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An Assessment of Remote Sensing Applications in Transportation

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Abstract

Remote sensing is an innovative science and technology that is aiding in numerous modes of transportation. Almost every aspect of transportation can benefit from utilizing imagery and data. Specifically, these technologies can be applied to planning, environmental impact assessment, hazard and disaster response, infrastructure management, traffic assessment, and homeland security planning ("Transportation and Remote Sensing," 1999). The United States transportation system is a critical component of our economy and mobility (Williamson, Morain, Budge, & Hepner, 2002). There are millions of miles of roadways and bridges to monitor and maintain. In addition, remote sensing can be utilized towards the development and planning of new infrastructure and transportation systems. Remote sensing provides the unique ability to detect changes in our transportation system on a real-time basis. Imagery can be collected from multiple platforms, including satellite, aircraft-based, and ground-based, which allows data collection to be tailored to a particular transportation application.

This paper will provide an overview of some of the potential applications of remote sensing in transportation. Due to the broad scope of this topic, several modes will not be discussed including aviation and marine. The main focus will be on ground transportation, infrastructure, and homeland security as it relates to transportation applications. Emerging technologies, such as hyperspectral remote sensing and LIDAR, will also be discussed. In addition, the Nebraska Airborne Remote Sensing Facility, one of only a few operating in the United States will be described. Two tribal communities in Nebraska are utilizing the data collected from the facility to address transportation issues.

An Assessment of Remote Sensing Applications in Transportation

Introduction

"Remote sensing is the practice of deriving information about the earth's land and water surfaces using images acquired from an overhead perspective, using electromagnetic radiation in one or more regions of the electromagnetic spectrum, reflected or emitted from the earth's surface" (Campbell, 2002, p. 6). There are numerous ways of defining remote sensing. Most descriptions have several things in common; remote sensing utilizes the electromagnetic spectrum, it is a process of acquiring information without being in direct contact with the object, and it involves reflected or emitted energy. Remote sensing is highly versatile and can be used in many applications within transportation. Potential uses for remote sensing in transportation include planning, environmental impact assessment, hazard and disaster response, infrastructure management, traffic assessment, and homeland security ("Transportation and Remote Sensing," 1999).

Remote sensing science and technology can be used to help address the country's critical transportation problems. Secretary of Transportation, Norman Mineata, stated "Our nation's transportation system faces significant challenges in congestion, intermodal connectivity, freight efficiency, and project delivery" ("Remote Sensing and Geospatial," 2003, p. 2). Within the United States, there are approximately 210 million vehicles, 4 million miles of roads, 500,000 bridges, 4 trillion passenger-miles, and 920 billion freight ton-miles (Williamson, Morain, Budge, & Hepner, 2002). The need for effective uses of technology within the transportation system in the United States has become critical.

Governing bodies are in need of fast, cost-effective, and accurate ways of collecting data on transportation systems.

The solution to some of the most critical issues in transportation can be aided by using remote sensing technology. There are several key reasons this science is so useful to the transportation community. Remote sensing combines a broad synoptic view with the ability to detect changes in surface features quickly and routinely. Satellite imagery, in particular, can provide consistent, repeat coverage of a particular area. The ability to gather information in near-real time and real-time provides a major advantage to the transportation community. The internet has made the transmission of imagery and data more accessible and timely. The data gathered from remote sensing can reduce human errors and be extremely accurate. Depending upon the particular application, utilizing remote sensing technology can be cost-effective. In addition, it can provide access to areas not readily available. Bridges or roads in remote areas of the country can be monitored utilizing remote sensing. This could possibly limit, or even eliminate, some field work, saving time and increasing safety.

The number and type of remote sensing sensors is continuing to increase in sophistication. There are numerous platforms and sensor options available for use. As the science evolves, advanced sensors are being designed. Many of the current sensors are extremely specialized while others have a broader range of uses. Remote sensing is not limited to satellite-based sensors. Imagery can also be gathered from airborne and ground-based platforms. Each of the three types has advantages and limitations depending upon the particular application. Many of these methods have already been developed by the military, but transferring this technology to civilians brings many other considerations that are less importation to the military such as economic, social, and legal ramifications.

The use of remote sensing in transportation is so crucial that the United States Department of Transportation (DOT) and the National Aeronautics and Space Administration (NASA) have partnered to improve the industry. The Transportation Equity Act, TEA21, directed the DOT to co-operate with NASA and form the National Consortia for Remote Sensing in Transportation (NCRST) (Thirumalai, 2002). NCRST was formed to administer a university research program in the application of remote sensing and spatial information technologies to transportation. The main objection of the program is to provide smarter and more efficient transportation operations and services (Thirumalai, 2002). NCRST enlisted four universities to focus on specific sections of transportation:

- Transportation Flows, Ohio State University
- Transportation Infrastructure, University of California at Santa Barbara
- Environmental Assessments, Mississippi State University
- Safety, Hazards, and Disaster Assessments, University of New Mexico

Each university, along with their other academia and commercial partners, has the responsibility to ensure that the results of any projects are made available to their respective communities. This must be communicated either by briefs, user guides, or white papers (Morain, 2001). Their goal is to find new, cost effective applications of remote sensing to be applied to transportation projects. The NCRST is a valuable source of information regarding emerging remote sensing applications in transportation.

