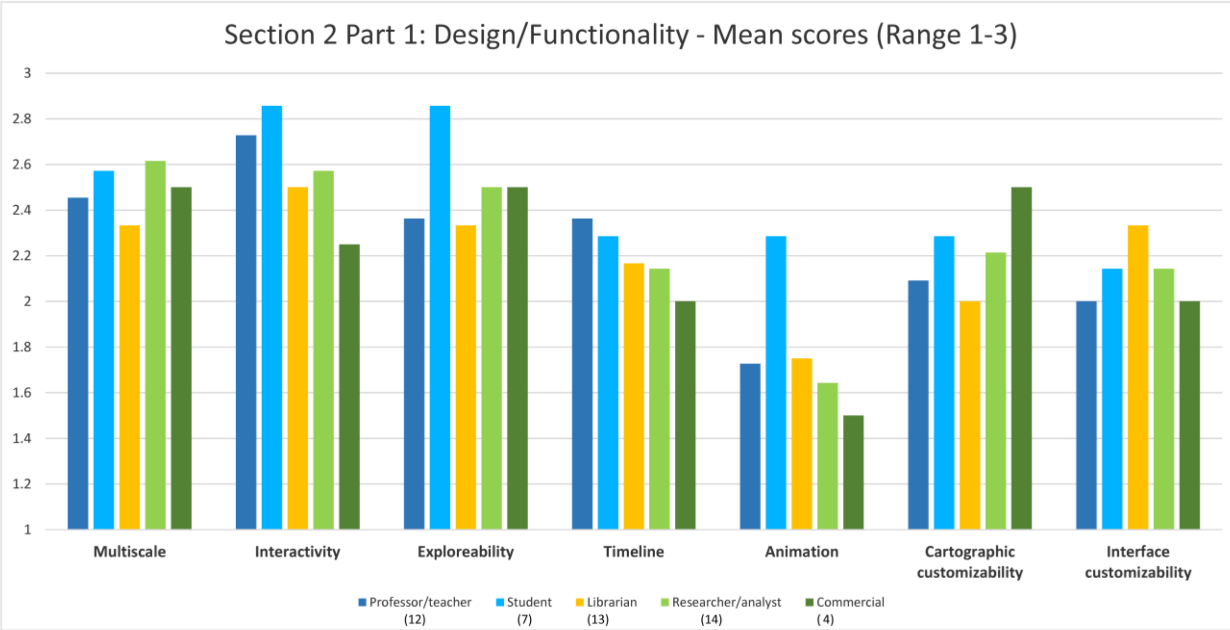
These questions were constructed to find out what features respondents considered most important in terms of control over graphic design of webmapping sites as well as methods of functional interaction with the underlying historical GIS data.

Figure 10: User needs survey Design/Functionality - Frequencies



As expected, all of these characteristics were rated important or extremely important more often than not. Interactivity (layer controls, pop-ups) and Exploreability (querying data) had the highest numbers of "Extremely". For historical GIS, we expected Timeline functionality to be more important to most respondents than the results appear to show. Animation (movement of features on map) had a high number of “Not important”. This could be expected as the main focus would be on the map and its features, and motion would be highly advantageous only for a subset of historical GIS scenarios such as migration or flow of trade goods. The idea was also raised (by a student RA) that there may have been an issue of confusing terminology, as some users may have interpreted "animation" as animated videos or images rather than animated data visualization. Cartographic and Interface customizability were rated as important by most, but significant numbers also rated these as unimportant, which is surprising, as it was thought that users would attach great importance to customizing the look and feel of the web-mapping for their target audiences.

Figure 11: User needs survey Design/Functionality - Mean scores

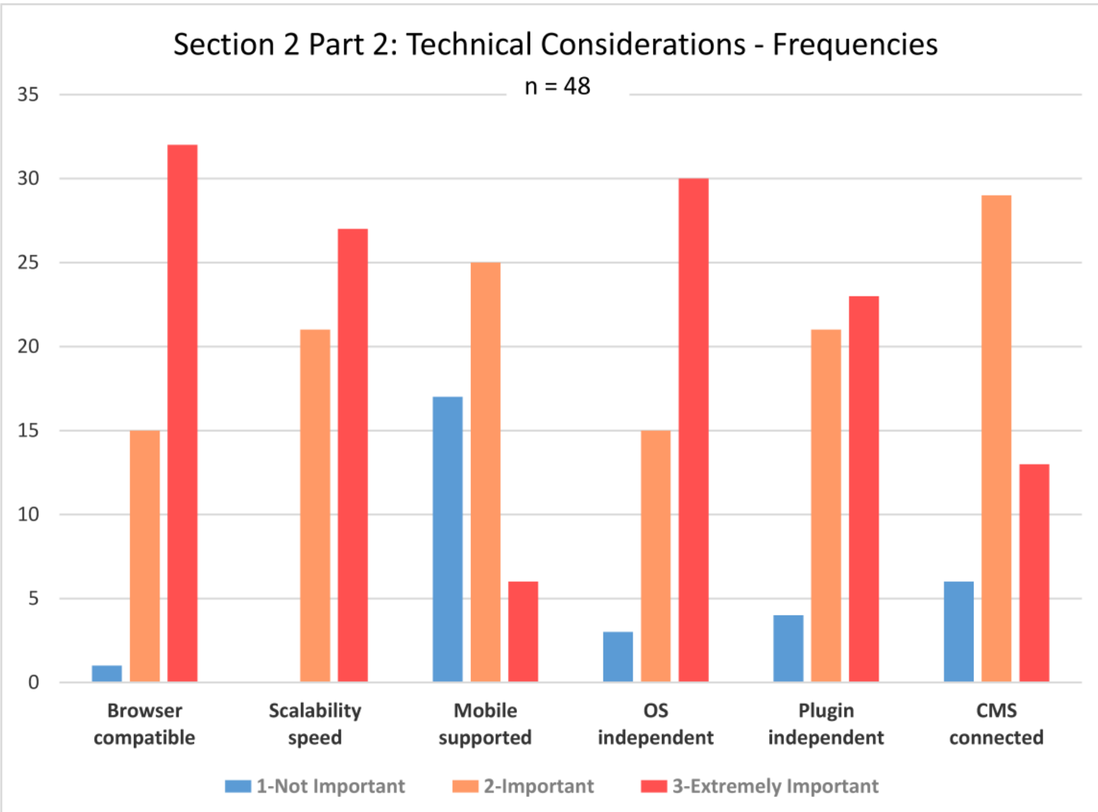


In terms of the mean values of importance by question by user type, again we may look for unexpected or outlying results among specific types of users. Relating these to the comments above about frequencies, what stands out here are groups that buck the trend. The most obvious are Students, who rated Exploreability much higher than the overall population. They do the same for Animation, rating it as Important more often than other types of users, including Professors, which may signify a significant disconnect in the education sector. Both Students and Professors consider Interactivity very important slightly more often than other groups. Cartographic customizability is rated highest by those in the Commercial sector, which perhaps indicates the need to satisfy clients with specially customized symbolization in visual displays. Librarians rate Interface customizability slightly higher than other groups; perhaps this reflects their orientation towards the needs of their clients who may emphasize the design of interactive functionality more than graphic design.

Section 2 -2: Technical considerations

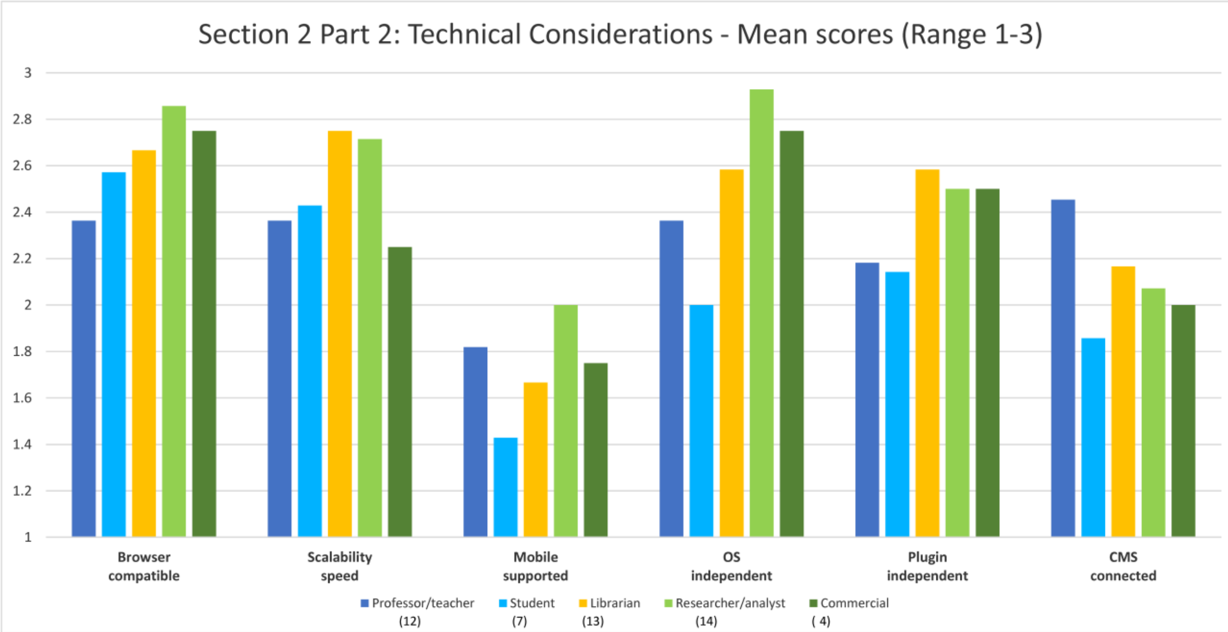
These questions were constructed to find out what features respondents considered most important in terms of technical considerations regarding platform, installation and performance.

Figure 12: User needs survey Technical Considerations - Frequencies



Again, the expectation was that all aspects of these questions would be considered important. (Cross-) Browser compatibility and Scalability/speed proved to be so (the latter question specified interacting with large data sets without delays, reiterating the importance of good, responsive connections to actual data.) The share of people seeing Mobile-supported as not important was surprising (again remarked upon by student RA) as the move towards mobile devices including tablets is very strong; perhaps some respondents interpreted "all mobile devices" as including phones but not tablets. Being OS (Operating System) independent was considered extremely important by many. Being Plugin independent was judged important by most - reflecting the move away from downloaded enabling technologies such as Flash. The last question, "Connection to Content Management database... (which could contain archival and historical records)..." was intended to address the needs of many historical and other Digital Humanities practitioners to connect or embed mapping within a CMS such as Drupal or Omeka which stores archival data. As a niche question, it was perhaps unsurprising that this was considered unimportant by some.

