Chapter 5
LiDAR Survey and Analysis in 2010-2011

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A surveyor's plat and town plan filed in 1836 set out an intended grid of blocks, lots, alleys, and streets for New Philadelphia. Geophysical, aerial infra-red, and archaeological investigations to date have located fragments of the town's remains now buried beneath agricultural fields and prairie (see, e.g., Fennell et al. 2009). In May 2010, the author received an award of grant support from the University of Illinois to launch a new project that will conduct a low-altitude aerial survey using Light Detection and Ranging (LiDAR) technology. This LiDAR survey will be employed to obtain new data on the actual spatial extent and contours of New Philadelphia's lots, streets, activity areas, and occupation sites.

This new LiDAR data set will be combined and analyzed comparatively with the data from a low-altitude aerial survey conducted in 2008 that utilized high-resolution infra-red sensors with grant support from the National Center for Preservation Technology and Training. Ground-based geophysical surveys, including methods utilizing electric resistivity and magnetic gradient sensors, have also been conducted at the site with long-term support from the National Science Foundation. Professor Art Bettis and doctoral student Mary Kathryn Rocheford of the University of Iowa are also launching a new geosciences research project to analyze changes in the New Philadelphia landscape over time (see Chapter 6). The New Philadelphia archaeology project presents an exceptional research opportunity to compare and contrast these disparate survey methodologies, data sets, and analytic frameworks both to advance the research goals of this multi-year project and also to produce new methodological insights for the benefit of archaeological and geosciences techniques and investigations nation-wide.

Low altitude aerial surveys with high-resolution LiDAR imaging have been used successfully at prehistoric and historic-period sites in the United States (Harmon et al. 2006; Petzold et al. 1999; Riley 2009). This project will apply the technique to detect the grid pattern of an historic period town site buried beneath 1-2 feet of agricultural fields and prairie grass. The LiDAR survey will also produce a micro-topographic analysis of the likely locations of past roadbeds, pathways, structural remains, and activity zone impacts embedded within and shaping the current landscape surface. The 42-acre New Philadelphia town site presents a unique opportunity to test the full applicability of this surveying technique. The intended spatial extent of blocks, lots, and streets reflected on a town plan filed with an Illinois court in 1836 can be mapped onto the existing landscape. To date, it is not known whether the planned extent and configuration of streets and blocks were actually built on the ground in the way they were depicted on the town plan. If successful, this survey technique will provide a nationally significant resource for applications nation-wide.

Aerial LiDAR Survey Methods

LiDAR technology transmits a stream of high-resolution laser light to the ground surface and records the differential time with which each pulse is reflected back to a receiving device (Figure 5.1). This high-resolution survey method records a three-dimensional elevation map of the "micro-topography" of the ground surface, accurate to mere centimeters of spatial resolution. Importantly, the stream of laser pulses penetrate beneath any vegetation coverage to measure the underlying undulations of the ground surface, producing a high-resolution, micro-topographic map of features impacting the ground surface contours.

LiDAR surveys have been used successfully on other sites to detect historic-period roads, pathways, and site contours not readily visible on the surface. LiDAR surveys can also detect the surface manifestations of buried archaeological remains of structures and activity areas that were otherwise obscured from visibility by vegetation cover, giving a "bare earth" view of the site (Ackermann 1999; Harmon et al. 2006; Petzold 1999).

Employment of such LiDAR surveys from low-altitude aerial platforms is particularly valuable when the resulting data are incorporated into a Geographic Information Systems (GIS) database and compared and contrasted with other types of archaeological and remote sensing data (Ackermann 1999; Harmon et al. 2006). At New Philadelphia, the LiDAR data will be incorporated into a GIS database and evaluated in comparison with visible-spectrum aerial photographs, high-resolution infra-red images of the 42-acre town site, and geophysical surveys of over 7 acres within the town.

Limited portions of the New Philadelphia town site have been investigated using electrical resistance and magnetic field gradiometry technologies (see Chapter 2 and Hargrave 2006). These geophysical techniques have detected archaeological features and the subsurface remains of part of a secondary street on the northern edge of the town site that matches the location reflected on the intended town plan. Yet, it is impractical to survey all 42 acres of the town site using ground-based technologies. A low-altitude aerial survey can be conducted efficiently and cost-effectively, and offers exceptionally valuable data results. The results of an aerial LiDAR survey can be matched against data from those portions surveyed previously and against the 1836 spatial plan for the town. In this way, researchers will be able to determine if the actual history of construction and settlement in the town matched the vision set forth the founder's 1836 prospective town plan.

