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# Cartographic Perspectives

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## LETTER FROM THE PRESIDENT

It was wonderful to see many of you in Greenville at the Society's 2013 Annual Meeting! Our October gatherings allow us to talk maps among kindred spirits, reconnect with old friends, be inspired, and learn new practical techniques for everyday mapping. Thank you to David Lambert and Peter Wrenn for hosting us in South Carolina, and to all of our presenters.

This year's Annual Meeting continued to blend web-focused "neo" cartography with desktop and print mapping including during Practical Cartography Day and our Saturday workshops. As interest in mapping has surged, so too has attendance at our Annual Meeting. We continued the 3<sup>rd</sup> session track this year to showcase more of your great work. NACIS isn't just about looking at maps, it's about sharing, leaning in, and building great maps.

Content, craft, design, and interaction all come together in cartography. This visual storytelling approach, as our keynote speaker Alberto Cairo so eloquently (and humorously!) presented, allows us to tease out a story's geographic characteristics and show them in context with map, text, and image.

The society was pleased to bestow the first Corlis Benefideo Award for Imaginative Cartography upon Newton and Helen Mayer Harrison for their contributions to the field of mapping. Cartography is often seen by the public as work opposed to imagination, grounded entirely in established fact. While this devotion to reflecting what is forms the heart of cartographic thinking, cartographers and artists who use maps as a basis for their work can (and do) take that grounding in fact and use it to venture into the world of the possible. The Harrisons certainly embody this principle.

As the Society's volunteer Board of Directors has changed, we've focused on documenting policies and procedures to help the Society run smoother. Many thanks to Tanya, Lou, and Susan for leading the "continuity" effort and especially to past Presidents Erik Steiner and Neil Allen for ensuring the Society has the stability and leadership to continue our great mission to further cartographic information.

As part of modernizing the Society, I'm pleased to report we are on track for relaunching [nacis.org](http://nacis.org) this year with a new look, updated content, and easier content management and back office systems.

This is a big year for NACIS! CartoTalk launched 10 years ago and our flagship publication, the only open-access journal for cartography, *Cartographic Perspectives*, turns 25. Please join me in Pittsburgh to celebrate these accomplishments and to talk maps. The 2014 Call for Participation can be found in the back of this issue, and is also posted at [nacis.org](http://nacis.org). What have you been mapping?

*Nathaniel Vaughn Kelso*  
President

# Evaluating Cross-blended Hypsometric Tints: A User Study in the United States, Switzerland, and Germany

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## ABSTRACT

*Cross-blended hypsometric tints display elevation while locally adjusting colors to match the differing natural environments of world regions. This paper presents the results of a study comparing cross-blended hypsometric tints with conventional hypsometric tints. Over 200 respondents in the United States, Switzerland, and Germany were asked to interpret the meaning of color on both types of hypsometric maps. The study revealed significant differences between map readers in the United States and the two European countries, and a general difficulty in correctly interpreting hypsometric colors. Most participants perceived hypsometric tints as representing both topography (elevation and land forms) and environmental phenomena.*

**KEYWORDS:** cross-blended hypsometric tints; user survey; color perception

## INTRODUCTION

CROSS-BLENDED HYPSONETRIC TINTS are a new type of elevation coloring for maps introduced in this journal (Patterson and Jenny 2011) that employ variable lowland colors customized to match the differing natural environments of world regions. A notable trait is the absence of green from arid lowlands, which is typical of traditional hypsometric tints.

A free raster dataset with cross-blended hypsometric tints is available on the [NaturalEarthData.com](http://www.naturalearthdata.com) website (Patterson and Kelso 2009). In the three years since becoming available, these tints have proven popular among mapmakers, with more than 100,000 downloads. Despite their widespread use, however, a basic question remains: are cross-blended hypsometric tints more understandable to readers than the conventional tints that they are intended to replace? The user study discussed in the following pages attempts to answer this question.

Starting in the mid-1800s in Austria (Kretschmer 1986; 1988), cartographers have used a variety of sequential

colors to depict elevation zones on maps, typically starting with green lowlands that change to yellow, beige, brown, red, or white in layered steps as elevation increases (see Patterson and Jenny [2011] for an overview). Later developments included hypsometric tints with shaded relief and depicting tints as gradients that continuously blend together rather than exist in discrete layers. Hypsometric tinting has become a de facto standard for small-scale physical maps found in atlases, on classroom walls, and in tourist publications.

Cross-blended hypsometric tints are very much like those described above but with a major difference: the lowland color varies depending on the natural environment of the region being depicted. For example humid lowlands with plentiful vegetation are shown in green—similar to a map with conventional hypsometric tints. Cross-blended hypsometric tints, however, depict arid lowlands with brown and polar lowlands with gray blue. In addition, the green tint in humid lowlands varies. Sub-arctic lowlands, such as western Siberia, appear as cold blue green, and tropical



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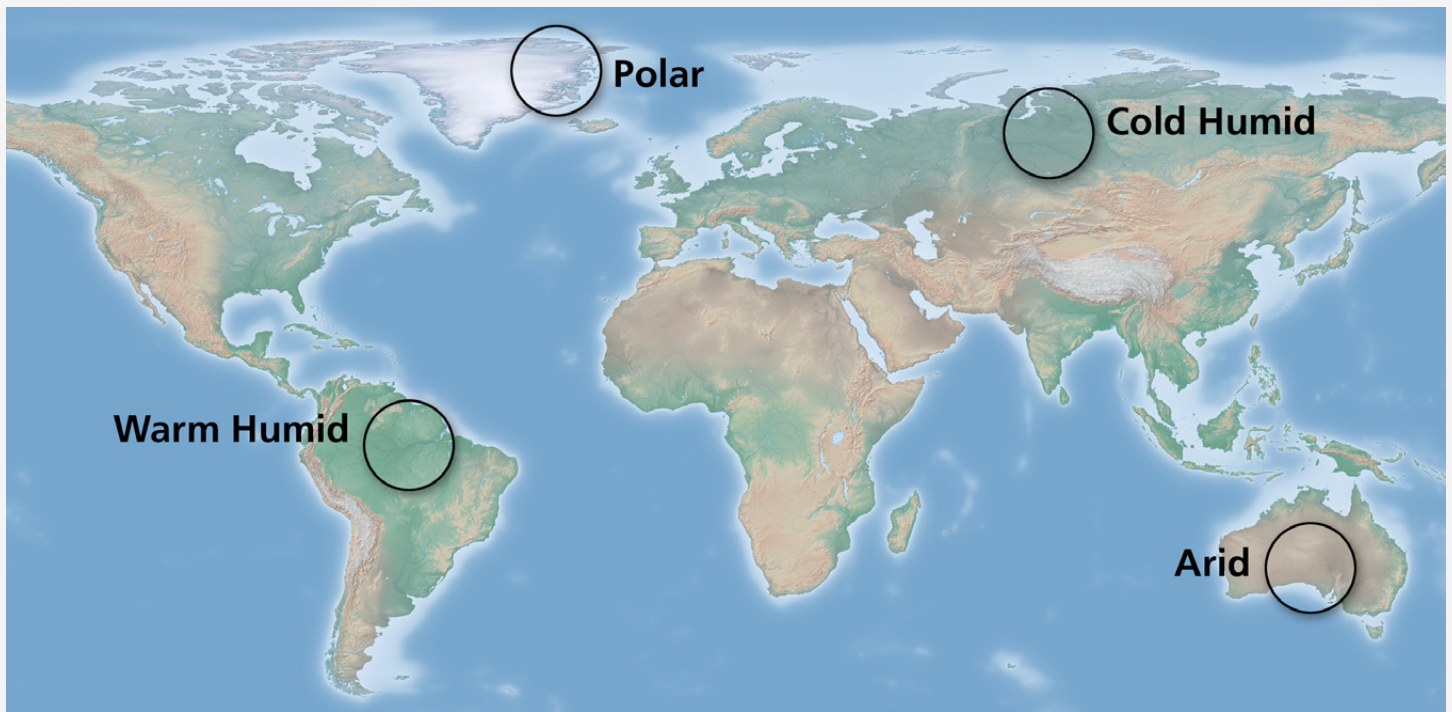


Figure 1: Cross-blended hypsometric tints have lowland colors that vary according to the generalized natural environment.

lowlands, such as the Amazon Basin, as warm yellow green (Figure 1). Alternative cross-blended hypsometric tint schemes for depicting these and other environmental regions are a possibility.

What motivated the development of cross-blended tints was the general concern among cartographers that casual readers of maps tend to confuse hypsometric tints with environmental factors, such as natural vegetation, land cover, or climate (Patton and Crawford 1978). The reason for this concern stems from the fact that many color schemes for hypsometric mapping do not align well with the theory of visual variables. After all, terrain elevation is an ordered sequence of values, which—in accordance with the theory of visual variables—is better mapped by varying color brightness than by varying hue or saturation. The potential for misinterpreting hypsometric tints is due to the use of varying hues, which—according to the theory of visual variables—is better at indicating nominal classes, such as vegetation types.

By representing lowlands with colors that depict both elevation and environmental factors<sup>1</sup>, the hope was that cross-blended hypsometric tints would better match how

many readers might interpret a physical map. For instance, if someone were to think that green represents vegetation and not low elevation, they would at least be partially right. Cross-blended tints are an attempt to design to the way people *actually* read maps instead of how cartographers *wish* they would.

#### PRIOR RESEARCH

Hypsometric tint research during the early and mid-twentieth century aimed at finding the best combination of colors for depicting higher and lower elevations. The research objective was to portray topography with as much of a three-dimensional appearance as possible on a flat sheet of paper (Patterson and Jenny 2011). The suggestion that people could confuse hypsometric tints for vegetation and other natural phenomena was put forward in the 1950s when Hal Shelton developed natural color maps as an alternative. He argued vociferously against using hypsometric tints on maps read by general audiences, calling them arbitrary (Patterson and Kelso 2004). Since then, the idea that perceptual problems might exist with hypsometric tints, especially among casual map users, has steadily grown in the cartographic community, based mostly on anecdotal evidence and assumptions.

1. In this text, the terms environment, environmental factors, or environmental phenomena refer to factors that influence the visual appearance of the landscape in a wide sense. Elevation is not considered an environmental influence in this context.

We know of only one cartography study that shows evidence that readers have trouble understanding hypsometric tints (Patton and Crawford 1978). Over 300 students in the United States were given a map of central Taiwan with Chinese characters to prevent learning about the study area by reading descriptive place names. Hypsometric tints were depicted on the map as stepped layers, and the map did not contain a shaded relief. Students looked at certain areas of the map indicated by Roman letters and answered what they thought was there in an accompanying survey, which offered two possible answers for each question. For example, “Point A is an area with: a) Many trees, b) Very few trees,” or, “The highest land is: a) Point E, b) Point B.”

Their study found that color hypsometric tints accurately transmitted data concerning elevation, but also transmitted

## STUDY DESIGN

TO LEARN MORE about the perception of hypsometric tints, we designed a user study with markedly different maps and a different survey methodology from the 1978 Patton and Crawford study. The map used by Patton and Crawford contained place names and a legend indicating the meaning of the hypsometric tints—our test maps contain no place name labels or legend. Patton and Crawford used stepped hypsometric layers and did not include a shaded relief—our test maps represent terrain with blended hypsography and shaded relief. Patton and Crawford’s respondents were children and young adults in the United States—we queried working-age adults living in the United States as well as Switzerland and Germany. Patton and Crawford asked multiple-choice questions—we made use of fill-in-the-blank questions that did not offer clues to participants about the meaning of map colors. While Patton and Crawford’s study focused on testing reading and interpretation of hypsometric tints, our research aimed at testing the perception of hypsometric tints, attempting to answer the following questions:

- Do adult map readers perceive conventional hypsometric tints as representing elevation, environmental phenomena, or a combination of both?
- Do cross-blended hypsometric tints effectively represent both elevation and environment, as was their design intent?

inaccurate and unintended information relating to vegetation, rainfall, and temperature. More importantly, green was often associated with dense vegetation and brown with sparse vegetation. This suggests that the idea behind creating cross-blended hypsometric tints has some validity.

If the Patton and Crawford study had a flaw, it was the possibility for introduced bias. The multiple-choice answers and map legend gave the test subjects direct clues as to what the map colors represented. They were not blank slates. Another issue was the population of test subjects—all were U.S. students from the 6th grade through college freshman. Left unanswered is how adults and those living beyond US shores perceive hypsometric tints.

- Which color is most strongly associated with elevation?
- Which color is most strongly associated with environment?
- Do Americans perceive hypsometric tints differently than Swiss and Germans?

## PARTICIPANTS

All respondents in our study were working-age adults from the United States and two European countries, Switzerland and Germany. The participants had no known ties to the field of cartography.

The US participants were largely employees of the National Park Service at the Harpers Ferry Center in West Virginia. Their professions ranged from custodial to senior management, although most held administrative and clerical positions. A student volunteer approached the European participants on the streets of Zürich and Berlin. He was instructed to seek out a random cross section of people who had been educated in Swiss or German schools. Altogether, slightly more than 200 complete sets of responses were collected, divided about equally between the United States and Europe.<sup>2</sup>

2. In this text, “European” refers to the Swiss and German respondents. It is likely that considerable variety exists in how European nationalities read hypsometric tint maps. In no way should our wording imply that the Swiss and German respondents represent all of Europe.



Anonymous map survey

1) Based on the map above, what do the following colors represent?

Mid elevation       Lowland

Highland

2) What general area of the world does the map show? Asia

3) Are you color blind or partially color blind?

No     Yes     Don't know

Anonymous map survey

1) Based on the map above, what do the following colors represent?

Mid elevation       Humid lowland

Highland       Arid lowland

2) What general area of the world does the map show? Asia

3) Are you color blind or partially color blind?

No     Yes     Don't know

Figure 2: Survey form for conventional hypsometric tints (left) and cross-blended hypsometric tints (right). The cross-blended maps had an additional color (brown for arid lowland) to identify. Respondents had to write in their answers, here with the hoped-for “correct” responses shown in blue.

The survey was a single letter-size page with the test map at the top and three questions below, some of which had multiple parts. The anonymous questionnaire took only a minute or two to complete. The response rate was close to 100%. Other than language, English in the United States and German in Europe, the questions were identical. For each of the geographic areas, 50% of the surveys had a test map with conventional hypsometric tints and 50% had cross-blended hypsometric tints (Figure 2).

### TEST MAPS

When creating the test maps, we employed a style commonly used for small-scale physical maps that combines hypsography and shaded relief. The cross-blended hypsometric tint map is an excerpt from the previously-mentioned base map available at [NaturalEarthData.com](http://NaturalEarthData.com). The conventional hypsometric tint map is identical to the

cross-blended map except for the lowlands, which are exclusively green (Figure 2). Additional information typical of small-scale physical maps—coastlines, rivers, lakes, and a bit of ocean—appears on both test maps. Labels and a legend are absent from the maps so as not to inform respondents about the relationship between the physical geography and the colors that they had to identify. The maps show southern Asia without the recognizable southern tip of India. This area offered advantages: elevations that range greatly from the Ganges and Indus river lowlands upward to the Himalayas and Tibet. The terraced topography—plains, plateaus, and basins—make the hypsometric tints combined with shaded relief easier to discern. With arid lowlands in the west and humid lowlands in the east, the region is ideal for depiction with cross-blended hypsometric tints. Finally, asking respondents to identify the map location made it possible to test prior geographic knowledge as a factor influencing the results.

## IDENTIFYING COLORS

Much like creating a map legend, the participants were asked to write in their responses next to color swatches immediately below the test maps. The swatches were arranged out of sequence and discontinuously so as not to look like a typical elevation scale. There were three swatches for the three conventional hypsometric tints (green, pale orange-brown, and white) and four swatches for the four cross-blended tints (green, brown, pale orange-brown, and white).

The small amount of space available for the written answers encouraged brevity, and faster responses, and made the analysis of results easier. Because the hypsometric tints were found throughout the maps, some areas clearer than others, it was advantageous for the participants to think holistically when giving answers. Their choice of words provided raw, unfiltered data—a basic vocabulary—on how they perceived hypsometric tints.

## COLOR VISION DEFICIENCY

Normal color vision was a prerequisite for the user study and four of the participants indicated having some degree of color vision deficiency, or “color blindness” as it is commonly known (Culp 2012). Disqualifying them reduced the number of accepted respondents from 217 to 213. This self-reported rate is about one half of that expected from the general population, males and females together. The 20 participants who indicated not knowing their color blindness status (18 Europeans and 2 Americans) were included in the study (Table 1).

## MAP LOCATION

By asking “What general area of the world does the map show?” the intent was to learn whether prior geographic knowledge helped the participants identify map colors. For example, someone knowing that the map was of northern India and Central Asia might do better than a geographically-challenged individual.

The map location responses were evaluated much like answers on any school exam and given a grade of accurate, partially accurate, or inaccurate. Grading was generous. For example, someone giving the very general answer “Asia” received an accurate grade, although most people gave more detailed answers. Partially accurate responses usually included several countries that were on the map, for example, Afghanistan, India, and China, and at least one that wasn’t, such as Russia or Thailand. The inaccurate answers were spectacularly off the mark and included Alaska, Austria, and Texas. Several people responded by writing, “don’t know” or gave no answer, for which they received an inaccurate grade. Country and state answers were more common than physical feature answers, even though the test maps did not contain political borders.

Map location answers varied significantly between the American and European respondents (Figure 3). Other results from the study showed this American/European dichotomy, which will receive attention in a later section. The map location answers were identical regardless whether the test maps had conventional or cross-blended tints.

	Participants Responding	Participants disqualified for color blindness	Participants accepted for analysis
<b>Hypsometric tint map:</b>			
<i>Conventional</i>	109	2	107 (50%)
<i>Cross-blended</i>	108	2	106 (50%)
<b>Where taken</b>			
<i>Switzerland/Germany</i>	110	2	108 (51%)
<i>United States</i>	107	2	105 (49%)
<b>Total</b>	217	4	213 (100%)

Table 1: Number of responding, rejected, and accepted participants in the study.

## METHODS AND RESULTS

OBTAINING THE RESULTS as written answers offered an unfiltered expression of how participants perceived hypsometric tints on the test maps. From map to eyes to mind to hand: participant answers reveal a diverse vocabulary, ranging from terse to flowery and from general to technical. We employed two methods to make sense of this Babel of words.

### METHOD 1: GRADING

Much like the map location answers described previously, the color answers identifying hypsometric tints were evaluated and received a grade of correct, partially correct, or wrong. The basis for grading was the “correct” color answers indicated by the blue text in Figure 2. For example, the gray-white hypsometric tint represents high elevation. If a person answered “highlands,” they would receive a correct grade. However, if they answered, “snow,” they would be wrong. An answer of “snowy highlands” would receive a partially correct grade. Pale orange-brown on the maps represents mid elevation. In this case giving “average height” as the answer was considered correct, “sandy terrain” wrong, and “tablelands” partially correct. Grading the cross-blended color answers required taking into account two variables. For example, with brown representing arid lowland, an answer of “lower/drier areas” was graded as correct, “mountains” wrong, and “dry terrain” or “lowlands” partially correct. The color answers—there were 745 total from 213 surveys—were graded twice by Patterson on different dates months apart to assure consistent grading. The resulting grades were nearly identical on each occasion and the few differences that emerged were resolved in a consistent manner.

Looking at all responses, only 15% of the 745 color answers were correct (Figure 4). The large percentage of partially correct—such as “snowy highland”—(38%) and wrong answers (47%) indicates a common inability to identify hypsometric tints correctly. A lower percentage of cross-blended hypsometric tint answers were correct (11%) compared

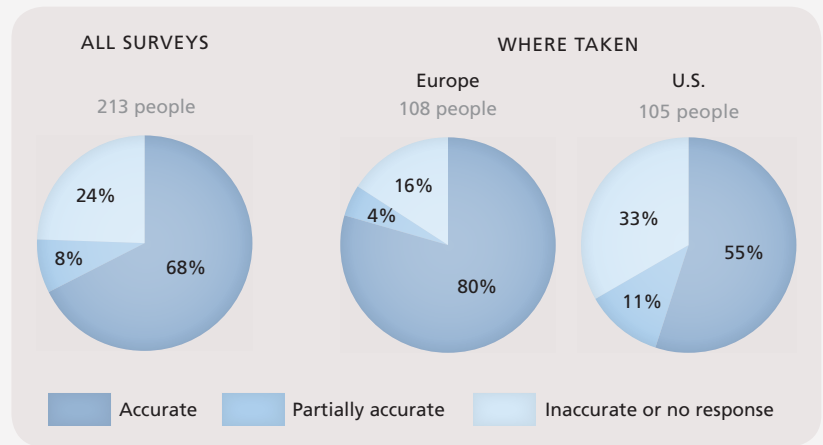


Figure 3: Map location answers. About one quarter of all participants gave inaccurate answers. The percentage of Americans giving inaccurate answers was twice that of Europeans.

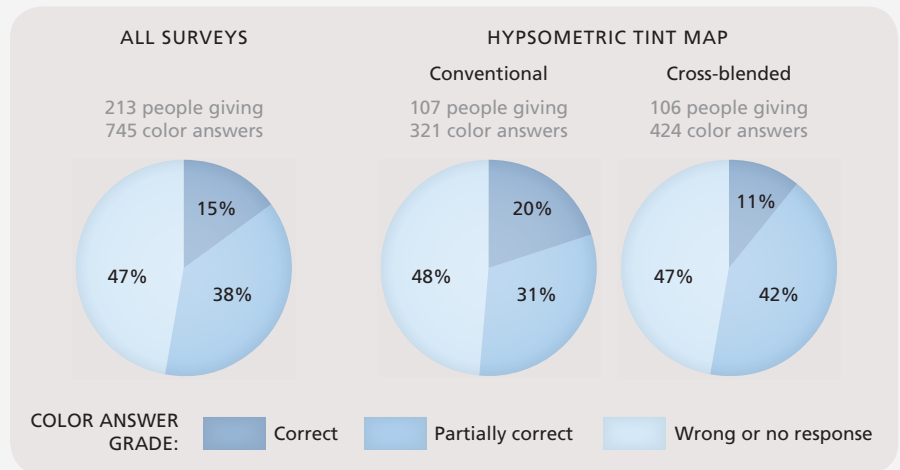


Figure 4: Graded color answers.

to conventional hypsometric tints (20%). This difference may have resulted from cross-blended tints representing two types of information—elevation and environment—lowering the chances for correct answers by one half.

