The following list of reports was generated from a TRID search performed by a Senior Librarian in Transportation Research Information Services, Transportation Research Board, National Academies of Sciences, Engineering, and Medicine in March 2019.

**Ports and Terminals**

**Detection of Ships at Mooring Dolphins with Hidden Markov Models** 2019
The Port of Amsterdam has attached sensors to the poles and the plates, which measure changes in the dimensions regarding the mooring dolphins. This report explores whether combining sensor data from the IJpalen and automatic identification system (AIS) data can produce beneficial insights into the dolphins' states.

**Can Game Theory Improve Compliance Rates to Sulfur Regulation?** 2019
The purpose of this paper is to develop a game theoretic modelling framework that improves the effectiveness of sulfur regulations enforcement. The existing legislative framework poses several challenges, stemming (mainly) from a highly non-homogeneous and spatially differentiated system, with cases where the penalty fines are as low as the benefit that the violator enjoyed from not complying. This paper presents the status quo of enforcement in different countries, where the regulation applies, and develops a game theoretic approach for a uniform violation fine system. A discussion on the implications of the global sulphur cap of 2020 concludes this paper with recommendations for transferability of this framework to other regulations are provided.

**Modelling Incentive Strategy of a Multi-Layer Cruise Supply Chain**. TRB 98th Annual Meeting, Transportation Research Board, 2019, 6p
With the support of the detailed berthing and operation agreements at company and/or port level, a game theoretical framework based on the Stackelberg model is proposed to capture the hidden information in the operation of a multi-layer cruise supply chain. Three major players - cruise port, cruise line, and the supplier - would make sequential moves based on the dominant position in the cruise operation in different stages. Cruise line is the critical element in the supply chain to bride cruise port, where the loading/unloading process is, and the supplier, who provide logistic services and work closely with local ship chandlers. In the first stage, the cruise port focusing on the greater good for the cruise community chooses to maximize passengers and/or to attract long-term contracts with the cruise company through possible subsidy. In the second stage, while negotiating passenger guarantee in the operating contract with the port, cruise line maximizes profit/revenue at the consideration of incentives. At stage three, a supplier with price-sensitive demand in the end market provides on-board necessities for the cruise line is introduced. Flexibly and reliability are examined in the chain in the process of fulfilling purchase orders of on-board consumables in emergency. The authors find that with incentive mechanism in terms of cash rebate and discount works better than penalty in most of the scenarios to improve the overall quality and reliability of the entire cruise supply chain.

**A Multi-Regime Vessel Trajectory Reconstruction Model for Ships in Port Waters Using AIS Data**. 97th Annual Meeting, 2018, 7p
AIS data plays an increasingly important role in collision avoidance, risk evaluation, and navigation behavior study. However, the raw AIS data contains noise that can result in wrong conclusions. The authors propose a multi-regime vessel trajectory reconstruction model which includes three steps, including (i) outliers removal, (ii) ship navigational state estimation and (iii) vessel trajectory fitting. This model can reconstruct the vessel trajectory in different navigation states, namely hotelsing, maneuvering, and normal-speed sailing. The normal-speed navigation trajectory is estimated with a spline model, which can fit any types of the trajectory even with circles. Then, the proposed model is tested and compared
with other three popular trajectory reconstruction models based on a large AIS dataset containing the
movement of more than 500 ships in Singapore Port. The results show that the proposed model performs
significantly better than the linear regression model, polynomial regression model, and weighted
regression model. The proposed model can decrease the abnormal rate of speed, acceleration, jerk and
ROT (Rate of Turn) from 43.42%, 10.65%, 59.25%, 50.33% to 0.00%, 0.00%, 17.28% and 15.81%,
respectively. More importantly, the navigational behavior, such as turning operation which is extremely
important in risk study, could be clearly shown in the trajectory reconstructed by the proposed model.