This paper will provide an overview, as well as examples, of some of the potential applications of remote sensing in transportation. Illustrations of the use of remote sensing for bridges, the trucking and rail industries, transportation planning, and homeland security will be provided. Specialized remote sensing technologies such as hyperspectral and LIDAR will also be discussed. In addition, the Nebraska Airborne Remote Sensing Facility will be described. This unique program is one of only a few operating in the United States. Transportation examples in Nebraska's tribal communities utilizing the remote sensing data and imagery collected from the Nebraska facility will be provided.

Considerations Before Using Remote Sensing Imagery

The use of remote sensing imagery and data in transportation projects is an exciting and emerging field. Almost every sector of transportation can utilize this technology to address critical issues. When remote sensing is combined with a Geographic Information System (GIS), it becomes very powerful. GIS allows users to manipulate, store, and display geographic data, including remote sensing imagery. Several layers of information can be displayed, such as satellite imagery of a corridor, soils, property records, and census data (Campbell, 2002).

Understanding remote sensing science/technology and the potential applications can be difficult. There are many considerations to take into account before the technology can be applied to a particular transportation problem. Users need to choose the type of platform: satellite, airborne, or ground-based. Each type has advantages and disadvantages depending upon the particular transportation application. The type of resolution (spatial, spectral, temporal, and radiometric) must be carefully considered.

Spatial resolution refers to the finest of detail or the smallest object that can be resolved by the sensor. It is usually measured in terms of distance (1 meter, 30 meters). At one meter resolution, an analyst can detect the pavement lines on roadways and at one foot resolution, manhole covers can be seen ("The Use of Imagery," n.d.). Spectral resolution refers to the specific wavelengths that a sensor can record. For example, color infrared imagery shows wavelengths in the visible and near-infrared regions of the electromagnetic spectrum. This type of imagery is particularly useful for identifying vegetation. The green vegetation shows up as red on color infrared images allowing vegetation to be easily distinguished from other objects. Temporal resolution refers to how often the same area is visited by a sensor. Many satellites, such as Landsat, regularly orbit the earth and take imagery of the same area every 16 days. Airborne imagery must be scheduled and can often be delayed by weather, clouds, and other constraints. Finally, radiometric resolution describes the sensor's ability to make distinctions between the reflectance values of different objects. Roadways will have a different reflectance response than vegetation. Several other factors need to be taken into consideration in order for remote sensing imagery and data to be useful to the transportation community, such as cost.

Applications in Remote Sensing for Transportation: Corridor and Project Management

Remote sensing is proving to be a vital resource for corridor planning projects. These projects generally involve drainage design, roadway design, mitigation plans, environmental evaluations, and public presentations. Imagery and data can be used to support the modeling of these long-term projects. Specific applications include using imagery during construction to monitor sediment run-off, monitoring contractor performance, monitoring bridge and pavement conditions during the construction process, route options through terrain analysis, land use analysis, inventory analysis, and environmental assessment ("The Use of Imagery," n.d.).

For example, the New Orleans Regional Planning Commission (NORPC) developed a Central Business District Land Use and Transportation Plan for Metairie, Louisiana. The NORPC used remote sensing to address the community's concerns regarding the new development plans. Aerial photography was used in planning the number of lanes, sidewalk locations, crosswalk locations, and the overall corridor width within the new Central Business District ("The Use of Imagery," n.d.).

Washington State's Puget Sound Interstate 405 corridor metropolitan area was in need of congestion relief. "By comparing the cost and quality of results obtained from traditional data collection methods used to meet National Environmental Policy Act requirements with those using the methods which this project will develop, this project aims to demonstrate an approach that uses remote sensing technologies to streamline environmental analysis in the transportation planning process" (King & O'Hara, 2002, p. 6). They are combining methods to take full advantage of what technologies are available.

Another application in which remote sensing is proving an invaluable tool is in calculating traffic flow. Average annual daily traffic (AADT) and vehicle miles traveled (VMT) are two important measures that are used in traffic planning and management. By combining aerial imagery with ground data, the cost of ground-based sampling efforts were reduced by more than 50% while substantially increasing the accuracy of AADT and VMT estimates. Airborne imagery enables collection of peak hour volumes, vehicle classification counts, turning movements at intersections and interchanges, and vehicle speeds ("Remote Sensing and Geospatial," 2003).