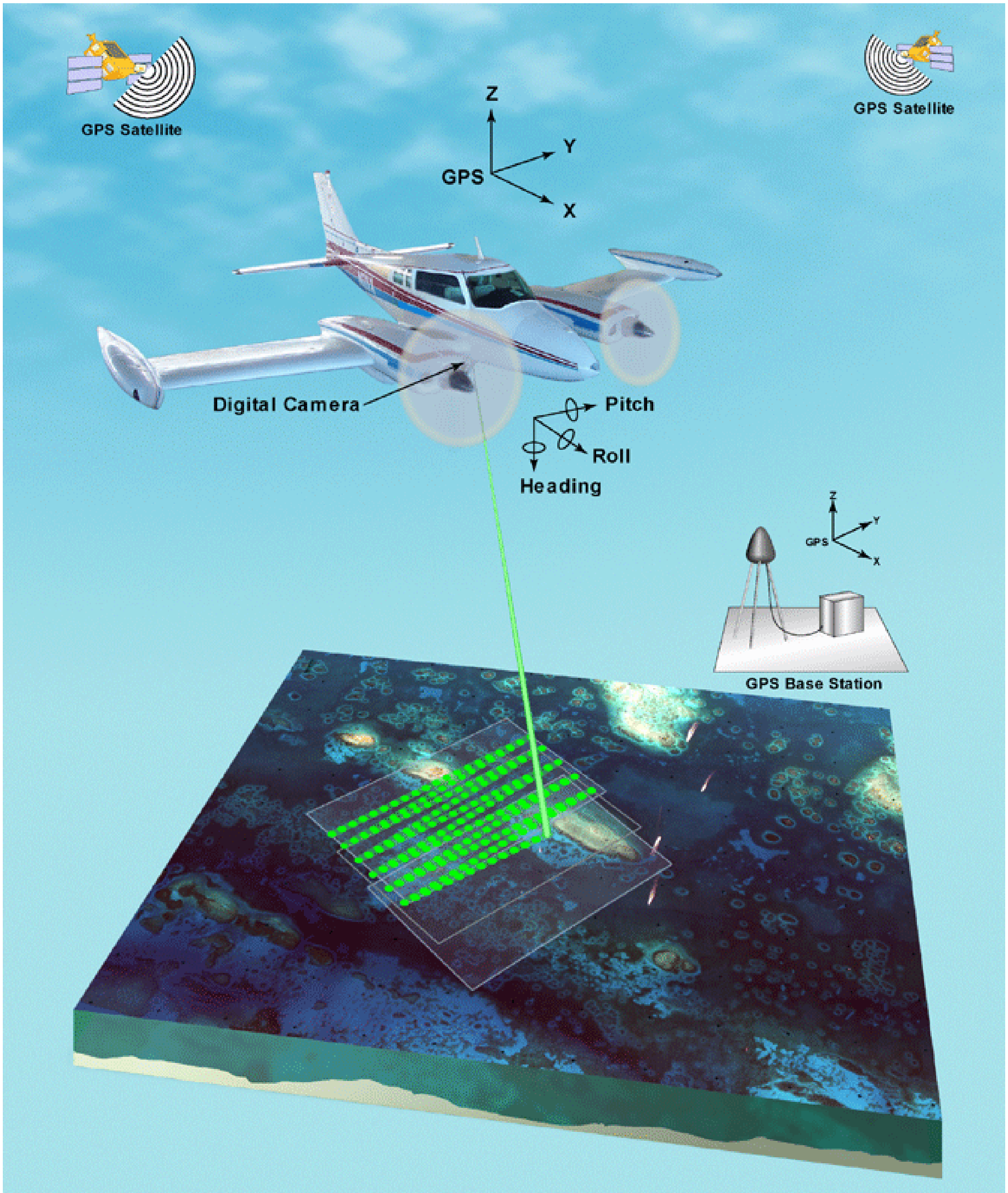

Figure 5.1. *This illustration from the U.S. Geological Survey web site details the main components and process for collecting LiDAR aerial survey data (image courtesy U.S.G.S. http://gulfsci.usgs.gov/tampabay/data/1_bathymetry_lidar/index.html).*

