

**APPENDIX C**  
**ANNOTATED LITERATURE REVIEW**

1. **Abeyrante RIR, Management of Airport Congestion through Slot Allocation, *Journal of Air Transport Management*, 2000, 6(1)29-41.**  
The lack of airport slots (the time allocated for aircraft to land or take off), particularly at airports which experience congestion, have reached unmanageable proportions in recent years. The International Civil Organization (ICAO) records that, by the end of 1997, there were 132 slot controlled international airports, (118 year round and 14 during peak seasons). Between 1989 and 1998, the reported number of commercial aircraft in service increased by about 60% from 11,253 to 18,139 aircraft. In 1998, 1463 jet aircraft were order, compared with 1309 in 1997, and 929 were delivered compared with 674 in 1997. In 1998, the total scheduled traffic carried by airlines of the 185 Contracting States of ICAO amounted to a total of about 1462 million passengers and about 26 million tons of freight. These figures are reflective of the rapidly increasing frequency of aircraft movements at airports, calling for drastic management of airport capacity. To cope with the demand, airlines are forming strategic alliances with themselves by utilizing such commercial tools as franchising, leasing and interchange of aircraft. The management of airport capacity through slot allocation is a critical consideration for the world aviation community. This article analyses the problem and discusses various issues related thereto.
  
2. **Babcock MW and Xiaohua L, Forecasting Inland Waterway Grain Traffic, *Transportation Research part E*, 2002, 38, 65-74**  
The purpose of this paper is to address a neglected area of water transportation forecasting — short-term forecasting of inland waterway traffic. A time series model is used to forecast Mississippi River Lock 27 grain tonnage for the 1989:1-1999:4 period. The model was selected on the basis of several measures of goodness of fit and out-of-sample forecasting performance. The out-of-sample forecasting performance of the model was good, as the percentage difference between the year 2000 actual and forecasted tonnage was less than 5.5% for three of the four quarters and only about 2% for the year.
  
3. **Dai MDM and Schonfeld PM, Metamodels for Estimating Waterways Delays through a Series of Waterway Queues, *Transportation Research Part B*, 1998, 32(1)1-19.**  
A numerical method has been developed for estimating delays on congested waterways. Analytic and numerical results are presented for series of G/G/1 queues, i.e., with generally distributed arrivals and service times and single chambers at each lock. One or two-way traffic operations are modeled. A metamodeling approach which develops simple formulas to approximate the results of simulation models is presented. The structure of the metamodels is developed from queueing theory while their coefficients are statistically estimated from simulation results.

The numerical method consists of three modules: (1) delays, (2) arrivals, and (3) departures. The first estimates the average waiting time for each lock when the arrival and service time distributions are known. The second identifies the relations between the arrival distributions at one lock and the departure distributions from the upstream and downstream locks. The third estimates the mean and variance of the departure times when the interarrival and service time distributions are known.

The method can be applied to systems with two-way traffic through common bi-directional servers as well as one-way traffic systems. Algorithms for both cases are presented. This numerical method is shown to produce results that are close to the simulation results.

The metamodels developed for estimating delays and variances of interdeparture times may be applied to waterways and other series of G/G/1 queues. These metamodels for G/G/1 queues may provide key components of algorithms for analyzing networks of queues.

4. Committee to Review the Upper Mississippi River-Illinois Waterway Navigation System Feasibility Study, National Research Council, ***Inland Navigation System Planning: The Upper Mississippi River—Illinois Waterway***, Washington, D.C.: National Academy Press, 2001, 130 pages.  
Starting in 1988, the U.S. Army Corps of Engineers investigated the potential costs and benefits of extending locks on the Upper Mississippi River-Illinois Waterway to 1,100 feet in order to relieve traffic congestion. In an environment charged with controversy, the US Army hired the National Academy of Sciences to review its reports on the feasibility of improvements on the waterway. In this present paper, a committee reviews the Corps' economic analysis and concludes, in part, that measures short of constructing longer locks have not been fully investigated. The committee recommends that the Corps take a serious look at the many "relatively inexpensive, nonstructural options" applicable to the UMR-IWW, and assess the potential costs and benefits of such options.
5. Committee to Review the Upper Mississippi River-Illinois Waterway Navigation System Feasibility Study, National Research Council, ***Review of the U.S. Army Corps of Engineers Restructured Upper Mississippi River-Illinois Waterway Feasibility Study***, Washington, D.C.: National Academy Press, 2004, 66 pages.  
This report, the first of three, encapsulates the committee's evaluation of the U.S. Army Corps of Engineers Restructured Upper Mississippi River-Illinois Waterway Feasibility Study. The committee reviews the model the Corps developed to aid in forecasting future levels of grain movement on the waterway and related costs. The committee also reviews the planning process and evaluated recommended measures for alleviating waterway traffic congestion. The primary recommendation related to traffic congestion is that non-structural measures should be evaluated, developed, and put into place before the Corps estimated the economic benefits of extending the locks. And in the event the lock chambers were lengthened, small-scale measures of traffic control would become essential during the construction process.

