Streamlining Transportation Corridor Planning Processes and Validating the Application of CRS&SI Technologies for Environmental Impact Statements
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The National Consortium for Remote Sensing in Transportation-Streamlining Environmental and Planning Processes (NCRST-SEPP) conducted research in transportation corridor planning and related Environmental Impact Statement (EIS) processes aimed at validating new and innovative uses of Commercial Remote Sensing & Spatial Information (CRS&SI) technologies for delivering streamlining benefits to on-the-ground transportation projects. Validation was accomplished by comparing results of new methods to results that were achieved and documented in a recently completed EIS for the I-69 and I-269, SIU 9 Project, which was jointly conducted by the Tennessee and Mississippi Departments of Transportation.

Research directions focused on transportation project tasks and activities for delivering outcomes of national significance as ensured by the participation and guidance of a Federal Highway Administration (FHWA) and Research and Innovative Technology Administration (RITA) organized Advisory Panel comprised of local and national representatives with competencies that include both technical and policy aspects of transportation project development processes.

For each stage of the EIS process, research tasks were developed to identify and compare traditional approaches with innovative methodologies that utilized CRS&SI technologies. Based on past research and development activities, technological tools were adapted to enhance and streamline the environmental review process. This research brief fulfills the NCRST-SEPP study’s intent to disseminate the fundamental information to transportation specialists, engineers, state and local transportation personnel, trade and economic development professionals, academics, community planners and citizens.

**INTRODUCTION**

Transportation corridor-planning processes are well understood and a high degree of consensus exists among practitioners about the stages and tasks that should be included as best practices. However, the current practice of conducting these planning processes does not typically employ full use of CRS&SI technologies in early stages to streamline and improve planning processes. This research project developed, integrated, piloted, and deployed demonstrations of CRS&SI technologies to understand, document, and refine the specifications for how these technologies may be made a part of standard operating procedures for transportation corridor planning.

**PROBLEM STATEMENT**
In June 1999, Transportation Equity Act for the 21st Century (TEA 21) officially authorized and prioritized I-69 as a national highway project. It is designed by Congress to connect major cities and enhance economic development and is a significant transportation project that potentially will alter the trade flow within North America. The study corridor begins at the interchange of Interstate 55 (I-55) and Mississippi 304 (MS 304) in Hernando, Mississippi and extends north through Memphis, Tennessee to the intersection of US Highway 51 (US 51) and State Route 385 (SR 385) in Millington, Tennessee. The I-69 SIU 9 and I-269 Corridor EIS provided an ideal testbed for the study area because it is in both urban and rural settings with terrain and environmental challenges, and it crosses state boundaries. The research project is located in DeSoto and Marshall Counties in northwest Mississippi and Shelby and Fayette Counties in southwest Tennessee. By utilizing a “pre/post” study design, rigorous comparisons of traditional methodologies were juxtaposed with new and innovative methodologies that utilized CRS&SI technologies.

The I-69 SIU 9 and I-269 Corridor EIS provided an ideal testbed for the two-year study. The research team was able to quantify the benefits of: multi-source remote sensing data and analysis for rapid evaluation of alignment options; screening of non-viable alternatives; identification of environmentally sensitive areas and impacts; advanced transportation modeling of normal and emergency operations; and new GPS technologies to enhance field data collection.
Employing the Multiple Criteria Decision Making (MCDM) framework provides an analytical tool that addresses problems associated with the use of current Geographic Information Systems (GIS) technologies for agency coordination and public participation. The proposed MCDM framework utilizes rankings as inputs (instead of pair-wise comparisons) for factor and attributes according to the different hierarchical levels. The framework is designed to simplify the decision-making processes and present a key solution and visual support. The core solution is flexible and capable for use in different scales. GIS are capable of handling massive amounts of data. When coupled with physical or economic models, GIS may be employed to transform and manipulate spatial and attribute data as needed to express values for evaluation criteria. Conceptually, MCDM can be implemented based on different approaches. Advances in informatics and spatial information provide a wide range of core-solutions. This research project coupled MCDM with the Analytical Hierarchy Process (AHP)—an innovative method to integrate decision-making processes and geospatial analysis—resulting in the development of a product called the Environmental Corridor Optimization and Planning ALignments (ECO-PAL) toolkit.
FHWA indicates that linking Planning and NEPA is an integral part of Planning and Environment Linkages (PEL). The term PEL is used when agencies include environmental considerations in transportation planning and carry activities or decisions into the NEPA process. Strategies to embrace, extend, strengthen, and deploy data, methods and technologies supporting PEL were a focus area of opportunities identified for the project to consider in refining directions for the CRS&SI technologies. The remainder of this brief highlights the results from the research project.