Where the surveys were taken—United States or Switzerland/Germany—and the map location answers may have influenced the color answer grades (Figure 5). A much higher percentage of Europeans identified the hypsometric tints correctly (22%) compared to Americans (8%) and the inverse was true for wrong answers. People answering the map location question correctly were also more likely to provide correct color answers than those who did not, 16% to 10%, suggesting that geographic

knowledge had a modest positive influence on reading hypsometric tints correctly.

A closer examination of the data reveals that Europeans who answered the map location question inaccurately also fared poorly on their color answers with 44% receiving wrong grades, up from 28% wrong grades for all Europeans. Conversely, Americans answering the map location correctly received little benefit to their color answer grades. However, the low numbers in these subset populations (11 and 13 people, respectively) argues against drawing firm conclusions.

**METHOD 2: CLASSIFICATION**

Aside from being right or wrong, a rather blunt measure, the words chosen by the respondents may provide nuanced insights on perceived map colors. A classification system helped bring order to the disparate words and terms collected from the surveys.

Since the questions were about hypsometric tints, classifying words relating to elevation was the first consideration. Doing this proved problematic because many of the answers had ambiguous meanings describing more than just elevation. For example, *plateau*, a common answer, defines land that is both elevated and flat. There was no way of knowing which of these definitions, or possibly both, a respondent had in mind. To avoid having to guess about the respondents' intent, the answers were classified more broadly as follows:

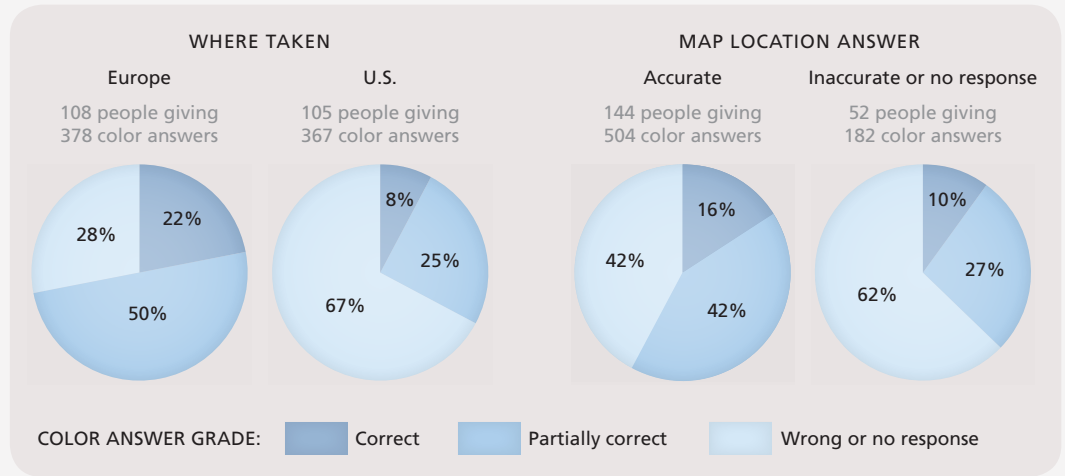


Figure 5: Graded color answers according to where the surveys were taken and the map location answers.

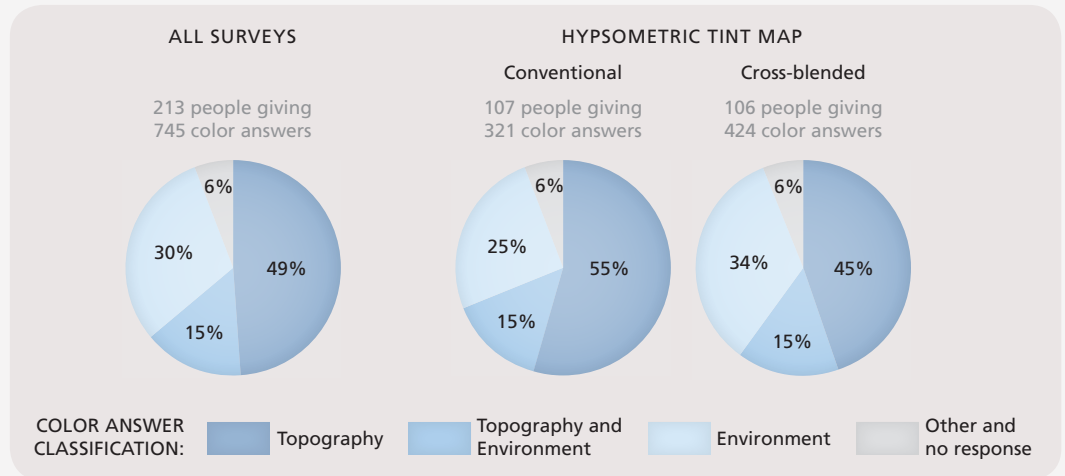


Figure 6: The classified color answers by hypsometric tint type.

1. **Topography:** words and terms describing elevation and/or terrain type. Examples include *highland*, *mountains*, *low plains*, and *rugged uplands*.
2. **Environment:** words and terms describing vegetation, land cover, and/or climate. Examples include *forest*, *cropland*, *snow*, and *arid land*.
3. **Topography and Environment:** words and terms describing both of the above. Examples include *snow-capped mountains*, *lowland forest*, and *cold mountains*.
4. **Other and no response:** ambiguous words and terms. Examples include *land* and *green land*.

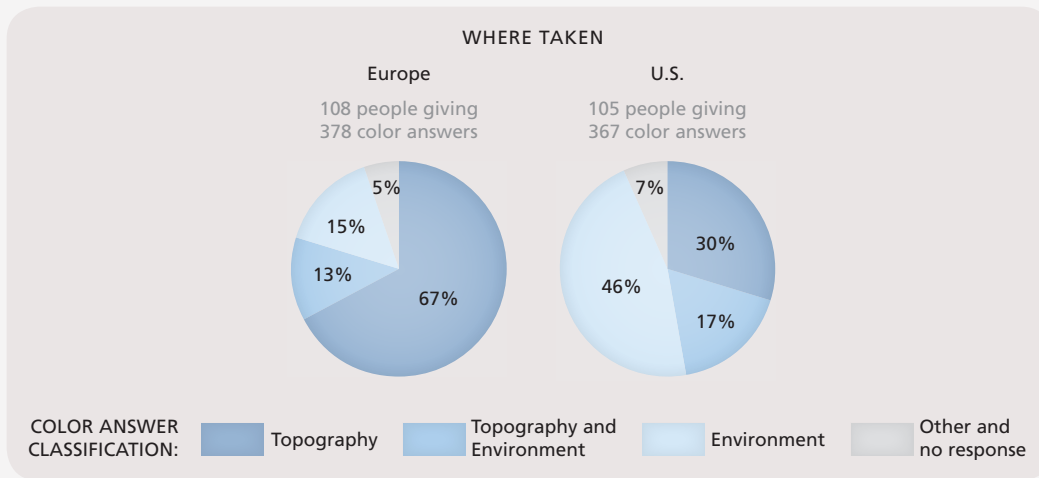


Figure 7: Classified color answers according to where the surveys were taken.

After classifying the answers twice as a check for consistency, the results show 49% of the total answers related to topography, 30% to environment, and 15% to a combination of both (Figure 6). That nearly half (30% + 15%) of the answers describe environmental phenomena at least partially points out again the mixed perceptions many people have of hypsometric tints. Cross-blended hypsometric tints registered more answers in the environment classification than conventional hypsometric tints, 34% to 25%. Since cross-blended tints are intended to depict topography and environment, this result is somewhat encouraging.

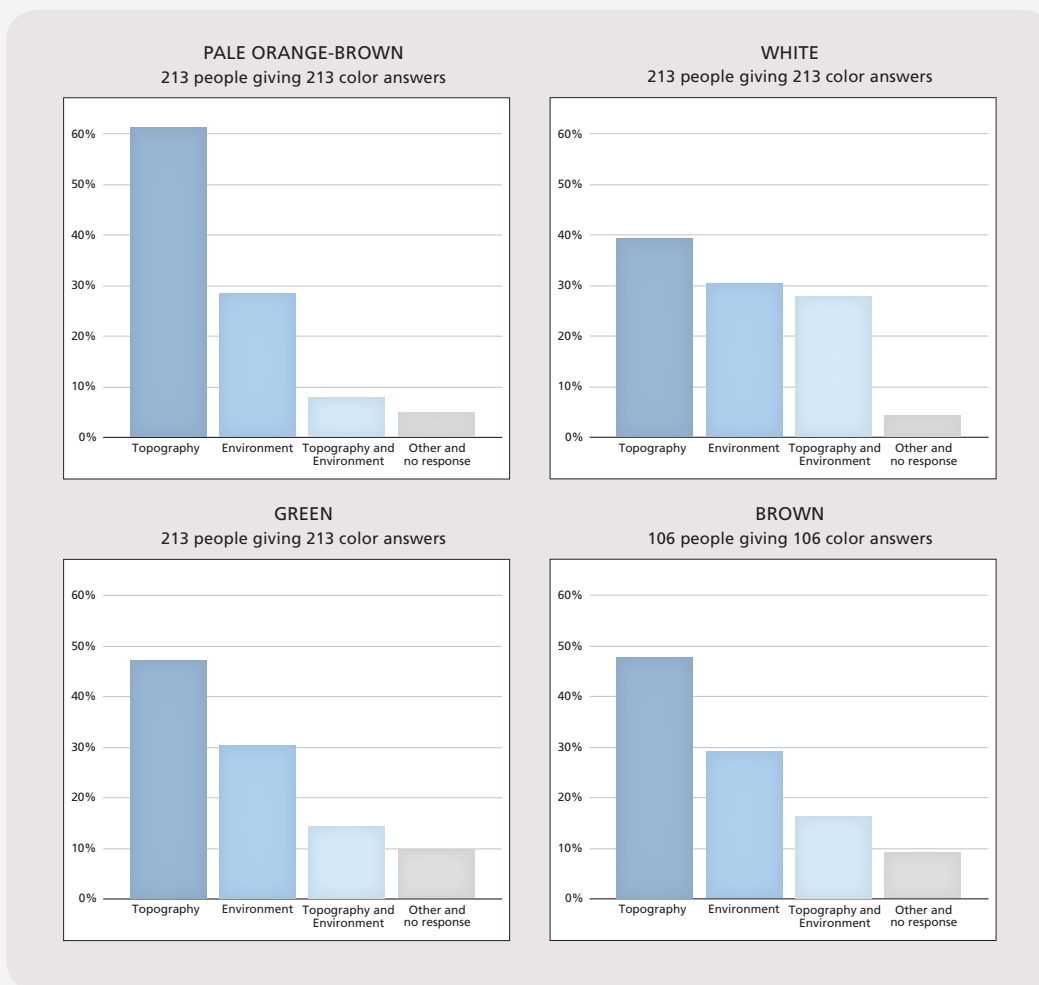


Figure 8: Classified color answers for each hypsometric tint.

The location of the survey seems to influence results (Figure 7). The majority of Europeans gave topography answers (67%) compared to only a minority of Americans (30%). Conversely, 46% of Americans and 15% of Europeans favored environment answers. These opposite perceptions of hypsometric tints by Europeans and Americans cancel each other in the aggregated results shown in Figure 6.

The test maps contain a mix of pale brown-orange, white, green, and brown hypsometric tints. The classified answers given for each of these colors reveal

additional perceptual preferences (Figure 8). The pale brown-orange color is the color most strongly associated with topography, with 62% of the answers falling in that classification. White is the color most classified as environment (31%), or mixed topography and environment (27%). The classification of green and brown responses are between these extremes and nearly identical to one another.

The wide divide between European and American hypsometric tint perceptions becomes apparent in a chart showing the percentage of responses classified as solely environment for each hypsometric tint (Figure 9). Those giving solely environment answers for pale orange-brown included 50% of the Americans and 0% of the Europeans. For green, 52% of Americans recorded solely environment answers, as did 11% of Europeans. Brown registered a similar percentage of environment answers for Europeans and Americans, but for different reasons. More than any other color, Europeans identified brown as solely representing environment, while Americans identified brown as the least environmental color. The divide between Europeans and Americans is also evident in the colors identified as solely topography (Figure 10). Europeans unanimously identified pale orange-brown with topography and over 50 percent of the answers identified the other colors as representing topography. Americans by contrast were about half as likely as Europeans to identify any of the colors as topography.

### SUMMARY OF RESULTS

Below are brief answers to the basic questions about hypsometric tints that framed the design of this study. These are followed by a broader discussion of the complex issues revealed by the collected responses.

**Q:** Do adult map readers perceive conventional hypsometric tints as representing elevation, environmental phenomena, or a combination of both?

**A:** *The respondents generally described hypsometric tints as a combination of topography (elevation and land forms) and environmental phenomena.*

**Q:** Do cross-blended hypsometric tints effectively represent both elevation and environment, as was their design intent?

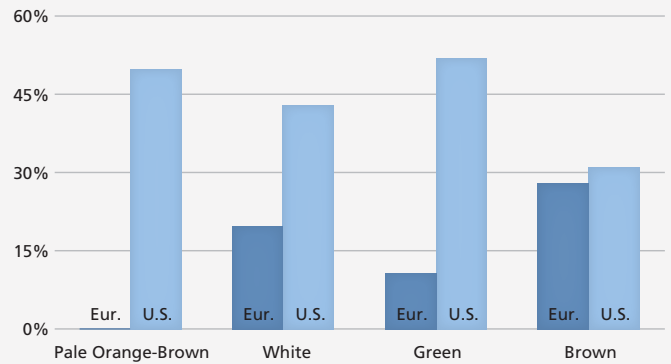


Figure 9: Percentage of color answers classified as solely environment for each hypsometric tint by Europeans and Americans.

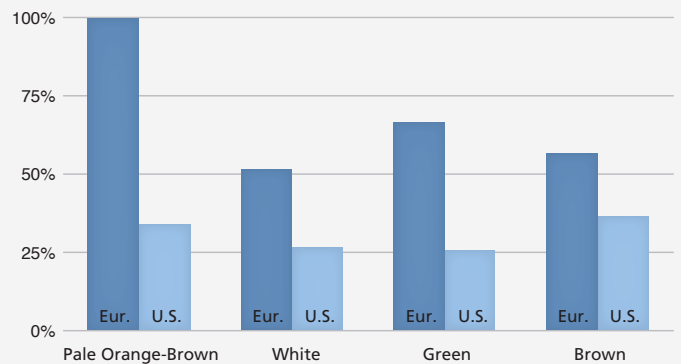


Figure 10: Percentage of color answers classified as solely topography for each hypsometric tint by Europeans and Americans.

**A:** *The results were mixed. Cross-blended hypsometric tints were no more effective in this regard than conventional hypsometric tints.*

**Q:** Which color is most strongly associated with elevation?

**A:** *Pale orange-brown.*

**Q:** Which color is most strongly associated with environment?

**A:** *Green, followed closely by white.*

**Q:** Do Americans perceive hypsometric tints differently than Swiss and Germans?

*A: Americans described hypsometric tints as environmental phenomena more often than did Europeans. A majority of Americans described green as representing environmental*

*phenomena. Europeans unanimously described pale orange-brown as representing topographic phenomena.*

## DISCUSSION

THIS STUDY, which was motivated by the desire to evaluate cross-blended hypsometric tints, yielded insights on those tints and on hypsometric tints in general. It supports the previous research by Patton and Crawford (1978) who found that map users frequently confuse conventional hypsometric tints with environmental phenomena, such as vegetation and climate. The Patton and Crawford study tested students in the United States. This study tested adults in the United States and Switzerland/Germany, broadening the demographic and geographic sample population. It also employed a different testing methodology. Instead of multiple-choice questions, respondents had to write short answers identifying what hypsometric tints on the test maps represented.

What emerged from the study were distinctly different responses from Americans and Europeans. Americans were far more likely to identify hypsometric tints with environmental factors. By contrast, Europeans overwhelmingly identified the same tints as relating to topography. An explanation for these perceptual differences could be education—Swiss and German students receive training on reading hypsometric tints while American students generally do not. In addition, many maps and atlases published in Germany, such as the commonly-used *Diercke* school atlas by Westermann, favor red tints at high elevations, which could help explain why all Swiss and German study participants associated pale orange brown with topography. Another difference between these two populations was the map location question, answered accurately by 80% of Europeans and 55% of Americans. This finding generally agrees with those of the National Geographic-Roper Survey of Geographic Literacy (2006).

This study cannot be definitive on cross-blended hypsometric tints. This scheme that uses brown to represent arid lowlands and green to represent humid lowlands went largely undetected by the respondents. Only 5% of their answers for brown were correct and 23% of answers for green were correct. Taking all of the cross-blended tints together, Americans were more likely than Europeans to identify them with mixed topography and environment

answers. Nevertheless, maps that employ cross-blended hypsometric tints should include a legend to avoid confusion about what they represent. The need for a map legend also applies to conventional hypsometric tints.

Differences existed in the responses to individual hypsometric tints. Taking into account all Americans and Europeans, white had the most mixed topography and environment answers. The majority of Americans (52%) answered that green represented only the environment. A remarkable 100% of Europeans gave answers indicating that pale orange-brown represented only topography. The brown answers were inconclusive.

Collecting written responses proved a workable method for testing users' perceptions of maps. Although the responses were sometimes messy and involved considerable time to analyze, they are assumed to provide an insight into what the test subjects were thinking. Not one person identified the hypsometric tints as anything other than physical geography phenomena—on that most elementary level the hypsometric tints succeeded.

The choice of words used to answer the questions was revealing. Nearly everyone described white on the maps with some combination of these terms: *mountain, cold, snowy, ice, glacier, high elevation, and alpine*. Several Americans used the somewhat unusual but logical term *snow caps*. Green was overwhelmingly described with words such as *lowland, plains, vegetation, forest, grass, and agriculture*. These words demonstrate the strong connection between color, nature, and language. As examples, the most common high mountain name worldwide regardless of the language is *white* or *snow* (Julyan 1984). And the etymology of *green* is from the west Germanic word *groeni*, meaning grass or to grow, an ancient association that has apparently persisted to today among the respondents.

An unexpected result was inconsistent answers by individuals. The majority of respondents (62%) identified hypsometric tints with a heterogeneous mix of topographic and environmental answers. Instead of seeing the map colors as

representing a continuum of related data, their responses were unsystematic. In other words, the mindset of the map author differed from that of the people reading it. This is another argument for always identifying hypsometric tints in a map legend.

With this study we can now say with more certainty that confusion exists over the meaning of hypsometric tints—conventional and cross-blended alike—especially among American audiences. This finding supports the recent trend by cartographers to produce natural color maps that combine land cover and shaded relief, Natural Earth being a well-known example (Patterson and Kelso 2004). But are these natural color maps a better alternative to hypsometric tints? Studies by Phillips et al. (1975) and Philips (1979) suggest the effectiveness of hypsometric tints for representing the third dimension (elevation) on a flat map,

an advantage that is perhaps diminished with the use of natural colors. Another study comparing hypsometric tints to natural color maps would seem the logical next step in this investigation.

Other avenues for hypsometric tint research include stepped versus blended color schemes, test maps with fictional landscapes to avoid any ambiguity introduced by prior knowledge, more realistic test maps with place name labels and spot elevations, and the wide-open arena of color preferences. Testing hypsometric tint maps with and without legends, to gauge if having a legend improves map reading ability, is also worth pursuing. It is a given that cartographers will continue making hypsometric tint maps for decades to come. More studies of this popular technique can only benefit those who read our maps.

## ACKNOWLEDGMENTS

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# Relationships between Methods for Presenting Information on Navigation Tools and Users' Wayfinding Behavior

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## ABSTRACT

*This study examines the effects of different methods for presenting navigational information on users' wayfinding behavior and spatial memory. In the first experiment, we examined tools that differed in the degree to which they induced the user to engage in deliberate route planning. We found that users of a tool that showed a route to the goal (the route tool) had a poor scene-recognition memory and simply followed the directed route, compared to users of a paper map which did not show a route. A tool that showed the direction toward the goal (the direction tool) was equivalent to the route tool with respect to users' scene-recognition memory, but allowed users to take routes more varied than the route tool and as varied as the paper map did. The direction tool affected men and women differently, inducing the latter to make more turns. Our second experiment examined the effects of the size of the device screen, and found that the map's advantage of allowing the user to attend to their surroundings diminished when the map was shown in small size. We discuss implications for designing effective navigational aids in different situations.*

**KEYWORDS:** navigational aids; mobile systems; spatial behavior; spatial representations; location-based services

## INTRODUCTION

SINCE ANTIQUITY, knowing about space and representing that knowledge in map form has been an essential part of human life, as indicated by the existence of ancient maps carved into stone or painted on cave walls (Black 2003). Maps are used for various purposes: for example, to depict the road network of an area, to show the spatial distribution of a specific variable of interest, or to delineate territorial boundaries. Importantly, maps show the locations of things and phenomena in the world schematically and at a reduced scale, and allow people to understand where they are in relation to other objects in the surroundings. Maps have thus been a major focus of research into human wayfinding and navigation (e.g., Blades et al. 1999, Liben et al. 2002, Lobben 2004).

Recently, with advances in information and communication technologies, many kinds of spatial representations and navigation tools other than traditional maps have been

developed (Gartner et al. 2007, Meng et al. 2008). In 2004, the US Department of Labor identified geospatial technologies as one of the most important emerging and evolving fields (Gewin 2004). Use of various location-based applications is commonly observed now, including mobile maps, in-vehicle navigation systems, and dynamic traffic information services (Küpper 2005, Mannings 2008, Girardin and Blat 2010).

These novel navigation tools have attracted the interest of researchers concerned with their effect on the user's wayfinding and spatial learning. Axon et al. (2012) argued that satellite navigation systems were perceived differently from traditional maps and could potentially change people's wayfinding behavior. Frean (2006) reported a concern that the use of satellite navigation systems might have negative impacts on people's geospatial literacy and awareness. Notably, findings from past research suggest that such



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technologically advanced systems do not necessarily serve the expected purposes of assisting the user in navigation and environmental learning.