6. Committee to Review the Upper Mississippi River-Illinois Waterway Navigation System Feasibility Study, National Research Council, ***Review of the U.S. Army Corps of Engineers Restructured Upper Mississippi River-Illinois Waterway Feasibility Study: Second Report***, Washington, D.C.: National Academy Press, 2004, 80 pages.  
In this second report, the committee reviews the “key issues, data, assumptions, and areas of controversy with the feasibility study.” After addressing integrated river system planning and ecosystem restoration, the committee laments that the Corps has still not adequately evaluated “several promising traffic management strategies” including priority rules at locks, the scheduling of tows, and congestion fees. Without a comprehensive analysis of non-structural measures, critics of the Corps’ plan to extend the locks can undermine the conclusions of the feasibility study.
7. Dai MDM, Schonfeld PM and Antle G, **Effects of Lock Congestion and Reliability on Optimal Waterway Travel Times**, *Transportation Research Record*, Paper No. 930596, 1993  
The congestion and variability of service times at locks significantly affect the cost and reliability of waterway transportation. This paper considers the effects of lock congestion levels and reliability on the operating cost of tows, assuming that tow operators have the opportunity to optimize speed in response to the delays they have already experienced and the delays they expect to encounter. The analysis method in this paper is useful for evaluating long-term consequences of lock improvements, as well as for optimizing speed from the viewpoint of operators.  
This analysis method optimizes tow operations in two stages. The first stage finds the optimal speeds for each individual tow, re-optimizing the speed after every lock. The second stage determines the optimal allowed delivery times and associated optimal speeds based on the lock transit time distributions. The optimization is guided by a total cost objective function which includes penalties for late deliveries.  
A four-lock section on the Ohio River is used for a case study in which various congestion levels and speed limits are tested. The resulting total cost functions are U-shaped with respect to the allowed delivery times. At given congestion levels, the optimal allowed delivery times and costs decrease as speed limits increase. The results also show how the optimal allowed delivery times and costs increase as congestion becomes severe.
8. Doxsey L, **Incentive Tolls for Congestion Management**, *Transportation Research Record 1576*, 1997, 77-84.  
A congestion pricing planning model was developed for the Port Authority of New York and New Jersey. The model is designed to evaluate possible incentive tolls for their effects on congestion delays at the six bridges and tunnels the authority operates between New Jersey and New York. The study used a stated preference survey administered to bridge and tunnel users, econometric choice

models, and plaza volume-delay relationships as a basis for simulating the effects of changes in toll structure. The survey identified characteristics of trips, and the trip makers. A stated preference choice exercise was included to reveal trade-offs among toll, plaza delay, facility choice, and time period when the crossing would be made. Responses to the exercise were combined with other survey data, and econometric models of choice were estimated. The models associate the probability of travel choices with the conditions faced at the alternatives. The policy evaluation planning model combined choice model results, survey responses from individual respondents, and data on facility conditions, volumes, and capacities. As input it accepts a user-specified menu of tolls and discounts, potentially varying both by hour and by facility. As output it predicts automobile volumes, average delays, total delays, and toll revenue by hour and facility. The model is constructed to achieve equilibrium among tolls, delays, and volumes. Application of the model indicates considerable potential for reducing plaza delays.

9. Fellin L and Fuller S, **Effect of Proposed Waterway User Tax on U.S. Grain Flow Patterns and Producers**, *Transportation Research Forum*, 2000(?), pp. 11-25.