Figure 13: User needs survey Technical Considerations - Mean scores

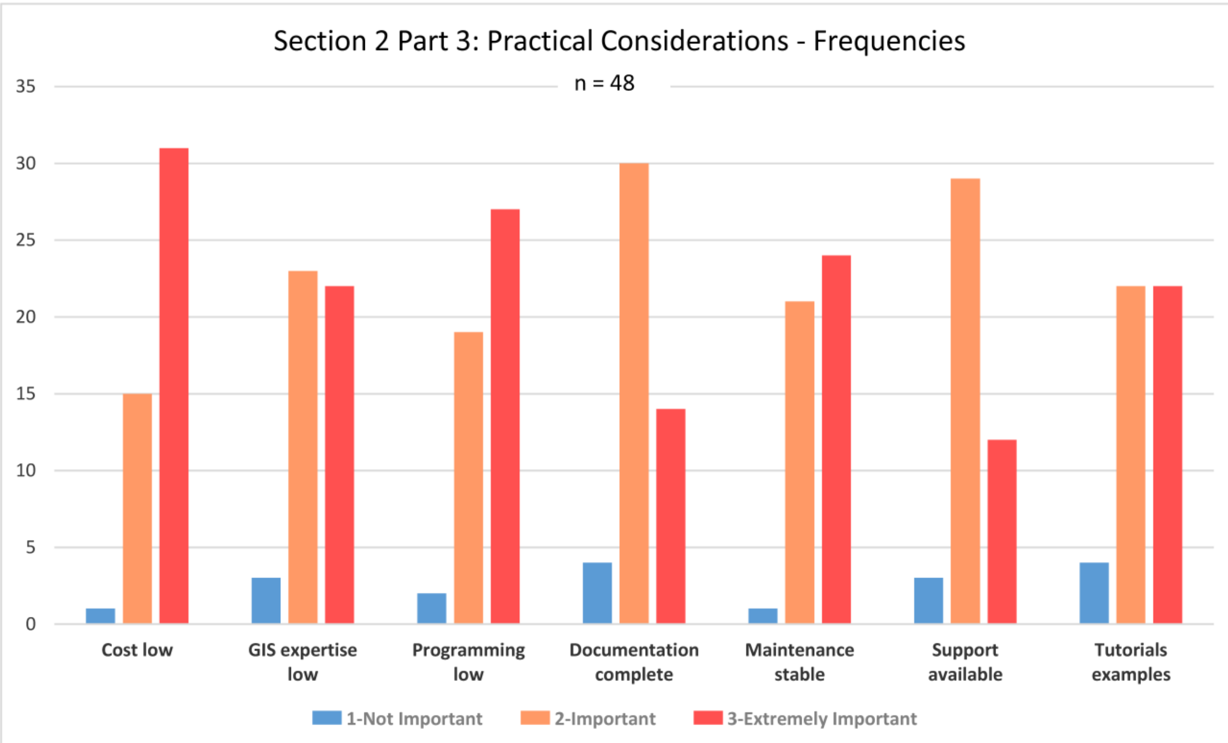


Looking at the breakdown of these questions by user type confirms that there are solid consensus of opinions for most, and may shed some light on the few unexpected findings noted above. It confirms the somewhat surprising fact that Mobile support is rated relatively low across the board, even moreso by students than by others. For CMS connected, it shows that the highest support is from Professors, and the lowest from Students. This does seem to indicate that students may not be as familiar with these kinds of research needs, and that they are most important to academics in specific fields that use these types of systems.

Section 2 - 3: Practical considerations

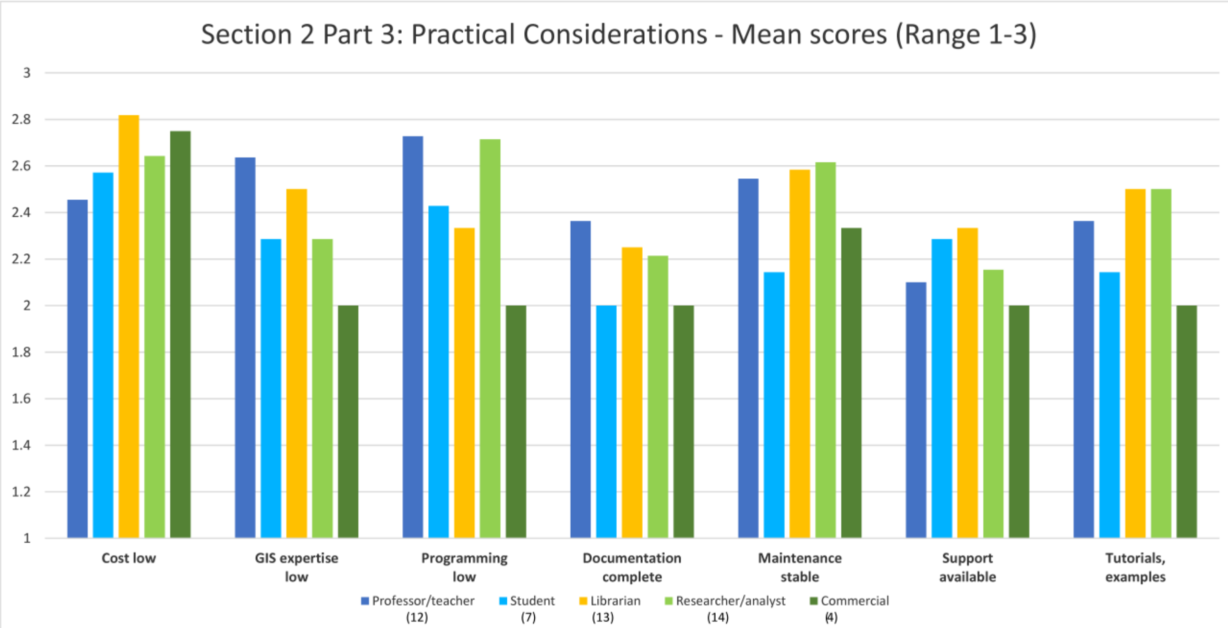
These questions address the practical and logistical issues related to implementing web-mapping for historical GIS: cost, expertise, maintenance and support.

Figure 14: User needs survey Practical Considerations - Frequencies



The question about "Cost" just considers the up-front or licensing cost of the technology, although of course all these considerations have an "operating cost" attached. (In retrospect, we probably should have used "Pricing" rather than "Cost" in this case.) As might be expected, this is widely considered very important. Regarding the necessary expertise to use the web-mapping technology, a significant proportion would like to do this without being an experienced GIS user, and an even larger number think it is important not to require web Programming expertise. These questions should have an impact on the types of technologies that we would recommend to an audience represented by our survey respondents. The last four questions, on aspects of support, show that documentation and support are important, but that Maintenance ("...long-term stability of the technology...") and Tutorials/examples ("...descriptions or demonstrations of how to implement the technology...") are even more important.

Figure 15: User needs survey Practical Considerations - Mean scores



When we review how the responses for practical considerations are broken down by user type, we again find overall consensus among groups. Related to the expertise questions, Professors and Librarians appear to want technologies requiring a low level of GIS expertise most strongly. Interestingly, Professors and Researcher/analysts think most unanimously that a low level of Programming expertise should be required. Again, if this is the prime audience for the partnerships services, we must take this into account. Regarding the final four questions, again, they are all considered important across the board, with Maintenance and Tutorials/examples a bit more so, especially in the long-term academic community. Comment by student RA regarding these results was : "Expected support and documentation to be ranked 'very important', but was ranked only 'important'. Seems like the users expect the system to be very intuitive, easy-to-use and user-friendly with little assistance needed." This may be true, however this may also reflect the multitude of video tutorials that seem to accompany many of the web-mapping platforms, and also represent the heavy reliance on examples or snippets of code which are used extensively as the basis for coding in the Open Source web-mapping community.

Section 2-4 : Open question at the end of Section 2

Are there any additional design, technical or practical considerations of web maps not listed above that are important in your team's design/development priorities?

Response rate: (7/50)
Comments and frequency:
Importance of ability or will learn to write simple codes, so that the web application can be modified, customized and enhanced (1)
Need for programs to be available in French (1)
Need for data portability, especially to move data easily if the technology discontinues (1)
Need to download data easily (1)
Need for multi-map views with comparable legend and histogram overlay (1)
Need for user input tools: to add comments, or to add box tools to add new data into the system (1)
Emphasize importance of CMS integration (1)

Summary of Section 2 results

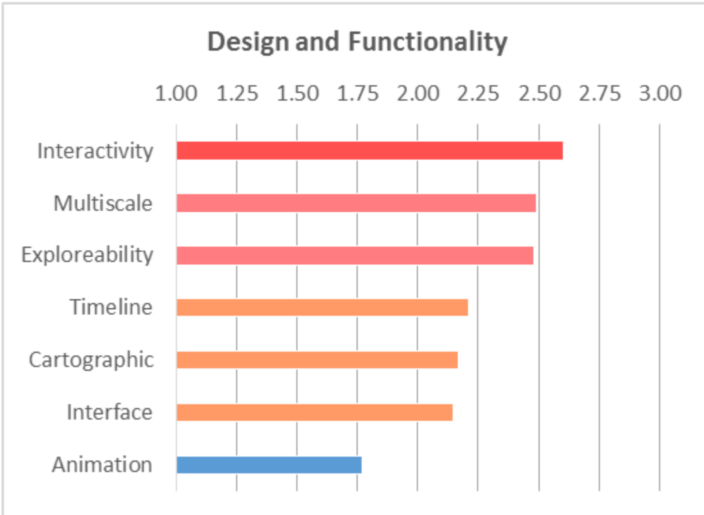
Figure 16, below, shows the overall mean scores for each question in Section 2, in descending order. This depiction hides some of the detail discussed above, both in terms of frequencies and user types. However, the results show broadly that respondents are looking for low-cost, easy-to-use and reliable web-mapping technologies, that allow their audience to explore their data in a flexible, user-centric way. They put a high emphasis on both multi-scale and highly interactive data exploration. Still important, but somewhat less so according to this survey, are sophisticated data representation capabilities. Customizability of cartographic representation and interface are highly desirable, but not essential to all. Niche functionalities, such as timeline sliders, animation, and CMS embedding, are very important to some sub-groups but not to all the respondents.

In terms of technical considerations, speed and scalability, and independence from browser type, operating system or plug-ins are all very important. Notably, these results are similar to those found by Roth et al in their study (Roth et al, 2014, p. 37). Support for mobile platforms is less uniformly highly valued.