Our streamlined EIS process is based on early data collection and the integration of existing plans with high quality data. With the early integration of plans, it is possible to begin the process with a sound understanding and reflection of long-range transportation plans, comprehensive plans, economic development plans and other plans that are in place to help guide development for the area. Transportation improvement projects as well as new corridor developments provide development energies and pressures that must be accounted for outside of the corridor right-of-way. Not only is land use affected, but all infrastructures of the area experience increased pressures. The pressures and development frameworks are considered and planned for in the local and regional comprehensive, transportation, and economic development plans and currently, these plans are not being utilized to help frame and guide transportation projects. Context Sensitive Solutions (CSS), spatial technologies, and the smart growth matrix all provide a mechanism for this integration.

Data and existing plans proved valuable when processed and put in similar projections and formats at the beginning of the process in order to set the baseline for all other data integration and analysis. One of the key aspects of this is that not only are existing plans and good data helping to drive the process, but the outcomes of the process will be in a data format that is compatible and transferable. Therefore the results are helping MPO’s, planning departments, etc. understand the impacts of this corridor so that they can plan accordingly.
From a national perspective, the purpose of the I-69/I-269 corridor is to improve international and interstate trade in accordance with national and state goals and to facilitate economic development in accordance with state, regional and local policies. Regionally, the corridor increases market accessibility, enhances mobility, and improves highway infrastructure and connectivity. Locally, the proposed development of the corridor caused citizens to express concerns regarding increased air and noise pollution, impacts to neighborhoods and schools, wetlands, and archaeological sites and historical resources, safety, loss of property, amplified urban sprawl, lower property values, the transportation of hazardous materials, and the creation of a drug traffic corridor. These different levels and units of analysis result in roadway planning becoming an often-contentious process. Delays to projects are frequently due to opposition, conflicting interests, and differing opinions from stakeholders, resource agencies, planning organizations, and others.

CSS are only obtainable and implementable with a good understanding and analysis of the corridor context. This is true for both urban and natural environments. Even with the increased capabilities and use of geospatial technologies and data, considerable gaps still exist in data dealing with community features.
Traffic investigation focuses on the determination of anticipated traffic flow characteristics of the proposed project through the application of analytical methods that can be grouped under the umbrella of capacity analysis methodologies. In general, the main traffic parameter used in EISs to describe the quality of traffic flow is the Level of Service (LOS). With the assistance of CRS&SI technologies, the results of these analyses can be expanded to all the roadways in the affected area and not be restricted to just the road segments directly affected. Hence, CRS&SI technologies can help deliver a much better understanding of the impacts of the different alternatives not only in terms of the quality and relevance of the information but also in terms of coverage. Additional information (e.g., freight volumes) not generally included in the EIS can be explicitly conveyed to facilitate a better decision-making process.

For example, this Purpose and Need Map shows the juxtaposition of the generalized “corridor definition area” as an output from the multi-scale MCDM, colored truck freight flow volumes, and road classifications with an overlay of the design of I-269 symbolized by mobility LOS. The modeling and GIS integration would benefit the FHWA by incorporating the I-69 system into the national freight modeling systems to determine how much new freight would be attracted by this system. Of local importance, this integration of modeling and GIS can deliver policy as well as operational insight that can be applied to the use of the system. In practice, these technologies can enable planning for operations and decisions about use so that freight flowing through the system may be routed away from segments of greatest congestion and north-south or other through freight traffic may be routed along I-269 or via other segments with ideal traffic and level of service conditions.