In the literature of spatial cognition, a distinction has been made between *navigation* and *wayfinding*. Montello (2005) defined navigation as consisting of locomotion and wayfinding, the latter of which involves goal-directed and planned movement of one's body in an environment. Taylor et al. (2008) discussed navigation as a special case of wayfinding where simple motor sequences or supportive mechanisms are used. Thus navigation involves less decision making or cognitive processing than wayfinding, in that a person follows a prescribed series of directions without the necessity of relying on internal representations of an environment. The present study aims to examine how navigation tools differing in the degree to which they induce or require the user to engage in route planning (i.e., wayfinding, as opposed to locomotion or navigation, in the above definitions) affect the user's spatial behavior and environmental learning. And the degree is varied in this study by the format of presenting navigational information on the tools.

In the literature, spatial knowledge has often been discussed in terms of landmark, route, and survey knowledge (Siegel and White 1975), and individual and group differences in the acquisition and use of these types of knowledge have been reported. Some people quickly acquire accurate survey knowledge in a new environment, whereas others stay at the levels of landmark and route knowledge even with repeated exposure to the environment (Ishikawa and Montello 2006). Similarly, people differ in the strategies of wayfinding, some using landmark- or route-based strategies and others using survey-type strategies (Pazzaglia and De Beni 2001). Men tend to perform better than women on spatial tasks that require survey (or configurational) understanding of environments (Ishikawa and Montello 2006), and in giving navigational directions men tend to use cardinal directions, while women use landmarks and egocentric (left-right) reference frames (e.g., Dabbs et al. 1998, Montello et al. 1999).

Accordingly, the use of navigation tools has been studied with respect to their effects on the acquisition of the three types of knowledge. Past research showed that users of navigation tools had difficulty acquiring accurate survey knowledge, compared to people who used maps or directly experienced routes (e.g., Krüger et al. 2004, Aslan et al.

2006, Münzer et al. 2006, Ishikawa et al. 2008, Willis et al. 2009).

In the present study, however, another type of spatial knowledge than landmark-route-survey knowledge is examined: people's memory of scenes in traveled environments. The reason is that having a good memory of the surroundings constitutes an important part of an enjoyable travel experience, as contrasted with heading to a destination without any attention to the surroundings. Concerning the characteristics of spatial behavior and learning by mobile users, Münzer et al. (2006) showed that users of mobile navigation tools did not remember the locations and directions of intersections as well as users of maps. Ishikawa et al. (2008) showed that mobile users traveled longer distances and stopped more frequently during travel than map users did.

As possible reasons for the ineffectiveness of navigation tools, two explanations have been suggested. The first concerns whether the user engages in conscious decision making about which route to take (i.e., deliberate route planning vs. simple following of route directions). Researchers described users of navigation tools as simply following the provided route instructions, and ascribed their degraded spatial learning to the lack of route planning or decision making (Péruch et al. 1995, Gaunet et al. 2001, Parush et al. 2007, Bakdash et al. 2008). In particular, Farrell et al. (2003) and Burnett and Lee (2005) discussed how the control of decisions about which route to take is an important component of deliberate route planning.

A second explanation concerns the size of the device screen. On mobile tools, maps are shown at a small size, and route information is provided in a piecemeal fashion without the whole route being visible simultaneously. This fact has been found to affect the user's wayfinding performance and knowledge about traveled routes (Dillemuth 2009, Willis et al. 2009, Gartner and Hiller 2010).

The present study addresses these two explanations by examining the effects that different methods for presenting navigational information have on the user's wayfinding and spatial learning. Specifically, it looks at people's travel behavior and memory of surrounding scenes when they use different navigation tools (we note that in this study, these tools are used "in situ" rather than for pre-planning purposes). Although past research suggests that the ineffectiveness of navigation tools relates to the users' simple following of directed routes, it still remains to be empirically

examined to what extent the users merely "follow" the directions. Therefore, this research examines the variation in the routes that users of different navigation tools take, by allowing them to choose their own routes to reach a goal. It also examines their memory of the surrounding scenes and the length of time that they look at the tool, as measures of the degree of attention paid to the tool versus to the surrounding space. The rationale is that in tourist navigation, helping the user to remember visited places is desirable, since simply moving between the start and goal without any memory of the places in-between may not be too enjoyable for the tourist.

To that end, two experiments were conducted. The first experiment focused on the issue of deliberate route planning versus simple direction-following, by comparing navigation

tools that show a route to the goal or the direction toward the goal with a paper map. If a tool that shows which route to take renders the task of navigation mere direction-following, users would take similar and less varied routes and remember the surrounding scenes poorly.

The second experiment focused on the size of the device screen, by allowing users to view a map for the whole route on the screen. If a map presented in smaller size distracts the users' attention from the surrounding space to the tool, their wayfinding performance and memory for the surroundings would be poor. Both experiments took into consideration sex-related differences in wayfinding as well, looking at whether the different navigation tools affect wayfinding behavior by men and women differently.

## EXPERIMENT 1

### METHOD & MATERIALS

**Participants.** Twenty-four college students (12 men and 12 women) participated in the experiment, ranging in age from 19 to 24 years with a mean of 22.3. They were students in various disciplines, including urban planning, environmental studies, geography, and computer science. Their experience in the use of maps and navigation tools was not found to correlate with the wayfinding behavior and spatial memory examined below.

**Study Area.** As the study area, a commercial district in Aoyama, Tokyo, was used. It is a popular area for street shopping and allows us to observe people's wayfinding behavior while they are walking around with interest in the surrounds. In the area, we selected three pairs of start and goal locations (i.e., participants traveled three routes), which were 770, 760, and 1,060 m apart, respectively, along the shortest route (Figure 1).

**Navigation Tools.** We developed two methods for presenting navigational information on a GPS-based smartphone system: a *route tool* and a *direction tool*. Both tools received good GPS signals in the study area and presented navigational information with good accuracy.

The route tool presented the shortest route to the goal. On the device screen (8.9 cm [3.5 in] in diagonal), a map of the area within a 150 m radius was shown in a north-up

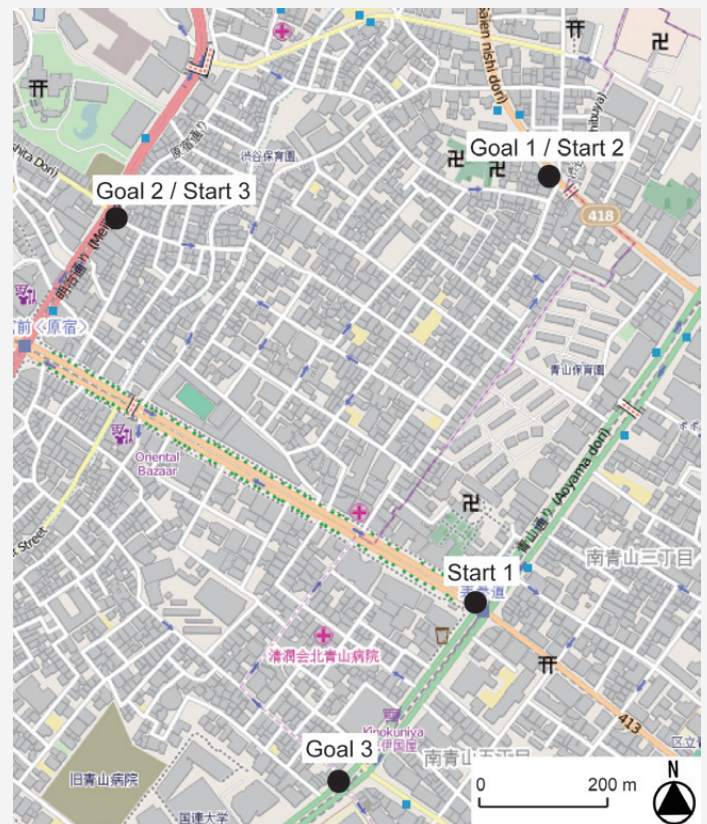


Figure 1: Map of the study area. Three pairs of start and goal locations were selected in the area. Participants walked between the locations in each pair using one of three navigation tools in counterbalanced order. © OpenStreetMap contributors. <http://www.openstreetmap.org>.

orientation, and the user's current location was updated according to their movements in space (Figure 2A). Due to the limited size of the screen, the start and goal locations were not shown simultaneously on the screen, and only part of the whole route was presented.

The direction tool presented the direction in which the goal was located relative to the user's current location (Figure 2B). No specific routes were indicated. A map of the area within a 150 m radius and the user's current location were updated according to their movements. The start and goal locations were not shown simultaneously on the screen. The direction tool was intended as a presentation format lying between the route tool and the paper map, in the sense that it does not show which route to take as the

route tool does, and presents information on a small screen in a more relational (or survey-type) manner like maps.

**Paper Maps.** A third method for presenting navigational information was a map printed on A4-sized paper with a scale of about 1:6,000 (chosen to match to maps in major travel guidebooks). On the paper map, the start and goal locations were marked, without any specific routes to the goal being indicated.

Of the three tools, the route tool provides specific instructions about which path to take, while the direction tool and the paper map provide information that is not tied to one route. The former shows the direction toward the goal on a screen of limited size and the latter shows the spatial relations between the start and goal locations.

**Scene Recognition Task.** After walking the three routes, participants viewed photographs and answered whether they had seen the scenes along the routes, on a 4-point scale (1 = *I certainly did not see it*; 2 = *I probably did not see it*; 3 = *I probably saw it*; 4 = *I certainly saw it*). Some of the photographs were scenes visible from the routes that participants took, and others were not.

For this task, 110 photographs were prepared in advance, which were taken along a wide variety of routes that we thought participants would possibly take. Thus we were able to select the photographs presented as visible and nonvisible according to the routes that they had taken. The average number of photographs presented to participants was seven for visible scenes and eleven for nonvisible scenes.

**Measured variables.** Concerning participants' wayfinding behavior, we measured (a) travel distance (standardized by the distance for the shortest-path route), (b) travel speed (given by the travel distance divided by travel time), (c) memory of the surrounding scenes, (d) the time that they spent looking at the tools, and (e) the degree of similarity between the routes that participants took.

**Design and Procedure.** Participants walked between the three pairs of start and goal locations using one of the three tools: the route tool, the direction tool, or the paper map. In the experiment a repeated measures design was employed, and the allocation of the three tools to the three pairs of start and goal locations was counterbalanced across participants.



Figure 2: Information provided by navigation tools. (A) On the route tool, the user's current location (the symbol around the center of the screen) and a route to the goal (the solid line from the start, denoted by an A, toward the lower-left corner of the screen) were shown. (B) On the direction tool, the user's current location and the direction toward the goal (the blue arrow pointing to the lower-left corner of the screen) were shown. (C) A map for the whole area that was available upon request to users of the route tool in Experiment 2. (D) The device-screen map used in Experiment 2, with the start and goal denoted by A and B. (Tools developed with Google Maps API. Map data © 2011 Google, ZENRIN.)

At the beginning of the experiment, participants were taken individually to the first start location and given one of the three tools. They were instructed that their objective was to go toward the goal, not to follow the specific routes that some of the tools would present, and that they were allowed to choose their own routes as long as they reach the goal. These instructions were intended to induce participants to not necessarily follow the route directions and to enable us to examine the variability of participants' routes with different tools.

The experimenter explained the information that each tool would present, and ensured that participants learned how to use it. We ensured that participants understood their current location and orientation at the start by having them align the tool with the surrounding space (with assistance if necessary). When they indicated that they were ready, participants started to walk toward the first goal. During the walk, they raised no questions or complaints about the operation of the tool. When participants reached the first goal, they were told that they would engage in the second travel from there, and started to go toward the second goal using another tool.

At the end of the experiment, participants answered a questionnaire which asked about their age, degree of interest in the study area, familiarity with the traveled routes, and experience in using navigation systems and maps. It took 90 min on average to complete all tasks.

Participants also filled out the Santa Barbara Sense-of-Direction scale, which consists of fifteen 7-point Likert-type questions about navigational abilities or preferences (Hegarty et al. 2002). People having higher scores on this scale have been shown to do better on updating their orientation and location in space as a result of self-motion. We thus used this scale as a possible correlate with participants' wayfinding behavior, but observed no significant effects (in both Experiments 1 and 2). This lack may have stemmed from the fact that sense of direction is more related to the understanding of configurational properties of the environment (i.e., survey knowledge) than to route following (Hegarty et al. 2006).

## RESULTS

**Travel Distance and Speed.** Since the routes were not complex, all participants succeeded in reaching the goals. For

each participant, we computed the distance traveled and the mean travel speed, and examined the differences among the three tools in a mixed analysis of variance (ANOVA), with the tool used (route tool, direction tool, or paper map) as a within-subject variable and sex (male or female) as a between-subject variable. An alpha level of 0.05 was used for all statistical tests.

There were no significant main or interaction effects for the distance traveled. There was a significant main effect of sex for the mean travel speed,  $F(1, 22) = 9.29, p < 0.01$ , with men traveling faster than women (Figure 3A, open symbols).

**Scene Recognition.** For each participant, we computed a memory-performance score, weighted by their degree of confidence. The score was given as the sum of the number of correctly identified scenes with greater confidence (i.e., *I certainly saw [or did not see] it*) multiplied by 2 and the number of correctly identified scenes with less confidence (i.e., *I probably saw [or did not see] it*), divided by the total number of scenes.

There was a significant main effect of the tool used,  $F(2, 21) = 5.29, p < 0.05$ . Post hoc paired comparisons (Bonferroni)

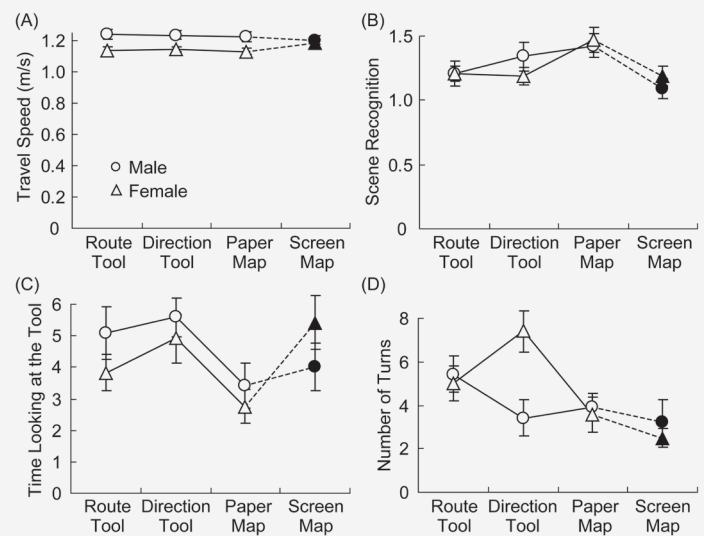


Figure 3: Comparisons of wayfinding measures for different tools: (A) travel speed, (B) scene recognition (memory-performance scores), (C) time spent looking at the tool (relative to travel time, out of 10), and (D) the number of turns that users made. Open symbols are for the three tools in Experiment 1, and solid symbols are for the device-screen map in Experiment 2. Vertical lines depict standard errors of the means.

showed that participants remembered the surrounding scenes better when using the paper map than when using the route tool (Figure 3B, open symbols).

**Time Spent Looking at the Tools.** In the questionnaire, participants indicated the length of time that they spent looking at each tool relative to their travel time, from 0 (*not at all*) to 10 (*all the time*). We confirmed that these responses were consistent with the experimenter's observations.

There was a significant main effect of the tool used,  $F(2, 21) = 7.63, p < 0.01$ . Post hoc comparisons showed that participants looked at the direction tool for a longer time than the paper map (Figure 3C, open symbols).

**Similarity between Participants' Routes.** To examine the degree of similarity between the routes that participants took, we computed cosine similarity between pairs of participants' routes. This measure is often used in text mining to compare the similarity between two documents represented as vectors (Tan et al. 2005). In our case, the similarity value, ranging from 0 to 1, is given by the equation

$$S_{ij} = L_{ij} / \sqrt{L_i L_j}$$

where

$S_{ij}$  = similarity between participant  $i$ 's and participant  $j$ 's routes,

$L_{ij}$  = length of route segments shared by the two participants' routes,

$L_i$  = length of participant  $i$ 's route, and

$L_j$  = length of participant  $j$ 's route.

In paired comparisons (Bonferroni), participants' routes were more similar to each other when using the route tool than when using the direction tool and the paper map, the latter two of which did not differ significantly (Figure 4, open circles). That is, participants tended to follow the routes as directed by the route tool, and to take a wider variety of routes when using the direction tool and the paper map (see the maps in Figures 5A–5C).

To examine the characteristics of the routes that users of the three tools took, we looked at the number of turns that participants made. An ANOVA and post hoc comparisons showed that men made fewer turns than women when using the direction tool (Figure 3D, open symbols),  $F(2, 21) = 4.69, p < 0.05$ .

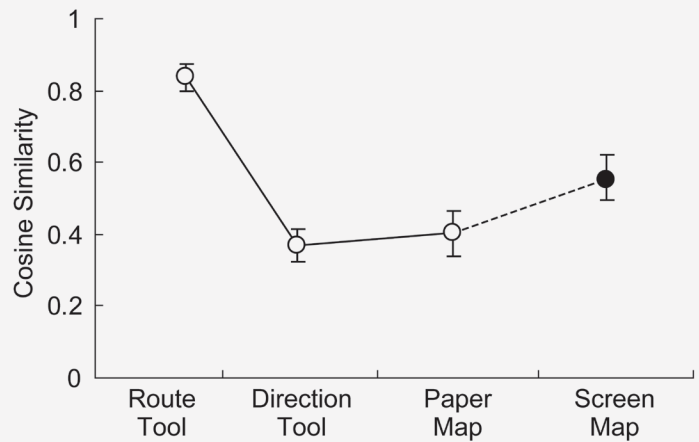


Figure 4: Cosine similarity values for different tools. Open circles are for the three tools in Experiment 1, and a solid circle is for the device-screen map in Experiment 2. Vertical lines depict standard errors of the means.

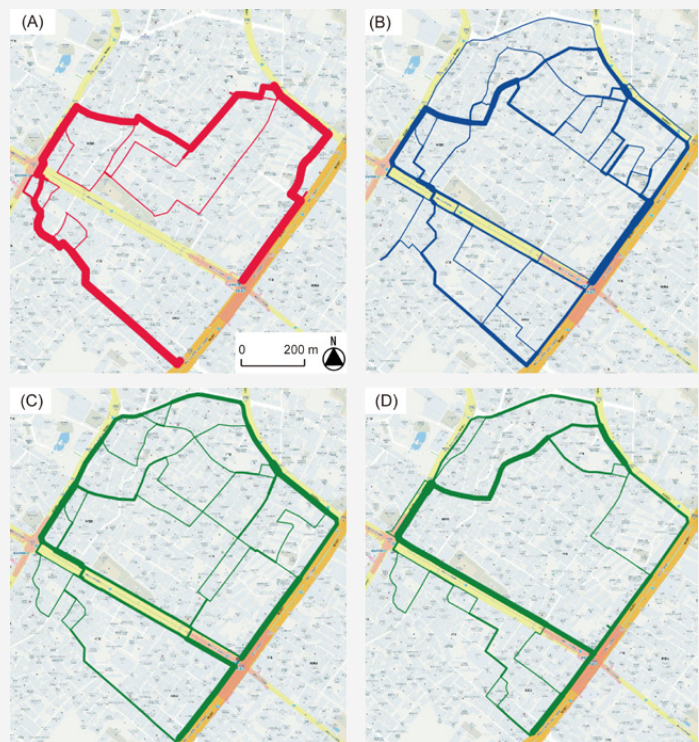


Figure 5: Maps showing the routes that participants took when using (A) the route tool, (B) the direction tool, (C) the paper map (in Experiment 1), and (D) the device-screen map (in Experiment 2). The thickness of the lines is proportional to the number of participants who traveled each route.

**Relationships with Interest, Familiarity, and Experience.** In the questionnaire, participants were asked about their degree of interest in the study area, familiarity with the traveled routes, and experience in using navigation systems and maps. To measure their degree of interest, participants indicated on a 5-point scale how much they were interested in the study area in terms of doing shopping, enjoying the townscape, seeing famous buildings or places, discovering new things, and learning about the area (a mean score of their responses to these questions was computed). For familiarity, participants answered how many times they had been to the study area. To determine their experience with navigation tools and maps, participants were asked how often they used them on a 5-point scale: 1 (*never used before*), 2 (*less than once a month*), 3 (*a few times a month*), 4 (*a few times a week*), 5 (*use every day*). Correlations of these variables with the observed measures of participants' wayfinding behavior were examined.

## EXPERIMENT 2

IN THE FIRST EXPERIMENT, paper map users remembered the surrounding scenes better and looked at the map for a shorter time, indicating that it has the advantage of allowing users to attend to the surroundings without distracting them. There seem to be two possible reasons for this advantage: (a) because the paper map showed the whole route between the start and goal or (b) because the paper map showed information in a larger size (on A4-sized paper vs. the 3.5-inch device screen).

To examine these two possibilities, we conducted an experiment in which a map for the whole route was shown on the device screen. In the second experiment, the route tool and the direction tool were provided with an option of allowing the user to view a map for the whole route on the screen, and the paper map was replaced by a smaller, on-screen map with a smaller cartographic scale.

If possibility (a) above is correct, participants in the second experiment would do as well as the users of the paper map in the first experiment. If possibility (b) is correct, participants would perform similarly to the users of the route and direction tools in the first experiment.

When using the paper map, participants who were more familiar with the study routes tended to travel more slowly and remembered the surrounding scenes better ( $r = -0.41$  and  $0.48$ , respectively,  $p < 0.05$ ). Those who were more interested in the study area also traveled more slowly ( $r = -0.43$ ,  $p < 0.05$ ). When using the direction tool, participants who had greater experience in using navigation systems were worse at remembering the surrounding scenes,  $r = -0.47$ ,  $p < 0.05$ .

In the questionnaire, participants also commented on the use of the three tools. For the route tool and the direction tool, their comments indicated that they wanted to view the entire route and know where the goal was located. For the direction tool, some participants mentioned that they preferred to know about routes, rather than the direction in which the goal was located. For the paper map, they wanted their current location and a specific route to be indicated, because they had difficulty knowing where they were located.

## METHOD & MATERIALS

**Participants.** Twenty-four college students (12 men and 12 women) participated in the experiment, ranging in age from 18 to 33 years with a mean of 21.8. These participants did not know about the first experiment. Similar to Experiment 1, they were students in various disciplines and their experience in the use of maps and navigation tools did not relate to the wayfinding behavior and spatial memory examined below.