Rural transportation routes present a unique type of problem. Rural routes typically are low volume roads with soft surfaces. These roads generally provide single point access to homes and businesses. The surface conditions across the road network can be inconsistent due to local weather phenomena and local traffic. Remote sensing can be utilized to provide a mechanism for monitoring these roads in conjunction with near real-time precipitation data. Rural roads are lifelines to many of these communities and identifying natural hazards, such as flooding, snow, fire, and hazardous materials, is critical (Benedict, Watson, & Friedman, 2001).

The NCRST-H (Safety, Hazards, and Disaster Consortium) developed a State, Local, and Rural Road Toolkit for planners to use to identify and manage issues affecting rural roads (Morain, 2002). The NCRST has been working with McKinley County, New Mexico to develop and test a model that identifies locations prone to flooding. Aerial photography and satellite imagery are being used to update the road network data. Detailed soil maps are not available for every area so satellite imagery is being used to extend and enhance these areas. Satellite imagery is also being used to estimate soil moisture and run-off (Benedict, Watson, & Friedman, 2001). While the specific data used in the demonstration are from a small road and drainage network in McKinley County, the concepts and requirements for the application are broadly applicable to any region.

<u>Applications in Remote Sensing for Transportation</u>:

Monitoring Bridges with Remote Sensing

Each year, taxpayers are paying millions of dollars to maintain bridges across the United States. Bridges deteriorate because of weather, especially deicing agents, and traffic. The steel reinforcement within the bridge begins to break down due to corrosion, and in doing so, cracking parallel to the surface starts to occur (Narayanan, 1996). In the past, bridges were checked by the chain drag survey to determine corrosion. When using this method, a trained technician listens for differences in pitch as a chain is dragged across the bridge deck. Good concrete will emit high-pitched tones, while deteriorated concrete will emit low-pitched, dull tones (Narayanan, 1996). This method requires a highly trained technician who can differentiate between the tones. Since the cracking occurs between the top surface and the top layer of the reinforcement, remote sensing is proving to be a useful tool for this application. Specifically, ground penetrating radar has been used to detect the corrosion in bridges. Ground penetrating radar works by emitting a very short pulse and recording the reflecting wavelength. Concrete that is not cracked and concrete that is cracked both produce unique signals. "Comparison of these signatures to theoretical simulations can lead to insight as to the locations of delaminations as well as the extent of the deterioration" (Narayanan, 1996, p. 5).

Another way bridges can be monitored using remote sensing is by comparing images before and after a major incident has occurred, aiding in evaluating the soundness of the structure. "Successful remote sensing toolboxes were demonstrated in cooperation with Wisconsin DOT to facilitate the location of bridges from remotely sensed imagery with attribute information from databases such as the National Bridge Inventory for optimizing the field inspection process" ("Remote Sensing and Geospatial," p. 4).

Applications in Remote Sensing for Transportation: The Trucking Industry

Driver fatigue and safety are critical issues in the trucking industry. The availability of parking spaces and rest areas are often inadequate to accommodate the rest requirements for truckers. During peak times, late evening and early morning, parking spaces can be sparse. As a result, truckers are pulling off onto the shoulders and exit ramps of the interstate which is hazardous. A 1996 study published by Federal Highway Administration (FHWA) "…estimated a current total nationwide shortfall of 28,400 truck parking spaces at public rest areas. The shortfall is projected to reach about 36,000 spaces over the next 5 years. The average current national truck parking space shortfall per rest area is 21" (Bronzini, Gomez, & Choudhary, 2001, p. 1). Typical rest areas built during the early interstate program provide about 35 diagonal parking spaces for cars and 12 parallel spaces for trucks. Trucks usually occupy more than one parking space because it is difficult to maneuver in and out. The result is that 12 spaces may only contain about 6 or 8 trucks (Bronzini, Gomez, & Choudhary, 2001). FHWA acknowledges that there is a nationwide scarcity of rest areas on interstate highways.

Remote sensing and field observations are proving to be valuable tools to help validate the problem. The technology has shown that there is a lack of sufficient parking places in rest areas. "Two public rest areas were selected for field studies: one located on I-66 west of Fairfax, VA, and the other on I-95 south of Washington" (Bronzini, n.d. p. 1). This study found that most truck stops are used overnight and that there was a consistent lack of parking spaces available during overnight hours. This caused alarm because of the possibility of drivers continuing to drive when they are tired or by parking illegally on the shoulders of the roads, causing hazards for all drivers.