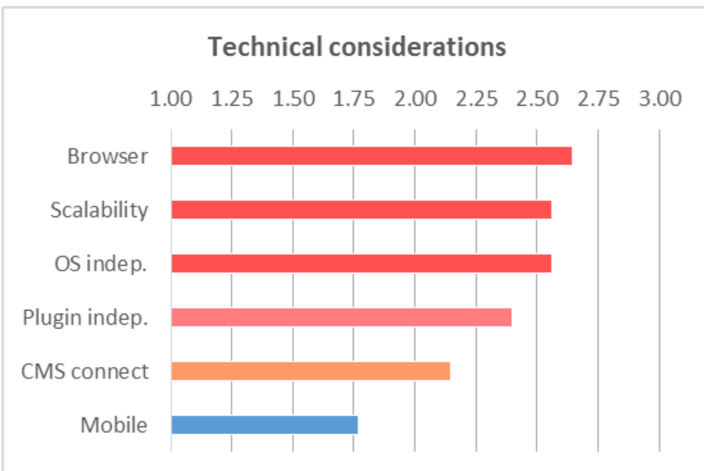
In terms of practical considerations, Costis the greatest issue. This applies to up front pricing, but also seems very importance in terms of secondary costs: time and resources spent in developing GIS and/or programming expertise, and maintenance costs such as down-time or upgrading costs for unstable or oft-changing technologies. Minimizing the difficulties and cost represented by these categories are all also very important to our respondents. Good documentation and support is also important, but somewhat less critical overall.

Students seem to expect more than the other groups in functionality and design, and expect less when it comes to technical and practical considerations. All other user types show a significant amount of similarity in most of the aspects considered here, with the occasional peak outlier for functionalities favoured by specific user groups.

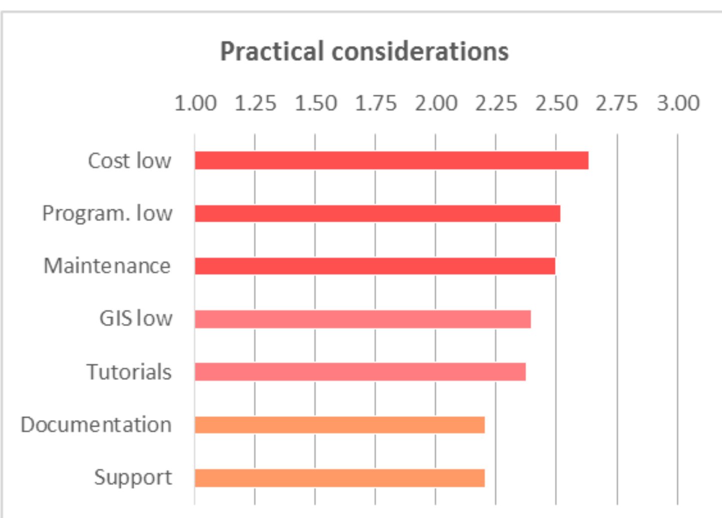
Figure 16 - User needs survey overall mean scores for each question in Section 2, in descending order



Section 2-1
Design and functionality



Section 2-2
Technical considerations



Section 2-3
Practical considerations

Section 3: Experience using Historical web-mapping technologies

Section 3-1: Technologies respondents had used and rating of engagement

Section 3 asked respondents if they have had experience creating or experimenting with historical web-mapping technologies. (See Appendix 3, Section 3 for layout.) If they had not, they were to skip this section. If they had, they were to rate their engagement with the list of technologies, choosing one of four options:

1. I have not heard of this technology
2. I have heard of this technology, but have NOT used it
3. I have used this technology within the past year
4. I have used this technology, but NOT within the past year

The candidate technologies were selected through the process outlined above, i.e. the competitive analysis we conducted by looking at technology websites to establish what they claimed to do, and experimenting briefly with each of them to evaluate these claims. The technologies were listed in alphabetical order in the survey. The results of this polling of technologies appears in tabular form on the following pages. The technologies are listed grouped by "Technology category" as defined in our classification scheme above, in the results tables. Figure 17 shows the frequency of each response for each technology. Each response option is colour coded, which effectively turns the table into a stacked frequency chart. Figure 18 shows the same data, but sorted by user type groups, to get a better understanding about differences in user experience between these groups.

The multiple choice listing of technologies was followed by three optional questions asking for written answers about the nature of their experiences with these technologies (how useful, whether abandoned, suggested improvements.) The responses for these will be summarized in the following section, on results to textual questions.

Figure 17 shows overall frequencies of use by level of engagement. One interesting point is how many of these technologies are unheard of by the majority of respondents (white area.) There were two technologies which had been heard of by a few but not used by any of the respondents (Heurist and Geomoose.) Heurist is popular in the Digital Humanities communities, Geomoose is a Mapserver based framework and was very popular among the FOSS4G (Free and Open Source for Geospatial) community 5-10 years ago. These observations emphasize two things: the rapid rate of change in popularity and usage among technologies (especially in the Open Source community,) and the widespread phenomenon of "siloing" (based on anecdotal evidence and some of the comments below) among user communities or within institutions, due to costs related to experimenting with and adopting new technologies (also found by Roth et al, 2014, p. 39.)

Looking at technologies that have been abandoned by many users is also instructive. These dominate in the Time-Enabled Map Mounting Services category, featuring more abandonments than current users. This category generally uses a time-line driven visualization approach, so high levels of abandonment may indicate a need being inadequately filled, or alternatively, a technology category becoming obsolete as similar tools are starting to be offered within more flexible technologies. The textual responses may help explain some of these questions.

Figure 17 shows that the technologies most commonly currently used were [Esri] ArcGIS Online and Google Maps API, each used currently or in the past by close to two-thirds of the respondents. Esri Story maps were also heavily used currently, by 36% of respondents. The Esri dominance is undoubtedly related to the accessibility of their products within the academic community, where licenses are available without cost or with an unperceived cost (institutional site-license). It is also undoubtedly related to the success of their products in providing positive results to users.

Figure 17: Experience using historical web-mapping technologies

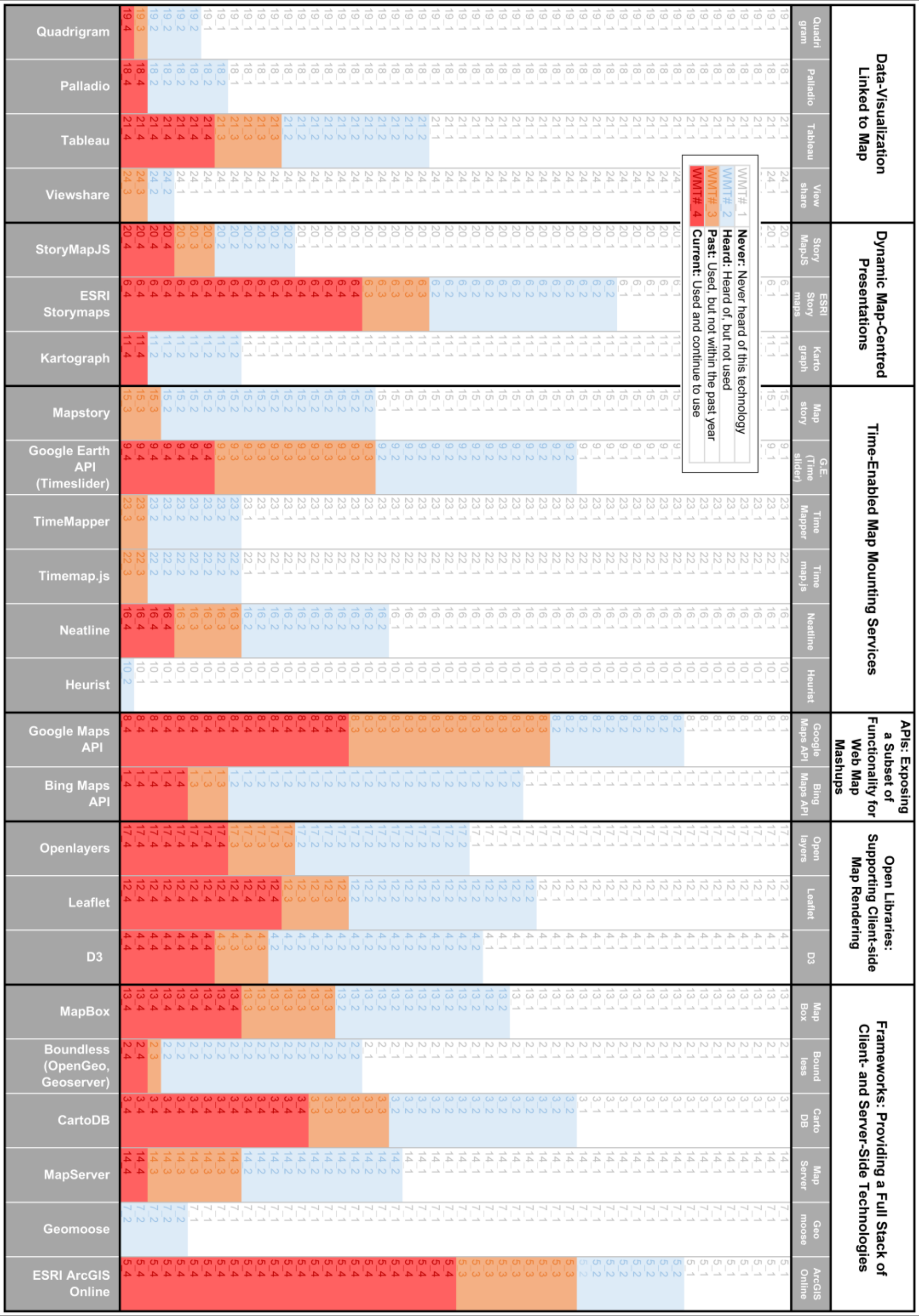
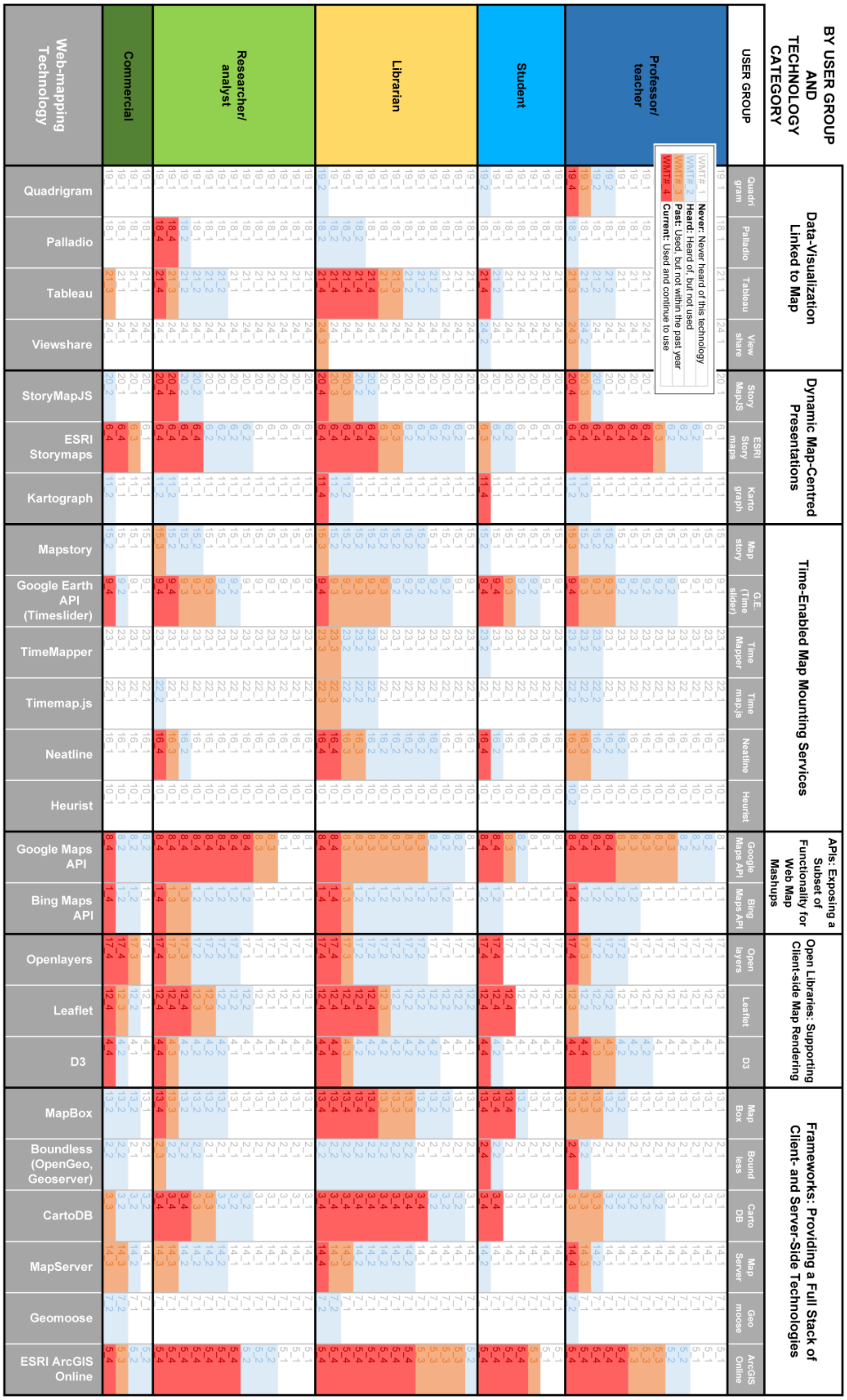