The administration recently proposed the barge fuel tax be increased from \$0.20/gallon to \$1.20/gallon. Because the increased tax could have important implications on U.S. agriculture, quadratic programming models of the soybean/corn sectors are used to evaluate the impact on flow patterns, producer prices/revenues and export levels. Results show the tax increase would divert 10.6 million metric tons from the inland waterways; 70 percent of the diversions are from the upper Mississippi/Illinois systems. The lower Mississippi River port area is projected to lose 9 million tons, while other Gulf, Great Lakes, north Atlantic and Pacific northwest ports increase by 3.35, 1.49, 1.74 and 1.40 million tons, respectively. Soybean/corn producers in Minnesota, Illinois and Iowa incur annual revenue losses of \$151 million and about 75 percent of the expected decline in all producer revenues. Exports of U.S. soybeans are nearly unchanged with the proposed tax increase while corn exports decline 2.16 percent. If the proposed tax were implemented, barge-transported soybeans/corn would increase federal revenues by \$89 million per year. The proposed tax increase has unfavorable implications for U.S. producers, grain handling/exporting industries and barge transportation firms, however, the impact is not judged to be calamitous.

10. Ferguson E, **Three Faces of Eve: How Engineers, Economists, and Planners Variously View Congestion Control, Demand Management, and Mobility Enhancement Strategies**, *Journal of Transportation and Statistics*, April 2001, 51-73.

The political acceptability (A) of public policy measures correlates positively with program effectiveness (E) and negatively with program cost (C) and other obstacles to implementation (I) under normal circumstances. Ferguson (1991) observed that the political acceptability of many demand management strategies

seemed to correlate negatively with implied program effectiveness. Engineers, economists, and planners each have their own unique professional standards. Increased effectiveness is the primary goal of engineering. Improved efficiency is the generally accepted standard in economics. Process issues are of vital concern in planning. A review of the literature indicates few studies in terms of all four variables of interest (A, E, C, and I) simultaneously. Three relevant studies are identified: one each by an engineer, an economist, and a planner. Raw data, regression results, bivariate correlation, and model output reveal that two of the three studies support the Ferguson hypothesis. The other supports a more traditional public policy model. E is the most influential variable in the engineer's data. C is the most influential variable in the economists' data, while I is the most influential variable in the planner's data. These revealing results suggest the subtle manner in which professional training and experience may alter perceptions of transportation and policies and programs in professional practice.

11. Forsyth P, **Privatisation and regulation of Australian and New Zealand Airports**, *Journal of Air Transport Management*, 2002, 8, 19-28.  
A brief background on the Australian and New Zealand airports is provided at the beginning of the paper. This is followed by a discussion of the approach to price regulation which Australian regulators are implementing in other industries; this gives an indication of how the—as yet new—regulation of airports will develop. Some specific regulatory issues are next considered; firstly, the merits of the dual till approach are considered, and then how the regulator is handling investments in new capacity. The New Zealand policy of no formal price regulation is examined; this is a less “light handed” form of regulation than it seems. Finally, the main problems of privatising and regulating Sydney are discussed.
12. Fuller S and Grant W, **Effect of Lock Delay on Grain Marketing Costs: An Examination of the Upper Mississippi and Illinois Waterways**, *Logistics and Transportation Review*, 1993, 29(1)81-95  
This paper evaluates the effect of lock delay on the efficiency of marketing the North Central U.S.'s corn and soybean production via the upper Mississippi and Illinois waterways. The analysis is accomplished with a multi-commodity least-cost network flow model. Lock delay was found to have an important effect on the cost of barging the region's surplus grain production. If the lock and dam system on the upper Mississippi and Illinois waterways is not continually upgraded, grain is redirected to less efficient modes, thus increasing the cost of marketing the region's grain surplus. These increased costs need to be weighed against the costs of upgrading lock capacity.
13. Gervais JP, Misawa T, McVey MJ and Baumel, P, **Evaluating the Logistic and Economic Impacts of Extending 600-Foot Locks on the Upper Mississippi River: A Linear Programming Approach**, *Journal of the Transportation Research Forum*, Fall 2001, 40(4)83-103.  
This article uses a highly disaggregated linear programming model to evaluate the short-run benefits of extending five 600-foot locks on the Upper Mississippi River