**Study Area.** The same study area and the same three pairs of start and goal locations were used as in Experiment 1.

**Navigation Tools.** By modifying the navigation tools used in Experiment 1, we developed three methods for presenting navigational information on a GPS-based smartphone system. Two of the methods were the same as the route and direction tools used in Experiment 1, except that in Experiment 2 the user was allowed to (a) view a map of the whole area between the start and goal locations on the screen for 7 seconds by pressing a button (Figure 2C) and (b) change the map scale (to zoom in and zoom out). On average, participants viewed a map for the whole area 1.8 times, and changed map scale 0.6 times, with no significant differences between the route and direction tools.



A third method was a static map shown on the device screen, which we will call a *device-screen map*. As the paper map in Experiment 1, it shows a map for the whole route (or area) between the start and goal, with the start and goal locations being marked (Figure 2D).

**Measured Variables.** We measured the same variables as in the first experiment concerning participants' wayfinding behavior.

**Design and Procedure.** Participants walked between the three pairs of start and goal locations using one of the three tools: the route tool, the direction tool, or the device-screen map. As in Experiment 1, a repeated measures design was employed, and the allocation of the three tools to the three pairs of start and goal locations was counterbalanced across participants. The experimental procedure was the same as that for Experiment 1. It took 90 min on average to complete all tasks.

## RESULTS

**Travel Distance and Speed, Scene Recognition, and Time Spent Looking at the Tools.** As in Experiment 1, all participants succeeded in reaching the goals. For the measured variables of travel distance and speed, scene recognition, and the time spent looking at the tools, there were no significant differences among the three tools in Experiment 2 (which is reasonable as the users of all three tools viewed a map for the whole route on the screen).

Therefore in the section below, we compare the performance for the device-screen map (solid symbols in Figure 3) to that for each of the three tools in Experiment 1 (open symbols in Figure 3), with a view to examining the two hypotheses ((a) and (b) mentioned above) in detail. Specifically, we employed an ANOVA with the tool used and sex as between-subject variables.

**Relationships with Interest, Familiarity, and Experience.** When using the device-screen map, participants who were more familiar with the study routes tended to look at the tool for a shorter time,  $r = -0.47, p < 0.05$ .

As in Experiment 1, participants commented on the use of the three tools in the questionnaire. For the route tool and the direction tool, their comments indicated the desire to know the location of the goal, and thus to have the map for the entire route available all the time. For the device-screen

map, many participants complained about the small size of the map and consequently the coarseness of the depicted information. A few participants wanted the map shown on the tool to be rotated automatically in alignment with their heading directions in the environment.

### COMPARISON OF THE DEVICE-SCREEN MAP IN EXPERIMENT 2 WITH THE THREE TOOLS IN EXPERIMENT 1

**Travel Distance and Speed.** For travel distance, there were no significant main or interaction effects. For travel speed, there was a significant main effect of sex, indicating that men traveled faster than women:  $F_s(1, 44) = 4.97, 4.91,$  and  $4.53$ , for the comparisons of the device-screen map with the route tool, the direction tool, and the paper map, respectively,  $p < 0.05$  (Figure 3A). These results show that participants' travel distance and speed did not differ depending on the tools, and men traveled faster than women with all tools.

**Scene Recognition.** In the scene recognition task, performance with the device-screen map was worse than with the paper map,  $F(1, 44) = 11.96, p < 0.01$ , but was not significantly different from the route and direction tools (Figure 3B). These results show that when the map was shown in small size on the device screen, the (paper) map's advantage of fostering the user's scene recognition memory diminished, down to a level equivalent to the route and direction tools.

**Time Spent Looking at the Tools.** The time spent looking at the tools was longer for the device-screen map than the paper map— $F(1, 44) = 4.98, p < 0.05$ —but was not significantly different from the route and direction tools (Figure 3C). As with scene recognition, these results show that when the map was shown in small size on the device screen, the map's advantage of allowing the user to attend to the surroundings diminished, with their attention being on the tool.

**Similarity between Participants' Routes.** As in Experiment 1, we examined the degree of similarity between participants' routes through a cosine similarity measure. Paired comparisons showed that the similarity value for participants' routes was larger for the route tool than for the device-screen map, which in turn had a larger similarity value than the direction tool and the paper map (Figure 4 solid circle, and Figure 5D).

We also examined the number of turns that participants made. The number of turns for the device-screen map was smaller than the route and direction tools:  $F_s(1, 44) = 8.60$  and  $9.19$ , respectively,  $p < 0.01$ . It was not significantly different than the paper map. There was a significant

## DISCUSSION

RESULTS FROM the first experiment show that when using the route tool, people remember surrounding scenes poorly, spend a longer time looking at the tool, and tend to follow the provided routes as directed by the tool. Compared to paper maps, their scene recognition memory was 20% lower, the length of time that they looked at the tool was 30% longer, and their routes were half as varied. That is, while paper map users attend more to the surrounding space than to the tool, route tool users simply follow the route instructions while paying less attention to the surroundings. Although it is popular for major commercial navigation systems to direct the user as to which route to take, this seems to have the negative effect of rendering the act of navigation into simple direction-following. The results also indicate that people do not always take the shortest-path route, as the route tool in this study instructed the user to do.

The direction tool was intended to lie in between the route tool and the paper map, in the sense that its instructions were not tied to a specific route, but presented in a more relational manner. The results showed that the direction tool was equivalent to the route tool with respect to the user's scene recognition memory and the time that they spent looking at the tool. The direction tool also allowed the user to take more varied routes than the route tool and as varied routes as the paper map did.

The direction tool also affected men and women differently, inducing the women to make more turns than men. This may be explained by the tendency of women to rely on landmarks and egocentric information in navigation: women turned as frequently as the direction shown by the tool changed, owing to subtle changes in their heading directions. By contrast, since men tend to consider the configurational or allocentric properties of the environment, they were not disturbed by subtle changes in heading and moved in the general direction in which the goal was located. Men approached the wayfinding task from a global perspective, women from a more local perspective. Interestingly, participants who had more experience using

interaction of the tool used and sex for the comparison of the device-screen map with the direction tool, indicating that women made more turns than men when using the direction tool:  $F(1, 44) = 8.03$ ,  $p < 0.01$  (Figure 3D).

commercial navigation systems were worse at remembering the surrounding scenes when using the direction tool. This implies that becoming used to following route directions makes globally oriented navigation difficult.

Participants' comments about the route and direction tools are also suggestive about route planning and configurational learning with these tools. Many participants mentioned that they wanted to view the entire route and to know where the goal was located. It indicates that these tools require the user to follow directions without knowing where they are heading or having a mental picture of the whole route. At the same time, participants' comments show that some people find it difficult to understand where they are located when using maps.

A practical implication of the results is that the direction tool may work in a situation where the "navigator," or the provider of navigational information, aims to expose the user to various places along various routes: for example in tourist navigation or sightseeing. In contrast, for a situation in which the navigator's principal objective is simply to guide the user to the goal, the route tool may be appropriate. But when the navigator wants the user to leave the visited places with a good recollection of the surroundings and the experience of traveling various routes, paper maps may be a good choice, at least for routes and environments that are not too complex.

In the second experiment, participants who viewed the map on the device screen in small size remembered the surroundings poorly, looked at the tools for a longer time, and took less varied routes, when compared to those who used the paper map in the first experiment. Thus the map's advantage of allowing the user to attend to their surroundings diminishes when it is shown in the small size of a device screen. As with the learning of configurational properties of environments (Dillemut 2009, Willis et al. 2009), the learning of surrounding scenes or scene recognition memory is affected by the size of the device screen.

## SUMMARY

OUR RESULTS SHOW that the presentation format commonly used on current navigation systems does not help the user to remember their surroundings or provide them with the enjoyment or freedom of exploring divergent routes as well as a paper map does. Also, a map's strength of allowing the user to comprehend the layout and spatial relations of objects is weakened when it is shown on a small smartphone screen.

Thus the format for presenting navigational information does affect users' wayfinding behavior and spatial memory. To better understand the use of advanced navigation tools,

more research from the perspective of human cognition and behavior, as well as from a technological perspective, is needed. Possible areas for further research include the level of generalization and map symbolization appropriate for mobile systems and users' preferences or strategies in wayfinding and navigation. The effects noted in this study of a user's prior experience with navigation systems also deserve further investigation. Continued empirical research on these issues would lead to the development of effective navigational aids that can adapt to various user attributes and wayfinding situations.

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# The West That is Wyoming: The Hebard Historic Map Collection, University of Wyoming Libraries

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IN 2009, the University of Wyoming completed a major expansion and renovation of William R. Coe Library, the main library on campus. Among the project's many improvements was the creation of a dedicated space to house and provide access to rare, valuable, and historically significant materials. The Libraries' Grace Raymond Hebard Collection, consisting predominately of published materials

about Wyoming and considered the most comprehensive of its kind, had been housed with the University Archives in the American Heritage Center since the mid 1990s. This collection was returned to Coe Library in 2010, where it was united with other special materials to create a new department: the Emmett D. Chisum Special Collections. One of the collections reunited in the new department at this time was the Hebard Historic Map Collection.

## THE HISTORY AND DEVELOPMENT OF THE HEBARD HISTORIC MAP COLLECTION

THE COLLECTION IS NAMED for Grace Raymond Hebard, who came to Wyoming in 1882. She worked as a draftsman for the United States Surveyor General's Office in Cheyenne, becoming the Assistant State Engineer in 1886. Her work as a draftsman involved creating maps from surveyors' notes. (Mackey 2005). In 1891, she was appointed a trustee of the University of Wyoming, five years after the University was established by the Wyoming Legislature. In 1893, she became Assistant Professor of Political Economics and, in 1894, the University's Librarian. She used her skills as a draftsman and cartographer throughout her career, tracing and mapping historic trails in Wyoming, drawing maps to accompany her books, and creating the *Map of the History and Romance of Wyoming* in 1928. Her collection of books and maps became the kernel of the Grace Raymond Hebard Collection on Wyoming history and culture and the Hebard Historic Map Collection.

During the time Hebard served as Librarian, the General Library contained books of general interest with more specialized materials residing in separate libraries administered by the departments. In annual reports to the University President, Hebard writes about both the General Library and the Political Economy department, which had its own library. In 1919, she compares the budgets for the General

Library and the departmental libraries, noting that some departmental libraries receive the same funding as the General Library. The only mention of maps in these reports are line items in the Political Economy Department budget, for "maps, supplies, and incidentals" (Grace Raymond Hebard to Aven Nelson, Grace Raymond Hebard papers, Box 4, Folder 1).

Almost from the beginning, the division between the General Library and the departmental libraries generated discussion. In the minutes from a Library Committee meeting dated August 9, 1894, the committee resolved to have all technical books cataloged as part of the University Library before being turned over to the departments whose professors purchased them. In 1923, the committee voted to consolidate all departmental libraries into the main library but the merger apparently did not take place until the 1960s. As of May 1, 1950—before the consolidation—the Main Library contained 157 maps; that number probably grew substantially after the consolidation as maps housed in the departmental libraries became part of the main collection.

Library newsletters and annual reports through the 1980s contain lists of materials purchased but maps are rarely



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Figure 1: Map of the History and Romance of Wyoming. 1928. Grace Raymond Hebard. Signed by Grace Raymond Hebard.

mentioned. This makes them seem an unimportant part of the collection but, in 1982, the Libraries hired their first Map Librarian, James Walsh. Also in 1982, a room was set aside to house historic maps and atlases within Coe Library, but the bulk of the map collection consisted of depository documents from the United States Geological Survey, the Defense Mapping Agency, the CIA, and other federal government agencies.

In an email message dated February 20, 2013, Walsh discussed how he worked to build the map collection during his tenure, adding collections of Wyoming city and highway maps and purchasing historic maps of the state. The first accurate count of maps in the main library collection was completed in 1983 and found 93,667 maps (Walsh

1983). The 100,000th map was added in 1984 (Walsh 1984). Walsh was named Geology and Maps Librarian in 1985, giving him responsibility for the map collections in both the main library and the Geology branch (the only departmental library not closed after the consolidation.) The Geology Library held 25,000 maps as of June 1986 (Walsh 1987).

The number of maps in the collections increased steadily over time, but maps were still not considered “full-fledged” materials. According to Janet Woods, who worked in the Geology Library beginning in 1981, maps were treated as tools at that time: they were checked out to researchers to use as they saw fit. Topographic maps were disposable and replaced when hard wear made them unusable. Maps were

acquired from the Wyoming State Geological Survey and the Federal Depository Library Program. Most depository maps were kept in the main library; topo maps and depository geologic maps were in the Geology Library. When maps were purchased, it was primarily for classroom use rather than collection building or historic preservation. Still, the first materials that UW Libraries paid to have preserved were a set of atlases, the *Geologic Atlases of Wyoming* (Janet Woods, personal communication). Maps may have been tools but they were tools worth saving.

In the 1990s, the Geology Library was renovated and the bulk of the map collection was moved to the Barlow and Haun Map Room. The historic collection remained at Coe Library and became the core of the Hebard Historic Map Collection. In the late 1990s, the decision was made to catalog the Wyoming maps in the historic map collection and place them at the American Heritage Center, an

archival institute within the University of Wyoming, with the Hebard Collection, where archives staff could provide access and where the materials were stored in an appropriate environment. Only the 7.5' topographic maps remained in the Historic Map Room.

When the Coe Library construction was completed and the new special collections area was ready, both the Hebard Collection and the historic maps were returned. The new space provides a reading room and secured stacks area. The stacks consist primarily of compact shelving, with a section of map cases for flat maps, and wall-mounted racks for rolled wall maps. A special set of drawers are fitted into one of the compact shelving ranges, to provide separate storage for small maps. This ensures these maps, no less important for their size, are better preserved and more easily accessible than if they were hidden among their larger siblings.

## SOME HIGHLIGHTS FROM THE COLLECTION

THE COLLECTING FOCUS of the Chisum Special Collections is the history and culture of Wyoming and the Rocky Mountain West, with one emphasis on Yellowstone and Grand Teton National Parks and other western National Parks. The Historic Map Collection supports this focus with maps depicting Wyoming and the West from its exploration to the present day.

The collection naturally contains several of Grace Raymond Hebard's published maps including her best-known one, *The Map of the History and Romance of Wyoming* (Figure 1). Most she created to accompany her books on Wyoming and Western history. For example, her *Map of the Oregon Trail and Overland Stage Routes* (Figure 2), created with E. A. Brininstool, was published as part of their 1922 book *The Bozeman Trail: Historical Accounts of the Blazing of the*

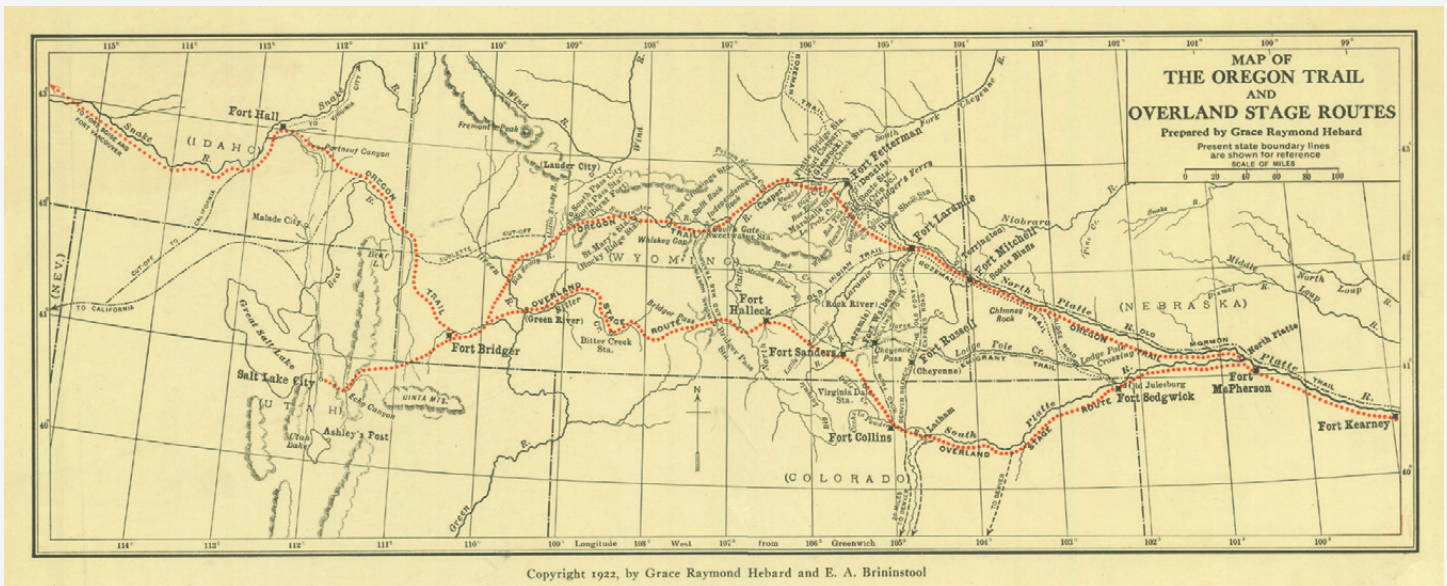


Figure 2: Map of the Oregon Trail and Overland Stage Routes. 1922. Grace Raymond Hebard and E. A. Brininstool.





Figure 3: Map showing the location of the Yellowstone national Park and its prospective railroad connection with the Eastern States. 1872?. National Railway Publication Company.

*Overland Routes into the Northwest, and the Fights with Red Cloud's Warriors.*

The Hebard Historic Map Collection received a significant addition when the University Libraries purchased a rare, hand-drawn plan of Fort Laramie, Wyoming. This plan was probably drawn on location during the late 1860s. Rumors of its existence had circulated for years but no copies had surfaced until recently. The plan of Fort Laramie is an important find and a real jewel of the collection.

In line with the focus of the Chisum Special Collections, the Hebard Historic Map Collection contains an extensive collection of maps of Yellowstone National Park, Grand Teton National Park, and the greater Yellowstone area. These range from historical maps showing the park's situation soon after its establishment, to tourist maps and promotional materials, to recent maps showing its geology, geography, and attractions. Several railroads issued maps of their routes depicting Yellowstone as a major destination that they served (Figure 3). Some of these maps, like the one issued by the Northern Pacific Railway in 1898, are quite beautiful (Figure 4). Some of the maps in the collection are also unusual. Right Way Tourist Guides published a map of Yellowstone in 1925 that depicts routes to and through the park in a style reminiscent of an urban transit map (Figure 5). *A Hysterical Map of Yellowstone Park* and its sibling, *A Hysterical Map of the Jackson Hole Country* (Figure 6), show routes and landmarks captioned with good-natured humor.

Some of these maps illustrate another major collecting focus: maps of transportation routes in Wyoming and the West. As well as showing the locations of trails,

railroads, auto trails and roads, and stations, transportation maps contain a wealth of other information about the period that they depict. For example, The B. F. Goodrich Company produced a national road map in 1915 (Figure 7) which shows major highways existing at the time (including the Lincoln Highway, which followed the route of the Transcontinental Railroad through Wyoming.) It also

Figure 4: The Yellowstone National Park via the Northern Pacific Railway (detail). 1898. Northern Pacific Railway Company.



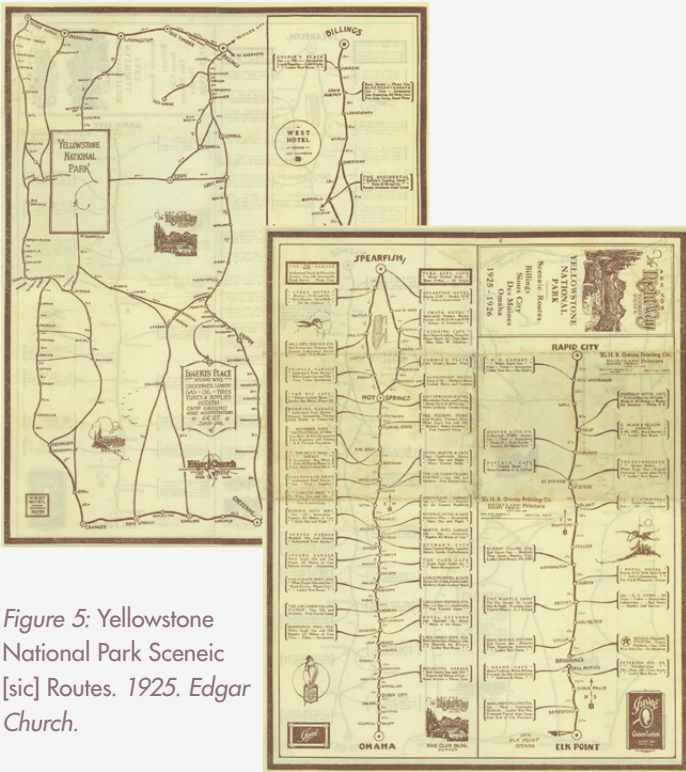


Figure 5: Yellowstone National Park Scenic [sic] Routes. 1925. Edgar Church.

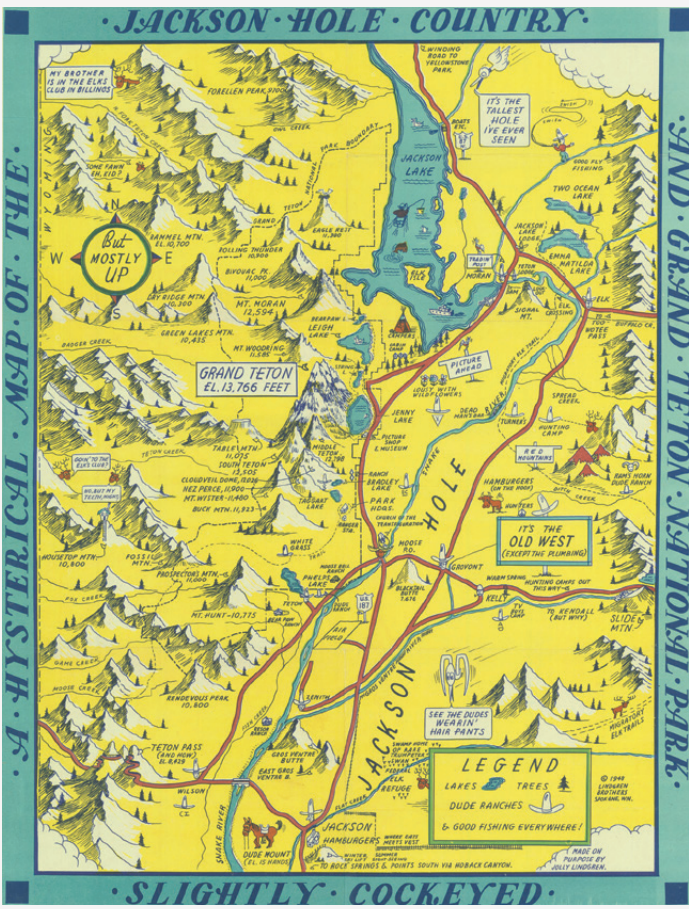


Figure 6: A Hysterical Map of the Jackson Hole Country. 1948. Jolly Lindgren.

