July 2006

NETS

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The Navigation Economics Technology Research Program

US Army Corps of Engineers®

IWR Report 06-NETS-P-03

Navigation Economic Technologies

The purpose of the Navigation Economic Technologies (NETS) research program is to develop a standardized and defensible suite of economic tools for navigation improvement evaluation. NETS addresses specific navigation economic evaluation and modeling issues that have been raised inside and outside the Corps and is responsive to our commitment to develop and use peer-reviewed tools, techniques and procedures as expressed in the Civil Works strategic plan. The new tools and techniques developed by the NETS research program are to be based on 1) reviews of economic theory, 2) current practices across the Corps (and elsewhere), 3) data needs and availability, and 4) peer recommendations.

The NETS research program has two focus points: expansion of the body of knowledge about the economics underlying uses of the waterways; and creation of a toolbox of practical planning models, methods and techniques that can be applied to a variety of situations.

Expanding the Body of Knowledge

NETS will strive to expand the available body of knowledge about core concepts underlying navigation economic models through the development of scientific papers and reports. For example, NETS will explore how the economic benefits of building new navigation projects are affected by market conditions and/or changes in shipper behaviors, particularly decisions to switch to non-water modes of transportation. The results of such studies will help Corps planners determine whether their economic models are based on realistic premises.

Creating a Planning Toolbox

The NETS research program will develop a series of practical tools and techniques that can be used by Corps navigation planners. The centerpiece of these efforts will be a suite of simulation models. The suite will include models for forecasting international and domestic traffic flows and how they may change with project improvements. It will also include a regional traffic routing model that identifies the annual quantities from each origin and the routes used to satisfy the forecasted demand at each destination. Finally, the suite will include a microscopic event model that generates and routes individual shipments through a system from commodity origin to destination to evaluate non-structural and reliability based measures.

This suite of economic models will enable Corps planners across the country to develop consistent, accurate, useful and comparable analyses regarding the likely impact of changes to navigation infrastructure or systems.

NETS research has been accomplished by a team of academicians, contractors and Corps employees in consultation with other Federal agencies, including the US DOT and USDA; and the Corps Planning Centers of Expertise for Inland and Deep Draft Navigation.

For further information on the NETS research program, please contact:

Mr. Keith Hofseth
NETS Technical Director
703-428-6468

Dr. John Singley
NETS Program Manager
703-428-6219

U.S. Department of the Army
Corps of Engineers
Institute for Water Resources
Casey Building, 7701 Telegraph Road
Alexandria, VA 22315-3868

The NETS program was overseen by Mr. Robert Pietrowsky, Director of the Institute for Water Resources.

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THE NAVIGATION ECONOMICS TECHNOLOGY RESEARCH PROGRAM

Prepared by:

Keith Hofseth
Institute for Water Resources

For the:

Institute for Water Resources
U.S. Army Corps of Engineers
Alexandria, Virginia

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www.corpsnets.us

THE NAVIGATION ECONOMICS TECHNOLOGY RESEARCH PROGRAM

Keith D. Hofseth, Institute for Water Resources, Alexandria VA, USA Keith.D.Hofseth@usace.army.mil

ABSTRACT

The U.S. Army Corps of Engineers (Corps), as part of its overall mission, assists in the development and improvement of U.S. ports. The improvements of interest relate primarily to waterway enhancements, such as channel widening and deepening, and provision of moorings and turning basins. Economic analyses of such improvements require estimating the reduction in transportation costs directly attributable to any proposed enhancement. Expenditure of Federal dollars for navigation improvements requires authorization and appropriation by Congress and the President. This process involves review of the proposed plans by stakeholders and other non-government organizations as well as the Corps. One focus of the debate in this review process has been the models used to evaluate projects. The nature of the Corps planning process and project review would be much enhanced if evaluation models were peer reviewed and as transparent as possible. The Navigation Economic Technologies (NETS) research program is designed to develop a standardized and defensible suite of economic tools for navigation improvement evaluation. The NETS research program has two focus points: expansion of the body of knowledge about the economics underlying uses of the waterways; and creation of a toolbox of practical planning models, methods and techniques that can be applied to a variety of situations.

