Abstract  This paper presents an innovative application of airborne laser and aerial photo technologies in conjunction with Global Positioning Systems (GPS) receivers for cost-effective management of highway corridors, airports, and related transportation infrastructure assets. This is accomplished by producing digital terrain models, generating digital mapping databases, and linking various data sources through user-friendly geographical information system (GIS) software. LIDAR is an acronym for Light Detection And Ranging, commonly called Airborne Laser Terrain Mapping. The LIDAR survey provides low-altitude, high speed laser scanning up to 81 sq. km (20,000 acres) per day, which permits an accuracy of 15 cm, and up to 0.3-m (1-ft) contours. There are no operating constraints, such as: vegetation cover, traffic, usage, or time of day. Results are presented from an on-going study of Raleigh Bypass highway alignment project funded by NASA through the Mississippi Space Commerce Initiative (MSCI) and supported by the Mississippi Department of Transportation. The data accuracy, efficiency, time saving, and cost-effectiveness of the airborne laser technology are compared to conventional ground based methods of terrain data acquisition. It is recognized that these airborne technologies are complementary to the currently used in-vehicle videologging and detailed visual condition assessment methods. An application of digital database acquired by the airborne LIDAR method is illustrated for Oxford, a small university town in a rural area of Northern Mississippi. Proof of concept and documentation of benefits will lead to a commercially positioned process and product mix of importance to every infrastructure manager.

BACKGROUND

Technologies for Managing Transportation Infrastructure Assets

Recognizing the importance of preserving national highway infrastructure assets, a one trillion dollars investment, the Federal Highway Administration (FHWA) has recently established an exclusive Office of Asset Management (1). The purpose is to monitor and manage all transportation infrastructure components within the right-of-way including: pavements, bridges, tunnels, interchanges, roadside safety hardware, and drainage structures. The concept of modern
infrastructure asset management and the role of noncontact remote sensing technologies for effective asset management have been discussed in depth by Hudson, Haas, and Uddin (2). Multi-purpose, self-contained vehicles have become popular among highway agencies in the last two decades, particularly as a part of a pavement management system (PMS). Self-contained condition survey vehicles are useful for collecting detailed highway inventory and condition monitoring data at high speeds using noncontact photography, video, laser, acoustic, radar, and infrared sensors (3). These data are primarily related to pavement attributes. However, even these ground based, noncontact technologies may suffer limitations resulting from time of day and traffic congestion, due to the traffic levels and proximity to urban locations, respectively. Additionally, both in-vehicle based and traditional ground survey can be quite hazardous. The new developments in airborne and spaceborne remote sensing technologies can now provide high-resolution georeferenced digital images of transportation infrastructure corridors. These options can provide complementary inventory data on the network level. The digital elevation model (DEM) generated by these remote sensing databases can be used for detailed rehabilitation strategies, design of drainage structures, and watershed modeling.

Integration of Asset Management Systems Using GIS

Linking the traditionally collected infrastructure attributes with geographical coordinates is not easy for visual displays on computer maps. Hudson et al (2), recommend geocoding and the use of geographical information system (GIS) to enhance the display of physical boundaries, retrieval of attributes on map displays, and integration of highway asset management systems with other groups of civil infrastructure facilities. Most of the GIS databases and maps are based upon the United States Geographic Survey (USGS) 7.5 minute quadrangle maps (scale 1:24,000) and minimal conventional survey data at 6-m (20-ft) or 3-m (10-ft) contours. The USGS data emphasize lack of accuracy and inherent inaccuracy encountered to conduct solid engineering analysis, develop cost-effective designs, or analyze maintenance strategies for large-scale networks.

Modern airborne remote sensing technologies, incorporating laser mapping, aerial photo survey, GPS, aircraft navigational aids, and portable high-speed computers have made it possible to collect extremely accurate and very friendly georeferenced digital terrain data. This paper presents the airborne laser mapping technology and its application for infrastructure asset management systems by linking various georeferenced data sources.