Figure 18: Experience using historical web-mapping technologies, by user type



We can analyze these results grouped by Technology category, and by examining Figure 18 as well, by user groups within these categories.

Data-Visualization Linked to Map: The most significant player here is Tableau, which is a business-oriented data visualization tool, followed by a few users of Palladio and Quadrigram. Tableau provides a quality product, and has very proactive marketing, especially via social media. Librarians make up the majority of its users among our respondents.

Dynamic Map-Centred Presentations: Esri Storymaps dominates this category, and as stated, is relatively widely used. The Esri Storymaps originally were conceived as the main Esri online application format, but they have devolved into a series or subset within the Esri ArcGIS Online web application templates. Having said that, they are still widely used as a map-based narrative format, and straddle all of the user type groups. The others in this category appear to be somewhat deprecated and occupy a niche among certain users.

Time-Enabled Map Mounting Services: Google Earth API using the Timeslider tool is the most used, followed by Neatline. See comments above regarding abandonment of this category. An interesting and possibly instructive case is MapStory, which was well funded and supported by academic and private foundations at its inception, produced awebsite on whichtimeline-based mapping worked fairly well, and seemed to be gathering a large community of users and sponsors by 2014. Since October 2015, however, it has been undergoing a massive technical re-working, and is essentially non-functioning, therefore abandoned by our respondents who had been using it. (See presentation from June 2016 mid-term conference on our website at: http://geohist.ca/wp-content/uploads/2016/07/CHGIS-June-2016-presentation-Marino.pdf.)
Neatline is based upon the Omeka Content Management System and continues to be somewhat popular among librarians and archivists.

APIs: Exposing a Subset of Functionality for Web Map Mashups: Google Maps API was used most frequently, Bing Maps API rather less - like the web maps themselves. They provide similar functionality, although Google is more robust (Roth et al, 2014, 39) but within a closed API which therefore provides little latitude for modification or customization on non-Google web servers. Google does provide good out-of-thebox functionality, integration with other Google tools (eg. Fusion tables) and quick start-up, especially for point-based web-mapping, and so has proven popular among in the academic community as seen by high proportions of professors and researcher/analysts who still use it.

Open Libraries: Supporting Client-side Map Rendering: Respectable numbers of respondents are using these Open Source, code-based modular javascript libraries, which is somewhat surprising given the preference for low-programming expertise solutions. Presumably this is a significant minority (eg. 24% of all respondents use Leaflet) who see these as the wave of the future, a common perception among the FOSS4G community. (Roth et al, 2014, 39-41.) Students are fairly well represented in this category, probably reflecting the use of these technologies in webmapping courses. Openlayers started first and has the most comprehensive set of mapping functionalities; Leaflet is perceived as more user-friendly in coding and more mobile-oriented; D3 is a more general data visualization tool (D3= data driven documents) with excellent tools for animation of data and graphic complexity, which also can be applied to maps. In general, these three technologies address somewhat different needs.

Frameworks: Providing a Full Stack of Client- and Server-Side Technologies

The most comprehensive category with the most robust features, these are heavily used by respondents. Esri's ArcGIS Online dominates current and former use (68% of respondents), followed by CartoDB (40%) and then by Mapbox (36%), which also attract significant numbers. ArcGIS Online use is evenly spread among user groups. Mapbox and CartoDB are also spread out among all groups except Professors and Commercial users. CartoDB is used heavily by Librarians, with an interesting zero abandonment rate among them, perhaps reflecting the significant investment of time/resources required to develop web-mapping with this technology, which then inhibits change. The other Frameworks technologies listed, Mapserver, Geomoose, and Boundless (Geoserver), have been popular in the FOSS4G development community in the past, but apparently have little current up-take among our survey respondents. CartoDB, MapBox, and Boundless are all companies which have grown out of the FOSS4G movement, and still provide their code as Open Source on Github, however they have moved away from their original concentration on providing source code, towards a new business plan focused on providing services: cloud-based hosting of map design and map services, consulting services, and customization of mapping and analysis for delivery on the web and by mobile. At the same time, Esri through ArcGIS Online has been moving towards the same place, from the opposite direction: away from desktop-based GIS towards online cloud-based services and solutions, while making (or continuing to make) much of their supporting code free for customization on Github as well (web application templates, for example.)

Section 3-2: Open questions at end of Section 3

3-2a. Among the above technologies used by you (or your design/development team), which do you use most commonly in your projects? What aspects of these technologies make them particularly useful in your work?

Response Rate: (30/50)
Mentions of technologies most commonly used and frequency:
CartoDB (10)
ArcGIS (9), ArcGIS Online (6), Esri Story maps (3)
Leaflet (8)
Google Maps (6)
D3 (4)
Google Earth (3)
OpenLayers (2)
Open Geo Tools, Quadrigram, Nunaliit, Zoomify, Torque.js/Turfs.js, MapServer, Post GIS, FME, Cartouche spatial de Drupal, Google Fusion Tables, Palladio, Mapwarper, Google My Maps, ArcIMS, Storyline JS, Geoserver (ALL 1)

Aspects of these identified as particularly useful, and frequency of mentions:
The ability for customization (4)
Easy to learn/use (4)
Having great visualization/User Interface (3)
Support timelines (3)
Low cost (3)
Fast speed (2)
Flexibility/options, Good documentation, Integration of aerial photography and imagery, Cloud storage (ALL 1)

Selected interesting comments:
"OpenLayers and D3. These tools easily integrate with other components."
"It very much depends on the partners that I am working with, and their audience/goals. Sometimes I recommend/use web-based platforms like CartoDB, sometimes Storymap JS, and other times ArcGIS/Online or Leaflet..."
"I am using Google Maps and Palladio currently to work on a project. I use Google maps to plot out events and information such as coordinates, and then build my data tables for use in Palladio. Google Maps is very useful ... I use it as a kind of geospatial notebook..."
"In terms of webmapping, I generally turn to CartoDB because it is easy to learn/teach..."
"Speaking in the past: Boundless (OpenGeo) tools and Leaflet have been used most often. D3 is becoming more commonly used in current work. It was crucial that we have a toolset that was configurable, compliant to open specs, and was available without ongoing licensing fees that would create budgeting difficulties for community partners."
"ArcGIS Online (not my personal preference, but the basics are easy to teach to non-coders). Mapbox builds on Leaflet to offer more customization options and I find it to be the most pleasing to use. Timelines and other display options for date-time attributes are very useful. ..."

3-2b. Among the above technologies used by you (or your design/development team), what would you like to see added to these technologies that would make them even more useful in your work?

Response rate: (21/50)
Features that would improve the web mapping technology:
Intuitive/easy map data representation without coding (3)
Aerial photographs and satellite imagery - easy to access and use (2)
Multiple image layers including historical maps - easy to access and use (2)
Basemaps - easy to access, use and customize for historical boundaries (2)
Time slider/timelines/multiple maps over time with shared legend(2)
Better tutorials, documentation (Leaflet, Palladio) (2)
Better data discoverability (CartoDB) (1)
More integration of FOSS4G components into ArcGIS Online (1)
Templates for particular projects/thematic maps organized by 'research objective' (1)
The ability to add animation (documentary, visual, audio) alongside a map (1)
Easy loading of datasets into Google Earth (1)
Ability to change projections, avoid Web Mercator (1)
Space for project description, metadata, publishing (1)
Improved storymapping (functionality of ArcGIS w ease of use of StorymapJS)
More GIS analysis options without limitations like licensing
Ability to show relationship or network visualization (1)

Selected interesting comments:
"Definitely, the ability to load a raster layer [an archival/historic map.] Every historian I talk to wants this."
"The data discoverability could be improved. ArcGIS online does this better in my experience."
"Projections! - I'm getting sick of looking at the same Web Mercator style map tiles on small scale zoom levels. This seems to be slowly becoming capable though with the development of of vector tiles and tools like D3.js."
"Ability to display documentary, visual, audio, or audio-visual context alongside a map."

3-2c. Among the above technologies used by you (or your design/development team), which have been abandoned completely? What aspects of these technologies led you to abandon them?