Expanding the Body of Knowledge

NETS research strives to expand the available body of knowledge about core concepts underlying navigation economic models through the development of scientific papers and reports. For example, NETS studies explore how the economic benefits of building new navigation projects are affected by market conditions and/or changes in shipper behaviors, particularly decisions to switch to non-water modes of transportation. The results of such studies will help Corps planners determine whether their economic models are based on realistic premises.

Creating a Planning Toolbox

The NETS research program also will develop a series of practical tools and techniques that can be used by Corps navigation planners. The centerpiece of these efforts will be a suite of simulation models. The suite will include models for forecasting international and domestic traffic flows and how they may change with project improvements. It will also include a regional traffic routing model that identifies the annual quantities from each origin and the routes used to satisfy the forecasted demand at each destination. Finally, the suite will include a microscopic event model that generates and routes individual shipments through a system from commodity origin to destination to evaluate non-structural and reliability based measures.

This suite of economic models will enable Corps planners across the country to develop consistent, accurate, useful and comparable analyses regarding the likely impact of changes to navigation infrastructure or systems. Also, these models are being developed without proprietary software so they can be shared with the public.

Currently, more than 40 studies have been completed or are underway related to coastal, inland and multimodal transportation. Detailed information on these studies is available at www.corpsnets.us/activities.html.

SOMMAIRE

La mission du Génie Civil Américain (US ARMY Corps of Engineers) inclue le développement et l'amélioration des ports aux ETATS-UNIS. Les améliorations en question inclues essentiellement le perfectionnement des voies d'eau, tels que l'élargissement et l'approfondissement de canaux, et la mise en place d'amarrages et de bassins de rotation. Les analyses économiques de telles améliorations nécessitent l'estimation de la réduction des coûts de transport directement attribuables à ces perfectionnements proposés. Le financement fédéral de ces améliorations de navigation ne peut se faire sans autorisation et appropriation du Congres et du président. Ce processus implique l'examen des plans proposés par des groupes d'intérêt et autres organismes non gouvernementaux ainsi que par le Génie Civil. Au cours de ce processus d'examen, le débat était centré, en particulier, sur les modèles employés pour l'évaluation des projets. Le processus de planification et d'étude des projets du Génie Civil serait considérablement plus efficace si les modèles d'évaluation étaient évalués par toutes les parties concernées et de façon aussi transparente que possible. Le programme de Navigation Economic Technologies (NETS) est conçu pour développer un ensemble normalisé et justifiable d'outils pour l'évaluation économique des projets d'amélioration de la navigation. Le programme de recherche du NETS a deux objectifs principaux : l'élargissement des connaissances des sciences économiques qui régissent l'utilisation des voies d'eau ; et la création d'une boîte à outils de modèles de planification, de méthodes et de techniques pratiques qui puissent être appliqués à des situations variées.

Elargissement des connaissances scientifiques.

Le programme NETS a pour but d'augmenter les connaissances scientifiques fondamentales des modèles de navigation, en publiant des papiers scientifiques et des rapports. Par exemple, les études NETS explorent dans quelle mesure les avantages économiques de nouveaux projets de navigation sont affectés par les conditions de

marché et/ou changements du comportement des expéditeurs, en particulier l'adoption de modes de transport alternatifs a la navigation. Les résultats de telles études veulent aider les planificateurs du Génie Civil à déterminer si leurs modèles sont basés sur des théories réalistes.

Créer un ensemble d'outils de planification.

Le programme de recherche NETS a également pour but de développer une série d'outils pratiques et de techniques qui puissent être employés par les planificateurs de navigation du Génie Civil. L'élément clef de cet ensemble d'outils consistera en une série de modèles de simulation – ces modèles permettront de prévoir la circulation internationale et domestique des navires et marchandises et de simuler l'impact de projets d'amélioration sur la circulation. Sera également inclus un modèle régional qui identifie les quantités annuelles de l'origine et les itinéraires ont utilisés pour satisfaire la demande prévue à chaque destination. Enfin, l'ensemble comptera un modèle microscopique qui détermine les charges individuelles à l' origine et leur parcours jusqu'à destination pour évaluer des mesures non-structurelles et fiabilité.