AIRBORNE LIDAR TECHNOLOGY

Airborne Light Detection And Ranging (LIDAR), commonly called Airborne Laser Terrain Mapping (ALTM) technology, is a cost effective, efficient method for creating high resolution digital terrain models (DTM) and contours for transportation and environmental applications at dramatically reduced cost and remarkable speed. The aerial photo images can be superposed on the digital maps produced by processing raw laser data. Al-Turk and Uddin have presented a detailed overview of the ALTM scanning head, aerial photography, and procedures of data collection and processing (4). Figure 1 shows a typical aircraft and flight path used for laser mapping.

Principles of ALTM Survey

ALTM survey relies upon extremely precise, real time aircraft positioning and highly accurate measurements of terrain characteristics. GPS is relied upon for positional accuracy of ALTM surveys. A high accuracy GPS receiver system is mounted on the aircraft, and a ground unit is set-up for providing ground control points. The ALTM unit records GPS positions using signals
from a minimum of 12 GPS satellites at least one time per second to obtain maximum accuracy, which is encoded on an 8-mm tape. An inertial measurement unit associated with aircraft avionics systems determines the required correction for the aircraft’s roll, pitch, and heading, which is referenced to the GPS time tag. Together, these two instruments calculate the aircraft position and orientation 50 times per second. The aircraft position and orientation are recorded at an unprecedented accuracy and reliability within the range of a few centimeters.

A pulsed laser system is the heart of the ALTM unit. From an aircraft flying a pattern over the survey area, a focused, infrared laser, (eye-safe at survey altitudes) sends up to 5000 pulses per second to the ground. A high accuracy scanner sweeps the laser pulses across the flight path and collects the reflected light. A laser range finder, consisting of high-precision discriminators and interval meters, measures the time between sending and receiving each laser pulse to determine the ground elevation below. By precisely calculating the time differential and knowing the speed of light, we then have the distance to the object. This is the basic principle for measuring vertical distance in three directions. The time interval meter can either record the first return from the laser, which would be for vegetation heights, or the last return from the laser pulse, which will be potential ground contact. The ALTM scanning mirror has the ability to scan back and forth from 0 to 20 degrees each side of centerline, at a frequency up to 70 times per second. By varying the aircraft altitude, the aircraft speed, the scanner angle, and the scanner frequency, the operator is able to program ground point spacing to fit the particular survey mission. All this information is stored on an 8 mm tape and tied to the GPS time tags.

Field Protocol for ALTM Missions

The ALTM technology has few constraints typical to conventional methods. It can survey day and night, at altitudes between 300 to 900 m (1,000 to 3,000 ft) above ground, over any terrain, and through most vegetation and canopy. Most of the highway application surveys are conducted
at a height of 500 m (1,500 ft) above ground level. The flexibility of day and night missions is subject to usual constraints of flying aircrafts at relatively low altitudes due to the applicable aviation rules. An airborne platform provides non-intrusive operation and no interference with highway traffic.

The aircraft is generally set for flying stability at 160 km (100 miles) per hour for good data collection purposes or flying at 296 km (185 miles) per hour for transit to and from missions. Before a flight, a ground-based GPS is set up on a known point in the survey area. Flight planning determines optimal LIDAR settings and aircraft parameters. A typical survey can collect data at a rate of up to 81 sq. km (20,000 acres) per day.

(a) Contour map from laser data    (b) Aerial orthorectified mosaic image

FIGURE 2  An illustration of contour from raw laser data and orthorectified photo image collected over I-55 interchange in Ridgeland near Jackson, Mississippi.