One of the most cost-effective approaches to obtaining LiDAR data is to employ the services of a firm that specializes in conducting such surveys. M. J. Harden Co. has been selected to perform these services. Through Harden's survey work, LiDAR data will be collected across the New Philadelphia town site and adjacent, surrounding landscape with multiple points per square meter and elevation resolution with an error factor of no more than 15 centimeters for each data point. The LiDAR survey will provide a micro-topographic data set across the contours of the town site with surface contours measured to "bare earth" levels. LiDAR data will be acquired using Harden's aircraft equipped with an Optech Gemini Airborne Laser Terrain Mapper (ALTM) sensor array (Figure 5.2). This system utilizes variable pulse and scan rates that enable the sensors to adapt immediately to varying topography and ground cover. As Harden's (2010) service statement describes, the "increased pulse rate of the Gemini greatly improves the efficiency of the ALTM by providing greater geographic area coverage while maintaining high point density." This Gemini multipulse technology thus provides the data acquisition benefits of acquiring maximum point density in the most cost-effective manner.

Figure 5.2. *Optech Gemini Airborne Laser Terrain Mapper sensor array utilized by M.J. Harden, a Geo-eye Company (image courtesy M. J. Harden).*

Harden will acquire LiDAR data for an area of 4.25 square miles, including the New Philadelphia town site and the adjacent surrounding landscape of related cultural features, such as a nearby community cemetery and contiguous 19th century farmstead parcels (see Figures 5.3 and 5.4). By including this slightly larger area of surrounding landscape the research team hopes to obtain valuable contextual data related to the town site and its transport pathways without a significant impact on the overall survey costs.

Harden will deliver the resulting LiDAR data sets to the NSF-REU management team for New Philadelphia. Those data sets then need to be integrated with our pre-existing data from ground-based mapping, aerial infra-red surveys, and geophysical surveys, utilizing GIS relational databases. Such GIS datasets allow researchers to georeference multiple sources of evidence and overlay them with one another in a computerized mapping display. This analysis will be undertaken by our NSF-REU management team with the assistance of Robert Marcom, Cultural Resources Mapping, who is a specialist in GIS, mapping, and remote sensing survey analysis. Mr. Marcom will assist us in creating an integrated Digital Elevation Model (DEM) with GIS applications that will integrate these multiple data sets and provide a robust means for comparisons, contrasts, and additional analysis.