Leveraging the Value of Land and Landside Access to Fund Port Infrastructure in Texas. Transportation
Research Record: Journal of the Transportation Research Board, Volume 2672, Issue 11, 2018, pp 41-52
This paper introduces port authority transportation reinvestment zones (TRZs), a funding tool created by
the Texas Legislature to help fund long-term economic development port projects. TRZs were first
introduced in Texas in 2007 as a tool to allow county and municipal governments to raise funds to help
pay for transportation improvements using the property tax mechanism. Since then, the legislation has
been amended to include other transportation modes, such as transit, rail, and parking facilities.
Amendments passed in 2013 introduced the concept of port authority TRZ, which expanded authorized
use of the tool to the state’s port authorities and navigation districts. Most of the existing funding tools
available to Texas ports focus on the development of infrastructure within port property. Port authority
TRZs complement existing funding sources by providing a funding tool flexible enough to fund port
projects both inside and outside port property. Port authorities can take advantage of the TRZ concept to
join forces with neighboring local governments and the Texas Department of Transportation to fund
landside transportation enhancements that improve port accessibility and the regional economy.
Currently, there are four active port authority TRZs in the following locations: Port of Beaumont, Port of
Port Arthur, Port of Brownsville, and Sabine-Neches Navigation District. This paper summarizes the legal
framework of port authority TRZs, describes the role that these TRZs play in port funding and finance,
and presents highlights of the port authority TRZs that have already been established throughout the
state.

The Impact of Port State Control on Ship Accident Using Bayesian Network Analysis TRB97th Annual
Meeting, 2018, 15p
Ship accident has always been the focus of research in shipping industry. This study tries to investigate
the impacts of the inherent attributes of ships and the port state inspected deficiencies on ship accidents
so as to evaluate the impact of port state control (PSC) on accident. It develops several Bayesian Network
models using data obtained from Lloyd's register of shipping, International Maritime Organization and
Tokyo Memorandum of Understanding. The models are then estimated using Greedy thick thinning (GTT)
and Bayesian search (BS) algorithms and the optimal model is chosen through comparison using four
different validation tools. The results show that the impacts of the port state inspected ship deficiencies
on the ship accident along with the inherent attributes of the ship. It also indicates that most of the PSC
deficiencies will affect the probability of accident indirectly. This suggests that it is possible to check the
key defect items and decide whether to carry out other inspections for other items in a port. This will
reduce the ship's inspection time, optimize the port country's inspection system, and improve inspection
efficiency.

Underkeel Clearance Reliability Model for Dredged Navigation Channels. Transportation Research
Record: Journal of the Transportation Research Board, Issue 2611, 2017, pp 41-49
This paper presents a reliability measure for selecting marine navigation channel maintenance depth.
Resource constraints have resulted in dredging requirements outpacing the funds available to the U.S.
Army Corps of Engineers to perform navigation channel maintenance dredging, but navigation managers
lack a method to objectively select maintenance depth alternatives to authorized project depths. The
reliability of a navigation channel can be determined as the probability that a vessel's net underkeel
clearance is greater than or equal to 0. Net underkeel clearance was hindcast from underkeel clearance
contributors that include sailing draft, water level, bathymetric elevation, vessel squat, and wave
response. This method was tested in Charleston Harbor, South Carolina, with an authorized depth of 45 ft. (13.7 m). The harbor includes two-way container, tanker, roll on–roll off, and passenger traffic with maximum drafts exceeding design depth. Vessel squat in transit is calculated on the basis of vessel speed, obtained from Automatic Identification System (AIS) data and a representative block coefficient based on vessel size and type. This study used archival AIS data, bathymetric surveys, observed water level elevations, and information collected by vessel pilots to calculate net underkeel clearance of vessel transits through each dredged location within the harbor in 2011. It was determined that channel reliability ranged from 98.7% to 100%. Channels with 100% reliability had minimum net underkeel clearance between 1.0 ft. (0.3 m) and 8.3 ft. (2.5 m). The approach provides a potential method to select maintenance depth alternatives to authorized channel depths that may result in maintenance cost savings that arise from avoided dredging and associated material management costs.


With the growing number of ships, emissions from the shipping industry now rank as one of the three major sources of air pollutants. This has aroused the concern of more and more countries and international organizations. To control shipping emissions, three ship emissions control areas (ECAs) have been set up in China. This study first evaluates the effectiveness of the ECA designed to reduce sulfur dioxide (SO2) emissions in the Shanghai, China, port area, and then estimates carbon dioxide (CO2) emissions reduction by regarding the ECA as a reduced speed zone by using container ships’ data. The case study of the port of Shanghai finds that for the year 2020, a reduction in SO2 emissions by at least 103,998.17 tons can be achieved with the 12-nmi ECA of Shanghai port, CO2 emissions can be reduced by 827,733.64 tons with a 12-knot speed limit in the 12-nmi ECA, and an additional SO2 reduction of 522.23 tons can be achieved by slow steaming within the ECA. The results also show that adoption of a shoreside power supply system can lead to a remarkable reduction of all the air pollutant emissions inventories. The positive effect of emissions reduction is much more significant than the extra costs incurred by ship operators and ports. The goal of reductions in emissions to improve the air quality of port areas could be achieved through adopting these "green" port policies in the future.