DATA PROCESSING AND APPLICATIONS

Processing of LIDAR Data and Aerial Photo Images

Following the flight, the LIDAR data tape is transferred to a ground-based computer station where a display of the recorded data is immediately made available. When the data processing of x, y, z coordinates is complete, a color coded map is generated. An orthorectified photo is used as a background to show planimetric features. Based on the specific needs, the data are also analyzed through the vegetation removal software. When this step is complete, the data are ready to be imported into a computer-aided design (CAD) system for further quality review and specific applications. The laser data are being used to provide 0.3-m (1-ft) interval contour mapping saving months on data delivery, and tens of thousands of dollars on cost, as compared to resources and time used in conventional ground based total station surveys. An example of a contour map generated for the I-55 interchange project in Ridgeland near Jackson, Mississippi is
shown in Figure 2 (a). Figure 2 also shows an aerial orthorectified photo mosaic image of the I-55 interchange at the same location. Figure 3 shows a three-dimensional (3-D) view of the processed laser data and orthorectified image at the same location. Close-up views of the interchange orthophoto are shown in Figure 4.

**FIGURE 3** Processed 3-D view airborne laser data and orthorectified photo mosaic collected over I-55 interchange in Ridgeland near Jackson, Mississippi

**FIGURE 4** Close-up views of aerial orthorectified photo collected over I-55 interchange in Ridgeland near Jackson, Mississippi.
LIDAR Data Accuracy and GIS Applications

Horizontal accuracy is better than 30 cm (12 in). Vertically, the LIDAR technology can be accurate within less than 15 cm (6 in). Up to 0.3-m (1-ft) contours are produced at a scale of 1:4,800. The creation of a large digital database provides both current and future benefits for mapping and other applications using any other GIS or CAD software for the area of coverage. In effect, it is a precise update of the traditional quadrangle map parameters not previously conceivable. Three-dimensional digital coordinate data are directly loaded into terrain mapping, GIS, or CAD software. This computerized data collection and downloading leads to efficient and error free data processing, map generation, and asset management databases. Conventional topographic surveys using total stations are slow. Higher pixel resolution is achieved in aerial photogrammetry if the survey is conducted at lower altitude of 1,524 m (5,000 ft) above the mean terrain level. Conventional aerial photogrammetry is conducted at about 3,048 m (10,000 ft) above terrain and limited by weather and vegetation cover operating constraints, time consuming data processing, and interpretation for digital elevation model. Aerial photo surveys in wooded areas are recommended in winter time in the absence of leaves for good quality and high resolution images.

Chatham County, in Georgia, became the first county in the United States that developed county-wide, digital, 0.3-m (1-ft) contour maps for the entire 1,000 sq km (250,000 acres). The entire project, from LIDAR data collection to GIS map generation, was completed in less than a year (5). Traditional survey would have required several years. A comprehensive and high-resolution GIS database is the backbone of all infrastructure asset management systems. Cost, accuracy, and timeliness validation of the innovative LIDAR technology, and associated “downstream” processes and products will lead to routinely available powerful tools across a broad spectrum of applications in the infrastructure management marketplace.

NASA/MSCI PROJECT FOR EVALUATION OF AIRBORNE LIDAR DATA

Overview

The airborne LIDAR remote sensing digital mapping technology in conjunction with GPS receivers and aerial photogrammetry, is currently being evaluated by the Center for Advanced Infrastructure Technology (CAIT) at the University of Mississippi (6). The study is focussed on 8 km (5 mile) long highway alignment project of Raleigh Bypass near Jackson, Mississippi. The study is funded by the NASA Stennis Space Center (SSC), home of NASA’s Commercial Remote Sensing Program, and the Mississippi Space Commerce Initiative (MSCI) with the support of the Mississippi Department of Transportation (MDOT).