Response rate: (15/50)
Web maps that have been abandoned:
Google products (4)
ArcGIS Online (due to cost/not much customizability)
D3.js (useful for real time data/interactive inforgraphics but mapping functionality/capabilities was not sufficient for needs)
GeoCommons (become open source and ESRI purchased it)
WorldMap from Harvard (aesthetic reasons)
Google Earth (ArcGIS to KMZ functionality not very good to use, likely looking for data that can be easily converted to the Google Earth platform)
Kartograph (deprecated)
Bing (ALL 1)
Other reasons for abandoning other technologies: lack of interoperability, institutional abandonment, cost-to-licence and programs that require coding (ALL 1).

Selected interesting comments:
"I got into web mapping after Flash, but I've visited a lot of broken digital history projects over the past year**. How do we future proof these projects**?"
"I used to love GeoCommons (it had time animation capabilities several years ago) but it started out open source, got purchased by Esri, and they ran it into the ground (it was an ArcGIS Online competitor)."
"Not me personally, but again the profs in my department who want to use mapping in their teaching abandon their attempts when they find they cannot incorporate historic/archival maps as a layer."
"The technologies are listed in your study are predominantly GIS or API development. They are for dedicated experts in cartography or IT development. Historians or other business experts (eg. epidemiological, statisticians) find these technologies barren."
"Anything that requires coding!"

Section 4 - Future considerations for Historical web-mapping
(Optional: Answer these questions if you have an opinion about them)

These were open-ended questions inviting respondents to write a short textual answer. Response rates varied from 17/50 to 30/50, and are listed with the questions, below. These responses have not been analyzed as such, but similar answers have been represented by key words or phrases, and the frequencies of those key phrases is listed in parentheses following them. "Selected interesting comments" have been extracted and quoted as well, for each question, as representing a common or synoptic sentiment within the user community. These have been studied and then considered in the formulation of the proposed principles of practice and plan to implement a pilot website, in Part 5 below.

4a: What is your favourite or preferred historical web-mapping or geovisualization website?

Note: The responses to this question may not provide as much insight as expected because some answered with sites dedicated to HGIS projects, and others identified technologies they like to use.

Response rate: (22/50)
Favourite technologies:
ESRI Storymaps (2)
CartoDB (2),
ArcGIS Online, Google Earth Pro, Omeka, Neatline, Google Maps, Palladio, MapStoryJS by Knightlab, Google MyMaps, Nunaliit (ALL 1)
Other Websites Listed:
https://maps.library.utoronto.ca/dvhmp/ (Don Valley Historical Mapping)
http://digital.library.mcgill.ca/countyatlas/ (Canadian County Atlas Project)
http://republicofletters.stanford.edu/index.html (Mapping the Republic of Letters)
http://peoplemaps.esri.com/toronto/ (Toronto Historic Maps)
https://www.ined.fr/fr/tout-savoir-population/graphiques-cartes/cartes-interactives-population-mondiale/ (La population en cartes interactives)
http://www.paninuittrails.org/index.html (Pan Inuit Trails)
http://www.davidrumsey.com/ (David Rumsey Map Collection)
http://historicalmaps.arcgis.com/usgs/ (USGS Historical Topographic Map Explorer)
http://www.port.ac.uk/research/gbhgis/ (Great Britain Historical Geographic Information System)
http://globaia.org/portfolio/maps/ (Globaia)

4b: What would you like to see online in historical web-mapping or geovisualization which you do not see now?

Response rate: (17/50)
Users would like to see:
Downloadable data (9 - in one form or another)
Greater integration with other applications, an intuitive plug-and-play animation application, ability to download data and perform complex queries, custom base maps, more municipal data records, open linked data, **how-to guides (showing instructions, and not just simple tutorials),** project and results-level data available, historical analysis tools, geo-referenced data, story-telling capabilities, ability to save work, projections and timeline slider. (All 1)

Selected interesting comments:
"Custom base maps (e.g. map tiles) that change over time alongside the overlaid data. For example, if a map is showing point data from 1900, have the base map a tiled paper map from the same era. Then if the user selects 1920 data, then the base map would change..."
Note: like "USGS historical topographic map explorer" site: historicalmaps.arcgis.com/usgs/
"A decent repository that is data rich, modern, contains decent historical analysis tools online and is highly visual in terms of historical map content."
"For Palladio, some ability to save work. You can download projects, but I am finding that the work is not always saved the way you created the map."
"More attention and commitment to the need to create and distributing robust datasets, so that every project does not need to reinvent the source data..."
"I would like to see data that is both spatially referenced, indexed and subject searchable and temporally cataloged."
"How to guides: Many researchers are interested in working with these technologies, but are unfamiliar with the tools, skills needed, even basic hardware and software needs. There are a significant number of tutorials available, often software-specific, but a library of project descriptions, with basic steps to getting projects 'off-the ground' or examples that researchers could break-down into step-by-step "how to's" would be a valuable resource, especially for institutions without a GIS or DH-focussed support centre."

4c: What historical/geographic data set you like to see made available online, which is not available online now, or is inadequate?

Response Rate (23/50)
Data that users would like to see
Census of Canada boundaries for all years (4)
Historical aerial/topographic photography (2)
Historical road networks (2)
Historical railways (2)
Updated/improved Historical Atlas of Canada (2)
Prairie Township grids, Agricultural census data, police records, city directories, MAP infrastructure, , political boundaries over time, provincial park datasets, satellite imagery, First Nations land claim changes, pipelines, federal/municipal data, CHS charts, provincial air-photos, historical land cover, boundaries of National and European countries (ALL 1).

Selected interesting comments:
"It would be useful to see more local municipal data records available from past years to present, particularly in the form of demonstrating the development of the municipality."
"Historical boundaries that look decent at large-ish/subnational scales are a [difficult] thing to find. There are a couple available (http://nils.weidmann.ws/projects/cshapes.html and http://www.cartotalk.com/index.php?showtopic=3462) but the scale of capture isn't that great, especially for dataset linked from CartoTalk. The Cshapes one is pretty great but only goes back to 1945. It'd be a hell of a project and maybe other resources exist somewhere, but historical boundaries are both valuable and rarely exist for the time period and/or location researchers require."

4d: We are considering creating a "Historical web-mapping technology profiles" section on our project website, where different technologies would be described and reviewed, and users would be able to comment based on their own experience and make recommendations about usefulness or suggestions for improvements. Is this something that would interest you and to which you might contribute based on your own experience?

Response Rate (30/50)
Is this something that would interest you and to which you might contribute..?
Most respondents said yes and would find it useful/insightful (25)
Some said maybe or that they would read but not contribute. (4)
One user said it was not necessary/appropriate for this project, more important to focus on specific technologies/tools (1)

Selected interesting comments
"I believe so. It is often that I find that I have never heard of a technology/tool that would have made my work better and easier. Having a place where I can browse and read about existing mapping technologies sounds great!"
"This would be useful. It might also be interesting to backwards engineer existing websites. "How did they do that" kind of posts."
"It would be useful to have a compiled list of various web-mapping technologies available to better understand their applications."

Part 5. Next steps: Developing principles of practice and for Canadian HGIS web-mapping activities, and plan to implement these in our Partnership development pilot website

Since there are so many different ways and means of visualizing these historical geographic questions, how can we as a group contribute to make it easier and more effective for users to create a web-mapping site for their research? How can we help them to choose and implement an effective way of visualizing their HGIS data and information? And how much of this question relates to the technology chosen, as opposed to the overall design approach that is taken, or to the availability and quality of data?

This Working Paper has attempted to analyze these questions in a systematic way. Part 1 attempted to identify what the current state of affairs is in HGIS in web-mapping and some of the inherent issues. Part 2 attempted to develop a classification for the available approaches and technologies. Part 3 has evaluated these tools using a number of different methods: describing them according to their stated goals, in a standardized way; comparing them against each other using a competitive checklist related to HGIS purposes; and mounting a user needs survey. The latter is reported on in Part 4, to understand our members' experiences with different technologies, and to see whether these technologies succeed well or poorly, relative to their implicit goals. From the latter we are also attempting to understand users' desires for future development. The next step in this process will be to analyze the results of these investigations in order to determine a set of principles we can apply to developing these tools, and make recommendations to users about how to meet their own goals. An initial attempt at formulating these is below.

(Proposed) Principles of practice for Canadian HGIS Partnership web-mapping activities

1. Support long-term sustainability and sharing of data and mapping
2. Support of visualization for both presentation purposes and data exploration and analysis
3. Support transparency of the web-mapping process, through good meta-data and documentation
4. Support of multiple platforms, both technical (OS, browsers) and mapping (including proprietary and FOSS4G technologies)
5. Working collaboratively to avoid duplication of effort and competition among current collaborators and potential partners

In addition to these principles, however, a plan is needed to explore how best to implement them in web-mapping activities. The following proposes a three-pronged approach.

(Proposed) CHGIS Partnership development web-mapping pilot website activities

a. **Analytical evaluation framework:** A set of questions to consider and evaluate in deciding on historical webmapping approach and technology
b. **Historical web-mapping technology profiles**: Standardized descriptive comparison of technologies, incorporating "reviews"
c. **Comparative examples of web-mapping approaches:** Examples of historical webmapping projects using the same data and citing the same goals but using contrasting technologies

5a. Analytical evaluation framework

The user needs survey and discussion at our meetings has indicated it would be useful to create an analytical framework for evaluation of a specific project's HGIS web-mapping data, goals, capabilities, and expectations. It has been suggested that part of this could be a checklist of questions that will constitute a "visualization needs analysis" for a specific historical GIS data set and use scenario. If possible, we may also be able to incorporate a tool designed to match users' needs and constraints to an appropriate design approach and technological solution.

Some of the important questions to consider for the historical geovisualization evaluation framework could be:

1. What are the stated communication goals for the webmap?
2. What is the target audience for the webmap?
3. What are the range of interaction options required for the webmap?
4. Given the above, what are the appropriate data to include for the webmap?
5. Given the above, what is the range of representation options for the webmaps?
6. Given all these, what is the range of technological options for the webmaps?
7. Can we come up with a list of "recommended" technology options?

One example of an online tool which takes a similar approach is the "Choosing Visualization for Transportation Knowledge Sharing" website, a project funded by the U.S. Federal Transit Administration. (See: http://www.choosingviz.org/). It has classified the visualization capabilities of 90 technological options, and provides a questionnaire-based tool for narrowing down the choice based on stated user needs. One issue with the site is that some of the technologies are out of date, if not obsolete. This emphasizes the need for a long-term plan for maintenance and updating of any web resource of this kind.

5b. Historical web-mapping technology profiles

The "Standardized descriptive comparison" of web-mapping technologies that we have begun to develop in this Working Paper will be used to generate a set of historical web-mapping technology profiles. The proposal is to mount these on the website, with a specific table or page for each technology. It may also be useful to include a tabular checklist of Representation/Interaction capabilities like that developed for the Competitive Analysis (see Figure 8 above) as an alternative way of describing each technology.