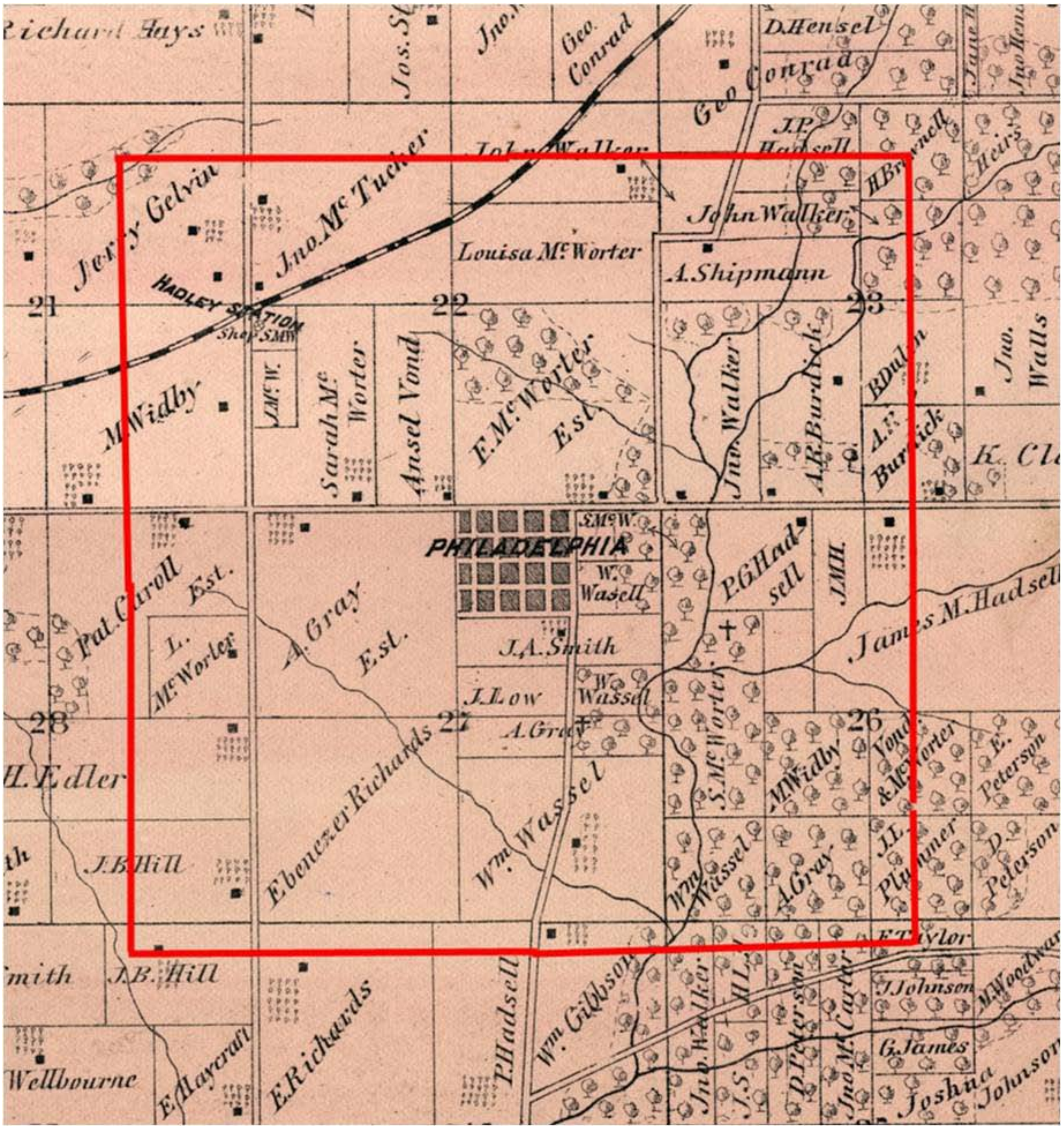

Figure 5.3. *Area of planned LiDAR survey by M. J. Harden. Overlay by Tyquin Washington, 2010 NSF-REU student, on 1872 map of Hadley Township (Ensign 1872:100).*