The Mississippi Space Commerce Initiative (7) is a partnership among the State of Mississippi (through the Department of Economic and Community Development), the University of Mississippi (on behalf of the universities of the Mississippi Research Consortium), NASA, and private industry. The MSCI is devoted to developing, commercializing, and expanding the remote sensing/GIS industry and work force in Mississippi. These goals are being accomplished through three functional elements: the research and development component, the Industry cluster component, and the workforce development and training component. MSCI, currently an 21 member company provides a wide variety of products and services including: emergency response systems, imaging systems, agriculture production information, digital imagery, elevation models, information technology and services, data acquisition, educational products, software and database development, technology support for litigation and health/medical, digital mapping, spacecraft and space transportation systems, and weather prediction. MSCI is serving as catalyst in providing a unique blend of governmental, educational and private industry resources in leveraging NASA technology to develop products, enhance the competitiveness of remote
sensing companies, support joint technology development initiatives, train and educate a workforce, and enhance the development of remote sensing and GIS research infrastructure.

The NASA/MSCI project is evaluating both technical and economic advantages offered by the airborne LIDAR technology for transportation industry applications, as compared to the conventional ground method. The LIDAR survey was conducted during a two-hour flight and all laser and GPS data were stored on one GB 8-mm tape. The data processing was completed within a few months. The digital terrain data and orthophoto images can be provided as standard CAD or Arcview GIS database files. On the other hand, the conventional topographical survey has taken many months, over a year and half, for data collection because of the presence of thick forest and farm land. The project was on-hold for five months to resolve some community concerns. The immense benefit of airborne LIDAR is the speed of data collection and processing, which is validated in this first independent study of LIDAR and traditional survey techniques.

Figure 5 shows a close-up of centerline profile from the three methods for the 8 km (5 mile) long Raleigh Bypass highway project. The number of ground elevation points from LIDAR and aerial photo methods are several times more than the total station survey. There is no statistically significant difference in the mean elevation data from the three methods at 95 percent confidence. The combined cost of LIDAR mission, aerial photo mission, and related data processing effort is about $45,000. This is much lower than the cost of the conventional total station survey, staking, and data processing at $166,000. Further evaluation is in progress to determine cost-effectiveness considering the combined costs of LIDAR for contour maps and ground based total station for layout and staking, expected to be almost half of the cost of the conventional total station survey without LIDAR data. Cost savings will be substantially higher for larger areas, difficult terrain, and heavily populated and congested urban areas.

**FIGURE 5** Comparison of centerline profiles from the three topographic survey methods

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TRB Committee AFD10 on Pavement Management Systems is providing the information contained herein for use by individual practitioners in state and local transportation agencies, researchers in academic institutions, and other members of the transportation research community. The information in this paper was taken directly from the submission of the author(s).
INTELLIGENT TRANSPORTATION SYSTEMS (ITS) DEPLOYMENT PROJECT

Overview

The city of Oxford, Mississippi, is conducting rural area deployment and integration of an Intelligent Transportation Systems (ITS). The City has appointed the University of Mississippi Center for Advanced Infrastructure Technology as Program Manager to conduct and coordinate this important and timely project. The ITS project is the result of intensive brainstorming and interaction among the city officials, public representatives, UM officials, and local civic organizations. The plan has been discussed at length with the state ITS coordination team of the Mississippi Department of Transportation and the supporting engineers of the Mississippi Division of Federal Highway Administration in Jackson, Mississippi.

Oxford is a relatively small city that has experienced unprecedented growth in recent years. Served by several state highways, the city is the home of the University of Mississippi (UM) and is an important business, commercial and education center for many small towns within a 40 km (25 miles) radius. A regional hospital, a federal court, and several other important agencies are also located in the city and serve surrounding areas including Lafayette and Panola counties in Northern Mississippi. Figure 6 shows the network of major roads and state highways in Oxford.