We will enlist the collaborators and partners in our project, many of whom have expertise in many of these technologies, to help in completing these descriptions, and will circulate these privately to the group for feedback before posting publicly. We also plan to incorporate a forum for users to communicate with each other about these tools. We suggest a "technologies review" section, where people could post reviews, or comment on others' opinions about technologies. Again, we intend to enlist volunteers from our collaborators and partners who have experience and expertise with specific technologies to act as expert curators for individual pages on the site. These people will be asked to be responsible for answering questions or moderating discussion about that tool.

As indicated above, this format has much in common with the work of the "GeoDirt" folks - the Geohumanities Special Interest Group of the Association of Digital Humanities Organizations (See: http://geohumanities.org/geodirt.) We have been in contact with them recently to see what basis for collaboration can be established, and what resources, data or expertise we may be able to share in developing our project's version of web-mapping technology profiles for historical GIS.

5c. Comparative examples of web-mapping approaches

Our original project proposal envisaged an interactive mapping website illustrating "best practices" of historical GIS project work. The main conclusion of all of the research and discussion in the project so far must be that "best practices" are dependent on the goals, needs and constraints of any specific project. Therefore, it is proposed that the method we should use for creating comparative examples of web-mapping should be to take some "typical" sample sets of historical GIS project data, enunciate specific goals for each of these in terms of the web-mapping priorities we learned about in our users' needs survey, run these through the analytical evaluation framework outlined above (by way of illustrating that process) and then develop web-maps and mount them online using several different technologies which have been identified as likely candidates to achieve the project goals. In this way we can demonstrate contrasting approaches embedded in a variety of technologies, to illustrate at least one example of how they work for different sets of data and for different users' goals.

The executive committee and project staff will choose the sample data sets and do the technical work involved in mounting these web-mapping projects. Collaborators and partners will then be asked to provide feedback on the sample sets proposed, and may be asked to provide data themselves. Where helpful, our project members will also be asked to advise or assist on the design and implementation of the web-mapping technologies selected. It is expected at least 3 project data sets will be utilized.

This part of the project will serve the complementary goal of testing the project's data distribution capabilities. The selected data sets will also be loaded into the pilot version of the Geoportal for the project. The attempt will be made to utilize the data directly from the Geoportal, where possible, thus testing how the data delivered may be used with different webmapping technologies. Special attention will be paid to point 3 in the list of principles above: the transparency of the web-mapping process, by means of meta-data and documentation. Efforts will be made to exemplify the meta-data standards as discussed in the White Paper on HGIS standards and best practices.

We will also try to document the web-mapping process in a way which would allow complete replication, to set high standards and a good example of what the partnership should expect in terms of project management and documentation. The suggestion has been made that it may also be useful to add detailed "how-to" documents for at least one of the example project data sets, for each of the candidate web-mapping technologies used for it. These would constitute a step-by-step walkthrough or tutorial exercise for users to follow to try out or test these technologies themselves. This would provide users with the opportunity to gain some practical experience with these technologies, allowing them to easily access and compare their basic capabilities.

Some sample data sets currently being considered are:

Historical Atlas of Canada Online Learning Project, Summary of Population Growth 1851-1961
http://www.historicalatlas.ca/website/hacolp/national_perspectives/population/UNIT_25/index.htm (Note: if viewing minimize browser window to a maximum of 1280x720 pixels)
Example of time series census data portrayed on a national scale.

Don Valley Historical Mapping Project (no webmapping currently)
https://maps.library.utoronto.ca/dvhmp/
Example of environmental change data in an urban setting, including multiple historical map sources.

Montréal, l'avenir du passé (selected applications - no webmapping currently)
http://www.mun.ca/mapm/eng/about_frame.html

Example of socio-economic data on a neighbourhood level in an urban setting, over multiple time periods.

Other possible suggestions:
A traditional First Nations historical land utilization mapping project. Perhaps based on:
Saskatchewan Métis Traditional Land Use Survey
http://www.hgis.usask.ca/saskatchewan-metis-traditional-land-use-survey/

Historical Railway map, based on map data compiled by Christopher Brackley, 7.5 million nominal scale, based on *Lines of Country* (Chris Andreae).
Example of historical infrastructure development over time.

5d: Next steps - Conclusion

The set of three approaches to web-mapping pilot website activities outlined above are ambitious within the scope of a short-term "development" project like ours, with limited resources. Discussion among the community and the executive has reached consensus that the project manager and RAs should make as much progress as possible on all three efforts - however, the priority on the web-mapping side should be approach **5c. Comparative examples of web-mapping approaches.** Over the remaining months of the project work will proceed to create sample projects online for several of the suggested data sets listed above. As much as possible, project collaborators and partners will be enlisted to participate and assist in this work. At the same time, the other project initiatives related to the Historical GIS data portal development, and work on best practices for Historical GIS, should be equally important priorities.

The final project conference and meeting has been set for the first week of June, 2017. At that time, reporting on the progress on each of these initiatives, and discussion of next steps for the partnership as a whole will be at the top of the agenda.

Selected bibliography

Battersby, S.; & Goldsberry, K. 2010. "Considerations in design transition behaviors for dynamic thematic maps." *Cartographic Perspectives*, 65, 16-32.

Brus, Jan, Alena Vondrakova, and Vit Vozenilek (eds.) 2015. *Modern Trends in Cartography, Lecture Notes in Geoinformation and Cartography*. Switzerland: Springer International Publishing. DOI 10.1007/978-3-319-07926-4_5

Carillo, German. 2012. Web mapping client comparison v. 6. Blog entry on website. http://geotux.tuxfamily.org/index.php/en/geo-blogs/item/291-comparacion-clientes-web-v6.

Dodge, Martin, Mary McDerby and Martin Turner (eds.) 2008. *Geographic visualization: concepts, tools and applications*. Chichester, England; Hoboken, NJ: Wiley.

Dodge, Martin, (ed.) 2010. *Classics in Cartography: Reflections on Influential Articles from Cartographica.* Chichester, England: Wiley-Blackwell.

Dodge, Martin, Rob Kitchin, Chris Perkins (eds). 2011. *The map reader: theories of mapping practice and cartographic representation.* Chichester, England; Hoboken, NJ : Wiley-Blackwell.

Gregory, I.N. and Geddes, A., eds. 2014. *Towards Spatial Humanities: Historical GIS and Spatial History.* Bloomington: Indiana University Press.

Knowles, Anne K. 2008. ed. *Placing History: How Maps, Spatial Data, and the GIS Are Changing Historical Scholarship.* Redlands, CA: ESRI Press.

Knowles, Anne Kelly, Levi Westerveld & Laura Strom. 2015. "Inductive Visualization: A Humanistic Alternative to GIS." *GeoHumanities,* 1(2), 233-265. DOI:10.1080/2373566X.2015.1108831

Kraak, Menno-Jan. 2014. *Mapping time : illustrated by Minard's map of Napoleon's Russian Campaign of 1812.* Redlands, California: Esri Press.

Kraak, M-J. and Ormeling, F. 2010. *Cartography: Visualization of Spatial Data*. 3rd edition. Chapter 8: Mapping Time. New York: Guildford Press.

Kraak, Menno-Jan and Allan Brown, eds. 2001. *Web cartography: developments and prospects*. New York : Taylor & Francis.

Lin, W. 2015. "Tracing the Map in the Age of Web 2.0." *Cartographica: The International Journal for Geographic Information and Geovisualization*, *50*(1), 41-44.

Muehlenhaus, Ian. 2014. *Web cartography : map design for interactive and mobile devices*. Boca Raton, FL : CRC Press.

Peterson, Michael P. 2014. *Mapping in the Cloud*. New York, NY: Guilford Press.
See website at: http://maps.unomaha.edu/cloud/index.html

Peterson, Michael P. (2015) "Evaluating Mapping APIs" in J. Brus et al. (eds.), *Modern Trends in Cartography, Lecture Notes in Geoinformation and Cartography*. Switzerland: Springer International Publishing. DOI 10.1007/978-3-319-07926-4_15

Poplin, A. (2015). How user-friendly are online maps? Survey based on experiments with heterogeneous users. *Cartography and Geographic Information Science*, 42(4), 358-376.

Pucher, Alexander. (2015) "Online Cartographic Atlas Products: Learning from the Past" in J. Brus et al. (eds.), *Modern Trends in Cartography, Lecture Notes in Geoinformation and Cartography*. Switzerland: Springer International Publishing. DOI 10.1007/978-3-319-07926-4_15

Robinson, A. (2011). Highlighting in geovisualization. *Cartography and Geographic Information Science*, 38(4), 373-383.

Roth R.E. (2011) A comparison of methods for evaluating cartographic interfaces. In: Proceedings of the 25th international cartographic conference, Paris.
http://icaci.org/files/documents/ICC_proceedings/ICC2011/Poster%20Presentations%20PDF/POSTERS%20SESSION%201/P-019.pdf

Roth, R. E. (2013). Interactive maps: What we know and what we need to know. *Journal of Spatial Information Science*, (6), 59-115.

Roth, R.; Donohue, R.; Sack, C.; Wallace, T.; & Buckingham, T. (2014). A process for keeping pace with evolving web mapping technologies. *Cartographic Perspectives*, 78, 25-52.

Roth R.E. (2015) Interactivity and Cartography: A contemporary perspective on UI/UX design from geospatial professionals. *Cartographica*. 50(2), 94-115.

Schobesberger, David. (2015) "Integrating User and Usability Research in Web-Mapping Application Design" in J. Brus et al. (eds.), Modern *Trends in Cartography, Lecture Notes in Geoinformation and Cartography*. Switzerland: Springer International Publishing.
DOI 10.1007/978-3-319-07926-4_15

Stefanakis, Emmanuel. 2015. *Web Mapping and Geospatial Web Services: An Introduction*. CreateSpace Independent Publications, July 2015.
http://www2.unb.ca/~estef/wmbook.html

Tsou, M. 2011. "Revisiting Web cartography in the United States: The rise of user-centered design." *Cartography and Geographic Information Science*, 38(3), 250-257.