Cet ensemble de modèles économiques permettra aux planificateurs du Génie Civil à travers le pays de développer des analyses conformes, précises, utiles et comparables d'étude d'impact des changements d'infrastructure ou des systèmes de navigation. De plus, ces modèles sont développés sans logiciel de propriété industrielle et peuvent ainsi être mis à la disposition du public. Actuellement, plus de 40 études du transport côtier, intérieur et multimodal ont été réalisées ou sont en cours. De plus amples informations sur ces études sont disponibles à www.corpsnets.us/activities.html.

KEYWORDS: Navigation, economics, modeling, forecasting, simulation, elasticity.

1. Background

The U.S. Army Corps of Engineers (Corps), as part of its overall mission, assists in the development and improvement of U.S. ports. The improvements of interest relate primarily to waterway enhancements, such as channel widening and deepening, and provision of moorings and turning basins. Economic analyses of such improvements require estimating the reduction in transportation costs directly attributable to any proposed enhancement. As the efficacy of any improvement depends on interactions within the entire system, these analyses are complex. Also, there is considerable uncertainty concerning the interaction of vessels in the channels. To properly evaluate the economic efficacy of any waterway improvement, a systems analysis explicitly incorporating uncertainty is required.

Expenditure of Federal dollars for navigation improvements requires authorization and appropriation by Congress and the President. This process involves review of the proposed plans by stakeholders and other non-government organizations as well as the Corps. One focus of the debate in this review process has been the models used to evaluate projects. The nature of the Corps planning process and project review would be much enhanced if evaluation models were peer reviewed and as transparent as possible. The Corps currently has no commonly adopted model for the evaluation of proposed deep draft navigation improvements. In fact, any of the Corps 37 districts may develop new tools and evaluation methods for each study. These models are often "black boxes" understood by only a few practitioners. Such models generally have had limited peer review and each may have its own set of assumptions regarding key parameters. Reviews of past efforts have revealed simple computational errors. This has created a credibility problem for the Corps, as highlighted by the quotes below:

- "Too many Corps projects are based on questionable economic and environmental studies. Project benefits are exaggerated while costs are underestimated..." (Scott Faber, Environmental Defense Fund)
- "…the Sierra Club has significant concerns related to the economic justification of the proposed project." (Sierra Club)
- "…the need to pursue nonstructural options…should not be peremptorily dismissed without full consideration…" (EPA)

The NETS research program was designed to address these and other concerns.

2. Goals of NETS Program Goals

The goal of NETS is to advance the Corps world-class engineering with state-of-the-art tools and techniques for economic modeling and analyses. There are two focus areas: expanding the body of knowledge regarding the economics underlying the use of the waterways and creating a toolbox of certified, practical planning models, methods and techniques that can be applied to a variety of situations. The knowledge and tools developed by the NETS research program are be based on:

- Reviews of economic theory;

- Current best practices both within and outside of the Corps;
- Data needs and availability; and
- Peer recommendations.

Every NETS research activity is measured against four basic standards:

- **Grounded in reality.** Research activities are based on the most accurate and complete data and all procedures, assumptions and conclusions are well-documented.
- **Intuitive.** The procedures, assumptions and sensitive variables underlying research activities must be reasonably transparent to users both inside and outside of the Corps.
- **Verifiable**. The most significant NETS research activities are peer-reviewed by a panel of independent experts.
- **Transportable.** NETS tools and techniques are designed so that they can be easily applied across geographic boundaries to projects of varying sizes and scopes.