Lafayette County, City of Oxford, and The University of Mississippi

FIGURE 6 Oxford and vicinity.
GIS - ITS Backbone

The development of a digital terrain database, using the innovative airborne LIDAR mapping technology and color aerial georeferenced photo, is an important component of the GIS supporting the ITS project for Oxford. It is a cost-effective, efficient method for creating high-resolution digital terrain models and contours. The resulting GIS precision database forms the rural ITS backbone. The GIS will have separate layers for terrain data, photos, and transportation networks. All important inventory and condition data attributes, layers of road network and signals, and eventually real-time traffic surveillance data will be incorporated in this comprehensive and accurate GIS. The GIS will be designed to accommodate differing infrastructure components and will be integrated with user-friendly asset management software, as shown in Figure 7.

FIGURE 7 Proposed GIS - ITS backbone system for Oxford.

Products and Benefits

Products include: accurate and detailed digital maps; digital terrain models; aerial georeferenced orthorectified photos of all of the city within its boundaries including the local airport, state highways, interchanges, old railroad tracks and crossings, university road network, alternative
routes for improved traffic flow and reduced response time of emergency service vehicles; a comprehensive GIS ITS backbone; digital mapping database; and traffic surveillance and tracking data from other parts of the Oxford ITS Project. The GIS will be used for linking important computerized information sources for all users. The public will have access through the Internet.

Benefits include enhanced safety and quality of life, cost-effective traffic management, improved emergency management, and information sharing through the use of GIS. Through the Internet and a wide area network several users can access the relevant GIS maps and time critical information for their specific applications such as: enhanced safety management, efficient incident management, improved emergency medical and fire brigade response, timely response by state highway patrol and city police, and improved traffic management. Virtual three-dimensional terrain simulation models will be developed, based on LIDAR data, for enhanced 3D visualization and other end-use applications using advanced image analysis software provided by the NASA and MSCI remote sensing companies.

Implementation of High Resolution GPS Monuments

As a part of the advanced digital mapping study of the Oxford ITS project, several high resolution GPS monuments have been established in the Oxford area. The Mississippi Department of Transportation, in cooperation with the National Geodetic Survey (NGS) of the National Oceanic and Atmospheric Administration (NOAA), recently directed the installation of six new geodetic control GPS monuments in the Oxford/University area in March 2001. One such monument was installed in the year 2000 at the University/Oxford Airport. The sites are referenced to the national High Accuracy Reference Network (HARN) established by the NGS to support the use of GPS by federal, state, and local surveyors, geodesists, and for other applications. Part of an array of some 208 such sites in the statewide Cooperative Base Network (CBN) in Mississippi, the GPS referenced monuments serve as ground control points as the airborne cameras and LIDAR instruments collect the remotely sensed data. The CBN sites were installed locally due to the significance of the ITS mapping project (8).

A high-precision GPS antenna mounted on the LIDAR-equipped airplane connects with the selected GPS monument sites and simultaneously records location of the data. After the flight, the remotely sensed information is downloaded and processed using specially designed computer software. Digital maps are produced, in which each image pixel represents a data point that is colored according to its elevation value. The end product is accurate, geographically registered longitude, latitude, and elevation positions for every data point. The LIDAR maps and the background georeferenced orthorectified photo mosaic layer are further analyzed for identifying features such as: roads, intersections and interchanges, buildings, vegetation, parking lots, automobiles, etc.

REMOTE SENSING FOR ENVIRONMENTAL ASSESSMENT OF TRANSPORTATION

Mississippi is a rich site for remote sensing research on transportation. All major modes of transportation are represented in the state, with major waterways and ports on three sides of the state, interstate highways, railways, pipelines, electric transmission lines, and airports. Additionally, the presence and commitment of the University of Mississippi-led Mississippi Space Commerce Initiative, and the commercial remote sensing program at NASA Stennis Space Center (SSC) make both Mississippi and proximal the Gulf Coast regions ideal sites to conduct research and development in remote sensing and related spatial information technologies targeted on transportation applications to facilitate and enhance sustainable use by both the public and the private sectors. The presence of the various modes of transportation infrastructure over a widely varying physical landscape is also enhanced by a diverse group of commercial and private transportation users, providing an even richer study site. One end of the state is anchored by
Memphis, self proclaimed and actual “Distribution Center of America” and the other end jointed by New Orleans, Gulfport, Pascagoula, comprising major intermodal points. This traffic creates credible and on-going real need for implementing infrastructure management systems. NASA, SSC, and MSCI are, therefore, exploring possible applications of remote sensing and spatial information technologies for the planning, operation, preservation, and assessment of the national transportation system using the unique site of Mississippi as one base.