There are, however, some associated costs. The main one is the institutional barrier. In many cases, the travel demand models used in the analyses are stand-alone models that have been reliably performing their task over many years. Therefore, there is an understandable reluctance to change these models/software utilities. However, as described above, there are many two-way interfaces with GIS platforms that have been developed for the most used travel demand models, which can help in this regard by making these connections transparent to the transportation analyst. The other option, switching to the new models that have integrated GIS capabilities, has a material cost associated with the software itself, and in some cases with the training of the technical personnel that run these models. The latter could be important, especially if the transition is to a different model that is currently been used; but these software utilities also bring many new capabilities that can be used in many other projects besides EISs.
MCDM’s methods for collaborative involvement, scenario evaluation, and comparative analysis can deliver decision makers and stakeholders valuable insight into the relative strengths and weaknesses of different solutions and the degree to which solutions achieve intended purposes and conform to prioritized goals. As spatial technologies have evolved and expanded, two areas that are receiving greater attention are the availability of social, economic, and environmental (SEE) data much earlier in the planning process and the development of visualization techniques which enhance both the public’s and the agencies’ review of project alignments and designs. This early introduction of pertinent SEE data into the planning process has allowed the linking of planning and NEPA to be an effective initiative for the development and prioritization of transportation infrastructure. Visualization is a natural and effective tool in not only the development of better transportation solutions, but in their acceptance by the public and reviewing agencies.

Our research highlights new forms of map documents that are available that not only show proposed highway projects, potential alignments, and aspects of projects, but also provide the ability to turn on and off specific map layers for easily viewing aspects of interest as well as the ability to add comments and mark up the map. These capabilities are available in GeoPDF files, and the participatory process can benefit greatly by the use of new and enabling technologies such as this. GeoPDF technology provides the capability to interact with GeoData used in the project mapping process. This open, accessible, and enabling technology presents a potentially enormous step forward for the public participation process in transportation project development processes. By utilizing the GeoPDF technologies, transportation planners can efficiently and effectively communicate project impacts through visualization, which can connect the community and transportation project planning, resulting in two way communication and information flow.
Using MCDM, coupled with National Hydrography Dataset (NHD), National Agricultural Imagery Program (NAIP), National Wetlands Inventory (NWI), and National Land Cover Dataset (NLCD), environmental and biophysical decision factors are represented as a thematic geospatial layer with attributes that express criteria being considered. This effort created a data subset that was used to compare features associated with corridor placement in the case EIS.

The basic need for continuous data across the study area means that decisions must be made about use of best available data. In the case of absent NWI data for the study area, an inspection of the areas classified as wetlands in the USGS NLCD showed close agreement with the NWI data for the majority of the study area. Since the NLCD is a nationwide dataset produced using consistent methods for the entire US, the availability of this data should not be a problem. For the purposes of environmental screening and for estimating wetland impacts across the study area, wetlands from NWI were used where available and wetlands from the NLCD were added for areas where NWI data were absent. The research uses GIS raster environment to accommodate the MCDM layers of information. This method enables transportation professionals a way to compute transportation corridors and alignments in a semiautomatic way to serve as EIS baselines.
According to transportation legislation, transportation projects should “support the economic vitality of the metropolitan area, especially by enabling global competitiveness, productivity, and efficiency” (USDOT, 2008, p. 3). As the nation continues to engage the global marketplace, transportation officials must also account for how the transportation system will influence the economic development and growth of a region. Understanding the direct, indirect, and induced economic impacts of a transportation system is an important component of completing the NEPA process. Traditionally, a Benefits-Cost Analysis (BCA) only measures the direct impacts regarding economic impacts. The BCA does not track the second and third order effects of highway improvement projects.

Employing the Regional Economic Modeling, Inc. (REMI) application provides analysts with a technological tool that enhances the economic impact analysis process and streamlines the data collection efforts. The REMI model is capable of integrating travel demand data with economic and demographic data to simulate project impacts. Moreover, with the utilization of REMI, economic impact output can be extrapolated to “known” growth patterns and mapped in visualization tools such as GIS.

