Project Title: Comprehensive GIS-Based Rural Regional Transportation Planning Models.

University: North Dakota State University

Principal Investigators:
Alan Dybing, Ph.D.
Research Analyst, Upper Great Plain Transportation Institute
alan.dybing@ndsu.edu
NDSU Dept 2880
P.O. Box 6050
Fargo, ND 58108-6050
701-231-5988

Pan Lu, Ph.D.
Research Analyst, Upper Great Plain Transportation Institute
pan.lu@ndsu.edu
NDSU Dept 2880
P.O. Box 6050
Fargo, ND 58108-6050
701-231-5185

Denver Tolliver, Ph.D.
Associate Director of Upper Great Plain Transportation Institute
Director of Mountain-Plains Consortium
Director of T&L Graduate Program
denver.tolliver@ndsu.edu
NDSU Dept 2880
P.O. Box 6050
Fargo, ND 58108-6050
701-231-7190

Research Needs
The provision of a cost-effective high-performance transportation infrastructure and efficient freight transportation network to support continued energy development is essential to economic performance and energy independence. However, proactive asset management and optimal life-cycle costs can only be achieved if the locations of energy production and impacted routes can be forecast 15 to 20 years into the future based on drilling phases and time-varying production intensities. Well output is variable, building to a peak during the first five years and flattening afterward. Inputs to the oil industry (especially sand and fresh water used in shale fracturing) and undesirable outputs (such as saltwater) must also be modeled, including the locations and potential quantities of water and sand suppliers and saltwater disposals sites. The sustainability

of water supplies and access to future water resources is a key issue that may constrain future production. While time series traffic counts are useful, they lag production growth curves during the early phases of energy production. Moreover, in the case of oil production, truck counts collected during the early phases tend to over-predict future traffic on certain routes, potentially resulting in inefficient investments.

For these reasons, a comprehensive Geographic Information System (GIS) is necessary to accurately forecast future production levels and predict the routes trucks will take to and from wells. Such a model must include origins and destinations for both inbound and outbound movements. Inbound movements include origins for freshwater at aquifer or river locations, sand from rail trans-load facilities, pipe and supplier from cities and rail trans-load sites, and rig specific movements from well site to well site. Outbound movements include time-phased movements from producing wells to rail and pipeline trans-load facilities. Moreover, as oil development densities increase in certain areas, above ground small diameter pipelines are constructed to minimize the transportation cost of crude oil to major pipeline collection points and saltwater to disposal wells. For these reasons, the model must be fully multimodal with detailed levels of resolution. Because of recent advances in GIS and spatial modeling, rural regional transportation models can be developed that are much more disaggregate and specific in nature than existing models based on aggregate transportation analysis zones. An outcome of this project will be a GIS-based rural regional transportation planning model modeling energy production locations and intensities at fine geographic levels (i.e., individual land sections and clusters of wells) so that truck, rail and collector pipeline flows and routes can be predicted with unprecedented levels of accuracy on a broad geographic scope.

Moreover, the specialized trucks used in the oil industry today are vastly different from the traditional ones used to transport grain and other commodities produced in rural regions. Oilfield pavements were initially designed without knowing the results of the oil boom with sudden increases of oil daily production in North Dakota from 150,000 BOPD (barrels of oil per day) in 2009 to almost 500,000 BOPD at 2010. The state's oil boom is bringing unanticipated traffic growth related to increased oil production and population growth. Some parts of the region's population base increased by an estimated 13% from 2009 to 2010 (Ryan-Holeywell, 2011), causing growth-related issues in the region, including shortages of housing and infrastructure needs. Rapid increases in the number of workers and construction activities are exacerbating traffic increases in the region due to building activities and Recreational Vehicle movements.

When too much traffic is transmitted through a road network, congestion occurs. Traffic related to oil work has resulted in congestion-related problems in many areas. With slow-moving trucks traveling narrow, two-lane roads, commuters may be forced to slow down when following trucks (i.e., the time percent following heavy vehicles increases and queues start to build). Moreover, commuters may be delayed as roads undergo frequent maintenance and are reduced to single lanes. For these reasons, the GIS-based rural regional transportation planning models should fully consider the impacts of increased oil traffic's on rural road congestion and maintenance. The outcome of the objective will be a traffic congestion impact model over time that reflects specific production locations.

Research Objectives:
With these new GIS-based rural regional transportation planning models, research should address two main objectives: 1) forecast future production levels and predict the routes trucks will take to and from wells, and 2) forecast the impacts of future oil production on rural highway congestion conditions or service levels. Road maintenance and resurfacing costs are being analyzed in complementary MPC studies.