- (UMR) to 1,200 feet. We model 1994-1995 corn flows in three counties of eastern, central, and western Iowa. Two scenarios are simulated based on either completed or partial pass-through of the cost savings associated with large-scale improvements on the UMR to grain elevators and producers. The estimate of the total annual costs of lock expansions is 4 cents a bushel. Total annual benefits accruing to grain producers and elevators are in the range of 0.21 to 0.43 cents a bushel. No environmental costs are included in the analysis.
14. Golaszewski R, **Reforming Air Traffic Control: An Assessment from the American Perspective**, *Journal of Air Transport Management*, 2002, 8(1)3-11. This paper examines institutional and economic reform of the ways in which air traffic control (ATC) services are provided in the U.S. It also contrasts the European and U.S. ATC systems in terms of size, scope, cost and organizational form. The paper suggests that many of the congestion and delay problems experienced in the U.S. result from the inefficient provision and use of air traffic capacity in the airport area, and these conditions are likely to continue or worsen if economic principles are not used to organize and provide ATC services. The paper notes that, while Europe has advanced more rapidly in the organizational and economic reform of providing ATC services, other problems remain. Because most large European airports have slot controls to limit demand in the airport area, its ATC congestion is more pronounced in the enroute environment.
  15. Griffiths JD, **Queueing at the Suez Canal**, *Journal of the Operational Research Society*, 1995, 46(11)1299-1309. This paper describes an investigation into the delays experienced by ships waiting to pass through the Suez Canal. The main objective of the Suez Canal Authority (SCA) is to provide an attractive service to ship-operators, and in doing so maximize the income received from canal tolls. Thus, SCA wishes to maximize the throughput of vessels, but also requires queueing delays to be held at an acceptable level. This paper quantifies both measures (throughput and delays), and illustrates how they are in conflict to some extent. The study is somewhat unusual in that it affords the opportunity to employ more than one OR technique (linear programming and queueing theory/simulation) in the quantification process. Some of the work reported was undertaken in a consultative capacity, and the remainder as part of an ongoing research programme.
  16. Hauser RJ, Beaulieu J and Baumel P, **Impact of Inland Waterway User Fees on Grain Transportation and Implied Barge Rate Elasticities**, *Logistics and Transportation Review*, 1985, 21(1) This study analyzes the effects of proposed waterway user charges on grain shipments. Two types of full-recovery user fees are included, a fuel tax and a segment-specific ton-mile tax. An interregional linear programming model is used in which cost coefficients of the base model are changed to reflect user-fee effects on barge rates. The model includes over 200 grain originating points to 67 domestic destinations and 15 export areas and from the port areas to 6 overseas regions. Rail, barge and truck loadings are estimated (including combination

- movements) with and without waterway user-fees. Implied demand elasticities for barge travel are estimated. Significant shifts in shipment patterns take place depending on the location.
17. Kerr GN, **Managing Congestion: Economics of Price and Lottery Rationing**, *Journal of Environmental Management*, 1995, 45(4)347-364.  
It is not uncommon for the carrying capacity for congestible facilities to be estimated before the allocation method is known. This paper shows how efficient capacity differs between two competing resource allocation mechanisms, one which is efficient (price) and one which is fair (lottery). The welfare theoretic implications of adopting lottery allocation rather than price allocation are illustrated from the perspectives of economic efficiency and the benefits obtained by resource users and suppliers. It is found that risk-neutral resource users will always prefer lottery allocation to price allocation. While price allocation is efficient, it is never in risk-neutral resource users' interests to have price allocation imposed. Conclusions are tested using a linear constant crowding demand function, in which case it is found that the efficient capacity for lottery rationing exceeds the efficient capacity where price is to be used to allocate a congestible resource. Objectives may be better met by joint use of allocation mechanisms, the implications of which are investigated using the linear demand model.
  18. Khisty CJ, **Waterway traffic analysis of the Chicago River and lock**, *Maritime Policy and Management*, 1996, 23(3)261-270.  
The vessel-carrying capacity of the Chicago River, Illinois, is restricted by a lock, separating the river from Lake Michigan. Currently, vessels passing through the lock experience long delays during summer months. An investigation and analysis of this system determined that although the system is now generally operating below capacity, the peak periods during summer weekends do approach capacity, and the situation is likely to deteriorate in the future. In addition, the river and lock have safety and traffic conflict problems that need attention. Recommendations to mitigate these problems are described.
  19. Lari AZ and Buckeye KR, **Evaluation of Congestion Pricing Alternatives in the Twin Cities**, *Transportation Research Record 1576*, 1997, 85-92.  
A congestion pricing study for the Twin Cities metropolitan area was conducted in 1995-1996 by the Minnesota Department of Transportation and the Metropolitan Council of Minneapolis and St. Paul (Twin Cities), with sponsorship by FHWA. The effort was designated a congestion pricing preproject study by FHWA. After an initial screening, 11 pricing options for the Twin Cities were considered. Five regionwide pricing options were ultimately evaluated in detail. Because of the need to understand the relationships and effects of various pricing options, it was necessary to develop and apply adequate evaluation criteria to those options. An evaluation matrix was created to help planners and decision makers make recommendations concerning the implementation of congestion

