ABSTRACT

A high-speed rail system is in early planning stages for the U.S. Gulf Coast. The environmentally sensitive Mississippi Gulf Coastal Corridor has been selected for an Environmental Impact Statement (EIS). This offers the opportunity to evaluate whether the use of remote sensing and geospatial technologies for the EIS can streamline the NEPA process. In managing and directing the EIS, the Mississippi Department of Transportation (MDOT) will work closely with the Federal Highway Administration (FHWA) and be supported by the U.S. Department of Transportation (DOT), Research and Special Programs Administration (RSPA) sponsored National Consortium for Remote Sensing in Transportation (NCRST). The NCRST is a university consortia program developed to advance remote sensing and geospatial technologies in transportation application areas including traffic, infrastructure, safety, and environmental assessment.

The environmental assessment consortium (NCRST-E) is lead by Mississippi State University (MSU). Recent research by NCRST-E used satellite imagery to assess environmental and land cover change along the Mississippi Coastal I-10 Corridor. This resulted in an improved understanding of regional change dynamics in the area. Ongoing research activities on land cover and land use change (LCLUC) detection and related environmental analysis will provide new and improved techniques and product implementation guides for using high-resolution image and elevation data in environmental assessment in transportation projects. The ongoing related research, data products, data processing guidance, and the expertise within the NCRST will provide resources and support benefit to relocating rail infrastructure and streamlining the Mississippi Gulf Coastal Corridor EIS process.

This paper presents the NCRST-E support to MDOT and the Mississippi Gulf Coastal Corridor EIS activities including data, information, and activities coordination as well as assistance in the technical oversight and validation of how remotely sensed data will be used in the EIS. The paper highlights the digital geospatial library to be developed by NCRST-E at MSU designed to serve specific data and information products to MDOT and other EIS project participants. These materials will also be made available through the on-line digital geospatial library to the public in an effort to use a remote sensing mapping and information portal to increase levels of public participation in the EIS process with the overall goal of improving the public service and community satisfaction provided by the envisioned transportation system.

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Introduction

The National Consortia on Remote Sensing in Transportation (NCRST) comprises four consortia established by the U.S. Department of Transportation and NASA to lead in the application of remote sensing and geospatial technologies in the transportation industry. The groups are organized around specific areas of focus that include transportation environmental assessment and planning, transportation infrastructure, transportation flows, and transportation hazards and safety.

Full details about the consortia and related research projects can be found through the web at http://www.ncrst.org. This site provides links to the four consortia. Each consortium maintains on-line information about its research and products.

NCRST-E

The environmental assessment consortium (NCRST-E) focuses research on the goal of providing cost effective corridor assessment and planning tools. NCRST-E is a consortium of academic, government, not-for-profit, and commercial partners with common goals of:

- Developing innovative remote sensing technology solutions for use in transportation environmental assessment and planning; in particular, the capabilities of new high spatial resolution, multispectral and hyperspectral instruments;
- Developing the tools necessary to extract environmental information efficiently from remote observations;
- Streamlining and standardizing data processing for information necessary to expedite NEPA environmental assessment requirements; and
- Expanding awareness and understanding of the value of remote sensing technology to transportation environmental professionals.

NCRST-E research applies remote sensing imagery of increased spatial, radiometric, and temporal resolution to the analysis of transportation impacts on natural and human environments. Strategic research areas of the NCRST-E include needs assessment for remote sensing information in transportation environmental assessment; corridor assessment and planning; land cover classification and change detection; wetlands mapping and
Remote sensing allows for the synoptic observation and analyses of urban growth. Satellite images with moderate resolution (10 to 30 meters) have for decades facilitated scientific research activities at landscape and regional scales. Recent availability of satellite- and aerial-based imaging systems data that provide spatial resolutions of 1m or better facilitates analyses that can be applied to urban growth and transportation development for site-specific investigations. Moreover, new hyperspectral sensors provide increased spectral resolution that can be used to further the analyses of environmental conditions and how urban growth and associated transportation development impact these conditions.

