Chapter 1: Introduction and Statement of Purpose

1.1 Introduction

Cartographers are restrained by the amount of information they can effectively display on a map because of the limitations imposed by the physical size of the desired product medium. When working in the traditional paper map medium, cartographers must consider the constant tradeoffs between the size, scale, and coverage of a map (Figure 1.1a). Specifying one of these aspects restricts the available options for the other two. For example, once the physical size of the map is set, the cartographer must prioritize the importance of coverage area and scale, as an increase in one will result in a decrease in the other. It is not always practical or possible to attain an effective balance between the three variables.

With the advent of geographic information systems (GIS), digital maps viewed on computer monitors have become as commonplace as their paper map counterparts. Computers have greatly aided cartography, with the Internet providing rapid access to rich geographic data and imagery while GIS tools allow for map design versatility. Despite these advantages, computer cartography faces the same cartographic limitations as does paper cartography. Computer screens are fixed in size. With viewing area fixed, the opposing requirements for greater map coverage area and scale of detail compete (Lloyd and Bunch 2003). Perceptually, users’ needs for both greater context and visible detail are at odds (Figure 1.1b). If users need to see more detail, they lose the overall context; however, if they view the entire coverage area, they lose the available fine detail. Typical computer displays therefore limit the ability to utilize fully digital maps and data sources because they are visually constrained by the bounding bezels of a single desktop monitor. While available panning and zooming tools allow users to navigate precisely to what they want to view, the fixed viewing window forces them to frequently zoom and pan to acquire the context and scale of detail desired (Slocum et al. 2005). Readily available high-resolution data and imagery can rarely be viewed at its full extent and quality simultaneously.

Currently, bulky cathode ray tube (CRT) monitors are being supplanted by thin, flat, liquid crystal display (LCD) or plasma screen monitors. In addition, many computers have the built-in capability to support multiple monitors. These coincident trends provide the means for making low cost, high-resolution displays by configuring multiple monitors to act as a single display (Hutchings et al. 2004) (Figure 1.2). Individual projectors only increase display area,
making high-quality imagery appear pixilated when viewed at close range. However, multiple monitors increase display area and maintain high-resolution across the entire display so that imagery appears clearly even when users are close to the screen (Bezerianos & Balakrishnan 2005). Such displays are useful for a variety of computing tasks such as group collaboration, viewing multiple applications simultaneously, or enhancing video gaming experiences. In particular, maps displayed on multiple monitor configurations provide a new geospatial visualization opportunity by incorporating both larger coverage areas and finer detail into a single view. The previously fixed small size of the viewing area is expanded, reducing constraints in achieving a balance between context and detail.

The effectiveness of large, high-resolution displays, especially for viewing maps and imagery, has not been studied thoroughly. Current research on multiple monitor displays has largely been conducted by computer scientists specializing in human-computer interaction. In most of these studies, typical office computing tasks (Ball and North 2005a; Grudin 2001; Simmons 2001; Tan & Czerwinski 2003; Czerwinski et al. 2003), video game interfaces, virtual environments (Ni et al. 2006; Polys et al. 2005), or perception tasks (Tan et al. 2003) were the focus of usability research and data collection. The few studies that have involved geospatial information and visualization were conducted using subjects with little to no map reading experience (Ball and North 2005b; Ball et al. 2005).

1.2 Statement of Purpose

Geographic information systems (GIS) and high-resolution imagery have an increasingly prominent role in many research institutions, government organizations, and private sector businesses. This trend creates a need for new visualization formats that can make full use of high-resolution digital data. One possible low-cost solution for this need is the use of multiple monitor displays that increase display area while also maintaining high-resolution. Research concerning multiple monitors has mainly been conducted within the field of computer science where geospatial applications compete with other programs and tasks for research attention.

The purpose of this research is to gain a better understanding of the utility of multiple monitor displays for working with geospatial information. By having experienced geospatial data users perform map reading tasks on various display sizes, I explored the possible task-completion benefits, usage strategies, and usability issues when using large, high-resolution
multiple monitor displays for geospatial data. Since multiple monitor displays allow for greater coverage and greater detail to be viewed at the same time, I hypothesized that, overall, subjects on larger displays would perform more accurately and efficiently than subjects using one desktop monitor. However, I also hypothesized that such trends may not hold for every map and task type, with simpler maps and accompanying tasks accomplished just as accurately and efficiently on a single monitor as on larger displays. This research will contribute additional understanding to the areas of visualization, perception, and map reading as well as providing new insight on the usability of low-cost, large, high-resolution displays for geospatial work in educational institutions, businesses, and government agencies.

This thesis has two additional chapters. Chapter 2 presents a review of previous work in both cartography and computer science relating to visualization and the increase in use of multiple monitor display configurations. Chapter 3 focuses on the results of my user study exploring map reading task performance using different display sizes. It is written in preparation for submission to the journal *Cartography and Geographic Information Science*. 
References


Figure 1.1. A) Tradeoff relationships in map design  B) Tradeoff relationships for map perception (modeled after Carstensen 2005). Mathematical symbols note the positive and negative relationships between items.
Chapter 1 Figures

Figure 1.2. Multiple monitor display constructed of nine 17” flat screen LCDs (3840 x 3072 pixels).