Applications in Remote Sensing for Transportation:

Analysis in Railways

Segments of a railroad from Gulf Coast townships in Mississippi are being relocated using remote sensing applications. "The three coastal counties in Mississippi Jackson, Hancock, and Harrison, have undergone considerable change in land use, population, wildlife habitat, demographics, and socio-economic conditions in the past 30 years" (King, & O'Hara, 2002, p. 3). Figure 1 shows the projected new location of the railroad.

Figure 1
Note: From King, R., & O'Hara, C. (2002). *Synthesis of remote sensing applications for environmental assessment*. Mississippi State, MS: National Consortia on Remote Sensing in Transportation-Environmental Assessment.

The demographics in this area have grown over the past 30 years showing a change from small, rural communities to communities involved in tourism and industrial activities. The moving of segments of the rail line will be a challenge due to the sensitive environment of the gulf coast areas.

Remote sensing was successfully used in the analysis of connecting the Alameda Corridor area of southern Los Angeles to the ports of Los Angeles and Long Beach with an intercontinental rail system. This was a $2.8 billion freight transportation system that used imagery to assist in planning where to locate the transfer stations and offport freight inspection facilities ("Remote Sensing and Geospatial," 2003).

Applications in Remote Sensing for Transportation:

Safety and Security Planning

Remote sensing science and technology is being used to enhance the safety and security of different types of transportation systems. Remote sensing provides a broad view with the ability to detect changes routinely and rapidly. By providing current information through imagery, it allows for efficient management of evacuation procedures and relief operations. This is a key resource for transportation managers and planners who need to protect critical infrastructure and transportation routes (Williamson, Morain, Budge, & Hepner, 2002).

"Thanks to NASA and NOAA (National Oceanic and Atmospheric Administration), remote sensing technology is advancing our ability to forecast disastrous events, thus improving our transportation tool kits" (Morain, 2001, p. 2). Natural disasters, such as floods, hurricanes, tornados, and fires occur across the United States every year. Remote sensing is not able to predict the event itself, but it is being using to prevent further damage or death to a community. It is doing this by finding potential problems with bridges, buildings, or roadways that may have been damaged. Any disruption to the national transportation system would have major impacts across the United States. Remote sensing can help mitigate the impact and provide decision-makers with the necessary tools to address the issues in a timely and accurate manner.

Remote sensing is being used to plan evacuation routes in case of a disaster. For example, Hamilton County, Tennessee, applied remote sensing to determine evacuation routes in case of a nuclear power plant disaster. Road networks and population estimates derived from imagery and supported in a GIS database, provided the basis for an evacuation simulation and plan. Remote sensing imagery has also been used in developing evacuation routes in case of a deadly fire. Detailed neighborhood maps were developed using remote sensing to produce models of evacuation routes in fire prone areas. "Remotely sensed imagery helps to identify the most fire-prone areas and to develop fire propagation models. Detailed neighborhood maps with microsimulation models allow emergency evacuation to be modeled at the level of the individual vehicle for avoiding congestion during evacuation" ("Remote Sensing and Geospatial," p. 4).

After September 11, 2001, new uses for remote sensing are being developed to assist in preparing and preventing against another attack. "Remote sensing and other geospatial information technologies provide a vital spatial and temporal foundation for all phases of the U.S. response to terrorist threats" (Williamson, Morain, Budge, & Hepner, 2002, p. 10). The phases listed include detection, preparedness, prevention, protection, and response and recovery (Williamson, Morain, Budge, & Hepner, 2002)

After the attack on the World Trade Center, the New York Office for Technology, along with EarthData's assistance, was collecting airborne data over Ground Zero. The team combined three remote sensing sensors; light detection and ranging (LIDAR), a high resolution digital camera, and a thermal camera to provide workers with as much information as possible to assist in recovery efforts (Hiatt, 2002). They were able to use this data to measure rubble, determine shifting in the surrounding buildings, and monitor the fires still burning below the rubble (Hiatt, 2002).

Emerging Remote Sensing Technologies:

Hyperspectral Remote Sensing

Hyperspectral remote sensing is also proving to be a useful tool in transportation applications. This type of remote sensing consists of hundreds of spectral bands of information that provide a distinctive reflectance signature. "Hyperspectral is a technology based on the phenomenon of electromagnetic (EM) spectra and its underlying principles" (Gomez, 2001, p. 4). These instruments are able to collect areas of data rather than fixed points and they provide fine spectral and spatial resolution.

Hyperspectral remote sensing has the unique ability to detect, identify, and map surface composition (Narayanan, Bowen, & Nickerson, 2002). Applications in transportation using hyperspectral data include material identification, trafficability analysis, plume analysis, disaster mitigation, and city planning (Gomez, 2001). Hyperspectral remote sensing has also been used to monitor pavement types associated with road maintenance. "In western states, HSI is a strong candidate for detecting noxious roadside weeds" (Gomez, 2001, p. 8).