- pricing options and pricing features within those options that best meet identified objectives.
20. Logi F and Ritchie S, **Development and Evaluation of a Knowledge-based System for Traffic Congestion Management and Control**, *Transportation Research Part C*, 2001, 9(6)433-459.  
This paper describes a real-time knowledge-based system (KBS) for decision support to Traffic Operation Center personnel in the selection of integrated traffic control plans after the occurrence of non-recurring congestion, on freeway and arterial networks. The uniqueness of the system, called TCM, lies in its ability to cooperate with the operator, by handling different sources of input data and inferred knowledge, and providing an explanation of its reasoning process. A data fusion algorithm for the analysis of congestion allows to represent and interpret different types of data, with various levels of reliability and uncertainty, to provide a clear assessment of traffic conditions. An efficient algorithm for the selection of control plans determines alternative traffic control responses. These are proposed to an operator, along with an explanation of the reasoning process that led to their development and an estimation of their expected effect on traffic. The validation of the system, which is one of only few examples of validation of a KBS in transportation, demonstrates the validity of the approach. The evaluation results, in a simulated environment demonstrate the ability of TCM to reduce congestion, through the formulation of traffic diversion and control schemes.
21. Martinelli D and Schonfeld P, **Approximating Delays at Interdependent Locks**, *Journal of Waterway, Port, Coastal and Ocean Eng.*, Nov. 1995, 121(6)300-307.  
As with much of the nation's infrastructure, the inland waterway system is in critical need of expansion and repair. Many of the inland waterway lock and dam facilities have become major constraints to navigation due to increased traffic and facility deterioration, leading to costly delays. Because funds for lock and dam improvements are severely limited, comprehensive analysis methods are necessary to ensure efficient allocation of resources among the many proposed improvement projects. Unfortunately, lock and dams are often treated as independent facilities with regards to operations, when in fact, there are likely to be significant interdependencies between locks when considering lock improvements. In this paper, a method is developed whereby the delays of a set of interdependent locks may be calculated. By incorporating interdependencies into benefit calculations of lock improvement projects, a more comprehensive assessment of improvement priorities can be established.
22. Niemeier HM, **Regulation of Airports: the Case of Hamburg Airport - A View from the Perspective of Regional Policy**, *Journal of Air Transport Management*, 2002, 8, 37-48.  
There are currently divergent trends in the regulation of airports in Germany. While traditionally airports have been regulated by cost-based regulation, a price cap regulation for Hamburg airport has been implemented in 2000. Given the objectives of economic welfare and efficiency the paper argues that the old

system is inefficient and results in a misallocation of resources. Regulation should be reformed by capping prices. An independent regulator should be established. Regulatory reform should be combined with reforms to intensify competition such as slot auctioning, further privatization with cross-ownership controls and open skies.

23. Perakis AN and Li J, **Recent technical and management improvements in US inland waterway transportation**, *Maritime Policy and Management*, 1999, 26(3)265-278.

Over the last several years, the US inland waterway transportation industry has significantly reduced its fuel consumption and improved its efficiency, with the side effect of less fuel tax collected per ton of cargo carried, despite the increase in cargo traffic. Fuel tax revenues are used for rehabilitation and construction projects on the inland waterway system, hence the US Army Corps of Engineers, providing us with relevant data over the interval in question, asked us to investigate this surprising reduction, and determine the main technical and fleet management improvements that caused it. Our research involved both visits with most major US inland waterways fleets, interviews with their engineers and managers, as well as statistical analysis of the above data. Technical improvements (such as engine plant efficiency increases), lighter, stronger building materials (such as light steel), and improved designs for better hydrodynamics, were not as important compared to management improvements (such as the use of computer-aided monitoring systems and advanced telecommunications, optimized tow configuration and speed, and increased triangular trips as opposed to simple round trips with returns empty). In addition, the demand for less expensive, imported steel for the US has resulted in an increased percentage of fully loaded return trips from New Orleans to the US Midwest, and hence also in increased fleet utilization.