The United States DOT Research and Special Program Administration (RSPA) has funded a four-years competitive grant to Mississippi State University’s (MSU)-led university consortium for establishing a national center of remote sensing technologies for environmental assessment projects. This has resulted in the establishment of the National Consortium on Remote Sensing for Transportation – Environmental Assessments (NCRST-E). The University of Mississippi-CAIT is a consortium partner, responsible for air quality analysis.

Remote spatial environmental assessments could be used potentially to streamline regulatory compliances, assess catastrophic hazardous waste releases, develop remediation strategies, improve coordination of emergency management activities, and provide a cost-effective mechanism to monitor environmental impacts and mitigation benefits. They can be used to produce an accurate, convincing, timely, and cost-effective environmental analysis. Although aerial remote sensing in the form of photography has been used in the transportation sector for some time, new innovative remote sensing technologies such as airborne LIDAR and multispectral satellite imaging have not been fully examined in this field. The NCRST-E project is building on current remote sensing technologies with respect to environmental assessments.

Primary products of the air quality component of this research project being conducted by CAIT at the University of Mississippi are: measurements of air pollution over highway corridors using the innovative Differential Absorption LIDAR (DIAL) remote sensing technology, modeling of wind speed and wind direction and their effects on transportation emissions and air quality using neural network and advanced regression techniques, implementation of these models and GIS outputs for assessing environmental impacts, and calibration of these models using bench mark data obtained from ground truth methods. Figure 6 shows the first site for DIAL measurements on Highway 6 in Oxford. The GIS created by the airborne LIDAR and georeferenced orthorectified photo mosaic on the Oxford ITS project will be used for air quality data management and analysis.

Traffic volume data and emission levels impact social and societal costs if analyzed on the basis of long-term infrastructure life-cycle costs. Based on this study, long term life-cycle cost models will be developed. Highway planners may be able to use these models for making better evaluation of alternative strategies for corridor planning, design, construction, maintenance, and asset management all with sensitivity to environmental impacts.

FUTURE OPPORTUNITIES IN REMOTE SENSING TECHNOLOGIES

The digital terrain model and 0.3-m (1- ft) contours developed and evaluated in the NASA/MSCI Raleigh project are excellent sources to evaluate the resolution and accuracy of spaceborne remote sensing data. The spaceborne remote sensing data can be collected relatively cheap many times in a year at reasonably high resolution, as shown in Table 1. This provides immense new opportunities to assess regional and corridor-level temporal changes and condition assessment of transportation infrastructure assets on routine long-term basis, and to assess damage caused by natural disasters and acts of terrorism.

The airborne LIDAR and aerial orthorectified photo data are still far superior in resolution and accuracy compared to the cheapest 15 m resolution data available from NASA’s latest Landsat7 satellite. The Space Imaging’s commercial IKONOS satellite provides 1 m high resolution data at relatively nominal costs, compared to airborne methods. This brief discussion shows the future opportunities and promises of the latest airborne and spaceborne technologies.
These remote sensing technologies can provide high resolution georeferenced spatial data and images for enhancing GIS applications and linking various different data sources for cost-effective transportation infrastructure asset management.