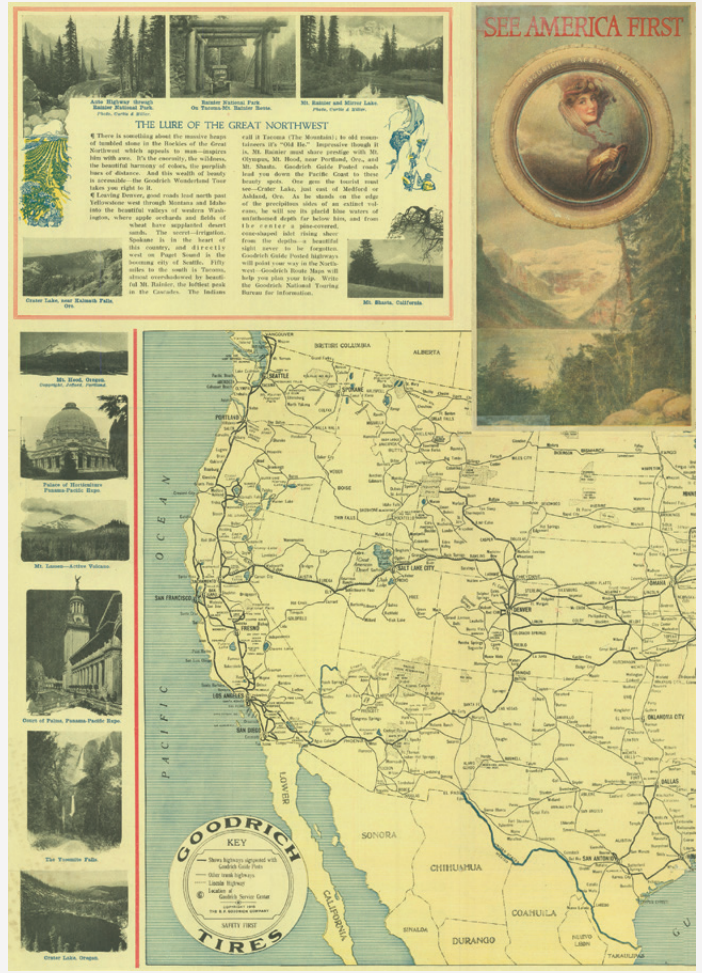


Figure 7: See America First (detail and panel). 1915. B. F. Goodrich Company.

includes photographs of landmarks all across the country, and text lauding the excellent driving conditions in several regions (remember, they were promoting tires).

The Chisum Special Collections is actively collecting maps of other Western national parks and monuments besides Yellowstone and Grand Teton (Figure 8). The creation and development of these specially designated public lands played an important role in the history and culture of the West. Tourism in the West is another topic of interest in the collection, particularly maps and promotional materials from dude and guest ranches in the region.

Government documents of historical significance make up another important part of the collection, reflecting its origin as part of the Documents, Maps and Microforms Department (Figure 9). Important expeditions by John C. Fremont, Ferdinand V. Hayden, and others were undertaken under the auspices of the federal government and the



Figure 8: Devil's Tower National Monument, Wyo (detail). 1954. United States Geological Survey.

maps they produced became part of the government record (Figure 10). These maps are now a part of the Historic Map Collection. The collection also contains an extensive set of recent and historic topographic maps of Wyoming and its surrounding states.

Over the past two years, the Chisum Special Collections has made a concerted effort to digitize many of the maps in the Historic Map Collection. In partnership with the



Figure 10: Map of the route pursued by the late expedition under the command of Col. S. W. Kearny, U.S. 1st Dragoons. 1845. William Buel Franklin.

Libraries' Digital Resources Department, these maps are scanned in a large format scanner and images are added to the catalog. This provides enhanced access to the maps while minimizing wear and tear on these valuable and sometimes fragile resources.

The maps in the Hebard Historic Map Collection have been used to illustrate articles on the history of Wyoming and the West. One of the most recent of these appeared in the Summer/Autumn 2012 issue of the *Annals of Wyoming*: "Dr. Siegfriedt and the Black and White Trail" by Ester Johansson Murray. *Annals* editor, Rick Ewig, in

Figure 9: New Map of the Route of Lewis and Clark, 1804-5-6. 1893. Elliott Cowen.



collaboration with Tamsen Hert, identified maps from the Historic Map Collection to trace the development and route of the trail and to illustrate the article. The Hebard

Historic Map Collection continues to be a rich and valuable resource for researchers in the history and geography of the American West.

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# Creating a Continuously Updated Animated KML Loop with a PHP Mashup

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*This is the first of three Practical Cartographer's Corner pieces in this issue which come from a graduate course entitled "Cartographic Methods," taught by Michael Peterson (mpeterson@unomaha.edu) at the University of Nebraska at Omaha during the 2013 Spring semester.*

## INTRODUCTION

GOOGLE EARTH (GE) can display timestamped features sequentially to create an animation on its interactive globe. The GE TimeSpan capability has been utilized to show a variety of imagery such as historical maps, or before/during/after imagery of remotely sensed landscapes for easy comparison of changes due to a particular event such as flooding. The period between such events can be minutes, days, or even years, and possibly be available at irregular user-specified intervals. As such, TimeSpan is

well-suited to properly display imagery that can be georeferenced, encoded into a Keyhole Markup Language (KML) file, and timestamped for sequential viewing. For imagery that is available at regular intervals, an automated process can be employed to create a continuously updated KML file. Here I describe such a process, a mashup that generates a loop of national weather radar imagery for viewing on Google Earth.

## PROCEDURAL OVERVIEW

A MASHUP IS TYPICALLY a combination of a several different processes, such as a script that generates output that is then compatible for viewing in another application. In this case, the server-side scripting language known as PHP is used to generate a KML file that can be opened and viewed in GE. In order to provide a continuously updated product, a Cron function (a time-based scheduler) is set up on a recurring basis and run as often as needed, usually when a new "most recent" image becomes available that can be added to the animated loop.

The National Weather Service (NWS) offers weather imagery, for example from satellites (clouds) or radar (precipitation), as near-real time static images or as animated loops, the latter showing perhaps the most recent 1–2 hours of recorded imagery. While provided via a web page, users can also download the latest imagery via FTP from the NWS or other sources. Websites showing animated radar or satellite loops usually display the imagery

by utilizing a Java applet or similar browser/client-side program. In 2009, the NWS began to provide a limited selection of their products in a KML format in an experimental fashion. However, the vast majority of weather imagery, including loops, is still supplied through traditional web pages. Due to the limited availability of current animated weather products in the KML format that can then take advantage of GE's functionality including zooming, panning, etc., I implemented a mashup that published a continually updating KML file. When opened in GE, it displayed a weather radar loop comprised of approximately 150 NEXRAD images over the contiguous United States (CONUS). Additionally, it is even possible to overlay other layers in GE such as a satellite (cloud) layer where those graphics may come in at different intervals (e.g., every 30 minutes). Each additional layer added will need its own KML file, perhaps even created by its own separate PHP mashup on a different schedule.



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## THE MASHUP

THE MASHUP PROCEDURE is controlled with the Cron function and programs that run a PHP script at user-specified intervals. In this case, due to the availability of a new CONUS radar composite every 10 minutes, the Cron function called the PHP script every 10 minutes around the clock (at every :00, :10, :20, etc. past the hour). An example Cron command line to run the radar.php script is as follows:

```
*/10**** php -f /home/bdmuller/  
public_html/cgi-bin/radar.php
```

where `*/10****` specifies running the timing interval of every 10 minutes, and `php -f` directs the running of a PHP script, in this case `radar.php` located in the specified folder. However, various web hosting services may include a graphical user interface to enter the timing interval for Cron jobs, as well as a *browse* option to navigate the user to the correct folder for the PHP script, so knowledge of the intricacies of the UNIX Cron command may not be necessary.

Once launched, the PHP script accomplishes the following steps, in this order:

1. Define time variables
2. Construct TimeSpan variables
3. Write to KML file
4. Rename each previously downloaded image to the next older version, and retrieve the most recent new radar image
5. (Optional) FTP (or move/copy) output files to another location, if desired

### STEP 1: DEFINING THE TIME VARIABLES

The PHP code starts out by defining the time variables necessary to accomplish all the tasks (Example 1). Time variables are defined for each time step in the TimeSpan loop sequence: one step for every 10 minutes (600 seconds) in this case. Variables for year, month, day, hour and minute need to be defined at each time step to build the TimeSpan variable text string in step 2 (below). Thus, each additional set of variables uses the time 10 minutes prior from the

previous time step, up to 4 hours prior to the present time, in order to define time variables. This results in 25 total time steps (including the beginning and ending times of the loop), but only 24 frames are shown in the animation as the first frame of the animation will be valid for the 10 minute window of time between 4 hours and 3 hours 50 minutes prior to the end of the loop.

```
<?php  
// compute time variables for previous imagery  
// at 10 minute intervals  
  
date_default_timezone_set('UTC');  
$b = time () - 600;  
$c = time () - 1200;  
$d = time () - 1800;  
$e = time () - 2400;  
$f = time () - 3000;  
$g = time () - 3600; // one hour ago  
$h = time () - 4200;  
$i = time () - 4800;  
$j = time () - 5400;  
$k = time () - 6000;  
$l = time () - 6600;  
$m = time () - 7200; // two hours ago  
$n = time () - 7800;  
$o = time () - 8400;  
$p = time () - 9000;  
$q = time () - 9600;  
$r = time () - 10200;  
$s = time () - 10800; // three hours ago  
$t = time () - 11400;  
$u = time () - 12000;  
$v = time () - 12600;  
$w = time () - 13200;  
$x = time () - 13800;  
$y = time () - 14400; // four hours ago  
  
$curYear1 = date('Y'); // now  
$curMon1 = date('m');  
$curDay1 = date('d');  
$curHour1 = date('H');  
$curMin1 = date('i');  
  
$curYear2 = date('Y',$b);  
$curMon2 = date('m',$b);  
$curDay2 = date('d',$b);  
$curHour2 = date('H',$b);  
$curMin2 = date('i',$b); // this last block of  
// code is repeated to define all time variables
```

Example 1: Sample of code that defines all the time variables.

## STEP 2: ASSEMBLING THE TIMESPAN TEXT STRINGS

Next, the PHP code (Example 2) assembles the TimeSpan variables in the format that Google Earth requires, in order to read them properly. The TimeSpan variable is formatted as follows:

YYYY-MM-DDTHH:MM:SSZZZZZZ

Where:

- “YYYY” represents the 4-digit year (e.g. 2013)
- “MM” represents the 2-digit month (e.g. 01 = January, ... 12 = December)
- “DD” represents the 2-digit day (e.g. 01, 02, ... up to 31)
- “T” is a text divider between the date and time segments of the TimeSpan variable
- “HH” represents the 2-digit hour (e.g. 00, 01, ... up to 23)

- “MM” represents the 2-digit minute (e.g. 00, 01, ... up to 59)
- “SS” represents the 2-digit second (e.g. 00, 01, up to 59)
- “ZZZZZZ” represents the difference from UTC in ± HH:MM (e.g. +04:00 if 4 hours ahead of UTC. Note: this is optional; it can be left blank if conversion to/from UTC and local time is not necessary or they are the same. If left blank GE will assume it is the local time.)

## STEP 3: WRITING TO THE KML FILE

The heart of the code is the generation of the KML output file, and this is accomplished through a series of `fwrite` commands that write to the file. Notice that in the first line of this section of code (Example 3), `unlink` is used as the PHP command to remove a file. After the file is recreated, `fwrite` commands specify the text to enter line-by-line to build the KML file using proper KML formatting

```
$T = "T";//create text strings for timespan variables
$H = "-";
$C = ":";
$Z = "00";
$tv1 = "{$curYear1}{$H}{$curMon1}{$H}{$curDay1}{$T}{$curHour1}{$C}{$curMin1}{$C}{$Z}";// now
$tv2 = "{$curYear2}{$H}{$curMon2}{$H}{$curDay2}{$T}{$curHour2}{$C}{$curMin2}{$C}{$Z}";// 10 minutes ago
$tv3 = "{$curYear3}{$H}{$curMon3}{$H}{$curDay3}{$T}{$curHour3}{$C}{$curMin3}{$C}{$Z}";// 20 minutes ago
$tv4 = "{$curYear4}{$H}{$curMon4}{$H}{$curDay4}{$T}{$curHour4}{$C}{$curMin4}{$C}{$Z}";// 30 minutes ago
$tv5 = "{$curYear5}{$H}{$curMon5}{$H}{$curDay5}{$T}{$curHour5}{$C}{$curMin5}{$C}{$Z}";// etc.
$tv6 = "{$curYear6}{$H}{$curMon6}{$H}{$curDay6}{$T}{$curHour6}{$C}{$curMin6}{$C}{$Z}";// etc.
$tv7 = "{$curYear7}{$H}{$curMon7}{$H}{$curDay7}{$T}{$curHour7}{$C}{$curMin7}{$C}{$Z}";//
$tv8 = "{$curYear8}{$H}{$curMon8}{$H}{$curDay8}{$T}{$curHour8}{$C}{$curMin8}{$C}{$Z}";//
$tv9 = "{$curYear9}{$H}{$curMon9}{$H}{$curDay9}{$T}{$curHour9}{$C}{$curMin9}{$C}{$Z}";//
$tv10 = "{$curYear10}{$H}{$curMon10}{$H}{$curDay10}{$T}{$curHour10}{$C}{$curMin10}{$C}{$Z}";//
$tv11 = "{$curYear11}{$H}{$curMon11}{$H}{$curDay11}{$T}{$curHour11}{$C}{$curMin11}{$C}{$Z}";//
$tv12 = "{$curYear12}{$H}{$curMon12}{$H}{$curDay12}{$T}{$curHour12}{$C}{$curMin12}{$C}{$Z}";//
$tv13 = "{$curYear13}{$H}{$curMon13}{$H}{$curDay13}{$T}{$curHour13}{$C}{$curMin13}{$C}{$Z}";//
$tv14 = "{$curYear14}{$H}{$curMon14}{$H}{$curDay14}{$T}{$curHour14}{$C}{$curMin14}{$C}{$Z}";//
$tv15 = "{$curYear15}{$H}{$curMon15}{$H}{$curDay15}{$T}{$curHour15}{$C}{$curMin15}{$C}{$Z}";//
$tv16 = "{$curYear16}{$H}{$curMon16}{$H}{$curDay16}{$T}{$curHour16}{$C}{$curMin16}{$C}{$Z}";//
$tv17 = "{$curYear17}{$H}{$curMon17}{$H}{$curDay17}{$T}{$curHour17}{$C}{$curMin17}{$C}{$Z}";//
$tv18 = "{$curYear18}{$H}{$curMon18}{$H}{$curDay18}{$T}{$curHour18}{$C}{$curMin18}{$C}{$Z}";//
$tv19 = "{$curYear19}{$H}{$curMon19}{$H}{$curDay19}{$T}{$curHour19}{$C}{$curMin19}{$C}{$Z}";//
$tv20 = "{$curYear20}{$H}{$curMon20}{$H}{$curDay20}{$T}{$curHour20}{$C}{$curMin20}{$C}{$Z}";//
$tv21 = "{$curYear21}{$H}{$curMon21}{$H}{$curDay21}{$T}{$curHour21}{$C}{$curMin21}{$C}{$Z}";//
$tv22 = "{$curYear22}{$H}{$curMon22}{$H}{$curDay22}{$T}{$curHour22}{$C}{$curMin22}{$C}{$Z}";//
$tv23 = "{$curYear23}{$H}{$curMon23}{$H}{$curDay23}{$T}{$curHour23}{$C}{$curMin23}{$C}{$Z}";//
$tv24 = "{$curYear24}{$H}{$curMon24}{$H}{$curDay24}{$T}{$curHour24}{$C}{$curMin24}{$C}{$Z}";//
$tv25 = "{$curYear25}{$H}{$curMon25}{$H}{$curDay25}{$T}{$curHour25}{$C}{$curMin25}{$C}{$Z}";// 4 hours ago
```

Example 2: Sample of code that assembles the TimeSpan text strings.



```

unlink('radar.kml');
$filename = 'radar.kml';
$handle = fopen($filename, "w");

fwrite($handle, '<?xml version="1.0" encoding="UTF-8"?>'. "\n");
fwrite($handle, '<kml xmlns="http://earth.google.com/kml/2.1">'. "\n");
fwrite($handle, '<Folder>'. "\n");
fwrite($handle, '  <name>TEST: GE animation of CONUS Radar Mosaic</name>'. "\n");
fwrite($handle, '  <description><![CDATA['. "\n");
fwrite($handle, 'Before animating, shrink time window in slider to minimum.'. "\n");
fwrite($handle, 'Animation only works in latest GE beta 4.0 (after Sept 13, or 14 for Mac).'. "\n");
fwrite($handle, 'Overlay shows NWS CONUS Radar Mosaic '. "\n");
fwrite($handle, 'NOTE: This is experimental.'. "\n");
fwrite($handle, ']]></description>'. "\n");
fwrite($handle, '  <LookAt>'. "\n");
fwrite($handle, '    <longitude>-100.00</longitude>'. "\n");
fwrite($handle, '    <latitude>50.406626367301044</latitude>'. "\n");
fwrite($handle, '    <range>10000000</range>'. "\n");
fwrite($handle, '    <tilt>0</tilt>'. "\n");
fwrite($handle, '    <heading>0</heading>'. "\n");
fwrite($handle, '    <TimeSpan>'. "\n");
fwrite($handle, '      <begin>'. "$tv25". '</begin>'. "\n");
fwrite($handle, '      <end>'. "$tv24". '</end>'. "\n");
fwrite($handle, '    </TimeSpan>'. "\n");
fwrite($handle, '  </LookAt>'. "\n");
fwrite($handle, '  <TimeSpan>'. "\n");
fwrite($handle, '    <begin>'. "$tv25". '</begin>'. "\n");
fwrite($handle, '    <end>'. "$tv1". '</end>'. "\n");
fwrite($handle, '  </TimeSpan>'. "\n");
fwrite($handle, '  <Folder>'. "\n");
fwrite($handle, '    <name>frames</name>'. "\n");
fwrite($handle, '    <description>Animation frames NWS CONUS Radar</description>'. "\n");

```

*Example 3: Sample of code that creates and opens the new KML file and writes the header information.*

and language. Text inside single quote marks (') is written to the KML file as-is, while variables like the `TimeSpan` values (`$tv1`, `$tv2`, etc.) are translated to their text string equivalent values when inserted between double quote marks ("). Each `fwrite` line ends with a carriage return command ("`\n`") so the output KML file is human-readable in a text editor or word processor.

After writing the opening section of the KML file, the PHP code becomes very repetitive (Example 4), repeating the segment of code between the lines `<groundoverlay>` and `</groundoverlay>` 24 times, once for each step of the animation. These repeating sections are identical except for the different `TimeSpan` variables in each section, as well as different hyperlink references to the correct graphical file for that time step. This section of code then closes the KML file with an `fclose` command once the final line of KML is written.

#### **STEP 4: FILE RENAMING SEQUENCE**

The last required step of the mashup is to rename each image of the loop to the next older version of the file, starting with the oldest image first (Example 5). This has the effect of keeping only the last 24 images (one every 10 minutes for 4 hours). This was done so as not to keep an endlessly large archive of all downloaded images. Once the renaming sequence is completed, the newest radar composite image is retrieved from the NWS website using the `file_put_contents` and `file_get_contents` commands shown in the Example 5 code.

#### **STEP 5 (OPTIONAL): FTP OUTPUT FILES TO ALTERNATE LOCATION**

Although not shown here, one optional step, given PHP's capabilities, is to use FTP or similar PHP file move/copy commands to transfer the updated files to a new server

```

fwrite($handle, ' <GroundOverlay>'."\n");
fwrite($handle, ' <name>CONUS - '."$tv24".'</name>'."\n");
fwrite($handle, ' <description>CONUS Mosaic</description>'."\n");
fwrite($handle, ' <TimeSpan>'."\n");
fwrite($handle, ' <begin>'."$tv25".'</begin>'."\n");
fwrite($handle, ' <end>'."$tv24".'</end>'."\n");
fwrite($handle, ' </TimeSpan>'."\n");
fwrite($handle, ' <Icon>'."\n");
fwrite($handle, ' <href>http://bdmuller.freetzi.com/Presentation/latest_radaronly-23.gif</href>'."\n");
fwrite($handle, ' </Icon>'."\n");
fwrite($handle, ' <LatLonBox id="BBOX">'."\n");
fwrite($handle, ' <south>21.652538062803</south>'."\n");
fwrite($handle, ' <north>50.406626367301044</north>'."\n");
fwrite($handle, ' <west>-127.620375523875420</west>'."\n");
fwrite($handle, ' <east>-66.517937876818</east>'."\n");
fwrite($handle, ' <rotation>0</rotation>'."\n");
fwrite($handle, ' </LatLonBox>'."\n");
fwrite($handle, ' </GroundOverlay> <GroundOverlay>'."\n");
// the section of code above is repeated for each frame of timespan loop and variable $tvxx is changed for each
// the section of code below is the final section to the end of the file
fwrite($handle, ' </GroundOverlay> <GroundOverlay>'."\n");
fwrite($handle, ' <name>CONUS - '."$tv1".'</name>'."\n");
fwrite($handle, ' <description>northeast Mosaic</description>'."\n");
fwrite($handle, ' <TimeSpan>'."\n");
fwrite($handle, ' <begin>'."$tv2".'</begin>'."\n");
fwrite($handle, ' <end>'."$tv1".'</end>'."\n");
fwrite($handle, ' </TimeSpan>'."\n");
fwrite($handle, ' <Icon>'."\n");
fwrite($handle, ' <href>http://bdmuller.freetzi.com/Presentation/latest_radaronly.gif</href>'."\n");
fwrite($handle, ' </Icon>'."\n");
fwrite($handle, ' <LatLonBox id="BBOX">'."\n");
fwrite($handle, ' <south>21.652538062803</south>'."\n");
fwrite($handle, ' <north>50.406626367301044</north>'."\n");
fwrite($handle, ' <west>-127.620375523875420</west>'."\n");
fwrite($handle, ' <east>-66.517937876818</east>'."\n");
fwrite($handle, ' <rotation>0</rotation>'."\n");
fwrite($handle, ' </LatLonBox>'."\n");
fwrite($handle, ' </GroundOverlay></Folder>'."\n");
fwrite($handle, ' </Folder>'."\n");
fwrite($handle, ' </kml>'."\n");
fclose($handle);

```

*Example 4: Sample of code that writes each groundoverlay segment of the KML file, repeated 24 times (once for each time step).*

or location such as your own public web site folder, if not already there. Commands like `ftp_open`, `ftp_put` and `ftp_close` are used to open an FTP connection, transfer

the selected files and then close the FTP connection when completed.