Appendix 1 - List of candidate web-mapping technologies included in User Needs Survey

Data-Visualization Linked to Map	Quadrigram	www.quadrigram.com
	Palladio	hdlab.stanford.edu/projects/palladio
	Tableau	tableau.com
	Viewshare	viewshare.org
Dynamic Map-Centered Presentations	ESRI Storymaps	storymaps.arcgis.com
	StoryMapJS	storymap.knightlab.com
	Kartograph	www.kartograph.org
Time-Enabled Map-Mounting Services	Mapstory	mapstory.org
	Google Earth API (Timeslider)	developers.google.com/earth/documentation/time (deprecated) replaced by developers.google.com/kml/documentation/time
	TimeMapper	timemapper.okfnlabs.org
	Timemap.js	code.google.com/p/timemap (Google map version of Simile timeline http://www.simile-widgets.org/timeline/
	Neatline	neatline.org
	Heurist	heuristnetwork.org/
APIs: Exposing a Subset of Functionality for Web Map Mashups (generally built on open libraries)	Google Maps API	developers.google.com/maps
	Bing Maps API	www.bingmapsportal.com
Open Libraries: Supporting Client-Side Map Rendering	Openlayers	openlayers.org
	Leaflet	leafletjs.com
	D3	d3js.org
Frameworks: Providing a full stack of Client- and Server-Side Technologies	MapBox	www.mapbox.com
	Boundless (OpenGeo)	boundlessgeo.com
	CartoDB	cartodb.com
	MapServer	mapserver.org
	Geomoose	geomoose.org
	ESRI ArcGIS Online	www.arcgis.com/home

Appendix 2: Examples of Standard Descriptive Comparison of selected web geo-visualization technologies

CartoDB - https://cartodb.com

- **Classification: Multi-purpose webmap technologies -> Frameworks -> Open frameworks**

CartoDB is a commercial, subscription based web mapping service provider. They provide data storage, visualization, and publishing especially geared to geographic information and web mapping. The web application consists of a set of online interfaces and APIs that support data import, storage and filtering; map configuration using predefined base maps and user data; and publishing onto the CartoDB web map platform.

On Cartodb.com's infrastructure, all activities are subscription-based, although a free tier is provided with limited storage, limited number of data layers supported by each map, and no privacy or brand customization features. CartoDB also offers enterprise solutions ranging from running a server instance on dedicated hardware managed by them to running a supported server within corporate institutional premises with support from CartoDB but these options are expensive. The implementation of CartoDB is available as open source but the installation is complex, existing documentation (http://cartodb.readthedocs.io/en/latest/install.html) is written in terms of an old operating system version (Ubuntu 12.04), and as a result the current state of software dependencies is not clear.

CartoDB supports data import from a wide variety of local geographic data file formats and via connections to commercial cloud storage providers (e.g., Google, Dropbox, Box) and to ArcGIS Server. The online Editor provides many cartographic styles and a reasonably intuitive interface for creating maps and configuring the look of layers in the map. Simple time line animations of data sets can be configured.

- Base Platform or Application: CartoDB (based on open source including PostgreSQL/PostGIS, JavaScript, Ruby, python)
- User interface: Menu/GUI, with code/script possible
- Programming language(s): JavaScript API
- Base map source(s): CartoDB provided (OSM data and Stamen designs), NASA Imagery available, custom and image base maps possible.
- Level of expertise for Programming: Low for basic features using interactive editor; Medium for use of APIs (JavaScript, HTML, and CSS can be directly edited for customization).
- Level of expertise for GIS: Low (although some understanding of geographic data formats would be useful).
- License/restrictions: Copyright CartoDB but rights granted for redistribution in binary and source code forms with attribution (separate open source licenses for bundled technologies; see above).
- Cost: CartoDB.com platform: free tier as described to Enterprise support at $825/month
  - Code: available free as open source.

D3 - https://d3js.org/

- **Classification: Multi-purpose webmap technologies -> Open libraries -> Open APIs (visualization libraries)**

D3 is a data manipulation library designed to enable data to be bound to elements in standards-based web documents and to allow standard web documents (HTML: HyperText Markup Language) to be structured based on the characteristics of data (e.g., the length of a list of numbers). By bridging the gap between data and web document structures, D3 can help you dynamically create document structures that reflect, and thus can be used to represent, your data. D3 also provides functions that can style HTML structures using web standards like Cascading Style Sheets (CSS) and can generate web standard graphics (SVG: Scalable Vector Graphics) to represent your data in a breathtaking variety of ways and with infinite possibilities for customization. But D3 is a programmer's toolkit and learning to use it effectively requires time and an understanding of some or all of the technologies mentioned.

D3 extensions support geographic coordinate systems very well. This allows geographic data (geographic coordinates with associated thematic attributes) to be manipulated much as any other data and allows geographically referenced data to be dynamically positioned within the graphics of a standard web document just as you would expect of any map drawing software. The result is that D3 can draw map layers on demand when given appropriate map data. Thematic map markers (e.g., locations of bike racks) can be styled using CSS.

Because D3 is a JavaScript library, it is straightforward to combine it with other web mapping clients that are also written in JavaScript (e.g., Leaflet or OpenLayers). This may allow for more complex base maps than you may want to create using D3 alone.

- Base Platform or Application: Standard Web Browsers.
- Programming language(s): JavaScript
- User interface: Code/script, with examples
- Base map source(s): D3 handles geographic data in GeoJSON or TopoJSON formats directly; can be combined with other JavaScript web mapping clients for more capabilities.
- Level of expertise for Programming: Medium-High. This is a programmer's tool.
- Level of expertise for GIS: Main focus of D3 is data manipulation; mapping with D3 would also require knowledge of geographic data formats.
- License/restrictions: Open source with a BSD license.
- Cost: Free and Open Source.

Mapserver – http://mapserver.org

- **Classification: Multi-purpose webmap technologies -> Frameworks -> Open frameworks**

Mapserver is used to convert geographic information, in a variety of formats, into web-friendly, transmittable information as part of web pages served using standard web protocols and formats (HTTP, HTML, CSS, etc.). The program was originally written in 1996 and is the longest-standing open source geographic web server implementation. Mapserver supports the server side of Open Geospatial Consortium (OGC) compliant services including web map services (WMS), web feature services (WFS), and web coverage services (WCS). It can also convert geographic information into a variety of image formats. Server side mapserver capabilities are often used in conjunction with client side web mapping libraries such as OpenLayers or Leaflet (running in a web browser).

Mapserver capabilities can be extended through the use of scripting facilities (MapScript) for which bindings have been created in a variety of programming languages (e.g., PHP, python, ruby). This can be used to augment basic web map functions to add map navigation or interactive drill-down capabilities or to provide access to additional, possibly non-graphic, information from other online sources such as databases and other services.

Web maps or web map layers are set up in Mapserver using a configuration file format specific to the system. These are generally written and installed on the computer server that runs the software using administrative access to that system. Although the open source GIS package QGIS provides some support for creating Mapserver configuration files, it is difficult to hide this configuration interface from anyone that would like to set up a map for web viewing. Except for very basic usage, creating web maps with Mapserver requires some understanding of a variety of web technologies including HTML, CSS, geospatial information formats, map projections, and likely at least one scripting language that has been bound to the Mapserver API (e.g., PHP, JavaScript).

- Base Platform or Application: Web server supporting Common Gateway Interface (CGI) capabilities.
- Programming language(s): Mapserver is implemented in C; MapScript can be used with a variety of programming language bindings.
- User interface: Code/script, with Menu/GUI possible (egs. QGIS, GeoMoose)
- Base map source(s): many common geographic information formats; OGC compliant services (e.g., WMS, WFS).
- Level of expertise for Programming: Medium (familiarity with web technologies is highly desirable).
- Level of expertise for GIS: knowledge of geographic information information concepts and formats would be very useful.
- License/restrictions: Open source with a X/MIT license.
- Cost: Free and Open Source.

GeoServer – http://geoserver.org/ (Also included in OpenGeo Suite: Boundlessgeo.org)

- **Classification: Multi-purpose webmap technologies -> Frameworks -> Open frameworks**

GeoServer supports publishing and editing geographic information on the world wide web using standards compliant service interfaces, especially the Open Geospatial Consortium (OGC) web map services (WMS, including transactional for online editing), web feature services (WFS), and web coverage services (WCS). GeoServer can read data from a variety of sources (e.g., spatial databases, other standards compliant services) and can convert geographic information into image formats or make it available through the OGC service APIs mentioned above.

GeoServer is implemented using Java and runs within an application server such as Apache Tomcat or Jetty. Most commonly, GeoServer's server side capabilities are combined with client side web mapping technologies such as OpenLayers or Leaflet to distribute and display web map data. Static styling configuration can be set up for maps and map layers and dynamic filtering can be applied from a capable web map client (usually as the result of user interaction).

GeoServer includes a management web interface which greatly simplifies the installation, configuration, and management of geographic information to be served.

- Base Platform or Application: Web server and java application server (e.g., Tomcat or Jetty).
- Programming language(s): GeoServer is implemented in Java, although this is mostly invisible to users of the system.
- User interface: Menu/GUI, with code/script possible
- Base map source(s): many common geographic information formats and sources; OGC compliant services (e.g., WMS, WFS).
- Level of expertise for Programming: low-medium (the web interface hides much complexity; configuration and installation require system administration knowledge).
- Level of expertise for GIS: knowledge of geographic information information concepts and formats would be very useful.
- License/restrictions: GNU GPL.
- Cost: Free and Open Source.
    - Support and services available through Boundless Geo, at a sliding scale of cost.

Appendix 3: Canadian Historical Web-mapping User Needs Survey

Note: Survey available online at:
http://geohist.ca/2016/05/a-canadian-historical-web-mapping-user-needs-survey
Available in French at:
http://geohist.ca/fr/2016/05/un-sondage-dutilisateur-cartographie

RECRUITMENT EMAIL

Invitation to participate in a User Survey: Web mapping for Canadian Historical GIS

As many of you already know, the Canadian Historical GIS Partnership Development project is underway to develop resources for conducting historical research in Canada using GIS (Geographic Information Systems) and other methods, and to explore ways of publishing the results of that research. A prevalent and popular method for doing this is through online mapping technologies. However, many different design approaches and software solutions are being used. We are conducting a survey to investigate current and emerging trends in the use of these technologies, and evaluate users' experiences and needs, and future desires.

The survey should take 10-20 minutes of your time, depending how many questions you choose to answer. It will provide valuable input to help direct the efforts of the project. To find out more please go to the survey page on our website:
http://geohist.ca/contact-us/web-hgis-survey

Thank you for considering filling out the survey.

Marcel Fortin, Principal investigator
Canadian Historical GIS Partnership Development Project

INFORMATION AND CONSENT FORM

Invitation to participate in User Survey: Web mapping for Canadian Historical GIS

Information and consent form

Principal investigator: Marcel Fortin,
Head, Map and Data Library,
University of Toronto
130 St George St, 5th Floor
416-978-1958 email: marcel.fortin@utoronto.ca

Project manager: Byron Moldofsky
Manager, GIS and Cartography Office
Department of Geography and Planning
100 St george St, 5th floor
416-978-3378 email: byron@geog.utoronto.ca

DESCRIPTION OF THE RESEARCH

You are invited to participate in a research study about using web mapping for historical research. This is part of a larger project to develop resources for conducting historical research in Canada using GIS (Geographic Information Systems) and other methods, and to explore ways of publishing the results of that research. A prevalent and popular method for doing this is through online mapping technologies. However, many different design approaches and software solutions are being used. The purpose of this study is to investigate current and emerging trends in the use of these technologies, and evaluate users' experiences and needs, and future desires.