In its Strategic Plan for Environmental Research, the Federal Highway Administration (FHWA) has a strategic goal to "Protect and enhance the natural environment and communities affected by highway transportation." The growth of transportation networks generates a host of environmental impacts ranging from deforestation, impacts on local and regional hydrology, and accentuation or enhancement of such land-atmosphere factors as the urban heat island phenomenon. Performance indicators and metrics have been developed for such areas as community satisfaction, EPA ratings of FHWA Environmental Impact Statements (EIS), on-road mobile emissions, percent of non-attainment and maintenance areas meeting mobile source emission budget goals, and ratio of wetland replacements from Federal-aid projects. Matching research and technical outreach to these strategic objectives, and measuring research performance results are tasks fundamental to the mission of the NCRST-E.

One of the early research efforts of NCRST-E studies patterns of land cover and land use change along the Mississippi coast. The study used available population and GIS data, acquired Landsat images from the 1970’s through 2000 and conducted analyses of changes on the landscape. These early studies highlighted the need for improved data and methods to assess complex coastal settings. Recently announced plans to conduct a rail relocation environmental assessment study for the CSX railroad along the Mississippi coast will draw significantly upon the resources, skills, expertise, and knowledgebase that are available through NCSRT researchers.
The Mississippi Coastal Corridor

The three coastal counties in Mississippi have undergone considerable change in land use, population, wildlife habitat, demographics, and socio-economic conditions in the past 30 years. In that time, Interstate 10 (I-10) has been completed, extensive population growth has occurred, and the coastal communities have changed from being mostly small fishing and shrimping communities to communities with a complex mixture of residential, commercial, industrial, urban, resort, and relatively unspoiled coastal wilderness areas. The population has gone from around 240,000 in 1970 to over 350,000 in 2000.

Figure 2. Mississippi coastal corridor.

NCRST-E studies of the Mississippi coastal corridor have highlighted significant changes and development that have occurred in the past 30 years that include significant population growth, the building of I-10, and the rapid growth of the tourism industry in the region. NCRST-E has conducted studies using GIS data, historical satellite imagery, and existing aerial image data to assess changes in the area. Initial exploratory comparative analysis of existing land cover classification data for the area compiled at various times over the past 30 years provided results that were not adequate for the identification of development trends or for spatially characterizing land cover and land use change. However, image and change detection analyses performed on satellite images scenes acquired for the area for the past 30 years provided valuable insight as to development patterns and trends while also indicating areas where future growth patterns may potentially stress sensitive wildlife habitat areas. These studies have illustrated the need to update information resources so that improved information will be available to those who must make decisions about future growth and development for the region.
Independent of NCRST-E project efforts, significant interest has been focused on the proposed relocation of the CSX railroad from its current location. The CSX railroad currently runs through the center of high growth areas along the shore and the proposed move would provide a high-speed rail running east-west along a more inland route, potentially farther north than the I-10 corridor. A recent congressionally funded project has been announced to conduct the environmental assessment for the CSX relocation project with the requirement that the assessment make broad use of remote sensing and geospatial technologies. The effort is strongly supported by the US DOT and NASA and is intended to help bring these technologies into mainstream practice.

Figure 3. Elevation enhanced Landsat 7 imagery of the Mississippi coast.

NCRST-E will support the environmental assessment of the CSX railroad relocation and I-10 corridor study by providing technical assistance in the selection and use of appropriate remote sensing and geospatial technologies to the team selected by the Mississippi Department of Transportation and the Federal Highway Administration to conduct the study. NCRST-E will also provide a compilation of existing remote sensing and geospatial data and information resources for the study through an on-line web-mapping portal that will include new data collected for the area and data collected during the assessment process.
The focus of the consortium’s activities in future years will include increased participation in transportation corridor assessment and planning with particular emphasis on the application of geospatial technologies that impact these processes. To that end, the consortium is currently conducting technical outreach activities with transportation agencies on specific projects. A significant technical outreach activity is currently underway in which NCRST-E will support the Mississippi Department of Transportation (MDOT) and the Federal Highway Administration (FHWA) in the Mississippi Coastal Corridor EIS activities with an emphasis on appropriate remote sensing and geospatial data collection and acquisition, data and information distribution, and activities coordination as well as assisting as needed in the technical oversight and validation of how remotely sensed data will be used in the EIS.

The major tasks of NCRST-E in this technical outreach activity fall into the following groups:

- Compilation and Organization of Existing Data
- Acquisition of New Remote Sensing Data
- Environmental Assessment and Information Products
- Information Technology for Data Management, Custom Data Production, and Distribution

This paper presents the planned information technology architecture to be used for the data management and coordination tasks to be conducted in support of the EIS.