The NETS research program is in the process of developing a series of practical tools and techniques that can be used by Corps navigation planners across the country to develop consistent, accurate, useful and comparable information regarding the likely impact of proposed changes to navigation infrastructure or systems. The centerpiece of these efforts will be a suite of simulation models. This suite includes:

- A model for forecasting **international and domestic traffic flows** and how they may be affected by project improvements.
- A **regional traffic routing model** that will identify the annual quantities of commodities coming from various origin points and the routes used to satisfy forecasted demand at each destination.
- A **microscopic event model** that will generate routes for individual shipments from commodity origin to destination in order to evaluate non-structural and reliability measures.

The NETS program is also investigating transportation theory, mode choice, and non-structural improvements such as tradable permits, congestion pricing and appointment systems. Event studies are efforts to document the economic affects of lock failures. NETS has documented four of these events in the last two years. Finally the program is developing models to estimate the emissions profile for the transportation system.

The remainder of this paper highlights will step through each of these areas and provide an introduction to each subject or activity.

3. Theory

Corps of Engineers transportation planning models incorporate decision rules that are generally based on a competitive market structure. However, we know that the transportation industry is characterized by horizontal and vertical integration with firms that exercise market power, at least in some markets. This difference between the real world and Corps models will bias the welfare estimate derived from the Corps planning models. What was needed was a better understanding of this bias. Is it significant and how could the Corps better incorporate market power into its planning models?

A series of efforts where commissioned by the NETS program to investigate this issue. Dr. Simon Anderson (University of Virginia) and Dr. Wesley Wilson (University of Oregon and IWR) have produced several papers examining these issues. In an early effort (Anderson, 2004) the authors construct and equilibrium model of a sequential bottlenecks, similar to a system of locks on a waterway. Access to the waterway is by truck. Prices are endogenous and congestion can be avoided by trucking around the bottleneck. The authors demonstrate a unique equilibrium specifying mode choice, congestion times and barge rates. Another effort (Anderson 2005a) examines the spatial modeling framework of Samuelson and Takayama-Judge (S-TJ). In S-TJ models markets are competitive and spatial regions are fixed. Both of these characteristics can bias the welfare analysis. The objective of this paper is to allow for market power and endogenous regions within the (S-TJ) framework. Finally, the authors develop a theoretical model (Anderson 2005b, Anderson 2005c) of a barge and rail transportation market reflecting Bertrand and Cournot competition. The authors use the perfectly competitive model as a benchmark and then introduce market power, first to the barge market and then to rail. Market inefficiencies are demonstrated and the welfare effect measured. The welfare affect is broken down to identify gainers, losers and overall change.

4. Estimating Shipper response

Current Corps planning models designed to assess the potential benefits and costs of proposed navigation projects on the inland waterways, rely heavily on assumptions about demand, (i.e. how much the waterways will be used by shippers). These assumptions relate in large part to how shippers will respond to changes in transportation costs and times. For example, Corps models generally assume no change in the quantities shipped between origin

and destination. Moreover, the mode does not change until a reservation price is reached at which point he entire annual quantity for that origin-destination-commodity triple is assigned to the alternative mode. Estimates show that relaxing this assumption will cause the benefit estimates from improving the waterways to vary considerably. This has become a major issue for critics of Corps evaluation techniques. An experts group recommended the Corps use revealed-choice and stated-preference survey techniques to more cogently estimate the shape of the demand curve. A series of surveys have been initiated to evaluate this technique. The goal is to estimate the demand curve for a variety of commodities on several of the major waterways.

For the first effort (Train 2004), a survey of grain shippers was conducted to obtain information about the mode and origin/destination (O/D) of their shipments, the next-best alternative mode and O/D, as well as factors that might induce the shipper to switch to the next-best alternative. An econometric model was estimated on the combined revealed-preference data (the shippers' observed choices in the market) and stated-preference data (the choices that shippers said they would make if transportation rates or times rose for their current mode and O/D.) The estimated model is used to forecast the share of shippers that would change mode and/or O/D in response to specified changes in transportation rates and time. The analysis indicates that many shippers would switch to an alternative mode and/or O/D in response to a relatively small rate increase for their current mode and O/D. The share who would switch rises with the magnitude of the rate increase, though less than proportionately. Shippers are found to respond to transit times in addition to rates, with the response to transit times being smaller than the rate response. While many shippers are found to respond to fairly small changes in rates or transit times, a large share of shippers are found to be essentially insensitive to large changes in rates and times.