To help bridge the gap, this project sought methods of community feature and land use recognition using standard GIS software. Furthermore, this project sought ways to incorporate proven smart-growth elements so that the community features and land use could be evaluated using the following eight smart-growth principles:

1. Provide a variety of transportation choices
2. Direct development toward existing communities
3. Mix land uses
4. Take advantage of compact building design
5. Preserve open space, farmland, natural beauty, and critical environmental areas
6. Create a range of housing opportunities
7. Create walkable neighborhoods
8. Create distinctive, attractive communities with a strong sense of place.

Providing this data in a visual format and integrating this data in MCDM allows project stakeholders to adjust the build and no-build scenarios to account for changes in growth patterns. This in turns allows local and regional planners, working through the MPO, to adjust long-term development plans accordingly.
The useful application of spatial information technologies for archaeological and cultural features is practiced at varying levels by different DOTs. Few high resolution GIS-based archaeological predictive models have been created for very large areas. Mn/Model, the statewide archaeological predictive model developed by the Minnesota (USA) Department of Transportation, is perhaps the first of its kind. Twenty regional models were developed using multiple stepwise logistic regression to create a composite statewide model. Models of archaeological survey bias were developed to help compensate for the lack of probabilistic data. Overall, the predictive model has met project goals and performs well for its intended purpose. By incorporating models into the earliest stages of transportation planning, the Department has been able to avoid potential impacts on archaeological resources and make cultural resource reviews more efficient.

In addition, NEPAssist provides a powerful web-based tool for enhanced environmental screening that provides detailed feedback about environmental concerns. Trends in technology to expose spatial information to web-based mapping and query tools are being extended to support tasks such as environmental screening. With the NEPAssist tool, users can define areas of interest by utilizing a polygon tool to outline an area of interest and query databases for information regarding transportation project development. NEPAssist raises important environmental issues at the early stages of project development, enhances collaboration with other agencies for review of NEPA documents, provides easy access to region specific GeoData, customizes regional assessments, and streamlines the review process.

As you can see above, probabilistic modeling and resource identification were incorporated into GIS and provide a basis for MCDM integration. When evaluating a number of transportation alternatives over a very large area, extensive surveys would be both costly and time consuming. An archaeological predictive model can help focus attention on alternatives that minimize the risk of encountering significant cultural resources. Such models also allow designers to make relatively minor modifications in alignments to avoid high risk areas. When the number of transportation choices has been reduced, models can be used to target survey areas efficiently. By eliminating surface surveys from areas where archaeological sites are not likely to be found, more resources are available to evaluate any sites found in the targeted, higher risk areas surveyed. Finally, accurate mapping of cultural features enables better assessment of impact and development of measures to mitigate and minimize those impacts. However, expansive development of geospatial databases for cultural resources will require cooperation with State Historic Preservation Offices, local Historic Preservation Commissions, National Forests and National Parks, and other agencies that may maintain files of archaeological sites or historic properties. More exploration into the capabilities of this predictive modeling integration, appropriate buffer distances per site and protection scenarios of identified resources is necessary.
This research developed and tested a flexible method that delivered diverse alternatives according to different input factors and attributes in its decision-making process called the Environmental Corridor Optimization and Planning ALignments (ECO-PAL) toolkit. The corridors produced from ECO-PAL present close similarity with the EIS approved corridor of I-269; however, the accuracy in terms of horizontal deviation remained unknown. This study was developed to attest the hypothesis of close similarity between the design of the transportation corridors computed from ECO-PAL and transportation corridors projected using traditional approaches.

Three different corridors were generated from ECO-PAL and compared to the design of the final I-269. We considered the similarity between the length of the alignments and the length of I-269 as the initial criterion. The three corridors passed to the 2-sigma criterion. In fact, the ECO-PAL corridors present length around 0.5% longer than the I-269, which we assumed excellent. On the next step in the evaluation process, a series of Euclidian Distances was considered to quantify horizontal deviations of the corridor regarding the alignment of I-269. Standard intervals were used to provide basis to quantify the matching. In the best case scenario, the right-of-way corridor matches in approximately 92% with the right-of-way corridor of the I-269, which is a very good mark. The analyses were conducted based on the raw ECO-PAL outputs, without considering the smoothing of transportation design character. Based on these results, the initial hypothesis is accepted.