Studies in California and Iowa have used hyperspectral remote sensing to assist in determining types of surface materials or distinguishing the difference between manmade materials, such as whether a roadway in concrete, asphalt, or blacktop. They were able to use hyperspectral remote sensing to determine where the application of centerlines was omitted. By comparing the imagery against the reference centerline map, and weeding out certain features such as rooftops, a new image was produced showing where the centerlines had and had not been applied (Thirumalai, 2002).

Emerging Remote Sensing Technologies:

LIDAR Remote Sensing

"A LIDAR system is an aircraft-mounted laser system designed to measure the 3D coordinates of features on the Earth's surface" (Renslow, 2001, p. 2). LIDAR stands for light detection and ranging. It sends a laser signal, ultraviolet, visible, or infrared, to the earth, and by measuring the amount of time it takes for the signal to return, we are able to determine the elevation in a given area. "For transportation applications, this measuring technology is extremely useful as personnel safety issues are minimized and the data may be collected day, night, or in shadowed areas" (Renslow, 2001, p. 4).

Innovative remote sensing technologies, such as LIDAR, are being utilized in many modes of transportation. Applications include right-of-way planning, landslide or hazard assessment, surface run-off, maintenance, inventory of facilities and structures, and development of highway corridors. LIDAR has been used successfully in slope assessment, allowing for the mapping of roadways that used to be inaccurate and time consuming (Renslow, 2001). Slope assessment had been an inaccurate process due to the difficulties of some terrain, but now difficult slopes are easier to map with LIDAR.

LIDAR has the ability to collect data during the day or night. This makes for the collection of intersection or roadway information easier since it can be collected during off peak times to determine the intersection's characteristics such as number of lanes or directional turning. During peek traffic hours, LIDAR can assist in traffic flow monitoring. For medium to large scale projects, LIDAR is a very efficient means of mapping terrain. It can detect vegetation separate from buildings. These features can then be removed to show a bare earth model (Renslow, 2001). LIDAR is very accurate, coming within centimeters of vertical accuracy.

> "As LIDAR is a relatively new spatial technology, standard procedures have not been developed to yield data with predictable accuracy comparable to current photogrammetric technologies. As a result, LIDAR has not been readily adopted by state DOTs for engineering design projects requiring accurate elevation data. Researchers evaluated LIDAR data in comparison with current photogrammetric methods. Using data provided by Iowa DOT, comparisons were performed among elevation surfaces derived from analytical plotters (i.e. mass points and breaklines), LIDAR and automatic extracted points from digital aerial photography (i.e., softcopy points), for a highway evaluation corridor in eastern Iowa. LIDAR (light detection and ranging) remote sensing is being shown to be a valuable tool in designing roadways" (Vonderohe, 2003, p. 1).

By using this technology, the Iowa Department of Transportation saved valuable time and money, an estimated 50% on designing a transportation corridor ("Remote Sensing and Geospatial," 2003).

On a 20 mile stretch of interstate, where three different interstates converge in Knoxville, Tennessee, LIDAR will be used to help detect nitrogen oxide emissions. Researchers want to measure nitrogen oxide and particulate matter emissions as trucks pass by. A stepped FM-AM LIDAR technique will be used to detect particulate matter and ultraviolet absorption which can detect nitrogen oxide emissions. Approximately 25,000 semi trucks pass through the Knoxville area and they are responsible for 40 percent of the nitrogen oxide emissions (Walli, 2002). Researchers are hoping that the study will make a major contribution towards understanding truck emissions.

<u>The Nebraska Airborne Remote Sensing Facility</u>

The University of Nebraska at Lincoln's (UNL) Remote Sensing Program and the University of Nebraska at Omaha's Aviation Institute (UNOAI) have cooperatively developed the Nebraska Remote Sensing Facility. The result of this partnership is the development of one of the most innovative airborne remote sensing facilities in the United States. The remote-sensing program at UNL consists of approximately 30 faculty members and is very competitive with other institutions in the depth of the work that is accomplished. The University of Nebraska at Omaha (UNO) has a strong aviation science and technology program which facilitates the facility air operations for the project. The combined strength of these two institutions have a unique specialty that will be a resource not only for Nebraska, but for the entire nation (Narayanan, Bowen, & Nickerson, 2002, p. 3). In addition, collaborations also take place with Creighton University's remote sensing faculty and UNO's Geography and Geology Department (Vlasek & Bowen, 2004).

Figure 2
Piper Saratoga

Facility Specifications

The Nebraska NASA Experimental Program to Stimulate Competitive Research (EPSCoR) program at the UNOAI currently provides support for an Airborne Remote Sensing Collaborative Research Team (ARS CRT). This highly skilled team of researchers operates the Nebraska Remote Sensing Facility through which a variety of technological advancements are being made. The ARS CRT is highly productive in its research endeavors, providing multi-institutional and inter-disciplinary research opportunity for Nebraska (Narayanan, Bowen, & Nickerson, 2002).