A similar study was conducted for grains and non-grains on the Columbia River (Train 2006). These efforts have demonstrated that the shape of the demand curve (shipper response) can be empirically estimated across a broad range of price, importantly, beyond the range of price observed in the market place. In 2006, the Upper Mississippi will be restudied and will include non-grain commodities. Also, on the Ohio River a survey is will be conducted for coal and non-coal commodities.

5. Modeling

The NETS research team has identified three levels of forecasting and evaluation models needed to properly evaluate the economic merits of proposed waterway improvements. The top tier is global, the second regional and finally micro. These models vary both in geographic scope and time. The global and regional models solve for a one year period while the micro models are at the individual vessel movement level. Projects are evaluated over a 50-year life. For commodities such as grains that are traded internationally, estimated traffic flows through a project must be consistent with a global understanding of the market. Moreover, because of the public nature of the evaluation, the model must be able to answer a wide variety of questions, e.g. how do flows change with the expansion of the Panama Canal?

Traditionally the Corps has used forecasting techniques that were a simple extrapolation of the past adjusted by expert opinion. They were not explicit empirically modeled relationships and could neither be reviewed by interested groups nor easily answer questions reflecting changed assumptions about the future. To overcome these shortcomings, a global spatial equilibrium modeling approach was adopted. The first effort (Wilson 2005) developed a methodology and analytical model to forecast grain shipments through the Mississippi River system. The methodology is generally applicable to a broad range of commodities. The focus of this study is on the world grain trade and expected changes in response to a multitude of evolving competitive pressures and potential structural changes. The model focus is on the competitiveness of the US grain and oilseed sector that is tributary to the Mississippi River system, and to assess impacts of critical variables on its competitiveness, and to project changes in flows for 50 years. Also, the forecasts are caste using stochastic optimization methods to measure distributions of future flows and explicitly measure risks.

Important parameters for the global grain model are forecasted for relevant periods forward and used to evaluate changes in flows through the targeted logistical channels. Projected import demands are based on consumption functions estimated using income and population and accounting for inter-country differences in consumption dependent on economic development. Each of the competing supply regions and countries were represented by yields, acres available for production of each grain, costs of production and interior shipping costs. A transportation network links these supply and demand regions and the model is solved to meet demands at the least total cost to the consumer. Changes in flow due to changes in infrastructure can be easily calculated, allowing the Corps to evaluate the affect of a port improvement on competing ports. Also, the model incorporated policy variable which allow for the examination of alternative policies, e.g. reductions in subsidies.

This methodology is being explored for use in forecasting other commodity groups. Currently NETS researchers are exploring its use for forecasting container flows, petroleum and coal. A first step in this process will be to add a user interface to the model to make it as transparent as possible. This will allow a broad range of user groups to participate in the traffic forecast discussion.

6. Regional Routing Model

The global spatial equilibrium approach provides the context for forecasting traffic through specific projects but is too aggregated to provide these estimates directly. To disaggregate these forecasted flows and provide project

specific traffic forecast a Regional Routing Model (RMM)is being developed. The work is being developed in partnership with other Federal entities to ensure the collection and integration of relevant information and explore common economic data and analytical methods.
As part of the initial phase of development, the Oak Ridge National Laboratory (ORNL) has develop a prototype RRM and supporting data base to assist USACE in linking economic (production and consumption) activity data on selected agricultural products to the movement of these products through the multi-modal (highway, rail, waterways) US transportation network. The resulting cost and flow matrices provide a basis for further analysis of the effects of changes in inland and intra-coastal transportation costs and future network structure changes on the distribution of commodity movements through specific seaports and waterways. The model solves for county to county flows and has been calibrated to the 2002 Commodity Flow Survey data. Also, the model will be wrapped in a GIS framework. This multimodal framework provides a method of examining potential modal changes along a corridor or port region based upon changing various operational and system metrics. Specifically this framework will allow the Corps to consider congestion in the alternative modes in addition to the traditional focus on the ports and waterways.