24. Pfliegl R, **Innovative Application for Dynamic Navigational Support and Transport Management on Inland Waterways: Experience From a Research Project on the Danube River**, *Transportation Research Record 1763*, 2001, pp. 85-89.

The widespread use of inland waterways as a common transport mode is a main objective of European traffic policy, specifically in view of the expected dramatic increase in transport along the Trans-European Network, a main economic lifeline in Europe. Transport operators' limited acceptance of the inland waterway reflects unreliable calculations of estimated time of arrival, shifting water levels or other environmental events, unexpected delays in passing locks and borders, and insufficient transport monitoring capability. Implementing a telematics-based river information service will help to alleviate waterway transportation problems on the Danube River early in the day and improve the safety and productivity of transportation by integrating river-based transport information services with the intermodal transport chain. The proposed system meets the requirements of the Supreme Shipping Authority of Austria to generate a tactical and strategic traffic image on the Danube in Austria to fulfill its legal commitments to ensure safe and

secure transport operations on the Danube. Communications interfaces will link the Austrian network connecting other users downstream as well (e.g., Hungary, Slovakia). Traffic information services will be provided to ship operators, ship owners, and transport operators carrying people and goods. The system consists of a transponder-based network using radio links embedded in a wire-based communications network on shore controlled by central management facilities providing tactical traffic information on a geographic-information-system-based application. A separate system and network management unit will ensure safe operations with a low failure rate, depending on the level of redundancy implemented. The overall system concept uses the results and provisional standards defined in the European Union project Inland Navigation Demonstrator for River Information Services.

25. Quiroga CA, **Performance measures and data requirements for congestion management systems**, *Transportation Research Part C*, 2000, 8, 287-306.  
Many metropolitan areas have started programs to monitor the performance of their transportation network and to develop systems to measure and manage congestion. This paper presents a review of issues, procedures, and examples of application of geographic information system (GIS) technology to the development of congestion management systems (CMSs). The paper examines transportation network performance measures and discusses the benefit of using travel time as a robust, easy to understand performance measure. The paper addresses data needs and examines the use of global positioning system (GPS) technology for the collection of travel time and speed data. The paper also describes GIS platforms and sample user interfaces to process the data collected in the field, data attribute requirements and database schemas, and examples of application of GIS technology for the production of maps and tabular reports.
26. Ronen D, **The Effect of Oil Price on the Optimal Speed of Ships**, *Journal of the Operational Research Society*, 1982, 33, 1035-1040.  
The tradeoff between fuel savings through slow steaming on the one hand, and the loss of revenue due to the resulting voyage extension on the other hand is analyzed, and three models for the explicit determination of the optimal speed of a ship are presented. Each model is applicable under different schedule of revenues, and the optimal speed is a solution to a cubic equation over the feasible range of cruising speeds.
27. Ronen D and Nauss R, **Upper Mississippi River and Illinois Waterways: How to Reduce Waiting Times of Vessels While Using the Current Infrastructure**, Center for Transportation Studies, University of Missouri-St. Louis, February 2003.  
The variability of lockage times, not the length of time it takes tows to get through locks, is one of the primary reasons for delays in the Upper Mississippi River and Illinois Waterways system. Reducing the variability of arrivals at locks as well as the variability in service times could speed up the entire system and result in reduced numbers of tows waiting in queues at locks. This paper recommends