WHAT WILL MY PARTICIPATION INVOLVE?

If you agree to participate in this research, you will be asked to respond to a series of questions about historical web mapping through an online form. It will take approximately 10-20 minutes to complete the survey.

WHO IS PARTICIPATING?

You are being asked to participate because of your interest in this subject - whether conceptual or technical. You may have used, or may wish to use these kinds of technologies for presentation or exploration of historical information. All potential users are relevant, whether primarily consumers, creators or designers of historical geographic web maps. Adult members of the academic, non-academic, government and commercial communities are eligible to participate. We expect in the range of 50 to 100 volunteers to participate.

HOW WILL MY CONFIDENTIALITY BE PROTECTED?

You will be asked for your name and email identification, to confirm you are a valid participant for the survey. You may be emailed for validation purposes. This information will be destroyed as soon as validation is confirmed. No identifiable personal information will be included or retained in the data, and all data will be collected and stored in a secure environment. Only the project investigator, manager and research assistant will have access to the data. The data will be destroyed at the end of the project (2017.) We anticipate using some direct quotations from
responses as representative examples of user opinion, but in the event we directly quote any of your responses, your anonymity will be protected as no identifiable characteristics will included.

HOW WILL THE RESULTS OF THE STUDY BE USED?
The results of the study will be published in aggregate form, as tables or charts illustrating responses. Publication will be in a summary report made available on the project website, and parts of the results may be included in subsequent reports, articles or presentations. These results will inform future plans for web-based resources to be developed by the project.

RISKS/BENEFITS
Risk to the participants are minimal. No personally identifying information will be retained linked to any of the collected data. Thus, there are no foreseeable physical or mental risks to participation. It is hoped and expected that participants will benefit from the insight gained about using these technologies, in the short term by reading the reports, and in the long-term by the success of the project in making it easier and more effective to design and use web-base historical maps, in Canada and beyond.

VOLUNTARY NATURE OF PARTICIPATION AND OPTION TO WITHDRAW
Your participation in this survey is entirely voluntary, and you may refuse to participate, or may decline to answer any question or participate in any parts of the survey – without any negative consequences. You responses are not recorded until the online form is submitted, so you may withdraw at any time during the survey. After submitting the survey, you may withdraw participation by contacting the study authors by email or telephone, up until the time that your identification data has been removed from your survey responses. Withdrawal at any time will have no negative consequences of any kind.

WHOM SHOULD I CONTACT IF I HAVE QUESTIONS?
If you have questions about the research itself, please contact the principal investigator Marcel Fortin or project manager Byron Moldofsky, as listed above.

If you have any questions about your rights as a participant, please contact the Research Oversight and Compliance Office - Human Research Ethics Program at the University of Toronto, by email (ethics.review@utoronto.ca) or telephone (416-946-3273).
The research study you are participating in may be reviewed for quality assurance to make sure that the required laws and guidelines are followed. If chosen, (a) representative(s) of the Human Research Ethics Program (HREP) may access study-related data and/or consent materials as part of the review. All information accessed by the HREP will be upheld to the same level of confidentiality that has been stated by the research team.

PROVISION OF CONSENT
By clicking the "Consent and Start Survey" button below, you agree to participate in this research survey according to the conditions explained above. This includes the possibility of your responses being quoted anonymously in subsequent research publications.
Please save this page if you would like a copy of the consent form for your records.

☐ CONSENT AND START SURVEY

ONLINE SURVEY QUESTIONNAIRE

About the survey:
Thank you for responding to this survey. It is directed at everyone interested in Historical GIS (HGIS) and visualizing historical information in a geographic context on the web, whether you have a casual interest or spend all your time professionally designing web-mapping sites. Although there are many fine distinctions in approaches to visualizing geographic information online, we use "Historical web-mapping" as a blanket term to cover all types of historical geovisualization.

The survey is organized as follows:
Section 1- Individual information: To identify what your interest is in Historical web-mapping **(required)**
Section 2: Needs and desires for Historical web-mapping technologies **(optional)**
Section 3: Experience using Historical web-mapping technologies **(optional)**
Section 4: Future considerations for Historical web-mapping **(optional)**

Section 1 – Individual information

Name:
email:
(Name and email will be removed from the data after initial validation, unless you answer Yes to the following)
Permission to retain email for follow-up purposes: Yes/No

Organization or affiliation (optional):
Position in that organization (optional):
(These are required if your organization is a web-mapping vendor or provider)

In a short phrase describe your current working relationship to Historical GIS and web-mapping, whether casual, volunteer, educational or professional:
____

How frequently do you use GIS (choose one)?

- daily
- weekly
- monthly
- yearly
- occasionally
- never
- I supervise or hire people to do this activity, but do not regularly complete it myself

How frequently do you work with historical data sets?

- daily
- weekly
- monthly
- yearly

- occasionally
- never
- I supervise or hire people to do this activity, but do not regularly complete it myself

How frequently do you design/develop web maps (choose one)?

- daily
- weekly
- monthly
- yearly
- occasionally
- never
- I supervise or hire people to do this activity, but do not regularly complete it myself

How frequently do you do web programming (for eg. javascript coding) in your regular activities (choose one)?

- daily
- weekly
- monthly
- yearly
- occasionally
- never
- I supervise or hire people to do this activity, but do not regularly complete it myself

If the above questions have not covered your regular activities related to HGIS, please explain in a few words:
____

Section 2: Needs and desires for Historical web-mapping technologies
(Optional: Choose for yourself whether to answer this depending on your experience)
If you are not technically oriented, please skip to Section 4.

Part 1. Rate the following design and functionality characteristics of web-mapping technologies, as they relate to you or your team's design/development priorities:

Characteristics	not important	important	extremely important
Multiscale: How important is it that the display of thematic map content responds seamlessly to change in map scale (i.e. zooming in to show more detail on content layers)?			
Interactivity: How important is it that the technology allows change in the map display to respond to user requests (egs. layer controls, pop-ups)?			
Exploreability: How important is the ability of the technology to allow user exploration i.e. “drilling down” into map data by means of query-based selection, reclassification, etc. ?			
Timeline: How important is it that the technology easily incorporates time-line or time slider controls to the map display?			
Animation: How important is it that there is dynamic movement of features or objects on the map?			
Cartographic design: How important is it that the technology allows the designer to customize the symbolization and look and feel of the map itself?			
Interface design: How important is it that the technology allows the designer to customize the interaction and look and feel of the user interface to the map?			

Part 2. Rate the following technical considerations of web-mapping technologies, as they relate to you or your team's design/development priorities:

Technical Considerations	not important	important	extremely important
Browser compatibility: How important is it that the technology works across browsers?			
Scalability/responsiveness: How important is it that the technology loads, represents, and interacts with large datasets without system response delays?			
Mobile support: How important is it that the technology works on all mobile devices?			
Platform dependency: How important is it that the technology works across all operating systems?			
Reliance on plug-ins: How important is it that the technology does **not** require a browser plug-in or installation of an executable?			
Connection to content management database: How important is it for the technology to incorporate a content management database (which could contain archival and historical records) integrated so that the results of user queries could be mapped?			

Part 3. Rate the practical considerations of web-mapping technologies, as they relate to you or your team's design/development priorities:

Practical Considerations	not important	important	extremely important
Cost: How important is it that the technology be low cost or free open source, or have low/flexible costs if commercial?			
GIS expertise: How important is it that the technology be useable without being an experienced GIS user?			
Programming expertise: How important is it that the technology be useable without being an experienced web programmer?			
Documentation: How important is it that there is a complete description of functionality provided by the technology?			
Maintenance: How important is it that there is long-term stability of the technology (e.g., regularity of updates, handling of deprecation)?			
Support: How important is it that there is contact support from staffed individuals or a user community (e.g., email inquiries, FAQs, forums)?			
Tutorials/examples: How important is it that there are descriptions or demonstrations of how to implement the technology?			

4. Are there any additional design, technical or practical considerations of web maps not listed above that are important in your team's design/development priorities?

____

____

____

Section 3: Experience using Historical web-mapping technologies
(OPTIONAL: Answer this if you have had experience using these)

Have you had experience creating or experimenting with Historical web-mapping technologies? Yes/No

If you answered no to the above question, please skip to Section 4.

Web-mapping technologies you (or your design/development team) have used:
Please rate your engagement with the following web-mapping technologies (please do not do web searches for these technologies while completing the survey):

Web-mapping Technology	I have not heard of this technology	I have heard of this technology, but have NOT used it	I have used this technology within the past year	I have used this technology, but NOT within the past year
Bing Maps API				
Boundless (OpenGeo)				
CartoDB				
D3				
ESRI ArcGIS Online				
ESRI Storymaps				
Geomoose				
Google Maps API				
Google Earth API (Timeslider)				
Heurist				
Kartograph				
Leaflet				
MapBox				
MapServer				
Mapstory				
Neatline				
Openlayers				
Palladio				
Quadrigram				
StoryMapJS				
Tableau Public				
Timemap.js				
TimeMapper				
Viewshare				
Others? (Fill in yourself):				
________________				
________________				
________________				

Among the above technologies used by you (or your design/development team), which do you use most commonly in your projects? What aspects of these technologies make them particularly useful in your work?

____
____

Among the above technologies used by you (or your design/development team), what would you like to see added to these technologies that would make them even more useful in your work?

____
____

Among the above technologies used by you (or your design/development team), which have been abandoned completely? What aspects of these technologies led you to abandon them?

____
____

Section 4 - Future considerations for Historical web-mapping
(OPTIONAL: Answer these questions if you have an opinion about them)

What is your favourite or preferred historical web-mapping or geovisualization website?

____
____

What would you like to see online in historical web-mapping or geovisualization which you do not see now?

____
____

What historical/geographic data set you like to see made available online, which is not available online now, or is inadequate?

____
____

We are considering creating a "Historical web-mapping technology profiles" section on our project website, where different technologies would be described and reviewed, and users would be able to comment based on their own experience and make recommendations about usefulness or suggestions for improvements. Is this something that would interest you and to which you might contribute based on your own experience?

____
____

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Thank you for participating in this survey

The contribution of your opinion and experience is much appreciated. The results of this survey will be available on the project website in report form, and will be used in the White Paper on Geovisualization. This and the other results of Year 1 research will be presented at an open-invitation video-conference on June 20, 2016.

To receive notices about this and other activities of the Canadian Historical GIS Partnership Development Project, sign up for our email list at:
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