## RESULTING ANIMATION

ONCE THE PHP CODE execution has completed, the new KML file is ready to open in GE. Upon opening the KML file, GE will recognize the `TimeSpan` commands and individual frames from each `groundoverlay` section. While

GE loads each of the 24 frames, it works best to manually advance the time steps on the `TimeSpan` slider bar the first time through, allowing a few moments for each frame to load. Once they have loaded, you can open the *Date*

and *Time Options* (click on the wrench icon on the TimeSpan control bar), then adjust the loop animation speed and check the *Loop Animation* box if desired. Once started, the animation will run in a continuous loop, and the user can zoom in, pan and rotate around any feature of interest, utilizing the full capabilities of GE. As an example, several images from the animated loop of April 22, 2013 can be seen in Figure 1. This particular KML file is available for download at: <http://bdmuller.comeze.com/Project/radar.kml>.

## SUMMARY

THROUGH THE USE of a mash-up method, a computer user familiar with Cron functionality, PHP commands, KML, and GE can create their own animated loops using different types of graphics that update on regular or even irregular intervals and display these within Google Earth. Just about any time-stamped graphical image that is produced in a recurring fashion can be assembled into a loop and viewed as a GE TimeSpan animation. Finally, the mashup can be customized to operate on any number of animation frames or timing intervals

## REFERENCES

Google. 2013. "Keyhole Markup Language, Time and Animation." Last modified November 14. <https://developers.google.com/kml/documentation/time>.

IBM. 2013. "UNIX Cron Format." *IBM DB2 Database for Linux, UNIX, and Windows Information Center*. Accessed April 15. <http://publib.boulder.ibm.com/infocenter/db2luw/v9r5/index.jsp?topic=%2Fcom.ibm.db2.luw.sql.rtn.doc%2Fdoc%2Fc0054381.html>.

```
//Previous files are renamed to the next older version each
//time the code executes until they are each overwritten keeping
//only the most recent 4 hours of the loop
rename("latest_radaronly-23.gif", "latest_radaronly-24.gif");
rename("latest_radaronly-22.gif", "latest_radaronly-23.gif");
rename("latest_radaronly-21.gif", "latest_radaronly-22.gif");
rename("latest_radaronly-20.gif", "latest_radaronly-21.gif");
rename("latest_radaronly-19.gif", "latest_radaronly-20.gif");
rename("latest_radaronly-18.gif", "latest_radaronly-19.gif");
rename("latest_radaronly-17.gif", "latest_radaronly-18.gif");
rename("latest_radaronly-16.gif", "latest_radaronly-17.gif");
rename("latest_radaronly-15.gif", "latest_radaronly-16.gif");
rename("latest_radaronly-14.gif", "latest_radaronly-15.gif");
rename("latest_radaronly-13.gif", "latest_radaronly-14.gif");
rename("latest_radaronly-12.gif", "latest_radaronly-13.gif");
rename("latest_radaronly-11.gif", "latest_radaronly-12.gif");
rename("latest_radaronly-10.gif", "latest_radaronly-11.gif");
rename("latest_radaronly-9.gif", "latest_radaronly-10.gif");
rename("latest_radaronly-8.gif", "latest_radaronly-9.gif");
rename("latest_radaronly-7.gif", "latest_radaronly-8.gif");
rename("latest_radaronly-6.gif", "latest_radaronly-7.gif");
rename("latest_radaronly-5.gif", "latest_radaronly-6.gif");
rename("latest_radaronly-4.gif", "latest_radaronly-5.gif");
rename("latest_radaronly-3.gif", "latest_radaronly-4.gif");
rename("latest_radaronly-2.gif", "latest_radaronly-3.gif");
rename("latest_radaronly-1.gif", "latest_radaronly-2.gif");
rename("latest_radaronly.gif", "latest_radaronly-1.gif");

//After renaming old files then retrieve newest CONUS Radar Mosaic
file_put_contents("latest_radaronly.gif",
    file_get_contents("http://radar.weather.gov/ridge/Conus/
        RadarImg/latest_radaronly.gif"));
```

*Example 5: Sample of code that renames each previously downloaded image to the next older version in the sequence ("23" becomes "24," "22" becomes "23," etc.)*

that the user desires, creating a custom animation suitable for viewing through Google Earth.

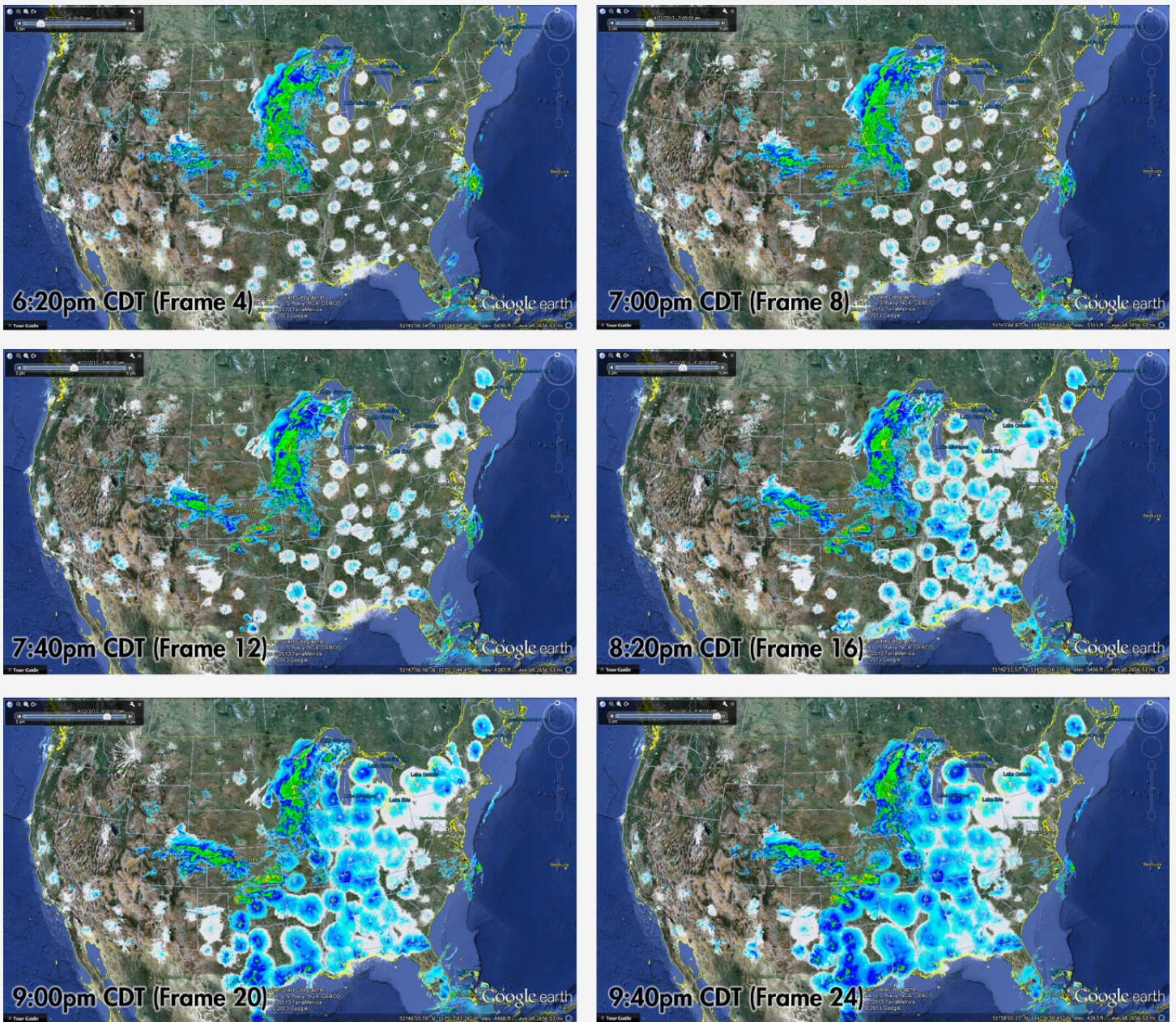


Figure 1: Selected frames from the animated loop of April 22, 2013.

National Weather Service. 2013. "National Weather Data in KML/KMZ Formats." Last modified August 14. <http://www.srh.noaa.gov/gis/kml/>.

The PHP Documentation Group. 2014. "PHP Manual." Last modified March 18. <http://www.php.net/manual/en/index.php>.



## Mapping the EXIF Data Stored in an Image

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*This is the second of three Practical Cartographer's Corner pieces in this issue which come from a graduate course entitled "Cartographic Methods," taught by Michael Peterson (mpeterson@unomaha.edu) at the University of Nebraska at Omaha during the 2013 Spring semester.*

ALMOST ALL PICTURES taken with mobile phones incorporate location within a portion of the image file. These Exchangeable Image File Format (EXIF) data are a standard part of each picture, and include a variety of information, including the device used, the lens, the exposure, and the date and time the image was taken (Wikipedia 2013). If the phone can determine its location through GPS, WiFi or cell phone tower triangulation, the latitude and longitude will also be captured.

The process of extracting location data is quite simple, and my purpose here is to give an overview of the necessary code and some of the options for displaying them. There are few requirements: the image must have an Internet address and must include the location within the EXIF part of the file. One thing to note is that some sites, such as Flickr and Facebook (Bailey 2010), often extract the EXIF data and then remove that information from the image; you will need the original images and not ones uploaded to Flickr or other similar sites.

PHP was used for extracting location data, as it has many built-in functions that are useful for this task. The PHP code in Example 1, checks to make sure there is locational data stored in the EXIF. Next, it extracts the data and does the conversion necessary to get the GPS coordinates into the proper latitude and longitude format. The data are stored as degrees, minutes, and seconds and need to be converted into degree decimal format. Finally, the function returns the properly formatted latitude and longitude. This point can then be placed on a map.

The PHP code in Example 2 places the latitude and longitude into the HTML code:

Line 1 — calls the function `readGPSinfoEXIF()` and sets the variable `$results` to the values returned.

Line 2 — sets the `$lat` variable equal to the value in the first element of the `$results` array.

Line 3 — sets the `$lng` variable to the second element in the `$results` array. It is then multiplied by `-1` to put the point in the proper hemisphere.

Line 4 — PHP outputs the HTML values for the body tag and inserts the call to the JavaScript function `initialize()` with the values for latitude and longitude returned from PHP variables.

Line 5 — PHP outputs the HTML code to create a table section and creates the first table row.

Line 6 — PHP outputs the code to create the first standard cell in the table and inserts the map variables.

Line 7 — PHP outputs the standard table cell that will contain the image that contains the locational data.

Line 8 — Closes the table row and table.

In Example 3, the JavaScript function `initialize()` creates the actual map and assigns the values to the title and info window. By querying the Google geocoder function with the latitude and longitude, the `initialize()` function can determine the closest address. The results are returned in a number of formats. For this example, the basic address, city, state, and ZIP information are returned. This reverse geocoding is only an estimate and is not guaranteed to be the closest address (Google 2013).



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```

function readGPSinfoEXIF()
{
    $exif=exif_read_data('outside.jpg', 0, true); //sets a variable with all
                                                //the EXIF data

    if(!$exif || $exif['GPS']['GPSLatitude'] == '') //Determines if the
                                                //geolocation data exists in the EXIF data
    {
        return false;           //no GPS Data found
        echo "No GPS DATA in EXIF METADATA";
    }
    else
    {
        $lat_ref = $exif['GPS']['GPSLatitudeRef'];
        $lat = $exif['GPS']['GPSLatitude'];           //sets a variable equal
                                                //to the Latitude
        list($num, $dec) = explode('/', $lat[0]); //calculates the Degrees
        $lat_s = $num / $dec;
        list($num, $dec) = explode('/', $lat[1]); //calculates the Minutes
        $lat_m = $num / $dec;
        list($num, $dec) = explode('/', $lat[2]); //calculates the Seconds
        $lat_v = $num / $dec;

        $lon_ref = $exif['GPS']['GPSLongitudeRef'];
        $lon = $exif['GPS']['GPSLongitude'];           //sets the variable for
                                                //the longitude
        list($num, $dec) = explode('/', $lon[0]); //puts the degrees into
                                                //a variable
        $lon_s = $num / $dec;
        list($num, $dec) = explode('/', $lon[1]); //puts the minutes into
                                                //a variable
        $lon_m = $num / $dec;
        list($num, $dec) = explode('/', $lon[2]); //puts the seconds into
                                                //a variable
        $lon_v = $num / $dec;

        //Calculates the GPS location in decimal form.
        $gps_int = array($lat_s + $lat_m / 60.0 + $lat_v / 3600.0, $lon_s
            + $lon_m / 60.0 + $lon_v / 3600.0);
        return $gps_int; //returns the coordinates
    }
}

```

Example 1: PHP code for extracting the EXIF data from an image.

Example 2: This code writes the HTML that displays the web page with the values gathered from the EXIF extract. The line numbers are only used for the line-by-line explanation.

```

Line 1 - $results = readGPSinfoEXIF();
Line 2 - $lat = $results[0];
Line 3 - $lng = $results[1] * -1; //the returned value for longitude
        //must be negative to be mapped on this side of the world.
Line 4 - echo "<body onload=\"initialize( $lat , $lng )\">" ;
Line 5 - echo "<table><tr>";
Line 6 - echo " <td><div id=\"map-canvas\" style=\"width: 800px; height:
        480px;\"></div> </td>";
Line 7 - echo " <td><img src='outside.jpg' width=200: height=300><td>";
Line 8 - echo " </tr></table>";

```

```

<script type="text/javascript" src="http://maps.google.com/maps/api/js?sensor=false">
  </script>
<script>
  var geocoder;
  var map;
  function initialize(lat, lng) {
    geocoder = new google.maps.Geocoder(); //name of the function //creates a new geocoder object
    var latLng = new google.maps.LatLng(lat, lng); //creates new lat and long object
    var mapOptions = {
      zoom: 11, //sets the zoom level to 11
      center: latLng, //makes the center of the map
      //the latitude and longitude of the image
      mapTypeId: google.maps.MapTypeId.ROADMAP //sets the type of map to be //displayed
    }
    //creates the actual map object with the previously set options
    map = new google.maps.Map(document.getElementById("map-canvas"), mapOptions);

    geocoder.geocode({'latLng': latLng}, function(results, status)
    {
      if (status == google.maps.GeocoderStatus.OK) { //logic chekt to see if // mapping successful
        if (results[1]) {
          marker = new google.maps.Marker({ //create marker at the //point from the image
            position: latLng,
            title: results[0].formatted_address, //create the title //of the map the same as the closest address found.
            map: map});
          var infowindow = new google.maps.InfoWindow({ //create an infowindow //to display the address also
            content: results[0].formatted_address});
          infowindow.open(map,marker);
        }
        } else {
          alert("Geocoder failed due to: " + status);
        }
      }
    });
  }
</script>

```

*Example 3: The JavaScript used to get the geocoded information based on the latitude and longitude returned from the PHP code.*

Now that the locational data have been extracted and the map has been created, the information is sent to the client and the point is mapped. The information is displayed in both the information window and the title, which displays when the mouse hovers over the marker.

Adjusting the display marker is possible. For example, a thumbnail image could be used to substitute the image for the marker. The image used as the marker needs to be small and should be in the Portable Network Graphics (PNG) format.

```

var image = 'beachflag.png';
var myLatLng = new google.maps.LatLng(-33.890542, 151.274856);
var beachMarker = new google.maps.Marker({
  position: myLatLng,
  map: map,
  icon: image
});

```

*Example 4: The JavaScript code to create a custom marker icon.*

In Example 4, `icon: image` is the code that assigns the image to the marker. At this point, we can also add a shadow with the code `shadow: shadowimage` where `shadowimage` is the location and name of the shadow file. This shadow file is usually a few pixels larger than the thumbnail image. One could also set the `shadowimage` to a grey image if the location is found



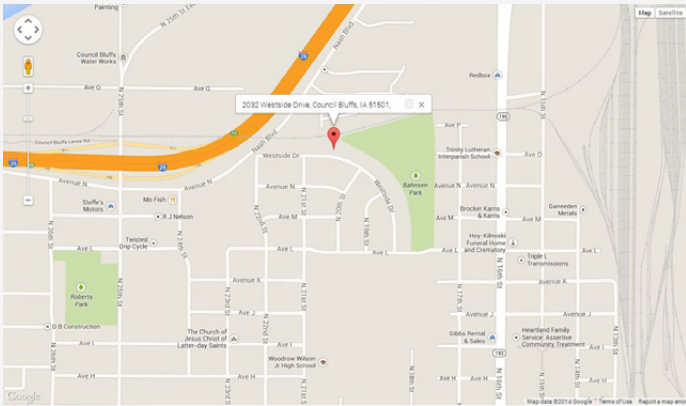


Figure 1: The image and its location based on data extracted from the EXIF part of the image file.

in the EXIF data, or alternatively the shadowimage could be red to indicate missing data (Figure 2).

Other forms of symbolization are possible. For instance, if the ZIP code is missing from the Google query, one could change the image to bounce with the animation: `google:maps.Animation.BOUNCE` code in the marker settings.

## REFERENCES

Bailey, Jonathan. 2010. "Flickr and Facebook STILL Strip EXIF Data." *Plagiarism Today*. Accessed April 14, 2013. <http://www.plagiarismtoday.com/2010/04/22/flickr-and-facebook-still-strip-exif-data/>.

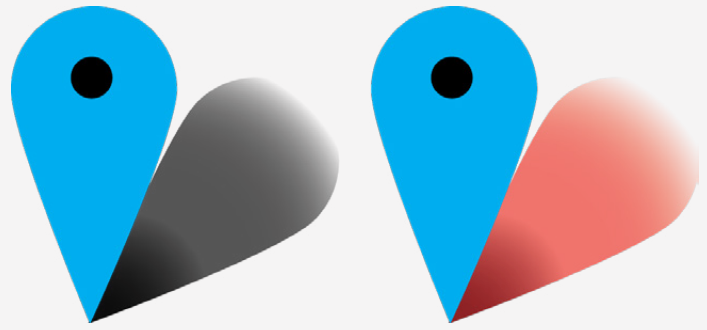


Figure 2: The first image is an example of a shadow that would represent the existence of EXIF data for location. The second image, using a red shadow, represents missing data.

There are many options available for displaying EXIF data that would allow the developer to add uniqueness and interactivity to their maps through images. The EXIF data are currently used in many popular applications and websites. The examples here use Google's API but this is not the only mapping API currently available. Leaflet and OpenStreetMap can both display the images and their respective EXIF data in a similar manner to Google.

In the end, it is up to the developer to decide which options to use and how to utilize the available API tools, and as geocoding becomes more popular, more tools and mapping options will become available.

With some imagination, it is easy to create a unique mapping experience with photos and EXIF data.

Google. 2013. "Reverse Geocoding (Address Lookup)." *Google Developers*. Accessed April 14. <https://developers.google.com/maps/documentation/geocoding/#ReverseGeocoding>.

Wikipedia. 2013. "Exchangeable image file format." Accessed April 14. [http://en.wikipedia.org/wiki/Exchangeable\\_image\\_file\\_format](http://en.wikipedia.org/wiki/Exchangeable_image_file_format).

# Map-based Input with Google Fusion Tables

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*This is the final of three Practical Cartographer's Corner pieces in this issue which come from a graduate course entitled "Cartographic Methods," taught by Michael Peterson (mpeterson@unomaha.edu) at the University of Nebraska at Omaha during the 2013 Spring semester.*

## INTRODUCTION

GOOGLE FUSION TABLES has become increasingly popular for its data sharing potential as well as its automatic geocoding service, which converts tabular address data to latitude and longitude coordinates and plots them on a map. Understandably, there is substantial documentation on the web devoted to helping people and organizations take advantage of these features. However, one area that is not well documented is how to enter point data through a map.

There are potentially very many practical applications for entering point locations. For example, a digital history project team using an online GIS to display and store their data may want to receive requests and corrections to their data set from other historians; or perhaps a crowd-sourced mapping project relies on input from many users

simultaneously, none of whom are GIS technicians. It is possible for a web developer to create a MySQL database on a server and grant users the requisite permissions to write to that database using information drawn from the map application.

Google Fusion Tables provides a viable and simple alternative for entering point data. Outlined here is how to build a basic, cloud-based method of map input that uses a combination of free Google services to acquire, manage, and display spatial data. An intermediate understanding of HTML and JavaScript is required to create a map-based input application with Fusion Tables. A prospective developer will need a web host for displaying pages and a designated Google account, preferably not a personal account.

## CREATING AND SYNCING THE FORM AND DATABASES

AS WITH ALL database applications, the structure of the database must be planned in advance. The process will synchronize Google Forms, Google Spreadsheets, and Google Fusion Tables, and so it is desirable to have the fields for all three of these match to ensure that data are being transferred and copied properly. If a developer wants to add a field to a Fusion Table, for example, and expects user input for those fields from a map-based application, a change has to be made at all levels, and this becomes more difficult after data input begins.

The process begins with creating a Google Form in Google Drive and adding text-field questions for "latitude" and "longitude," in addition to any other attribute information that a developer might want to attach to mapped data points. For custom styling options in the final output, some question should involve a categorical variable that can be queried later (the example here asks the user to categorize the type of point, assigning a numerical value of 1, 2 or 3 from a radio button selector to fill the form field). Afterward, the developer should click *Choose response destination* in the menu bar and elect to create a new Google Spreadsheet in which the responses will be stored.



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Once the spreadsheet is in place, a Google Fusion Table is created in Google Drive by choosing **Create > Fusion Table**, importing the newly-created spreadsheet that is already synchronized with the form. Because the latitude and longitude fields have to be submitted through the form as text, they come into the Fusion Table as text as well, and this property has to be changed for mapping data. Changes are made to columns in Fusion Tables by choosing **Edit > Change Columns** in the menu bar. Columns are selectable on the left, and, once highlighted, their properties are displayed on the right. Latitude and longitude should be changed to *location* types, *two column location* should be checked. Once changes are saved, and before returning to Google Drive, it is very important to record the unique ID for the Fusion table. The ID is a 40-character alphanumeric string accessed by selecting **File > About** in the menu of the Fusion Table, and this string is needed for accessing the table using the Google Maps API. Finally, the table should be shared.

A little bit of script editing can synchronize the Fusion Table with the form, but first a project has to be prepared and authorized to use scripts on a user's account. This work is done in the script editor, which is accessed in the response spreadsheet by selecting **Tools > Script Editor**. The very first task is setting the project properties for the script, accessed in the menu bar of the script editor, by selecting **File > Project Properties...** The developer has to enter his

Figure 1: Entering project properties to authorize scripts.

Property	Value
docid	"PUT_THIS_IN_QUOTES"
username	<input type="text" value="yourgoogleaccount"/>
password	*****

[+ Add row](#)

## CREATING THE MAP INPUT SYSTEM

GOOGLE FORMS AUTOMATICALLY generates a webpage for form submissions. Clicking on *View live form* from the spreadsheet and viewing the source code for the form, or grabbing the *embed form in a webpage* link allows a developer to view the HTML code for the standard input form. Within this code are several items of interest. First

or her Google account username, and add rows to enter the account password and a “docid,” which will be the variable used to identify the Fusion Table ID to which the spreadsheet will sync (Figure 1). It is very important to enter the “docid” field in quotation marks.

After project properties have been set, a custom script can be developed to synchronize the spreadsheet with the Fusion Table. The process can be extremely complicated, even for those who have experience writing scripts. Fortunately, Kathryn Hurley of the Google Fusion Tables team has provided a very useful script specifically intended to synchronize Google Spreadsheets and Google Fusion Tables. The script can be accessed from <http://khsamples.googlecode.com/svn/trunk/code/appscript.js> and it should be copied from its source and pasted into the script editor window, replacing all of the placeholder text that may be present. Again, Google has made some minor adjustments to their online documents system since the creation of the script. In particular, the Google Fusion Table ID field is now a string rather than a numeric ID, so it important that the value for docid is contained within quotation marks in the project properties window. That way, the script will properly identify the Fusion Table to which it is supposed to send data. With the script copied into the editor window, the project should then be saved.

The last steps of syncing the form and databases involve automating and authorizing the sync process. In the script editor menu, the developer should choose **Select Function > onFormSubmit**. Then, the steps should be run by selecting the small triangle *Run* button from the menu. The program prompts the developer to authorize. After authorizing the behavior, the developer should select the *Triggers* (clock icon) from the menu and click to add the trigger mechanism: *Run: onFormSubmit, Events: From spreadsheet, “on form submit.”* After the steps have been completed, input generated from the form will automatically write to the Fusion Table as well as the response spreadsheet.

of all, the URL listed in the form action section is the target spreadsheet to which the form is sending data. Each segment of the form lists a variable name that represents a column in the database to which records are added (e.g., “name = entry\_1739129090”). These fields precede the text that indicates the title for each input box. There is also an