In transport, the problem of demand exceeding capacity often occurs with congestion as a result. The resulting delays impose substantial efficiency loss. Price discrimination by peak load pricing is a well-recognized way of handling the problem. Such schemes are, however, often politically controversial because they might disadvantage vulnerable groups of passengers. An alternative is the use of a priority scheme. In this paper, a framework positioned within the traditions of cost–benefit analysis is established to examine the welfare effects of granting one group of passengers’ priority on transport modes characterized by limited capacity and low frequency. The case is a trial arrangement initiated at a rural car ferry crossing in Northern Norway intended to ensure that local commuters (traveling to and from work) can board for the desired departure. With respect to pricing, road authorities have a stated objective that fares and discounts at ferries be equal throughout the nation. Hence, for local political authorities to ensure local commuters a predictable transport alternative by price discrimination is neither desirable nor legal. The empirical evidence demonstrates that loss of social welfare caused by congestion problems at a port can be potentially reduced by introducing such a priority scheme. Recommendations are provided in relation to the number of users required for the priority arrangement to render a positive net benefit for society. This ex ante information is useful for policy makers when they are evaluating whether to initiate such priority schemes to reduce efficiency loss in passenger transport markets.

Evaluating the Role of Resilience in Recovering from Major Port Disruptions. TRB 96th Annual Meeting, Transportation Research Board, 2017, 14p

Ports play a critical role in a nation’s economic system. The impact of a major port disruption can reverberate across the entire economy through regional and national supply-chains. This paper develops
an analytical framework to estimate the total economic consequences of port disruptions and illustrates its usefulness in a case study. Various types of resilience tactics on both the supplier-side and customer-side are formally integrated in the economic consequences analysis. The Enormous Regional Model (TERM) multi-regional computable general equilibrium model is adapted to analyze the economic consequences and the effects of various resilience tactics of a major disruption to the adjacent Ports of Los Angeles and Long Beach that lasts one year. The modeling results indicate that without the consideration of port and economic resilience, the disruption scenario could cause total gross domestic product (GDP) losses of over $12 billion in California and $16 billion at the national level. However, resilience can reduce these impacts by about 80% for California and over 90% for the nation as a whole. Major resilience tactics on the supplier-side are ship re-routing and export diversion for import use. Major resilience tactics on the customer-side are use of inventories and production recapture.


The explosive economic growth in China has spurred interests in one of the oldest, most economic transportation mode, inland waterway transportation in recent years. As economic growth, logistic distributions, and passenger movements are demanding more and more transportation capacity, the need for maximize throughput or optimizing operations along inland waterways, especially access to ports, becomes urgent. This manuscript documents an optimization model that is based on ship domain theory and tidal water characteristics along the time domain. The optimization model not only incorporates physical properties of the navigation channel but also take regulation compliances, safety standards, and economic returns into consideration. Applying the optimization model to the operations of an inland waterway in the lower range of Yangtze River, Funan Channel, researchers have demonstrated that the optimized, hybrid operations will not only increase the throughput measured in Cargo Load, but also improve safety and management of the port.

Inland Rivers

Route Choice Model in Inland Waterway Network: A Case Study in China. TRB97th Annual Meeting, 2018, 8p

Using the data in a part of a waterway network in Southern China, this paper presents a hybrid model to analyze the route choice behavior in this inland waterway network based on the Discrete Choice Model. Fuzzy Logic and Factor Analysis are introduced to process the attributes of the available alternatives. Fuzzy Logic is used to describe the qualitative variables by transforming them into fuzzy values. Factor Analysis is used to deal with these variables to mine the potential factors, simplify the model and avoid the redundancy of information. A computer program is developed to simulate the traffic flow in the study region based on the model. The simulation demonstrates that the model can well reproduce the traffic flow, including waiting time, and can be applied to study the capacity of the network.