This facility also fosters close interaction between the university and industry as well as government agencies nationwide. The Nebraska Airborne Remote Sensing Facility is currently the only full-time operating platform in the United States. Since remote sensing technology is poised to enter the commercial market in the near future, the advantage of such a facility will benefit not only the conduct of high-quality research, but also help spawn spin-off companies designing novel low-cost airborne sensor systems. This result provides opportunity for commercialization of research and immediate transfer of technology (Narayanan, Bowen, & Nickerson, 2002).

Figure 3
Airborne remote sensing mission in progress over the Winnebago Reservation.

The collaboration between UNL and UNO, seen through the ARS CRT, provides a unique opportunity to utilize the capabilities of UNOAI's single-engine Piper Saratoga. This aircraft gives UNL's remote-sensing scientists a ready-at-hand airborne platform and provides the UNOAI with advanced aviation technology applications for educational support. University ownership of an aircraft equipped with key sensors allows flexibility in data acquisition and demonstrates significantly enhanced precision (Narayanan, Bowen, & Nickerson, 2002).

The Saratoga was modified to accommodate the ARS CRT's remote sensing equipment. The following sensors serve as equipment on the aircraft:

- Kodak DCS-420 color-infrared digital camera
- Analytical Spectral Devices (ASD) spectroradiometer operating in the 350-2500 nm wavelength range

- NASA Goddard Space Flight Center provided and refurbished Airborne Laser Polarimeter System (ALPS) operating at 532 and 1064 nm wavelengths
- UNL developed noise radar scatterometer operating at 1.275 GHz (L-band) and 10 GHz (X-band) frequencies

  Canon 2500 digital video camera
- Airborne Imaging Spectrometer (AISA) hyperspectral imager operating over the 400-900 nm wavelength range (Narayanan, Bowen, & Nickerson, 2002)

<u>Transportation Applications on</u>

<u>Nebraska's Native American Reservations</u>

The NASA Nebraska Space Grant & EPSCoR Program has placed an emphasis on working with Native American communities in the state. In 2002, a Geospatial Extension and Research Specialist (GES) was hired to help disseminate geospatial technologies to tribal communities. The GES acts as a liaison between tribal communities and the Nebraska Airborne Remote Sensing Facility. The Winnebago and Santee Sioux are extremely interested in using remote sensing and other geospatial technologies to manage tribal resources including transportation routes and infrastructure.

Figure 4
Winnebago Reservation
Color-infrared imagery

Overflight missions were conducted in 2002 of the Winnebago and Santee Sioux Reservations with a color-infrared camera mounted on the Piper Saratoga from the Nebraska Remote Sensing Facility. In 2003, the AISA sensor was used to collect data and imagery of the Winnebago Reservation. The hyperspectral sensor collected 35 bands

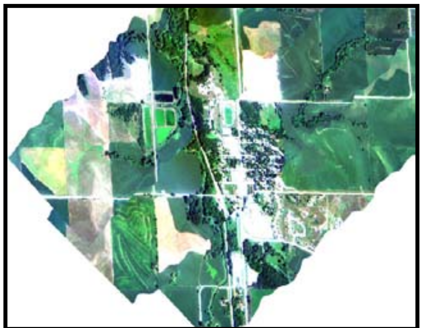

Figure 5
Hyperspectral Imagery of the Winnebago Reservation

of data and imagery. There are numerous potential uses of data and imagery for transportation applications on both reservations.

The Winnebago Reservation is particularly interested in utilizing remote sensing for transportation planning purposes. There are few roads on the Reservation so keeping these roads in good condition is extremely important.

The hyperspectral data collected over the reservation could be utilized for many purposes. A railroad track runs near the town center where most of the major buildings are located. Hyperspectal imagery could identify weed problems along the tracks. These weeds could potentially be a fire hazard if sparks from the train were to ignite them.

Figure 6
Santee Public School is located in lower left corner of this image. Planning evacuation routes around major infrastructure is an important use of remote sensing imagery.

The Santee Sioux Reservation is located near the South Dakota border by the Missouri River. One of the applications of the color infrared imagery is evacuation route planning around critical infrastructure such as schools or city offices. Hyperspectral imagery could be utilized for pavement monitoring. Santee is served by two major roads which make them critical to the transportation network of the reservation. These roads are rural and have a low-volume of traffic. In the winter these roads are low priority for snow removal making them hazardous at times. These roads can be vulnerable to wash-outs by floods and erosion. Precipitation data along with remotely sensed imagery could be used to monitor these critical roadways (Williamson &Watson, n.d.).