- further investigation of non-structural measures to alleviate waterway traffic congestion.
28. Southworth F, *Analysis of Lock Transit Curves Options For Use in Modeling Upper Mississippi and Illinois River Locks*, Oak Ridge National Laboratory, 2002.  
The purpose of the analysis described in this report was to assess the accuracy and robustness of two simplified lock transit time estimation methods for use in the economic analysis of Upper Mississippi and Illinois River lock improvements. As such, the study is part of a larger effort to estimate the dollar savings to shippers from the provision of a navigable waterway along the Upper Mississippi and Illinois Rivers. This larger study has been charged with analyzing river traffic by using the US Army Corps of Engineers (USACE) Tow Cost – Equilibrium (TCM/EQ) modeling system to simulate annual flows up and down these two rivers, including the passage of tows through locks. Accurate and robust lock transit time estimates are crucial to such a study, because traffic congestion at locks can cause significant and costly delays to tows.
29. Tellis R and Khisty CJ, **Social Cost Component of an Efficient Toll**, *Transportation Research Record 1576*, 1997, 140-146.  
Efficient tolls are tolls that ensure that the price paid by the roadway user is equal to the increment of social and private costs resulting from the highway use. Setting these tolls accomplishes an important objective: to correct the current practice that allows driving to be subsidized by government and non-users. Without restrictions on vehicle ownership and unlimited access to the nation's cost-free roadways, drivers do not pay for the social costs they generate. If motorists were required to pay their fair share of these social costs, travel decisions would probably be altered. Unwarranted trips, especially during peak hours, would be reduced because roadway space would be priced to accurately reflect the actual cost of driving. Beyond private costs, society is burdened with paying for infrastructure construction and maintenance, highway services, wasted fuel, pollution, accidents, and congestion costs from travel delays. The cost to society of automobile travel is assessed so that a charge can be made for the social cost component in computing what an efficient toll should be. It is found that the social cost fee during non-peak travel comes to 0.67¢/vehicle-km (1.08¢/vehicle-mi). Travel during peak periods is far more expensive with the addition of congestion costs. The value of time drives up these costs, and the charges amount to 5.68¢/vehicle-km (9.14¢/vehicle-mi) for peak-period travel.
30. Ting CJ and Schonfeld P, **Efficiency Versus Fairness in Priority Control: Waterway Lock Case**, *Journal of Waterway, Port, Coastal & Ocean Eng.*, March/April 2001, 127(2) 82-88.  
Delay at a congested service facility, such as a waterway lock, depends on the control policy used. The shortest processing time first (SPF) policy, which is a promising priority control policy, can significantly reduce the average delay/barge compared to the normally used first come first served (FCFS) policy. SPF tends to

- favor large groups of barges, i.e., tows, at the expense of smaller ones. This paper modifies the SFP policy to consider fairness among tows in queues. One modified algorithm, called fairer SPF (FSPF), limits the number of tows allowed to pass any particular tow. The case study indicates that FSPF can yield most of the benefits of SPF without greatly sacrificing fairness.
31. U.S. Army Corps of Engineers, *Upper Mississippi River – Illinois Waterway System Navigation Feasibility Study: Final Integrated Feasibility Report and Programmatic Environmental Impact Statement*, September 2004, 705 pages. Found in two separate volumes in the past, this document combines the Upper Mississippi River-Illinois Waterway System Navigation Feasibility Study and the Environmental Impact Statement. This document outlines improvements for the waterway for the future, specifically addressing navigation efficiency alternatives ranging from small-scale, non-structural measures to the construction of new locks. The study recommends new lock construction as necessary to support anticipated levels of future waterway traffic. Some small-scale measures, such as mooring cells, switchboats, and an appointment scheduling system should be explored for use until large-scale measures are in place.
  32. U.S. Army Corps of Engineers, *Upper Mississippi River - Illinois Waterway System Navigation Study: Summary of Small-Scale Measures Screening (Interim Report)*, April 1999, Rock Island, St. Louis, and St. Paul Districts. The Upper Mississippi River—Illinois Waterway System Navigation Study (Navigation Study) is a feasibility study addressing navigation improvement planning for the Upper Mississippi River and Illinois Waterway (UMR-IWW) systems for the years 2000-2050. This study assesses the need for navigation improvements at 29 locks on the Upper Mississippi River and 8 locks on the Illinois Waterway and the impacts of providing these improvements. More specifically, the principal problem being addressed is the potential for significant traffic delays on the system within the 50-year planning horizon, resulting in economic losses to the Nation. The study will determine whether navigation improvements are justified, and, if so, the appropriate navigation improvements, sites, and sequencing for the 50-year planning horizon. The feasibility study also includes the preparation of a system Environmental Impact Statement (EIS). The goal of this interim report is to summarize the entire process of identifying and screening the small-scale measures, leading up to the selection of a final set for use along with large-scale measures in developing alternative plans. However, the final product of the System Navigation Study is the feasibility report, which will constitute the decision document for processing to Congress. Small-scale measures are navigation improvements of smaller scope than constructing a new lock or extending the existing lock chamber. The process first identified a universe of 92 potential small-scale measures that might improve system efficiency. The items were then qualitatively screened to select those measures most suitable for further detailed analysis. The first two steps are presented in greater detail in the *General Assessment of Small Scale Measures* report dated June 1995. Following the selection a smaller group of the most