```

map = new google.maps.Map(document.getElementById('map-canvas'),
    mapOptions);

google.maps.event.addListener(map, 'click', function(event) {
    addMarker(event.latLng, map);
});

google.maps.event.addListener(map, 'click', function(event) {
    var lat = document.getElementById("latbox").value = event.latLng.lat()
    var lng = document.getElementById("lngbox").value = event.latLng.lng()

```

*Example 1: Setting listeners for map click events and acquiring values for the variables.*

*ID* field that identifies each form box relative to other elements on the page. Lastly, an important item to note is how the HTTP POST command is used to submit records to the database. Whether data are being sent using this combination of Google Maps API and Google Forms, or whether a developer is attempting to send data to a Fusion Table directly, the POST command is the standard format for inserting data into Google Drive documents.

The map application input system for the Fusion Tables database therefore is focused on capturing user-defined information in the browser, most importantly latitude and longitude, and routing that information to the form input boxes by way of creating user-defined variables that link up with the ID names of form input variables.

Once the map has been called in an initialize function, listeners have to be set, waiting for users to commit a single click event and capture the coordinates of that click. The code follows a simple `document.getElementById(XXX)`.

`value = format`. Examples 1 and 2 document working excerpts of this procedure using Google Maps API v.3.

With listeners and events set to capture coordinates to variables, the next step is copying the code from a Google Form into the same code as the map (alternatively, it is possible to create a custom HTML form that uses the same POST command to write to the same location). The *id* fields of the form that are intended to represent latitude and longitude should be reset to the event variables that are used to capture latitude and longitude, respectively (Example 2).

Once the changes to the code have been made and saved, input to the form posts to the Fusion Table. Each submission represents one new row in the Fusion Table, and all form fields are likewise attached to the coordinates, much like a true desktop GIS stores data to locations. If desired, the rows can be edited in the Fusion Table without affecting the records in the spreadsheet.

```

<form action="https://docs.google.com/forms/d/ldzJ3x3GcOqWzHKmtCPX859mvQvnAcx0-PD6AH8CzaCA/formResponse"
method="POST">
    <spanclass="ss-q-title">Description</span>
    <input type="text" class="ss-q-short" name="entry_180163717" />
    Latitude:
        <input size="19" type="text" id="latbox" class="ss-q-short" name="entry_1739129090" value="">
    Longitude:
        <input size="19" type="text" id="lngbox" class="ss-q-short" name="entry_1554287385" value="">

```

*Example 2: Changing the id= field to correspond to the variables for latitude and longitude.*

```

layer = new google.maps.FusionTablesLayer({
  query: {
    select: 'Number',
    from: 'li_puliVU7S4PwTrdmmYkNsJWUk1B10Bx1EhD8'
  },

  styles: [
    {where: "'Code' = 1", markerOptions: { iconName: "red_blank"}},
    {where: "'Code' = 2", markerOptions: { iconName: "blu_blank"}},
    {where: "'Code' = 3", markerOptions: { iconName: "grn_blank"}},
  ]});