The tribal communities of Winnebago and Santee are beginning to realize the potential applications of remote sensing technologies for transportation on the reservations. Both tribes are very receptive to utilizing remote sensing science and technology to improve transportation planning and monitoring. The Nebraska Airborne Remote Sensing Facility continues to serve as an important resource for these communities. New sensors are currently under development including LIDAR. When the sensor becomes operational, these communities are more than willing to serve as test sites for calibration. The data and imagery collected is processed and given to the tribes to use.

Conclusion

As remote sensing science and technology continues to evolve, the use of this data for transportation applications will expand. Remote sensing offers many potential advantages including timely information, cost savings, and improved safety and accuracy. The United States transportation system continues to face many challenging problems. The future will demand that we find innovative ways to deal with our transportation system as our population, demographics, and economy change. Geospatial technologies such as remote sensing and GIS are exciting new tools to transportation decision-makers. As remote sensing becomes more accessible, it will accelerate the implementation of this technology in addressing critical transportation issues (Bowen, Vlasek, & Webb, 2003).

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Appendix 1
Acronyms

AADT	Average Annual Daily Traffic
AISA	Airborne Imaging Spectrometer
ALPS	Airborne Laser Polarimeter System
AMA	American Planning Association
ARS CRT	Airborne Remote Sensing Collaborative Research Team
ASD	Analytical Spectral Devices
ASPRS	American Society for Photogrammetry and Remote Sensing
BTS	Bureau of Transportation Statistics
CALMIT	Center For Advanced Land Management Information Technologies
DOT	Department of Transportation
DOQ	Digital Orthophoto Quadrangle
EM	Electromagnetic
EPSCoR	Experimental Program to Stimulate Competitive Research
FHWA	Federal Highway Administration
GES	Geospatial Extension Specialist
GIS	Geographical Information System
HSI	Hyperspectral Imaging
IRS	Indian Remote Sensing
LIDAR	Light Detection and Ranging
LPTC	Little Priest Tribal College
NASA	National Aeronautics and Space Administration
NCRST	National Consortium for Remote Sensing in Transportation
NEGEP	Nebraska Geospatial Extension Program
NHPN	National Highway Planning Network
NOAA	National Oceanic and Atmospheric Administration
NORPC	New Orleans Regional Planning Commission
NSGC	Nebraska Space Grant Consortium
NTSB	National Transportation Safety Board
PVT	Position, Velocity, and Time
RSPA	Research and Special Program Administration
TMIP	Traffic Model Improvement Program
TRB	Transportation Research Board
USDOT	United States Department of Transportation
USGS	United States Geological Survey
UNL	University of Nebraska at Lincoln
UNO	University of Nebraska at Omaha
UNOAI	University of Nebraska at Omaha Aviation Institute
VMT	Vehicle Miles Traveled

Appendix 2
Web Resources on Remote Sensing and Transportation

AirPhotoUSA
http://www.airphotousa.com

American Planning Association (AMA) Land-Based Classification Standards
http://www.planning.org/lbcs/index.html

American Society for Photogrammetry and Remote Sensing (ASPRS)
http://www.asprs.org

Bureau of Transportation Statistics (BTS)
http://www.bts.gov

Canadian Center for Remote Sensing
http://www.ccrs.nrcan.gc.ca

Cold Weather Aviation and Marine Research Icing and Remote Sensing
http://www.crrel.usace.army.mil/aviation_icing/Icing_and_Remote_Sensing.html

Commercial Remote Sensing Products and Spatial Information Technologies Program in cooperation with NASA
http://scitech.dot.gov/research/remote/index.html

Digital Globe
http://www.digitalglobe.com

Earth Resources Observation Systems (EROS) Data Center
http://edcwww.cr.usgs.gov/

Evaluating LIDAR Accuracy for Highway Engineering Design
http://www.ncgia.ucsb.edu/ncrst/research/lidaraccuracy/first.html

Federal Geographic Data Committee
http://fgdc.orv

Federal Highway Administration (FHWA)
http://www.fhwa.dot.gov

FHWA Resource Locator
http://highwayexpertise.fhwa.dot.gov

Hyperspectral resources
http://www.techexpo.com/WWW/opto-knowledge/IS_resources.html

Indian Remote Sensing Satellites
http://www.isro.org

Keeping our Homelands Safe
http://www.imagingnotes.com/mayjun02/hiatt.htm

Keyhole
http://www.keyhole.com

National Aeronautics and Space Administration (NASA)
http://www.nasa.gov/home/index.html

National Aeronautics and Space Administration Remote Sensing Tutorial
http://rst.gsfc.nasa.gov/starthere.html

NASA John C. Stennis Space Center
http://www.ssc.nasa.gov/

National Consortia on Remote Sensing in Transportation (NCRST)
http://ncrst.org/ncrst.html