Research Methods: The following major tasks have been included in the scope of this study:

Task1: Literature Review: A national and state literature review pertaining to traffic impacts on rural highway congestion and methods of forecasting well locations and linked movements.
Task2: Data Collection: the primary inputs required to run the GIS-based rural regional transportation planning models will be collected or developed including
- Routable highway network shape-files and speed limits associated with roads
- Existing well locations, time-varying production intensities, and potential quantities of oil
- Oil truck configurations and associated recommended driving speeds
- Locations and potential quantities of water and sand suppliers and saltwater disposals sites
- Freshwater or river locations, routes for sand movements from rail facilities, pipe and suppliers from cities and rail sites, and rig specific movement
- Producing wells, trans-load rail locations and trans-load pipeline facilities

Step3: Analysis and Evaluation: In this task, a forecasting tool will be developed to estimate production locations, production intensities and production life spans.
Step4: GIS-based routing and location models shall be developed that provide estimates of inbound and outbound movements.
Setp5: Preliminary Evaluation of Affected Rural Highway Service Level Impacts: Under this task, the envisioned outcome will be the affected oilfield highway congestion impacts over time based on the estimated inbound and outbound oil related movements.
Step5: Final Report: A final report will summarize all tasks and findings including 1) Identification of sources to obtain necessary inputs, 2) Summary of production and location estimation models, and assumptions, 3) Summary of inbound and outbound movement routings, 4) Summary of affected rural highway congestion impacts over time, and 5) Recommendations.

Expected Outcomes
Mitigation of the effects of booming industry-generated traffic levels and their impacts on congestion is very important to the sustained growth of shale oil and gas industries in the United States. Improved models are badly needed. In North Dakota, the oilfield traffic analysis and rural highway congestion models made possible by this project will facilitate better understandings of oil-related traffic and truck configurations and greatly improve state and local planning efforts.

This project will explore the use of forecasting tools and GIS software to develop a comprehensive rural regional transportation planning model that incorporates better understandings of booming industries and how these booming industries will affect rural highway congestion levels. In addition, the project will directly provide inbound, outbound movement forecasts and oil production locations for the next 20 years for the North Dakota oilfields. These research findings and contributions will advance the implementation of GIS-

based rural regional transportation planning models for all rural areas that may be experiencing shale oil or gas production or other economic booms.

Relevance to Strategic Goals

The proposed research project and its potential outcomes are directly related to the goals of Economic Competitiveness, Livable Communities, and State of Good Repair. The project directly focuses on evaluating and implementing a sophisticated rural regional transportation planning model to provide better understandings of how estimated oil production levels will impact traffic levels and route selection, resulting in improved predictions of rural highway congestion, which in turn will help planners attain livable community goals and improve decision-makers understandings of the effects of these vital commercial flows on economic competitiveness.

Educational Benefits:

Students who are interested in learning transportation planning, traffic forecasting, traffic assignment, and traffic congestion models can be involved in this project at different levels.

Work Plan:

All project tasks will be completed from April 1, 2012 to June 30, 2013. The last phase of the project will be dedicated to reviewing and finalizing the final report. A detailed project schedule is provided in the table below.

Table 1: Proposed Project Schedule

Task	Description	Months from work authorization											
		1	2	3	4	5	6	7	8	9	10	11	12
1	Literature Review	▨	▨	▨									
	a.　Identify key sources	▦											
	b.　Review and analyze sources		▦										
	c.　Prepare memorandum for this task			▦									
2	Data Collection				▨	▨							
	a.　Familiar with GIS software				▦								
	b.　Identify the resources of the data and achieve the data				▦								
	c.　Identify the required information and achieve the information					▦							
3	Analysis and Evaluation						▨	▨	▨				
	a.　Well location estimation model						▦	▦					
	b.　Well production estimation model						▦	▦					
	c.　Well life estimation model						▦	▦					
	d.　GIS based inbound and outbound routing models								▦				
4	Preliminary Evaluation									▨	▨	▨	
	a.　Verify the forecasting models									▦			
	b.　Estimate the affected rural highway congestion impacts over years										▦		
	c.　Analysis the congestion impact results										▦	▦	
5	Final Report												▨
	a.　Draft final report												
	b.　Prepare and finalize the final report												▦

Project Cost:
Total Project Costs: $300,000
MPC Funds Requested: $150,000
Matching Funds: $150,000
Potential Source of Matching Funds: Montana and/or North Dakota DOTs

TRB Keywords: Advanced Rural Transportation System; Geographic Information System; Traffic Congestion; Dynamic Traffic Assignment; Industrial Trucks;

References:

North Dakota Department of Transportation (2012) (NDDOT). *North Dakota Drilling and Production Statistics* (2012), North Dakota, U.S.A., https://www.dmr.nd.gov/oilgas/stats/statisticsvw.asp (last access time: 3/8/2012)

Ryn Holeywell. (2011). *North Dakota's Oil Boom is a Blessing and a Curse*. Governing the States and Localities, http://www.governing.com/topics/energy-env/north-dakotas-oil-boom-blessing-curse.html (last access time: 3/8/2012)

Kwok Hung Lau. (2009). *A GIS-based Stochastic Approach to Generating Daytime Population Distributions for Vehicle Route Planning*. Transportations in GIS,2009,13(5-6): pp. 481-502

Ammar Alazab, Sitalakshmi Venkatraman, Jemal Abawajy, and Mamoun Alazab. (2011). *An Optimal Transportation Routing Approach using GIS-based Dynamic Traffic Flows*. 2011 3rd International Conference on Information and Financial Engineering, IPEDR vol.12 (2011), IACSIT Press, Singapore