7. Project Evaluation Models

The Corps incorporates forecasted flows into project evaluation models. These models are of two varieties; the annual models and the aforementioned microscopic models. The annual modes solve for annual movements, congestion and cost using aggregated data and assumptions. The microscopic models generate and route individual vessel and tows through the system, tracking delays and cost.

The Corps has developed two types of annual models. On the Ohio River the Corps' Planning Center of Expertise for Inland Navigation (PCXIN) has developed the Ohio River Navigation Investment Model (ORNIM). ORNIM is a suite of tools that incorporate forecasted flows with engineering reliability of structures to optimize system maintenance and waterway improvement investments over time. This suite of tools represents some of the most advanced waterway modeling accomplished by the Corps. However, intrinsic to the model are the traditionally used right angled demand curves. These curves assume waterway traffic is unresponsive to rates until a reservation price is reached at which point the entire annual movement is shifted to the next least cost mode. NETS researches are working with the PCXIN to modify ORNIM to relax this assumption (Langdon 2005).

On the Mississippi River the Corps has developed the ESSENCE model. The ESSENCE model recognized the shortcomings of right angled demand curves and allowed for the specification of a downward sloping demand curve. However, the ESSENCE model retained the assumption that the entire annual flow would switch to an alternative mode at a user specified reservation rate. Moreover, in application the demand curves where based on expert judgment sans any empirical investigation. The NETS survey work (Train 2005) has shown that many shippers are captive to the waterway and will not switch even if waterway rates exceed the alternative mode price. NETS researchers are working with the Mississippi Valley Division team to incorporate the findings of the Mid-America Grain Study (Train 2005) into the ESSENCE model. This addresses both the issue of using empirically estimated curves and the assumption of 100 percent mode shift at the reservation rate.

To properly evaluate the affects of some project improvements it has been necessary to develop microscopic event scanning models. For example as new, larger ships enter the world's fleets, existing channels often must be deepened and widened or new channels must be created. Establishing the need for such modifications requires detailed economic analyses. Assessing the benefits of such modifications requires a holistic examination of vessel traffic into the port, which can best be achieved through a microscopic simulation model. The HarborSym model is a simulation model that allows planners to analyze the economic impact of channel-widening projects. HarborSym calculates transit times and transportation costs by predicting vessel interactions based on user-provided vessel trip data and harbor transit rule information. Unproductive wait times result when vessels are forced to delay sailing due to transit rules and the movement of other ships within the system. HarborSym captures these delays.
HarborSym allow users to analyze changes within a port system without modifying complex computer codes. Users are able to create models for specific harbors using a graphic interface and populate and manage information related to port infrastructure, traffic movements and harbor rules. Vessel movements are animated during the simulation making it easier for users to determine if the model is accurately representing their system. A post-process animation with three-dimensional vessels is available to demonstrate the model's capability to decision-makers and stakeholders. The model enables planners to more accurately predict the benefits of channel-widening projects. It provides a "transparent" approach to channel-widening analyses that can be duplicated by outside researchers. Using the model, analysts can calculate changes in transportation costs that will result from proposed modifications of the physical dimensions of the channel. Currently the widening version of HarborSym is available on the web site (Hofseth 2005) and a channel deepening version is under development.
The second microscopic model being developed by the NETS team is the Navigation System Simulation (NaSS) Model. Currently, the Waterways Analysis Model (WAM) is currently the most procedurally developed lock simulation model used by the Corps. However, the WAM is limited in several regards. It is a difficult model to use, which is being addressed by another NETS project (WAM BPP). More importantly, the WAM is written in a proprietary language which makes it difficult to understand and revise; it is not well suited to analysis of a system of locks; it is not well suited for analysis of shipper and carrier behavior in reaction to disruptive lock closures; it is not

well suited for analysis of various traffic management schemes; it does not include engineering reliability modules; and it cannot optimize navigation system investments and management actions.