National Highway Institute
http://www.nhi.fhwa.dot.gov

National Highway Planning Network (NHPN)
http://www.fhwa.dot.gov/planning/nhpn/index.html

National Oceanic and Atmospheric Administration City Lights
http://spidr.ngdc.noaa.gov/

National Transportation Safety Board
http://www.ntsb.gov/

Office of Planning, Environment, and Real Estate
http://www.fhwa.dot.gov/hep/index.htm

Research and Special Program Administration (RSPA)
http://www.rspa.dot.gov

Sanborn
http://www.sanborn.com

Space Imaging
http://www.spaceimaging.com

SPOT IMAGE

http://www.spotimage.com

TerraServer
http://www.terraserver.com

The Nebraska Geospatial Extension Program
http://geo.unomaha.edu

Transportation Equity Act for the 21st Century
http://www.fhwa.dot.gov

Transportation Research Board (TRB)
http://www.trb.org

Travel Model Improvement Program (TMIP)
http://tmip.fhwa.dot.gov

University of Nebraska at Lincoln's Center For Advanced Land Management
Information Technologies (CALMIT)
http://www.calmit.unl.edu

United States Department of Transportation
http://www.dot.gov

United States Geological Survey (USGS)
http://www.usgs.gov

University Consortium for Geographic Information Science
http://www.ucgis.org/

Appendix 3
Commonly Used Image Data

Landsat - Data Uses: sediment loads, turbidity, sea surface temperature, water quality issues, and thermal bar (salt, sediment, fertilizer, and chemical pollutants in run-off are concentrated in a small band of warm water near the shore)

- Price: Approximately $500 per scene

SPOT - Data Uses: land use/landcover, vulnerable zones under threat from deforestation, erosion and desertification, and plant/crop health

- Price: Approximately $1200-$1900 per scene

IRS (Indian Remote Sensing Satellites) – Data Uses: vegetation and crop discrimination, global observations of climate, ocean and atmosphere, observing oceanographic parameters like winds, sea surface temperature, waves, bathometry and internal waves, and studying the atmospheric constituents, pollution and for monitoring ozone and greenhouse effect

- Price: Approximately $900-$3900 per scene

SPIN-2 – Data Uses: satellite images of the entire U.S. and major urban regions around the world

- Price: $500 per scene starting

DOQ – Data Uses: used to develop and revise vector files of transportation, cadastral, and land use/land cover information and as a base map for wetlands, soil, land parcel, farm-field boundary, forest inventory, and other natural resources mapping, analysis, and planning applications

- Price: base charge of $45.00 per order, plus $5.00 shipping, plus $7.50 for each black and white (grayscale) 3.75 x 3.75 DOQ purchased or $15.00 for each color DOQ

IKONOS - Data Uses: Municipal planning, transportation, environmental, facility management, mining, agriculture, and remote area mapping/forestry

- Price: Approximately $1500-$1800 per scene

QuickBird - Data Uses: assessment and management of land, infrastructure, and natural resources

- Price: Approximately $8160.00 per scene

OrbView – Data Uses: pipeline routing, new construction planning, farming, forestry, and travel planning

- Price: Approximately $249 – $975 per quarter quadrangle

ASTER - Data Uses: Vegetation, sediment, surface temperatures

- Price: FREE to current NASA researchers (must fill out a form to become an authorized user), otherwise $60 per scene

Appendix 4
Free Geospatial Software Programs

dlgv32 Pro
http://mcmcweb.er.usgs.gov/drc/dlgv32pro/index.html

ArcExplorer 2
http://www.esri.com/software/arcexplorer/index.html

ArcExplorer 4
http://www.esri.com/software/arcexplorer/index.html

Mr Sid Geo
http://www.lizardtech.com/download/dl_options.php?page=popular

Freelook
ftp://ftp.rsinc.com/pub/freelook/

Global Mapper
http://www.globalmapper.com/

ViewFinder
http://gis.leica-geosystems.com/erdascentral/freedownloadsPVT.asp

Voloview
http://usa.autodesk.com/adsk/servlet/index?id=3239384&siteID=123112

SPRING
http://www.dpi.inpe.br/spring/english/download.html

MultiSpec
http://dynamo.ecn.purdue.edu/~biehl/MultiSpec/

GRASS
http://grass.itc.it/download.html

TNT
http://www.microimages.com/

OpenEV
http://openev.sourceforge.net/

FreeGIS
http://www.freegis.org/index.en.html

GeoCommunity Software

http://software.geocomm.com/

Guthrie CAD and GIS
http://www.guthcad.com.au/

GIS Software Downloads
http://spatialnews.geocomm.com/newsletter/2000/16/software.html