Information Technology for Data Management and Coordination

One of the most difficult challenges in transportation and regional planning is data and information management. Providing needed geospatial data to decision makers, planners, engineers, and analysts is a difficult task that is further complicated by the use of large geospatial image data sets that are needed for maps and analysis products. These data sets usually comprise large data files that are difficult to transfer, require significant storage resources, and are time-consuming and complicated to process. The development of computational solutions for the storage, management, custom product creation, and distribution of image data and other geospatial data sets is of vital interest to transportation agencies.

The report highlights a computational geospatial data library (geolibrary) that is being developed at Mississippi State University. One of the first goals for the geolibrary will be serving specific data and information products to MDOT and other EIS project participants for the Mississippi coastal corridor effort. Information and materials will also be made available through the on-line geolibrary to the public in an effort to use a remote sensing mapping and information portal to increase levels of public participation and satisfaction with the EIS process in the overall goal of improving the public service and community satisfaction provided by the transportation system.
Traditional image processing and geospatial data workflows typically involve highly skilled analysts who prepare data for use by engineers, planners, and other data users who in turn use the data to create custom maps, perform analyses, and tabulate data. Image analysts usually have expensive graphics workstations, complex software, and access to extensive data storage. Much of the work of these analysts is conducted using complicated image processing and GIS software. One of the most time-consuming set of tasks involves the preparation of image and base map materials that are useful for custom maps and analysis. Tasks such as image registration, ortho-rectification, coordinate transformation, creating mosaics, creating digital terrain models, and fusing data to produce custom products can be extremely time consuming and labor intensive. Mississippi State University will develop resources to perform many of the “heavy-lifting” tasks of geospatial data management, image processing, custom product development, and product distribution that are an increasingly significant part of transportation planning, environmental assessment, and transportation design.

**Figure 4.** Traditional and computational image processing workflows.
Mississippi State University has entered into a strategic partnership with ImageLinks to develop and enhance geospatial data library technologies. In a recent press release it was announced that "The Computational Geospatial Technologies Center (CGTC) at Mississippi State University (MSU) has entered into a strategic partnership with ImageLinks of Melbourne, Fla. As part of this agreement, CGTC has purchased ImageLinks RasterWare Appliances technology to serve as the spatial data processing engine in MSU’s Geospatial Library."

"The Geospatial Library will provide researchers and federal organizations access to remote sensing data, maps, and spatial information required to assess the human and natural environment and to plan transportation and infrastructure development projects," said Dr. Chuck O’Hara, Associate Research Professor at MSU. "In addition, users may feed new geospatial data back into the library during projects for access by the public and other organizations..........

Integration of the ImageLinks RasterWare technology with ERC’s massive computer capabilities will create one of the most powerful spatial data processing systems in the academic and commercial sectors. The digital library will be part of an ERC 1,024-node Beowulf Cluster with 14 servers dedicated to Geospatial Library functions and the ability to allocate more processing power to the library as needed or desired.

O’Hara said, "Participation in the ERC research cluster provides the ability to research the scalability of geospatial data processing, to evaluate where parallel processing algorithm improvements are needed, and to provide the needed computational horsepower to process massive, high-resolution geospatial data sets for large geographic areas."


The geolibrary will provide access to an extensible set of data. A master data list and data documentation is being developed for the initial data to be included and this data will be added to over time as the project develops and matures. Complete documentation of the geolibrary application for the Mississippi coastal corridor can be found on-line at the NCRST-E web site under the data heading.

http://www.ncrste.msstate.edu

Geolibrary Activities

The geolibrary will be developed in a multi-tier architecture with a back end, middleware, and a front end for client applications. Each part of the architecture may eventually be geographically distributed among different sites. However, the initial development will focus on development at Mississippi State University with the primary facilities at the Engineering research center as well as at the University Libraries, MSU Extension Service, and the Remote Sensing Technologies Center. Extensibility of the geolibrary to other sites not at the MSU campus will be explored and developed over time as funding permits, partnering relationships are established, common standards and methods are agreed upon, and infrastructure put in place.
Figure 5. Basic architecture of the computation geospatial data library.
The back end will comprise server hardware, data storage, databases, and data processing engines. The middleware will provide computational services that will include security for all connection types, data exploration services, internet mapping and analysis services, and data distribution services. The front end will be provided through web browsers and client applications that either connect locally or via internet methods. MSU will develop research activities for components within all parts of the geolibrary architecture and a research plan document is available at the geolibrary web site.

http://www.erc.msstate.edu/geotech/geolib

Central to the goal of fostering the use of geospatial and remote sensing data in transportation planning and assessment is the need to provide improved methods for managing, processing, and distributing custom geospatial data product that provide appropriate scale, resolution, and accuracy. The MSU geolibrary effort will facilitate these needs and it is expected that the initial efforts to provide services for the Mississippi coastal corridor project will be built upon and the geolibrary will be used to provide needed data for other “hot spots” where projects requirement include similar data needs.