This effort will develop an entirely new system simulation and optimization model that builds upon the capabilities of WAM and addresses the shortcomings identified above. NaSS is intended to be the most advanced navigation system simulation tool available to the Corps and general public.

With the NaSS model planners will be able to evaluate non-structural measures as well as traditional capacity expansion measures. The NaSS model will accommodate the analysis of congestion pricing, locking policies, lockage efficiency measures, scheduling or tradable permits. This work effort will lead to better decisions regarding navigation system improvements and management through the use of a model that better simulates real world operations and optimizes potential investments and traffic management actions.

8. Non-Structural Measures

Delays caused by congestion on the inland waterway system are costly for shippers and have a negative impact on the economy and the environment. Tradable permits are one proposed non-structural solution for dealing with the problem. Tradable permits involve regulators determining an overall level of tolerable activity, in this case on the nation's inland waterways, then allocating tradable rights, permits, or quotas to operators generating the trips, up to a tolerable level. Companies that keep their trip levels below the allotted level could sell their surplus permits to other firms or use the allotment for one of their other facilities to offset excess trips there. Firms that run out of allowance must buy them from other companies or face legal penalties. In either case it is in the financial interest of the participating firms to reduce trips as much as they efficiently can.

An effort (Plott 2005) was undertaken to evaluate the efficacy of tradable permits on the inland waterway system. Based on the characteristics of the marketplace and the nature of the congestion, the authors were less optimistic about systems that penalize “slow” lockages, as the length of the lockage may be influenced by factors beyond the control of the operators. Some of the same forces that can affect the time in a lock, such as weather, can also affect arrival times. This made fixed appointment based systems less attractive relative to a system that allows greater flexibility. Moreover, the general desirability of allowing for the flexibility of market participants to respond to changing market conditions in a manner, as much as possible, of their own choosing, made command and control systems unlikely to be the most useful line of inquiry. It was decided that a tradable priority permit system was likely to best serve the objectives of reducing the costs of congestion, including costs associated with uncertainty and providing a means to measure the value of increased lock capacity.

Some instances of congestion are likely unavoidable, particularly given the industry concern over lock outages, weather conditions, etc and the seasonal nature of some parts of the system. To assist in reducing the costs during these periods, and to allow some ability to measure the costs of the delays, the authors propose a system of tradable permits for priority. This system would give operators of high priority permits preference in the queue. It would allow operators to exchange their position if market conditions warranted. The authors demonstrated how this system would reduce the cost of congestion, not by reducing it, but by allowing it to shift to operators who had lower delay cost. This system was inspired by an ad hoc system industry established in anticipation of a major waterway disruption.

An appointment system has also been proposed to reduce delays caused by congestion on the inland waterway system. A study (Mundy 2005) to examine the potential use of an appointment system to reduce wait times and congestion was conducted. Under such a system barges would be assigned times to pass through a lock and dam system. The researchers developed simulation tool to measure the effects of a variety of appointment strategies and to prepare the groundwork for additional operational testing of an appointment system. The study qualitatively examined the economic benefits and costs of an appointment system, but concluded that the intervention into the market implied by an appointment system would not be justified at current levels of traffic. Also, the authors concluded that at “high” levels of traffic an appointment system would also be ineffective, leaving only a window of traffic levels for which an appointment system maybe justified. Justification of an appointment system would depend on how long the system was projected to stay within that window.

9. Externalities

It is widely recognized that transportation contributes greatly to air emissions. Moreover, inefficient systems contribute exponentially. The NETS program has begun an effort to add to the models being developed the ability to estimate air emission by mode and corridor. This will allow planner to consider the impact of waterway improvements on transportation related air emissions. This effort will tie the freight traffic in the Regional Routing Model and vessel movements in the HarborSym model directly to energy requirements and implied air emissions.