In addition, the best ECO-PAL alignment was smoothed and a series of metrics of linear comparative analysis were computed to quantify possible enhancements along the 300-foot construction corridor. The metrics showed significant improvements after applying the highway design characteristics.

This research brief highlights the various technologies that were utilized by NCRST-SEPP to identify and validate the streamlining techniques. These technologies coupled with the MCDM approach provide researchers and transportation officials with an assortment of options for integrating technologies into the NEPA process. As shown in this project, these technologies capture and highlight pertinent information at early stages in the NEPA process. In addition, the utilization of these tools streamline the NEPA process, compared to traditional methodologies. As FHWA continues to seek initiatives and programs to streamline the NEPA process, the findings in the project establish a founda-
tional compilation of technologies and methodologies that can support planning and environmental linkages as well as “best practices” to achieve the goal of streamlining the environmental review process.

However, there is a general need for improved availability of standard federal GeoData for all areas and improved map quality of data products. In addition to availability of nationwide datasets, there is a significant need for improved standardization of local and MPO data provided through education, standards-based directions, and structured outreach for developing useful cross-purpose datasets that are consistent and adequately documented. Finally, there is a need for basic tools that can conduct screening and reporting of results for easily used analysis and reporting.

Traditional approaches to black and white image photography and scanned data products are giving way to digital image products. Digital high-quality ortho-rectified images can be delivered quickly after acquisition providing data useful to all project personnel across divisions and departments, yielding improved planning, design, environmental analysis and public meetings.

**KEY BENEFITS**

- Remote sensing data collected early in a project provides resources useful through the project life cycle – A “Collect Once and Use Many” approach can be applied.
- This is very near-term “prime-time” technology showing promise in many areas.
- Has been successfully demonstrated in multiple states.
- Promises meaningful streamlining to various NEPA processes.
- Helps preserve the intent of NEPA to consider all alternatives.

**BARRIERS TO ADOPTION**

- Pilot applications must be taken to production mode to deliver validated products.
- Applications must be defined in terms of vital data inputs, alternative sources of data for analyses and documented processing methods to enable transferability of applications.
- Applications must be implemented in various regions to deliver understanding of how different geographic settings impact implementation and require adaptations.
- Requires contracting, procurement, and implementation language that DOT practitioners can readily use to ensure that technologies are appropriately contracted, applied, and delivered as needed in actual project development practices. Science must be reduced to practice.
Given the need for continuous and improved data collection, exploration of the use of Unmanned Air Vehicles (UAV) and Unmanned Air Systems (UAS) for transportation planning, PEL and NEPA process streamlining should be considered. Data consistency, availability, completeness, level of organization, standards-based quality, methods of easy exchange, web-based publishing, maintenance, and stable funding for developing and supporting data use are all high-level needs. Standard and traditional methods of data holdings and use must give way to newer technologies that can extend and transform the usefulness and overall benefits of GeoData.

Future research should focus on additional elements of the environmental review process. For example, analysts should examine technological tools that can predict, highlight and provide visualizations of endangered species as well as hazardous waste. These data, uncovered at earlier stages in the NEPA process, can reduce process time and unforeseen costs, which is key to achieving environmental streamlining.

In addition, future researchers should partner with SDOTS and FHWA to shadow the environmental review efforts. This research endeavor will highlight “best practices” and enable researchers to utilize the innovative technological and methodological approaches highlighted in this document in real time.

Finally, although this research shows each element of the NEPA process analyzed individually, future research should focus on analyzing elements of NEPA process collectively. With CRS&SI technologies, the ability to develop multiple layered visualizations will enhance the understanding of a project area’s context. Further CRS&SI technologies, predictive modeling techniques (including history, archaeology and protected/endangered species) and integration of economic analysis could provide the basis for incorporating NEPA with Context Sensitive Solution (CSS) principles. Collectively, these actions could result in substantially improved PEL and project streamlining.
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