- promising measures, the *Detailed Assessment of Small Scale Measures* (December 1998) was conducted to quantify the costs, performance, and impacts of the measures. The additional information provided the necessary details for a final secondary screening summarized in this report. The five measures remaining after this screening (guidewall extensions with powered kevels, switchboats with guidewall extensions, congestion tolls/lockage time charges, mooring facilities, and approach channel improvements) will be incorporated into the systemic analysis for use in developing alternative plans and the final evaluation and comparison of costs, benefits, and impacts.
33. U.S. Congressional Budget Office, *Paying for Highways, Airways, and Waterways: How Can Users Be Charged?*, May 1992, Congress of the United States, Washington, D.C.  
The methods of financing highways, airways, and waterways influence both the amount of revenue that can be raised and the efficient allocation of resources. The concept of revenue adequacy—whether revenues cover costs—is important to the cash-strapped federal government, but it also has implication for efficient allocation of resources in the long run. If the costs of an investment project cannot be recovered from those who use it, the project’s feasibility comes into question. But an investment that benefits society is worth making, even though it may not be possible to charge users for it. This often characterizes goods and services provided by the federal government, and it underlies the rationale for government rather than the private activity in certain sectors. Revenue adequacy can provide information about the demand by users for public investments, but it alone cannot be the criterion upon which investment decisions are made.
34. U.S. Department of Transportation, *Upper Mississippi River and Illinois Waterways: Non-Structural Measures Cost-Benefit Study (Draft)*, September 2003, Prepared for the U.S. Army Corps of Engineers, Mississippi Valley Division, by the John A. Volpe National Transportation Systems Center, 95 pages.  
In this report, the Volpe Center examined the issue of non-structural measures to improve the efficiency of the Upper Mississippi River and Illinois Waterways. The report specifically addressed excess lockage time fees and tradable permits. The Center concluded that excess lockage time fees would prompt barge operators to install better line handling equipment on barges and improve personnel training or simply pay the fee, both options generating a modest net benefit. The Center also concluded that tradable permits, as part of a scheduling system, were “infeasible” on the Upper Mississippi River and Illinois Waterway navigation system given the nature of service on the waterway.
35. U.S. General Accounting Office, *Factors to be Considered in Setting Future Policy for Use of Inland Waterways*, 1975, Report to the Congress by the Comptroller General of the US, Washington, D.C., 58 pages.

This report presents factors which the Congress will need to consider in establishing a national policy for funding inland waterways improvements and operations and in considering proposals for imposition of waterways user charges.

36. Wei CH, Dai MDM and Schonfeld PM, **Computational Characteristics of a Numerical Model for Series of Waterway Queues**, *Transportation Research Record 1333*, 1992, pp. 45-54

A numerical method has been developed for estimating delays on congested waterways represented by series of G/G/1 queues (i.e., with generally distributed arrival and service times and one chamber per lock). It is based on a metamodeling approach that develops simple formulas to approximate the results of simulation models. The functional form of the metamodels is derived from queueing theory, whereas their coefficients are statistically estimated from simulation results. The algorithm scans along a waterway and sequentially estimates at each lock the arrival distributions, departure distributions, and delays. It can be applied to systems with two-way traffic through common bidirectional servers as well as to one-way traffic systems. Computational results are presented to illustrate the speed and convergence properties of the algorithm and to investigate some of its variants. The algorithm works satisfactorily and flexibly with different convergence criteria and scanning processes. For an illustrative 20-lock system, parameter estimates converge with five iterations and less than 3 sec of CPU time to differences lower than 0.1% between successive iterations. The computation time increases only linearly with the number of locks in the system, thus allowing the analysis of very large systems of interdependent queues.