10. Independent Peer Review

The peer review process is one of the cornerstones of the NETS program, providing a “reality check” to ensure that each NETS study is of the highest quality and credibility. All significant NETS products are thoroughly reviewed by the NETS team of Corps and academic experts. Select studies, which represent important foundations

for future work or analysis, are thoroughly reviewed by an outside team of independent, academic experts. The researchers must address any issues that are identified before the study can be finalized.

Each of these peer reviewers are experts in the subject matter being reviewed and have no direct interest in the outcomes. Review documents produced by the process include:

- Study Purpose and Objectives Statement
- Summary of Conclusions
- Summary Review Statement on Validity and Quality of Findings
- Individual Comments and Issues for Resolution

When a NETS product is ready for independent review, it is submitted to a contractor with a suggested list of the technical expertise required to properly review the item. The contractor selects up to three independent reviewers from the list that have the appropriate technical expertise. The number of reviewers selected is determined by the Corps and reflects both budgetary considerations and the level of importance the item has to the overall program. To the extent possible, reviewers are selected randomly from the set or subset of reviewers that have credentials in the necessary specialty area.

The contractor then manages the review process. Comments are provided to the Corps anonymously. The Corps knows neither the names of the reviewer selected nor the author of any comment provided. The Corps then communicates the review comments to the project team for review response. The Corps has the option of selecting a specific reviewer. When this is done, that fact is part of the review process documentation.

11. Event Studies

NETS researchers have documented the economic impact of four separate system closures during the last two years. In 2003 the main lock chamber at the Greenup Locks and Dam was closed for major maintenance and repair. The work, which was originally scheduled to last three weeks, ended up lasting seven weeks, due to unexpected, but necessary emergency repairs to the lock's main chamber. The extended closure forced shippers using the lock to make a number of short- and long-term decisions regarding transportation of their goods.

Through a survey of shippers and carriers using the Greenup Locks and Dam, as well as analysis of other data, this study assessed how shippers responded to the closure, evaluate the economic impact of these decisions and determine if shippers made long-term operational adjustments as a result, such as switching to all-overland modes of transportation. The study includes a compilation of "lessons learned" from the experience and identified changes in operational or maintenance procedures that resulted from the closure.

The survey tool and data developed during the study help Corps planners assess the potential impact of other such closures and to plan steps to limit this impact.

This type on analysis was repeated for the closure events at McAlpine Lock and Dam, the Hannibal Lock & Dam and Lock and Dam #27.

12. Communications

The NETS research team has made an effort to make the process as well as the products of the research effort available to the public. To this end a web site was launched in January 2005 (www.corpsnets.us). The web site contains fact sheets describing each research effort, draft reports as well as final products. Each month is published “NETS NEWS!” an email based notice of recent accomplishment of the NETS program. Finally, NETS team members make presentations to a multitude of interest groups, both governmental and non-governmental.

13. Acknowledgements

This paper is the largely based on NETS program documentation and reports. Often whole paragraphs are transcribed from this work and can be found in the referenced papers or on the NETS web site. As the technical director for the NETS program the author’s function has been to edit these sources and combined them for this paper.

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The NETS research program is developing a series of practical tools and techniques that can be used by Corps navigation planners across the country to develop consistent, accurate, useful and comparable information regarding the likely impact of proposed changes to navigation infrastructure or systems.

The centerpiece of these efforts will be a suite of simulation models. This suite will include:

- A model for forecasting **international and domestic traffic flows** and how they may be affected by project improvements.
- A **regional traffic routing model** that will identify the annual quantities of commodities coming from various origin points and the routes used to satisfy forecasted demand at each destination.
- A **microscopic event model** that will generate routes for individual shipments from commodity origin to destination in order to evaluate non-structural and reliability measures.

As these models and other tools are finalized they will be available on the NETS web site:

http://www.corpsnets.us/toolbox.cfm

The NETS bookshelf contains the NETS body of knowledge in the form of final reports, models, and policy guidance. Documents are posted as they become available and can be accessed here:

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