Stimulating Inland Waterway Transport Between Seaports and the Hinterland from a Coordination Perspective. TRB 97th Annual Meeting, 2018, 5p

With the trend towards less-polluting and sustainable transport solutions, the European Commission aims to strengthen the competitive position of inland waterway transport, and to facilitate its integration into synchromodal logistic chains. To stimulate inland waterway transport, it is essential to ensure smooth containers transshipments from seaports to hinterland and vice versa. Currently, inland vessels usually spend unnecessary long times in the port area due to insufficient terminal and quay planning with respect to the sailing schedules of the vessels. Coordination among multiple vessel operators and multiple terminal operators is required to improve the efficiency and reliability of inland vessels transport within the port. For this, four recently proposed classes of coordination strategies from the authors' earlier work are reviewed. Two levels of cooperativeness, including partially-cooperative and fully-cooperative, as well as two types of interaction, including single-level and multi-levels are considered. The proposed coordination strategies are compared and evaluated from a methodological perspective and from an
information needs perspective. The results provide insights for vessel and terminal operators in the ways in which they can cooperate with each other: vessel operators can decide to what extent they would like to coordinate their actions based on the information requirements of each coordination strategy; terminal operators can estimate information that should be made available during different coordination phases. Moreover, the results also provide insights for policy makers or practitioners to determine the most suitable coordination strategy under different circumstances.

**Semantic Model of Inland Ship Behavior Based on Ontology Engineering.** TRB 97th Annual Meeting, 2018, 6p

Ship behavior is critical for the safe operation of marine transportation, especially inland waterways. With the increasing availability of Automated Identification System (AIS) data and modern communication technology, large amount data from multiple sources may be gathered and analyzed to understand ship behavior. Given the complexity associated with dynamic ship behavior patterns and magnitude of big data, the ship behavior cannot be fully expressed based on the raw data itself. So it’s necessary to find a way to reveal the true meanings of collected data and overcome the semantic gap between data and human cognition. In this manuscript, the authors applied ontology engineering principles in developing a semantic model of inland ship behavior with multiple levels of interrelated semantic networks. After defining cognitive ship behavior and event, authors analyzed semantics of ship behavior from trajectory to sub-trajectory, then to trajectory points, which are the basis of semantic model. A case study using inland ship along the Yangtze River in China is documented to test and validate the model.


This paper introduces a framework to monitor and predict the occupancy of mooring space in harbors for medium sized inland shipping vessels, using the Automatic Identification System or AIS. Research was conducted on AIS data from 2015 and 2016 at the Houthavens: a small harbor basin, which is mainly used for Barges and other inlands shipping vessels. Photographs of the Houthaven were used as ground truth. AIS data can be inaccurate. Positions are often off by several meters and the emitted speed is higher than zero while the ship is in fact moored. Another problem is that the AIS can be switched off. At night or when leaving their vessels, shippers often switch off all electronic devices. AIS is also switched off because of privacy considerations or to evade harbor dues. To handle these issues, various solutions are proposed: The speed must be lower than one knot, sudden changes in locations or implausible speeds are filtered, an area outside the Houthaven is monitored and the stay time must be at least 30 minutes. In this way, it was possible to reach a 100% accuracy in predicting mooring space occupancy. Two methods are proposed to predict future occupancy: the use of an empirical Markov model and parametric Markov model. Although these systems seem promising for predicting the state of the harbor a few hours in the future, more data could be used to analyse trends. Applications could be planning and decision making or applications for shippers to plan for mooring.


Description: The United States freight transportation network is one of the great strengths of the country. The system moves 55 million tons of goods worth more than $49 billion each day. In addition, freight supports 44 million jobs. Yet, the dynamics of freight movement are changing, driven by factors such as e-commerce and global demand. Planning, programming, implementing and maintaining adequate freight infrastructure remains a challenge for transportation agencies. As state departments of transportation (DOTs) integrate freight prioritization processes into agency practices and increase efficiency in addressing these considerations, many are also seeking guidance and resources that demonstrate effective approaches. As a result, there is substantial opportunity to share and leverage effective practices within various areas of freight investment analysis and methodology from across the country.
Freight investment project prioritization approaches increasingly underpin planning and programming decisions. However, these approaches can differ widely by State DOTs. The objective of this research project is to synthesize existing freight project prioritization practices. Information to be gathered will include, but not be limited to:

1. What freight assets do State DOTs own?
2. How do State DOTs prioritize investments for those facilities?
3. How are agencies prioritizing freight projects within a broader multimodal prioritization framework?
4. What data sources are being used in the prioritization process? What data gaps exist?
5. How are agencies incorporating freight performance measures into the prioritization process?
6. What is the decision making process? What are the factors influencing the prioritization?
7. How are agencies organized to support freight investment decisions (e.g. agency leadership and staff, internal/external committees and agencies, coordination across modes, timing)?
8. What institutional barriers are State DOTs facing when integrating freight into the project prioritization process? Information will be gathered through a literature review, a survey of State DOTs, and no less than six concise case studies that highlight different freight project prioritization approaches. The product of this research will be a report that provides an overview of the current state of freight investment prioritization and methodology. As well, this study will identify gaps in project prioritization practices, gaps in knowledge, and research needs.