### TABLE 1  Comparison of The New ‘High Resolution’ Spaceborne and Airborne Remote Sensing Technologies

<table>
<thead>
<tr>
<th>Satellite</th>
<th>Spatial Resolution</th>
<th>Spectral Resolution</th>
<th>Temporal Resolution (days)</th>
<th>Footprint (km x km)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Landsat 7</td>
<td>15 m</td>
<td>7 bands</td>
<td>16</td>
<td>185 x 185</td>
</tr>
<tr>
<td>IKONOS</td>
<td>1 m</td>
<td>3 bands</td>
<td>3.5 -5</td>
<td>11 x 11</td>
</tr>
<tr>
<td>Orbview3</td>
<td>1 m</td>
<td>4 bands</td>
<td>3</td>
<td>8 x 8</td>
</tr>
<tr>
<td>QuickBird</td>
<td>0.82 m</td>
<td>3 bands</td>
<td>1.5- 4</td>
<td>22 x 22</td>
</tr>
<tr>
<td>ASTER</td>
<td>VNIR: 15 m IR: 30-90 m</td>
<td>14 bands</td>
<td>In Space Shuttle</td>
<td>Variable</td>
</tr>
<tr>
<td>Orbview4</td>
<td>1m</td>
<td>4 bands</td>
<td>3</td>
<td>8 x 8</td>
</tr>
<tr>
<td>SPOT 5 (A,B)</td>
<td>2.5 m 20 m (Mid IR)</td>
<td>4 bands</td>
<td>1- 4</td>
<td>60 x 60</td>
</tr>
<tr>
<td>Airborne Photo</td>
<td>0.15 m</td>
<td>Visible band</td>
<td>On Demand</td>
<td>2 x 2 at 3,000 m</td>
</tr>
<tr>
<td>Airborne LIDAR</td>
<td>0.15 m</td>
<td>NIR band</td>
<td>On Demand</td>
<td>Very Dense *</td>
</tr>
</tbody>
</table>

Notes: IR = Infrared  
NIR = Near Infrared  
VNIR = Very Near Infrared  
* Laser measurements at about 500 m above mean terrain level: less than 1 m x 1 m on ground

### SUMMARY AND CONCLUSIONS

The airborne LIDAR laser mapping and photography data collection system offers several unique advantages over conventional ground based survey methods. Currently, this innovative technology has the capability to perform 0.3-m (1- ft) interval contour mapping, even through vegetation, and collect high-resolution photo images. Safety issues alone are compelling and the differential accuracy and comparative costs make the methodology tradeoff very attractive. With the speed, safety, efficiency, and digital formats of this airborne, noncontact method for topographic surveying, it can truly revolutionize the future of surveying, digital mapping, and accurate GIS databases, and their applications for infrastructure asset management. Several case studies are described involving the airborne LIDAR and aerial photography for the development of digital terrain models and GIS databases. Of course, these innovative remote sensing technologies complement the detailed visual and ground vehicle based inventory and condition assessment methods traditionally used for highway and infrastructure asset management.

The development of a high resolution and accurate digital terrain mapping database for Oxford and surrounding area in Northern Mississippi is being carried out using airborne LIDAR laser mapping and aerial photo survey. The digital data will be used to establish a comprehensive precision GIS which will form the ITS backbone to support all data flows, information access, and 3D visualization. It will be integrated with the data flow from advanced traffic surveillance equipment. The GIS database will be used for incident management by law enforcement agencies, emergency response management, and on-line information access by citizens. The GIS will be integrated to asset management software, traffic surveillance data, and real-time traffic tracking study.

An important consideration in managing the national transportation infrastructure is our ability to provide timely and accurate inventory and condition assessment of infrastructure assets. A digital database of vital infrastructure assets and elements will be very useful for estimating...
periodic preservation budgets, cost-effective planning, and executing emergency management strategies in the case of natural disasters and acts of terrorism. The complementary use of airborne and spaceborne remote sensing technologies will accelerate the huge data collection and processing efforts, which are essential for full and timely implementation of GIS-based infrastructure asset management systems.

ACKNOWLEDGMENT

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DISCLAIMER

The contents of this paper reflect the views of the authors who are solely responsible for the facts, findings, and data presented herein.

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