

## **Geospatial Information in Complex Mobile Field Settings**

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Field data collection and information management are essential to numerous government field operations. Geospatial data and emerging computing technologies offer the potential to vastly expand the type and quality of support available to the field worker during field campaigns. This requires the development of appropriate field tools and computing systems to responsively and reliably support secure information exchange between the stored repositories, remote services, and the mobile field environment. For example, new models for extensible computing infrastructures are needed to support field activities with intermittent and highly constrained mobile computing settings. At the same time, methodological principles are needed to guide user interface design for displaying geospatial information resources with limited screen environments for scientific data collection.

In this paper, we provide a brief overview of recent investigations that focus primarily on the field user and application component of Project Battuta. More details are presented in Clarke (2001), Clarke et al. (2003), Murphy and Nusser (2003), Nuernberger (2003), Nusser and Fox (2002), and Nusser et al. (2003). Prior research on computing infrastructures is presented in Miller and Nusser (2003) and Miller et al. (2001).

To develop a more general model of field environments, we have formalized field operations via use cases for a broad range of application settings, and studied the functional and data requirements in each instance. Application domains can be arrayed on a spectrum from constrained to open-ended environments, which vary in several dimensions. The constrained domains often found in federal statistical survey settings are characterized by operations that are intensively planned, and that present limited options to the bulk of the field force. In open-ended domains, more typical of field management in disaster recovery and basic field science, a wide range of functions are needed that are difficult to anticipate in advance.

The ability to make use of advanced information technologies, particularly GIS, in a field context that is fully mobile and operational anywhere has the potential to impact field operations in numerous ways, and to change fundamentally the nature of such work. For example, the use of technology to continuously monitor and analyze data as they are acquired in the field raises new and interesting potential to modify sampling strategies, and to avoid the disadvantages of strategies that must be planned in the office in advance of the field campaign, and executed without review. We have developed prototypes for new GIS-aided sampling strategies that are capable of resolving such questions as: 1) should another sample be taken; 2) where is the most cost-effective location to take the next sample; 3) what is the quality of the knowledge obtained thus far in the sampling? The prototypes are based in a model-based geostatistical framework that evaluates the effects of samples at specific locations on the estimated variance of the quantity of interest.

Another component of Project Battuta has been the design and testing of a wearable computer and software for field computing. We have concentrated on the task of navigation, using a computer designed and built over the duration of the project. The computer uses a monocular color display clipped to a pair of glasses, and is spatially enabled using a global positioning receiver, allowing real time viewing of maps and images in the field. Our recent work has focused on user testing of our wearable prototype and software design. In a field test currently underway, a group of users are completing a five-location navigation test over several kilometers of outdoor hiking on the UCSB campus. Our control group is equipped with the same map and image navigation data and GPS, but on an iPAQ palm computer equipped with ESRI's ArcPad software. Test subjects are recording tracks from the GPS, which are being analyzed in the context of similarly recorded user interface menu choices. Users so far seem to prefer to

have a high degree of flexibility in what displays are chosen, and are willing to make multiple updates and changes in the display to suit particular field tasks, such as panning and zooming. Various field conditions have also exposed the major problems with the system, not the least of which is battery life.

In federal statistical survey settings, we have considered both handheld and tablet devices that display maps and aerial photographs. Field research has demonstrated that spatial cognition theory provides a framework to address the wide variability in spatial abilities and geographic knowledge that exists among field staff for navigation. Further, for planning, navigation, and address verification tasks, alternative presentations of map information and GIS tools (e.g., routing utility, GPS position indicator) offer the potential to reduce planning and navigation time and to increase the accuracy and success rate of address verification. A crucial finding is that multiple strategies are needed to accommodate diversity in user characteristics as well as varying information needs for different components of the navigation task. Research is currently underway to explore data collection for geographic features (e.g., agricultural tracts) using tablet computers equipped with GIS. GIS has a highly specialized user interface to support ad hoc manipulations of geospatial data via software tools. Preliminary results indicate that even when the standard GIS software interface is partially constrained and simplified to focus on a specific data collection task, the software is still too complex for staff unfamiliar with geospatial data concepts, resulting in numerous errors and inconsistent application of data collection protocols.

We are now considering extensions of the current infrastructure, which is primarily focused on user-infrastructure interactions. New functionalities being investigated include user-to-user interactions, such as collaboration services to improve the ability to share information among field staff and to provide virtual supervision. In addition, we are planning to explore GIS services that provide access to a broad array of geospatial information resources and analysis tools available via the cyberinfrastructure. As with other components of Project Battuta, infrastructure model extensions will consider human-computer interface design in the context of desired field functionalities.

- Clarke, K.C., 2001. Cartography in a mobile internet age. *Proceedings, The 20th International Cartographic Conference, ICC2001, Beijing, China, August 6–10th, 2001* 3: 1481–1488.
- Clarke, K.C., Q. Du, A. Nuernberger, and T. Pingel, 2003. Wearable GIS. *Proceedings, 21<sup>st</sup> International Cartographic Conference, ICC 2003, Durban, South Africa, August 10–15*.
- Miller, L.L. and S. Nusser, 2003. An infrastructure for supporting spatial data integration. *Federal Conference on Statistical Methodology, Washington, DC*.
- Miller, L.L., N. Sathe, M. Hua, D. Sekaran, S. Nusser, and P. Zhao, 2001. An infrastructure for delivering geospatial data to field users. *Proceedings of the IASTED International Conference on Parallel and Distributed Computing and Systems*, pp. 378–382.
- Murphy, E.D. and S.M. Nusser, 2003. Evaluating user interfaces for accommodation of individual differences in spatial abilities and way-finding strategies. *Proceedings of the UAHCI 2003: 2nd International Conference on Universal Access In Human-Computer Interaction*.
- Nuernberger, A., 2003. *A Wearable Geographic Information System: General design principles and 2-D map display for navigation*. Master's Thesis, University of California, Santa Barbara.
- Nusser, S.M., L.L. Miller, M.F. Goodchild, K. Clarke, 2002. A user-centered framework for next-generation field data collection. *Proceedings of dg.o 2002 National Conference on Digital Government Research, Los Angeles, CA*.
- Nusser, S.M. and J.E. Fox., 2002. Using digital maps and GPS for planning and navigation in field surveys. Iowa State University Department of Statistics Preprint 2002-09. Available at: <http://www.stat.iastate.edu/preprint/articles/2002-09.pdf>
- Nusser, S.M., L.L. Miller, K. Clarke, and M.F. Goodchild, 2003. Geospatial IT for mobile field data collection. *Communications of the ACM* 46: 64–65.