Remote Sensing Data Collection and Analysis Activities

NCRST-E will play a role in helping to compile existing and collect new data that are appropriate for use in the EIS and regional assessment processes. Much of the data to be compiled will be vector data that describe such things as population, natural resources, environmental conditions and features, political boundaries, human-made and natural linear features, point locations, and facilities. Many vector data sets will be included in the geolibrary, but the primary research focus of the computational geolibrary will be on remote sensing and raster data products. The complete list of vector and raster data sets to be made available will be fully described in the master data list for the project on the geolibrary web site.

While vector data can be complex and highly detailed, significant research challenges must be addressed in managing, processing, and distributing high-resolution raster geospatial data to facilitate the effective and efficient use of these data in transportation planning and assessment processes. It is expected that the remote sensing and raster data that will be used in geolibrary will include, but not be limited to:

- Historic satellite image data
- Historic land cover and land use data
- Digital elevation data from available data sets
- Digital raster graphics of USGS topographic quadrangle maps
- Digital orthophoto quarter quads (DOQQs) from the USGS
- New high-resolution aerial image data
- New high-resolution multispectral satellite image data
- New high-resolution aerial hyperspectral image data
- New high-resolution digital elevation data
The raster data will provide information at different spatial and spectral resolutions and scales and will facilitate analyses of many complex issues. These data will be used in parts of the environmental impact assessment process and to provide basemap materials or analysis layers in some or most of the following assessments:

- Effects on Land Use Patterns
- Effects on the Social Environment
- Effects on Transportation
- Effects on Public Safety
- Effects on Noise Levels
- Effects on Air Quality
- Effects on Water Resources
- Effects on Wetlands, Wildlife and Farmlands
- Effects on Coastal Zone Resources
- Effects on Public Lands
- Effects on Archaeological or Historic Sites
- Notification of and Comments from Public Agencies and Public Interest Groups

It is expected that the contract for the EIS will be awarded in the summer or early fall of 2002. NCRST will be prepared to work closely with the EIS team and the public agencies involved. NCRST’s support in acquiring needed data, providing expertise in geospatial data processing and analysis, and providing management and coordination of geospatial data resources for the effort will help assure the successful use of geospatial and remote sensing data and technologies in the transportation planning and assessment effort. How these data may be used in different aspects of the environmental impact assessment process will be documented as a result of the project. The resulting reports and findings of the Mississippi coastal corridor EIS will provide a wealth of information about how geospatial and remote sensing data can help streamline environmental assessment processes and help to improve the services that are delivered to the general public.
Summary and Conclusions

Many agencies have a significant interest in the availability and use of geospatial and remote sensing data. The acquisition, management, image processing, custom product creation, and distribution of data are challenging tasks. Developing computational solutions that meet the needs of government to develop and deliver improved services is a benefit to all. Furthermore, developing supportive geospatial data libraries for multi-agency interests and activities allows for the pooling of resources, reduction in duplication of effort, accomplishment of tasks for which there are common priorities, and other synergies that may be better defined over time.

The effective collection and use of remotely sensed geospatial data may provide significantly improved efficiencies in planning and assessing transportation infrastructure projects. To fully support these potential improvements, computational geolibraries are needed to efficiently manage, process, customize, and deliver geospatial and remote sensing data to planners, managers, analysts, engineers, and other stakeholders. The geolibrary at Mississippi State University will provide a research platform for investigating the benefits of delivering geospatial and remote sensing technologies to transportation planning and assessment processes in the most highly efficient and effective manner possible using computational and advanced information technologies.
Figure 1. National Consortia on Remote Sensing in Transportation.
Figure 2. Mississippi coastal corridor.
Figure 3. Elevation enhanced Landsat 7 imagery of the Mississippi coast.
Figure 4. Traditional and computational image processing workflows.
Figure 5. Basic architecture of the computation geospatial data library.