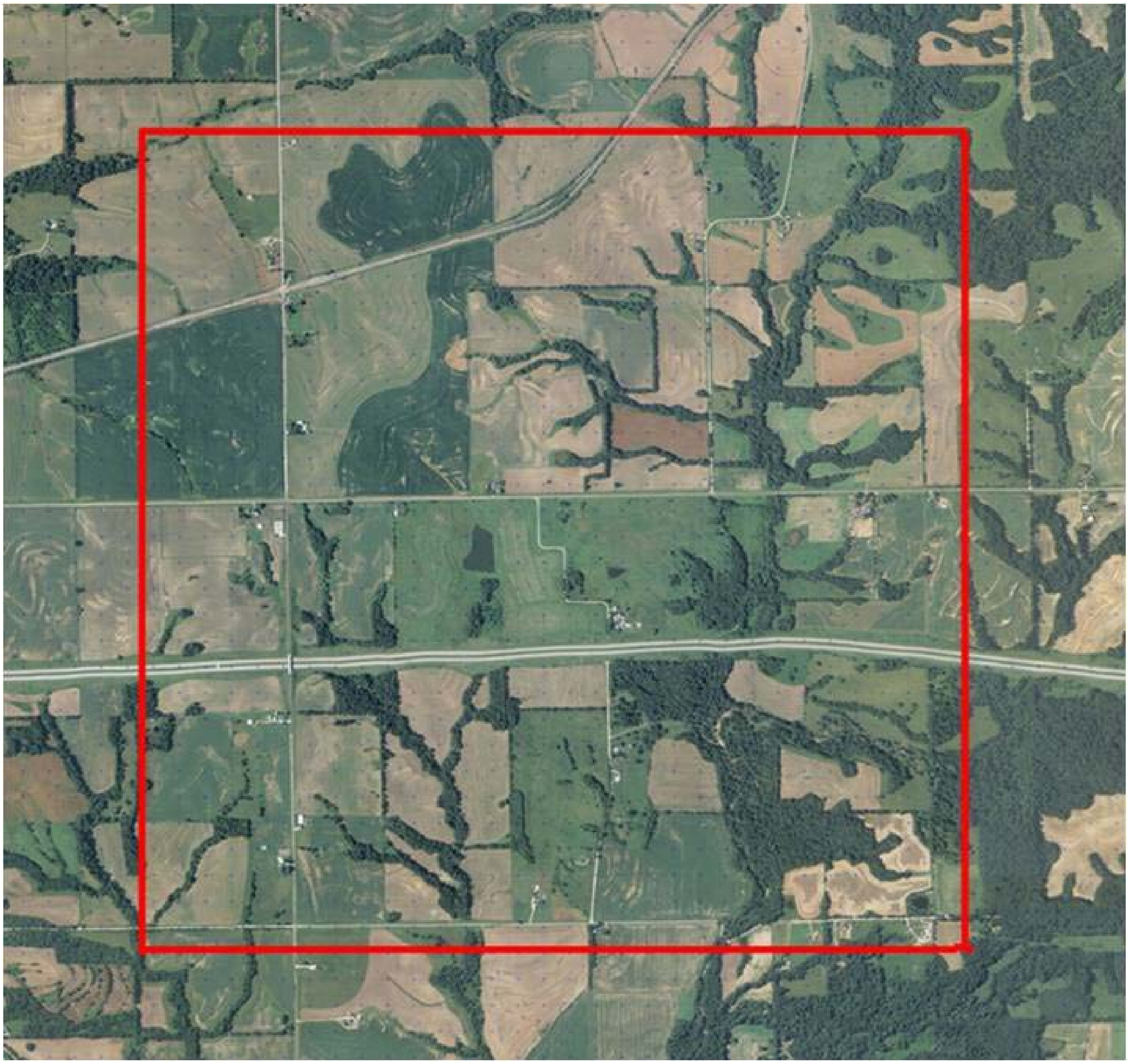

Figure 5.4. *Area of planned LiDAR survey by M. J. Harden. Overlay by Tyquin Washington, 2010 NSF-REU student, on 2010 satellite image of landscape surrounding the New Philadelphia National Historic Landmark.*

Results, Reports, and Significance of this Research Project

The results of the LiDAR survey will be compared and contrasted with the data from ground-based geophysics and low-altitude aerial thermal imaging of the town site. All of these data sets will be geo-referenced and integrated using spatial mapping programs such as GIS. Researchers will use these data to create extremely accurate photo-mosaics of the entire town site. These will depict, compare, and contrast LiDAR, thermal, visible spectrum imagery, and geophysical data.

Peer-reviewed journals such as *American Antiquity*, *Archaeological Prospection*, *Historical Archaeology*, and the *Journal of Field Archaeology*, offer relevant venues for reporting on the results of this project and the applicability of the techniques to similar sites nation-wide. The interpretations will be compiled into reports and collaborative articles to be disseminated through popular journals and news media, internet, and newsletter publications. Conference and workshop presentations at the annual meetings of the Society for American Archaeology, Society for Historical Archaeology, American Anthropological Association, and archaeological prospection workshops will also be targeted. In addition, collaborating archaeologists and historians working on the New Philadelphia site have engaged in an active program of research and data dissemination through widely recognized public internet sites: http://www.anthro.uiuc.edu/faculty/cfennell/NP/.

These reports and articles will identify the value of applying the technological methods of low-altitude aerial surveys to comparable, large-scale archaeological sites, as the New Philadelphia town site presents a unique opportunity to test the applicability this technology. The results and conclusions obtained through the survey at New Philadelphia, will demonstrate the potential for future developments and innovative applications of this technology for archaeology sites across the country.

The results of this LiDAR survey will also provide a template for planning future ground-based excavations at New Philadelphia. We intend to continue excavations at the New Philadelphia town site in future years, either through archaeological field schools sponsored by participating universities, or through field schools sponsored by grant agencies such as the NSF. Excavations within such a large-scale site as the 42-acre town of New Philadelphia must be conducted in an efficient and cost-effective manner by choosing locations with utmost care from available remote sensing survey data. The excavations completed by our archaeologists in five years of summer field schools have yielded highly valuable data while uncovering less than one percent of the spatial extent of the town site. It is impractical to excavate the remains of an entire 42-acre site; data from methods such as the aerial LiDAR survey proposed here will provide invaluable resources for undertaking efficient and effective research in the future.

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