layer.setMap(map);

```

Example 3: Google Maps API Styling from Fusion Table data.

## STYLING THE INPUT

RECENT ISSUES of *Cartographic Perspectives* have addressed Fusion Tables styling options, focused on setting the styles in the Fusion Table interface and using “buckets” to establish choropleth map color schemes (Peterson et al. 2012). Adding styles directly to records in the Fusion Table, however, saves the style and associates it directly with the data. While this gives significant control to the developer about how features are displayed, it also restricts the range of potential map applications that can be built by limiting the way that the data can be used. Google Maps API allows application creators to address the issue of styles based upon their own needs. Just as the previous steps have outlined the development of a crowd-sourced database input system, this section anticipates that multiple individuals also want to access the data in their own ways.

Fusion Tables layers are styled using Google Maps API by expanding the layer definition section. Rather than calling the table in one line of code, it is queried and styles are set by defining the symbol for each feature. Point data markers are defined in the marker options by using `iconName`: to reference an icon by name from Google’s list of markers and colors. For example, `red_blank` is a plain red marker symbol, while `blu_blank` is a plain blue marker symbol. The process of styling polygon data is similar, except



Figure 2: Markers styled according to Google Fusion Table input.

that `polygonOptions` is used instead of `markerOptions`, and, rather than calling a specific icon, the developer defines a fill color using `fillColor`: and `fillOpacity`: to set an HTML color code and opacity level (from 0 to 1), respectively.

In the example, the `Code` field is the Fusion Table column containing descriptions that users selected for point data when they submitted to the database (Example 3).

Because the previous Google Form input steps provided a radio button with distinct and mutually exclusive categories, a user adding data through the map interface is storing information about feature classes to the database. The end result is a map that effectively recognizes user-defined classes (Figure 2).

## SUMMARY

EXPLOITING GOOGLE'S SERVICES for their robust data management properties does constrain the developer to Google's limitations, such as the exclusive use of a web Mercator projection in all mapping, or the fact that icons come from a pre-selected marker list. On the other hand, a crowd-sourced geospatial data entry project can be established quickly and deployed in the cloud using only the free tools made available by Google. The combination of Google Fusion Tables, Google Forms, and the Google Maps API provides a map input tool that circumvents issues associated with setting up and giving user access to a MySQL database that stores data. Between Google Fusion Tables and Google Maps API, styling options allow a developer to query user inputs and customize symbols

automatically based on any set of parameters, potentially minimizing time demands associated with regularly updating and managing data appearances on a map. The methods outlined here are intended to serve as guidance for all parties, although more advanced developers may seek more control over the database and styles. Ultimately, small organizations and individual hobbyists working with crowd-sourced data input are those most likely to benefit from the process described here.

Working code from the input example is available from: <http://robsheward.hostzi.com/samplecode.htm>, and the finished map showing the styled Fusion Table data is available at <http://robsheward.hostzi.com/samplecode2.htm>.

## REFERENCES

Peterson, Michael, Kelly Koepsell, Gabriel Pereda, and Spencer Trowbridge. 2012. "Cloud Mapping: Google Fusion Tables." *Cartographic Perspectives* 71:77–90. <http://www.cartographicperspectives.org/index.php/journal/article/view/cp71-peterson-et-al/html>.





I'VE ALWAYS LOVED maps. When I was a kid, I could spend hours poring over atlases and plans of my home town. I could get completely lost in them, daydreaming, making up stories in my head about the people living in the places that the maps depicted. More often than not, I was one of those people. Then I discovered fantasy novels and role-playing games and I started drawing maps as well as looking at them.

I made this map of Val Nevan, an entirely fictional city, with a medieval fantasy story or role-playing game in mind. This means that the map is essentially a prop; its

function is to help convey the mood and look of the place the story is set in. Besides giving the players or readers a clear understanding of the layout of the city, it has to draw them into the story. It has to help them become immersed in it, to give them an idea what it's like to actually walk around the city.

To achieve this goal, I believe the map needs to fit the world. It should look as though someone living in that world made it, using the tools he had access to. As such, most of my inspiration for this piece comes from city maps by sixteenth- and seventeenth-century cartographers like Braun, Hogenberg, Blaeu, and de Wit. Their technique,





projection, colors, and enormous amount of detail are ideally suited for the job.

Drawing it by hand, then, seemed the most obvious choice. As gorgeous as many entirely digital maps may look, I feel they would be out of place in this case. Imagine the map in the opening scene of *The Lord of the Rings* looking like a satellite image—goodbye, suspension of disbelief! I did the linework and lettering with pencils and technical pens on paper. This approach creates some imperfections and gives the drawing a certain roughness, which I believe enhances its character. After scanning the map, I had to color it digitally, because I lack the skills to do so with real paint. I did my best, however, to mimic hand-painted watercolors.

The colors on old maps look very vibrant and warm and add greatly to their appeal. I used similar, but slightly less saturated colors for this piece. Combined with an aged-paper background, they create that warmth without becoming too garish or cartoony. I colored most of the rooftops red, but the important buildings have blue roofs to make them stand out more.

The amount of detail in this map is also very important. The more detail, the livelier the city looks. A parallel

projection is perfectly suited for that. A top-down view would only show the contours of the roofs. With a parallel projection, however, you can see the buildings' façades and, with the right colors, even their construction technique (such as stone, brick, or half-timbered). Further details include fences, orchards, gardens, sheds, and small barns or granaries on staddle stones. I also drew some people here and there—a few farmers working the fields, soldiers training and people walking around.

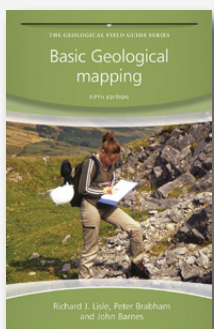
My main motivation here was to recapture those daydreams I had when I was growing up. It was like an exercise in nostalgia, and it worked. While I was working on this map, I lost myself in it again. I hope that others can lose themselves in it, too.

**Sources:** this map was made using traditional media and Adobe Photoshop CS4. The old paper background is a free stock image from Struck\_Dumb, found at <http://struckdumb.deviantart.com/art/Old-Paper-85821415>.

*Brian van Hunsel is a thirty-something hobbyist from the Netherlands. Some of his other work, a larger version of this map, and his email address can be found at <http://blaidddrwwg.deviantart.com>.*





BASIC GEOLOGICAL MAPPING, 5<sup>TH</sup> EDITION

*The Geological Field Guide Series*

By Richard J. Lisle, Peter Brabham, and John W. Barnes.

John Wiley & Sons, 2011. 240 pages, maps, diagrams, illustrations. \$39.95, softcover.

ISBN: 978-0-470-68634-8

**Review by:** Raechel Bianchetti, Penn State University

In its fifth rendition, *Basic Geological Mapping* does not disappoint. Building upon the first four, this latest edition expands the authors' previous coverage on technology's place in geological mapping and provides more details on structural geologic mapping. It is a no-frills pocket guide that presents fundamental geological mapping techniques to novices in an easy-to-understand manner. For professionals, it's a quick reference guide, surveying a range of measurement and reporting methods used in the geologic discipline.

The authors—including Peter Brabham, who takes over as second author for the late John Barnes—begin with a brief introduction on the importance of geological mapping, and some of the commonsense safety precautions that should be considered when heading out to the field. Subsequent chapters cover every facet of geological field mapping, beginning with complete coverage of the proper equipment for surveying and ending with some guidelines for drafting geologic reports. In between, chapters include detailed accounts of field measurement methods, cartographic techniques including standard color and symbol usage for generating field copy maps, and even a chapter dedicated to reading topographic base maps.

The chapters are short, to the point, and crammed full of practical information. The authors make no excuses for this, stating early on that the book is meant to cover the “rudiments of geologic mapping.” This book fits right in with the other five books in Wiley-Blackwell's *Geological Field Guide Series*, which cover topics such as mapping geologic structures and field description of metamorphic and sedimentary rocks. Its strongest points are its clear

step-by-step directions for techniques, which are often complimented by helpful diagrams. For example, in the chapter entitled “Technological Aides to Mapping,” examples of land surveying methods using optical surveying and total stations provide basic instructions for each of the methods as well as complete diagrams showing proper set up. The book is full of diagrams and photographs that support the text body, including three full color geological maps.

The longest chapter in the book, “Methods of Geological Mapping,” is dedicated to covering a variety of measurement techniques used in the field. The chapter begins with coverage of the most basic methods, such as traversing, and concludes with the use of aerial photography for interpretation of geologic features. The authors' descriptions of the difficulties of interpretation of geologic features due to different environmental factors are thorough and supplemented with potential solutions. For example, vegetation cover can be an indirect indicator of the rock types underneath. This is an important consideration for both field mapping as well as the interpretation of aerial photography.

The book places a lot of emphasis on mapping in the United Kingdom and is written for a largely UK-based audience. The authors' word choices and all of the references throughout the book are specific to UK resources, such as the *British Standard BS5930:2999 Code of practice for site investigations* in reference to safety guidelines for digging. In most cases where a reference is made to such documents, there is no comment made about equivalent documents in other regions. While this does not diminish the quality of the guide itself, it can mean that readers need to be aware of the equivalent regulations and resources for their region of interest.

The one place that I feel this book falls short is its explanation of geological mapping from the point of view of actual map creation. The majority of the book is dedicated to the collection of geological information in the field, stressing the importance of thorough field notes and field maps, but only dedicates only two short chapters to the creation of the maps themselves. The first chapter, “Field Maps and Field Notes” is dedicated to transcription of field data, and



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linking field notes to the maps generated *in situ*. Neatness, completeness, and factual display of the information collected are emphasized, while details such as the use of dashed versus solid lines for inferred or known contacts are scattered throughout. The second chapter, “Fair Copy Maps and Other Illustrations” is aimed at creating a clean map that shows selective information. Though not explicitly stated in the book, the authors mean data generalization, and describe which information from a field map transfers to the fair copy map. Some considerations that a geologist makes are familiar to any cartographer, including map function, clutter control, and scale.

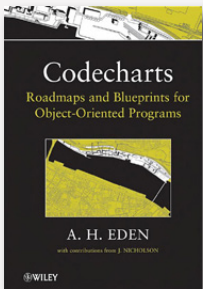
The authors emphasize the use of hand-drawn maps in this book; while they do consider the use of GPS, GIS, stereographic aerial photography, and even Google Maps, the majority of instruction is aimed at the use of paper and pencil for the creation of both the field map and fair copy map. There is brief mention of the use of computer drafting and modeling in these two chapters. The chapter titled “Field Maps and Field Notes” covers the use of drafting software for the generation of fair copy maps, but warns that the use of GIS for generating geologic maps is very time consuming. Despite this, the authors list the basic steps in transferring their hand drawn field maps into

a GIS. In the chapter titled “Fair Copy Maps and Other Illustrations” briefly introduces the use of geological modeling software such as RockWorks and Datamine for creating three-dimensional models from data collected in the field.

The book concludes with a chapter covering geologic report writing. The material covers report structure, referencing systems, and some general comments about the importance of clear and well-written reports for conveying geologic information. This chapter serves as a nice reminder for students of how to compose a report, and offers useful information on writing specific to geologic information.

Overall, I would recommend this book as a useful introductory textbook for geology students heading out for their first field mapping experience, or as a general reference handbook for the more advanced geologist. The book is succinctly written and contains many useful tricks and tips for a wide array of geological measurement techniques. I would recommend students using this book for geology courses outside the United Kingdom to explore the guidelines and map resources available to them in their home countries.

## CODECHARTS: ROADMAPS AND BLUEPRINTS FOR OBJECT-ORIENTED PROGRAMS



By Amnon H. Eden, with contributions from Jonathon Nicholson.

John Wiley & Sons, 2011. 243 pages, no maps, 123 code charts, many diagrams. \$93.95, hardcover.

ISBN: 978-0-470-62694-8

**Review by:** Jed Marti, Artis LLC

If you're interested in the design and structure of large-scale programs such as Geographic Information Systems from the perspective of designing your own, you might find this book of some interest. As the author points out, software systems are the most complex things our civilization has created, and their sordid past is filled with failure. Codecharts define the components and structure of object-oriented programs in simple graphical terms, somewhat like how antiquated flow charts mapped decisions, loops, and computations into something easier to

understand than Fortran code. The aim is to create a visualization that will “fit on the side of a van.” It is hoped that programs developed from Codechart descriptions will have better structure than those that are not. By providing a mapping between LePUS3, the language of Codecharts, and Java (other languages are possible), it is possible to verify that a Codechart models a Java program.

There are 18 chapters divided into 3 sections. The first section compares Design Description languages and Codecharts (and its language LePUS3) to the more widely known Universal Modeling Language (UML), of which the author is very critical. The second, and largest, section describes modeling the various components of Object Oriented programs and presents examples of common practice and structures. The final theory section proves the completeness of Codecharts and provides an entrance for formal verification of programs so described.

I approached this book with three questions:

1. What, if anything, does this book have to do with Cartography and Geographic Information Systems?
2. Can the methodology proposed be of help to the practitioners thereof?
3. Is this a good textbook?

Sadly, I conclude that the answers are nothing, no, and not likely for any programs or systems we might find interesting. A Cartographer will find no interesting maps or charts; there are no dragons marked on the Codecharts, there are no route numbers on the Roadmaps. Black, grey, and white are sufficient for all diagrams presented. The book has a high-resolution map of an urban manufacturing area on the cover but that is the extent of the cartography.

Can learning this practice provide any assistance to the learned cartographer? Here I think Codechart's generalization level fails the potential user. The language of Codecharts is object-oriented programming, not the *lingua franca* of Cartography and Geographic Information Systems. Contrast this with Scalemaster diagrams (Roth et al. 2011), where the description is in terms of geography and geometry—the abstraction is in terms of the problem to be solved, not the underlying implementation. Furthermore, this abstraction drives the implementation in the way that a Codechart written before the implementation cannot. One might hope to derive a Codechart from this description, but the promised benefits are unlikely to be useful or cost effective for the program's users or implementers as this involves learning an unfamiliar representation.

The authors make the assumption that programmers are competent machinists and cannot be relied upon to create things without the benefits of a fancy flowchart. While this may be true in enterprise systems with organized hordes cranking out Java, many of the great systems of our time such as SAS (statistics), ARCInfo, Maple (Computer Algebra), and Matlab, amongst others, were designed and at least initially implemented by leaders in their fields with a goal and firm grasp of the field's principles and perhaps set of *ad hoc* flow charts and state diagrams at best. The success of these enterprises invites emulation, not replacement.

If the methodology isn't particularly useful for GIS, can it aid the broader community of programmers? The laudable goals are object structure correctness, re-usability, and visualization. Following Codechart strictures may very well lead to such programs but only for certain applications—those similar to the case studies for support libraries for XML, 3D graphics, and other similar application program interfaces. It's very hard to see where a new, stand-alone program, perhaps even using these Codecharted APIs, would benefit. A Codechart may define the 3D texture mapping method in the class hierarchy but has little to say about what it does and how to use it—you're still required to read the manual to find this out. What have you gained?

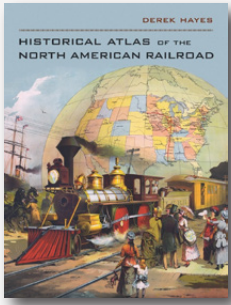
Though the Universal Modeling Language has achieved a certain level of acceptance for complex systems it is unclear that the rigorousness of Codecharts is required or supportable in a research or academic environment. The support for only Java limits applicability to systems that don't require great efficiency for large amounts of data. The authors wistfully hope that support for C++ and other useful object-oriented languages may follow, but with minimal return on investment, I think few would find this worth their effort.

Is this a textbook that one might use in the Geography and Computer Science classroom? This is unlikely for three reasons: 1) There are no aids or even suggestions for exercises, 2) There is no indication of how to accurately judge a Codechart's quality, 3) Large scale acceptance of UML. Contrast this with the extensive exercises in the classroom staple *The Art of Computer Programming* (Knuth 2011), where the exercises are the most important part of the text and problems range from obvious to PhD theses. Though the book presents case studies for the usual design patterns, the methodology lets you produce functional yet clumsy object structures. Finally, there's the inertia of large-scale acceptance of UML with all its flaws. *Codechart's* goals are laudable but must provide more added value to leap this hurdle.

## REFERENCES

- Knuth, D. E. 2011. *The Art of Computer Programming*. 5 vols. Boston: Addison-Wesley
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## HISTORICAL ATLAS OF THE NORTH AMERICAN RAILROAD



By Derek Hayes.

University of California Press, 2010.  
224 pages, maps, illustrations, index.  
\$39.95, Hardcover.

ISBN: 978-0-520-26616-2

**Review by:** Russell S. Kirby,  
University of South Florida

Derek Hayes is a prolific author of historical atlases, most of which have focused on regions or specific areas. In the *Historical Atlas of the North American Railroad* he turns his focus to a topic for which cartographic approaches have held a fascination for travelers, railroad enthusiasts and scholars, illustrators, artists, and advertisers from their earliest origins.

The book is organized in a series of topical sections, each beginning on a new page but not formatted as traditional chapters. The sections focus on specific events or developments in railroad history, often examining activities involving a single rail line or competitive activity. Each section includes a narrative text heavily interspersed with railroad maps and illustrations. Some of the former are ingenious pieces of period advertising or artwork from the 19th and 20th centuries, while others depict railroad routes or networks.

From an aesthetic perspective, this atlas has considerable appeal. Published in a large format with a hardcover binding that folds open to enable effective viewing of the entire page, virtually every page has one or more maps or other illustrations, reproduced in color or black and white depending on the nature of the original documents. Sources for all illustrations are provided, and the atlas includes an index. Each topic includes a narrative to place the illustrations in appropriate context. Unfortunately, the atlas includes

neither references nor a bibliography of monographs and articles to which the reader might refer for more details concerning the maps and events described in each section.

A better name for this book might have been *A Compendium of Printed Maps and Illustrations Showing Railroad Routes and Networks*. None of the illustrations included are taken from the broad literature on North American railroad history. The sections focus primarily on eras or time periods in transportation history rather than on evolution of systems or networks over time. If a reader were interested, say, in the evolution of the Burlington Northern Santa Fe railroad network from the inception of each progenitor to the present day, or that of any other major line, maps of this nature are nowhere to be found. If the reader wanted to see the dynamic role of railroads in the development of the Chicago metropolitan area (or any other North American region), this atlas has little to offer. If the reader wanted to see a series of maps showing abandoned railroad lines by decade, or railroad corridors that have been repurposed for mass transit, rails to trails, or other uses, again illustrations depicting these phenomena are not included. Those north of the border may feel that the Canadian contribution to the North American railroad receives limited focus, while Mexico is almost absent from these pages.

The *Historical Atlas of the North American Railroad* is a beautiful book in many respects, attractively produced and economically priced for a book of its nature. A serious railroad historian or hobbyist will find much to enjoy in its pages, but as an ancillary as opposed to a key resource. If faced with a choice between this volume and James Vance, Jr.'s *The North American Railroad: Its Origin, Evolution, and Geography*, the scholar will undoubtedly prefer the latter book. The librarian will need to weigh whether there is an audience sufficient to warrant making this a reference volume as opposed to a book for the stacks.

# Interview with a Celebrity Cartographer: Daniel (daan) Strebe

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*Daniel (daan) Strebe is a software engineer and specialist in map projections, in addition to being a map enthusiast in general. He has been a frequent attendee and contributor at NACIS Annual Meetings. Daan manages Maphematics LLC, and engineers Geocart®, a software package which handles map projection and reprojection.*

*Continuing CP's annual "Interview with a Celebrity Cartographer" series, daan was interviewed recently by 2013 NACIS Student Board Member Paulo Raposo.*

## Paulo Raposo

Daan, thanks. Really appreciate your willingness to take this interview for the CP readers. We'll head right into the questions.

Given that you are a map projections expert, you've got an aptitude for math, and mathematicians sometimes have really diverse subject-matter interests. So why maps for you?

## daan Strebe

I don't know that I can give you a rational reason. I started being interested in maps at a pretty young age. I developed my first map projection in 8th grade. In fact, I still have that map. It was of world history. It turns out the projection already exists. It's called the Eckert I. Which, I thought was a fine thing when I discovered it already existed. At least it lent some sort of validity to what I had done. I didn't do a lot with creation of maps or map projections after that. I did create a couple maps of Middle Earth in my early teens, Tolkien's material. And of course, I consulted maps anytime I was going to go anywhere. I always found them interesting, highly useful. I poured over maps as a child because I couldn't really go anywhere, so I would go there on maps instead. So there was always this background of interest in maps, but I never spent a huge amount of time on them until the late 1980s issue of *National Geographic* where they announced their adoption of the Robinson

Projection and all of that was included in an article on map projections in general. I read the article on projections and thought that was interesting, and saw Robinson's projection and thought that wasn't so interesting, and thought I could do a lot better. And that turned out to be a little quixotic, I suppose, but that was the beginning of the vigorous interest in map projections.

## Paulo

You developed your own map projection, the Strebe. Do any of its properties reflect anything intrinsic or personal about you?

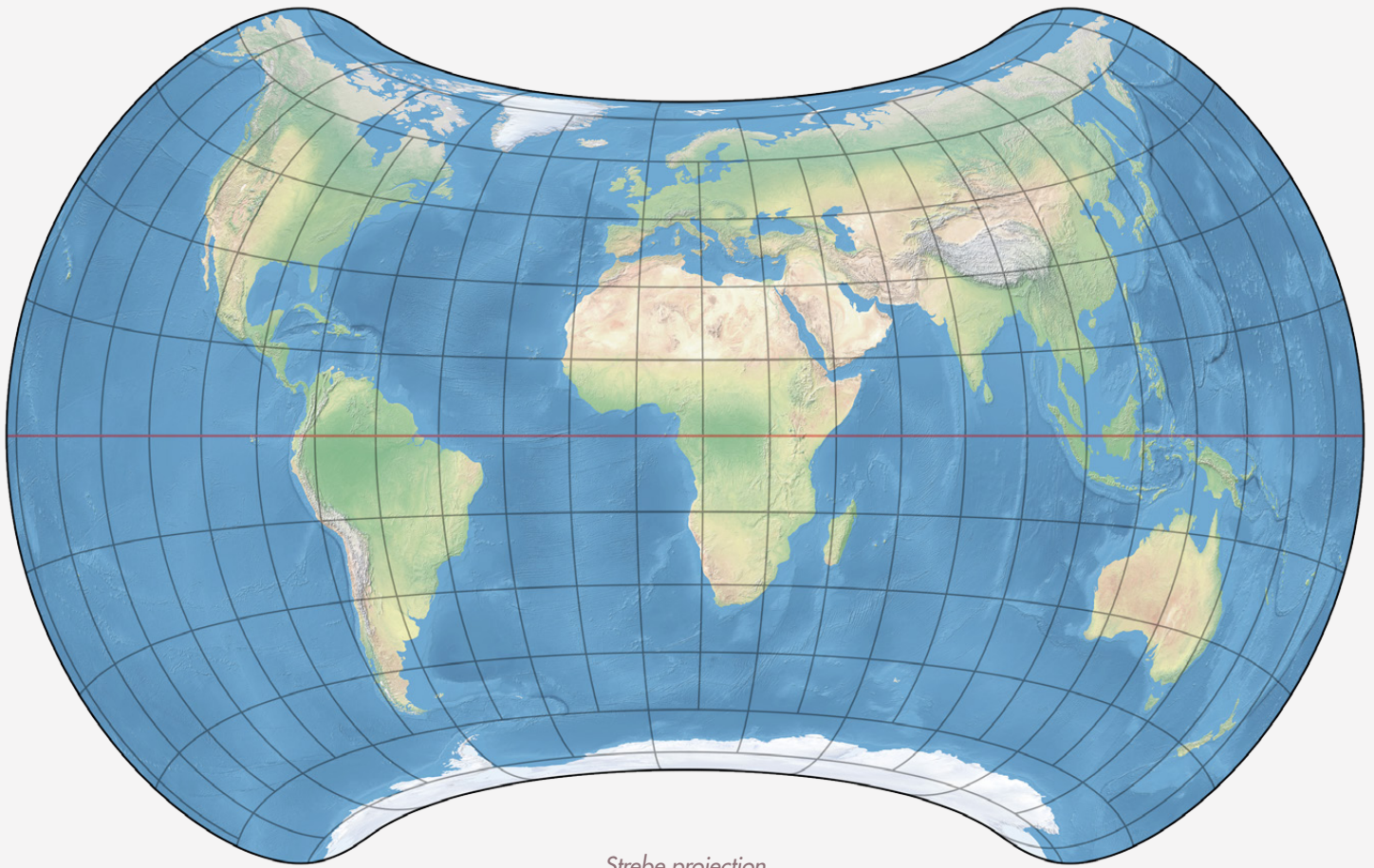
## daan

I would like to say no. I'm sure a psychiatrist would think otherwise – there's always some deep constructionism that somebody wants to apply to anything anybody does. But as a matter of fact I've developed a lot of projections, the particular one that you know of has garnered a certain amount of fame. That one is an equal-area projection, and it was designed to be equal area of course, but the other reason it exists is that it is the culmination of those efforts I started back in 1989, because I thought I could do something that I liked better than the Robinson. And the purpose of that projection is to preserve symmetry. It's something that's not supposed to look too horribly unfamiliar, it's not supposed to be sliced up with interruptions, and most importantly



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*Strebe projection*

the major technique I used was to push the distortion the distortion into the Pacific as much as possible and preserve the shapes of the land areas, while also keeping the map equal area.

### **Paulo**

Do you have a favorite projection, or a least favorite, and why?

### **daan**

I probably have something closer to a least favorite if I thought about it, which I haven't. I don't really dislike any particular projection, and I don't have a favorite either, because a favorite to me means that it must be the best, and if it's the best, that I have to ask: the best for what? And as soon as you start asking "the best for what," then you have to start listing up a bunch of criteria, and those criteria are never going to apply to every circumstance. Obviously, I like the projections that I've developed for various reasons. And the Strebe 1995 projection I like for world maps if you want to do a map with that sort of presentation. But in the end, as far as I'm concerned, people should be exposed to a diversity of projections and a diversity of displays of

those projections, and orientations of those projections, precisely so that they don't develop the kinds of prejudices that Peters, for example, was all about.

### **Paulo**

Do you have a favorite map?

### **daan**

That's an interesting question... No. I would say no, and for almost the same reasons that I don't have a favorite map projection. There are exemplary maps that people have made really interesting and historical statements through. And some of those I deeply respect. Mercator's 1569 map is fabulous. There are other historical maps that are of wonderful design aesthetics that I really enjoy. And frankly when it comes to things like world maps, we really are talking about aesthetics. All of them are going to be so completely distorted in some fashion or another that the choice of the projection becomes not so important unless you are specifically trying to do something like present spatial data that requires preservation of areas, for example. So, it is largely an aesthetic decision. Therefore, if you ask me what my favorite maps are, probably rather than point

to some modern piece of precision I would point to historical maps that have great aesthetic value for me.

## Paulo

There are examples out there of bad cartographic analysis on account of people not understanding map projections. Do you think the situation, in general, or in academia, news, or the public, is serious? Do you have any ideas about how to address it?

## daan

The situation is not serious for the simple reason that it doesn't crop up often, and when it does, people don't die because of it. We are in an interesting time when a lot of people make maps, who don't know a lot about making maps. Fifty years ago, making maps was an arduous project, and so you didn't generally get a lot of amateurs doing it; the people who did it generally knew a little about what they were doing. So, even though we see misuse of projections, in general people were more or less doing the right thing with their projections. These days we have automated tools for creating maps, and GIS of course has been responsible for a huge proliferation in the misuse of things like the Plate Carrée, or "geographic" coordinate system, things like that, people doing presentations of things that require proper distribution of areas, phenomena based on areas. Or they get on Google Maps and do their mashups using Mercator for those sorts of purposes, without any inkling that they're completely misusing the projection and not portraying at all what they think they're portraying. So I think that the opportunities have proliferated greatly, in the same way that I think desktop publishing came out, when people were all excited about the fact that anybody could be a document publisher. Basically, while it really improved the efficiency of people who were creating documents, it also greatly improved the efficiency of people who were producing garbage.

## Paulo

What's the most difficult cartographic project you've undertaken? Any important lessons learned from doing it?

## daan

Since I'm not a practicing cartographer that's a particularly interesting question. It does always pertain to map projections itself, and in that sense, I would say it is my ongoing efforts to characterize the conditions for optimality in an equal area projection. And I have not published anything



Daan Strebe (left) and Paulo Raposo (right), meeting for espresso in Toronto.

on that, but I have spent a good 20 years now of mental effort on trying to solve this problem.

## Paulo

A little more of a fun question: if you could have an hour with Mercator, or Albers, or Eckert, or Mollweide, or Ptolemy, or whoever your favorite past projection-maker is, who would it be, and what would you talk about?

## daan

Okay! I suppose it would be Lambert, Johannes Lambert. He was the person who turned map projections into a science. He applied calculus to the problem of determining how to develop a map based on properties that you wished to preserve. And I would talk to him about everything that he really wanted to talk about, because aside from mathematics he was a brilliant person. He was a Renaissance Man in many ways, he was an expert in all sorts of scientific topics. He has his name attached to things in several branches of science, and while I don't know a lot about him personally other than the biographical details of his life, I have to imagine that he has a keen insight into a lot of topics that I'm interested in.

## Paulo

What's the most impressive piece of scholarship you've ever read, in any field?

## daan

That would be Newton's *Principia*. I think that that's the most quintessentially scientific piece of writing that I have ever been exposed to.

**Paulo**

Is it for the essential scientific nature that it impresses you, or the breadth or the depth...?

**daan**

It's some of that but it's also the fact that he has expressed these ideas in economical ways, and he was always brilliantly insightful in getting to the heart of the matter, whatever the matter was.

**Paulo**

Very broadly put, what do you see in the future of cartography?

**daan**

I firmly believe that cartography as an aesthetic practice will endure for a very long time. I don't see that we are going to be able to automate all of it away in the near term. We're not going to be able to automate most of it away in the medium term, and in the long term I'd be a fool to predict anything because for all I know, computer programming and basic science research will be automated away. We simply do not know. It depends on what happens in the fields like artificial intelligence. But the invasion of computers into the craft is only going to deepen, that's obvious, that's clear. A lot of the difficult problems of automated cartography will continue to see revolutionary improvements, and once in a while there will be revolutionary improvements, in things like sophisticated generalization. That's been a huge problem in automating cartography, obviously, and algorithms to do that are going to improve

incrementally, indefinitely. And beyond that, boy, I would consider myself pretentious and probably a fool to predict much more of it.

**Paulo**

One last question: any favorite NACIS Annual Meeting memories?

**daan**

*(laughs)* Let me think about that... By far my fondest memory was the one time I met John Snyder, and that was the first NACIS meeting that I attended. And it was Wilmington, North Carolina, in 1995. Or 1996—somebody's gonna have to check the history of the meetings (*Editor's note: it was 1995*)—but that's where it was and when it was, and it was such a momentous meeting for me, for one thing because it was my first, for another it was my first meeting with so many of the dear folks at NACIS that I see every year now, and finally because it was my first, and tragically last, meeting with John Snyder, who was a complete hero of map projections. We spent a lot of time together. We had corresponded for years back then. In fact I had spent countless hours on the telephone with him from Tokyo, where I was based during the early '90s, discussing analytical ideas on map projections, and finally being able to meet him and to talk about those things in person was cathartic.

**Paulo**

Thanks for your answers to the questions!

# NACIS 2014 Annual Meeting: Call for Participation



## NACIS2014 Pittsburgh

OCTOBER 8–11 *Cartography and Time*

Love maps, data, visual storytelling, and cartographic design? Make your plans now to participate in the Annual Meeting of the North American Cartographic Information Society in Pittsburgh, Pennsylvania: October 8<sup>th</sup>–11<sup>th</sup>. Join with other professionals and enthusiasts from government, commercial, and not-for-profit groups along with academics, scholars, map/GIS librarians, artists, technologists, and students. Visit [nacis.org/2014](http://nacis.org/2014) for more details, including hotel reservations.

We'd love for you to be a part of our program in Pittsburgh! You are invited to submit proposals for traditional presentations or you can organize custom sessions, panels, discussions, and workshops. We encourage presentations related to our theme of Cartography and Time, but all cartographic topics are welcome! Visit us at [nacis.org/abstracts](http://nacis.org/abstracts) to tell us how you'd like to participate. **Online submissions are due by May 31<sup>st</sup>** at [nacis.org/abstracts](http://nacis.org/abstracts). Please send questions to program chair Alex Tait: [veep@nacis.org](mailto:veep@nacis.org).

In addition to participating in the main program, you can also get involved in one of our two all-day preconference events:

### **PRACTICAL CARTOGRAPHY DAY**

Join professional cartographers and scholars for this all-day event. Presentations, demonstrations, and more!

*Andy Woodruff and Rosemary Wardley*  
[pcd@nacis.org](mailto:pcd@nacis.org)

### **GEOGRAPHIC DATA COLLECTIONS DAY**

This all-day session will focus on cartographic and geographic data collections management. New ideas welcome!

*Abraham Kaleo Parrish and Tsering Wangyal Sharwa*  
[pml@nacis.org](mailto:pml@nacis.org)

### **MORE WAYS TO PARTICIPATE**

**Map Gallery:** Display your latest creation for all to ponder throughout the meeting.

**Student Map & Poster Competition and Student Dynamic Map Competition:** Cash prizes of \$500 awarded to the best maps in three categories: print, dynamic narrative, dynamic interactive.

Online submissions for the Map Gallery and competitions are due September 12<sup>th</sup>. More information is available online at [nacis.org/2014](http://nacis.org/2014), and questions may be directed at Martha Bostwick: [posters@nacis.org](mailto:posters@nacis.org).





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Articles should be submitted online, in OpenOffice, Microsoft Word, or RTF file format. Each manuscript is reviewed by the editor, one or more members of the editorial board, and at least one external reviewer. By uploading to the CP website, authors agree to not submit the manuscript elsewhere until the CP editor has reached a decision. Any submitted manuscript must not duplicate substantial portions of previously published material.

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Content should be submitted online via the *Cartographic Perspectives* website, [cartographicperspectives.org](http://cartographicperspectives.org).

**OPINION/RESPONSE PIECES:** CP welcomes topical responses to previously published articles. The length of such pieces may vary; however, we suggest 2,000 words or less as an informal guide.

**ILLUSTRATIONS:** Maps, graphs, and photos should convey ideas efficiently and tastefully. Graphics should be legible, clean, and clearly referenced by call-outs in the text. Sound principles of design should be employed in the construction of graphic materials, and the results should be visually interesting and attractive.

- All graphics must be in digital form, either digitally generated or scanned. Preferred formats are .tif, .ai, .eps, .jpg, or press-ready .pdf.
- Images must not be embedded in the manuscript, but should instead be included as separate files.
- Color images should be submitted in CMYK mode where possible.
- Images in raster format must, at minimum, be 600px wide; at least 1000px is strongly preferred. Images will be printed at 300 ppi.
- Where possible, graphics should have a transparent, rather than a white, background.
- Digital art files should be cropped to remove non-printing borders (such as unnecessary white space around an image).
- The editor reserves the right to make minor adjustments to illustrations.
- Authors are responsible for ensuring that they have permission to use all illustrations.
- Image orientation should be the same as intended for print.

- For vector files, fonts should be embedded or converted to outlines.
- Type sizes below 6 point should be avoided.
- Captions should not be part of the illustration. Instead, please supply captions within the text of the article.

For questions on specific guidelines for graphics, please contact Assistant Editor Daniel Huffman for more information: [daniel.p.huffman@gmail.com](mailto:daniel.p.huffman@gmail.com).

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**TITLE:** The title serves as the author's invitation to a diverse audience. It should be chosen wisely. The title section should include the full name(s) of the author(s) and academic or other professional affiliation(s).

**ABSTRACT:** An abstract of 250 words or less should summarize the purpose, methods, and major findings of the paper.

**KEYWORDS:** Five to ten keywords should be listed at the end of the abstract.

**REFERENCES:** References should be cited parenthetically in the text, following the author-date system found in *The Chicago Manual of Style*, 16<sup>th</sup> ed. ([chicagomanualofstyle.org](http://chicagomanualofstyle.org)). When making a direct quote, include the page number. Examples: (Doe 2001) and (Doe 2001, 38).

**Books:** Invert the first author's name (last name, first initial or name, and middle initial). Middle initials should be given wherever known. For books with multiple authors, authors' names are listed in the order in which they appear on the title page, with the last author's name preceded by a comma and *and*. Note: With more than ten authors, invert first author's name and follow it with a comma and the words *et al.* without italics in the reference list.

The general format is: Name of author(s). Year. *Title in Italics*. City of Publication: Publisher Name.

MacEachren, A. M. 1995. *How Maps Work*. New York: Guilford Press.

Robinson, A. H., J. L. Morrison, P. C. Muehrcke, A. J. Kimerling, and S. C. Guphill. 1995. *Elements of Cartography, 6<sup>th</sup> Edition*. New York: John Wiley & Sons.

**Articles in Periodicals:** Author's or authors' names as in *Books*, above. Year. "Title of Article." *Title of Periodical*, volume number, page numbers [follow punctuation and spacing shown in the following example].

Peterson, M. 2008. "Choropleth Google Maps." *Cartographic Perspectives* 60:80–83.

**Articles in edited volumes:** Name of author(s). Year. "Title of Article." In *Title of Edited Volume*, edited by [Editor's or Editors' names, not inverted], page numbers. City of Publication: Publisher's Name.

Danzer, Gerald. 1990. "Bird's-Eye Views of Towns and Cities." In *From Sea Charts to Satellite Images: Interpreting North American History through Maps*, edited by David Buisseret, 143–163. Chicago: University of Chicago Press.

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Cartography Associates. 2009. "David Rumsey Donates 150,000 Maps to Stanford University." *David Rumsey Map Collection*. Accessed January 3, 2011. <http://www.davidrumsey.com/blog/2009/8/29/david-rumsey-donates-150-000-maps-to-stanford>.

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*A Plan of the City of New York and its Environs*. P. Andrews, sold by A. Dury in Dukes Court, St. Martins Lane, surveyed by John Montessor, 1775.

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# Cartographic Perspectives

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