Agent-Based Model of Navigable Inland Waterway Tow Operation Procedures. Transportation Research Record: Journal of the Transportation Research Board, Issue 2611, 2017, pp 11–18

Transportation modeling within the context of extreme weather events induced by climate change is critical to understand and improve the resilience of transport systems as the world moves further into the 21st century. Among transportation modes, navigable inland waterways in particular face severe challenges to their future reliability as a result of extreme weather events. The economic implications of inland waterway operational efficiencies on commercial shipping have been studied in detail for several decades. Less well understood, however, are the effects of tow operation procedures enacted during adverse river conditions that have resulted from extreme weather events. This paper describes a model of a waterway segment that simulates stakeholder decision making and tow operator behavior to provide stakeholders with insights into the possible benefits of waterway action plans as operational guidance documents. Simulations run for a test area of the navigable inland waterway system indicated that operational procedures recommended in waterway action plans might have a significant impact on waterway operational efficiencies, which suggests that the model may be a useful decision-support tool for waterway stakeholders.

Analysis of Seasonal Variation of Upper Mississippi River Towboat Traffic. TRB96th Annual Meeting, Transportation Research Board, 2017, 14p

The Upper Mississippi River (UMR) traffic is unsteady due to freezing in winters as well as seasonal variation in demand for transporting commodities. This study quantifies the effects of the UMR traffic seasonality, using Lock Performance Monitoring System (LPMS) and Operations and Maintenance of Navigation Information (OMNI) databases. The research shows that towboats which serve most peak-period lockages of the UMR system shift to some extent to the Illinois and Ohio Rivers during the UMR off-peak. No such significant seasonal shift to other rivers is observed. This study supported the development of US Army Corps of Engineers’ navigation system simulation (NaSS) model by providing practical information about towboat use in the U.S. inland waterway network.


The explosive economic growth in China has spurred interests in one of the oldest, most economic transportation mode, inland waterway transportation in recent years. As economic growth, logistic distributions, and passenger movements are demanding more and more transportation capacity, the need for maximize throughput or optimizing operations along inland waterways, especially access to ports, becomes urgent. This manuscript documents an optimization model that is based on ship domain...
theory and tidal water characteristics along the time domain. The optimization model not only incorporates physical properties of the navigation channel but also take regulation compliances, safety standards, and economic returns into consideration. Applying the optimization model to the operations of an inland waterway in the lower range of Yangtze River, Funan Channel, researchers have demonstrated that the optimized, hybrid operations will not only increase the throughput measured in Cargo Load, but also improve safety and management of the port.

**Modeling and Optimization of Barge Shipping.** TRB 96th Annual Meeting, Transportation Research Board, 2017, 18p

Barge transportation is a cost-effective approach to transport cargoes between ports along a river such as the Rhine. This is particularly true for the collection and dissemination of cargoes between a major sea port and the usually smaller inland ports located along the river. Under the current low carbon trend in the society, barge transport has evident advantages over trains and trucks. In this paper, the authors address a barge scheduling problem by developing a mathematical model and an exact optimization algorithm.

**Economic Analysis of Inland Waterway Transport Chain Based on Multinomial Logit Model.** TRB 96th Annual Meeting, Transportation Research Board, 2017, 13p

The primary goal of this study was to determine appropriate policies to increase the proportion of freight transported by water on the Hangyong (Hangzhou-Ningbo) canal, thus improving the economic efficiency of the canal. The appropriateness of the policies depends on the preferences of shippers. This study examined Hangzhou-to-Ningbo shipping container usage. Factors such as the transportation chain time and cost, the characteristics of the shippers (number of employees and annual freight tonnage), and the value of the freight were used to construct a transportation chain utility function. Through surveys, data on shipper choices for transportation were obtained to model the decision process. Multinomial logit and mixed logit models were used to model decisions. The most suitable model was selected according to the level of significance of the estimated parameter values. It was determined that the transportation chain time and cost are the most significant factors in the decisions of Hangyong canal freight shippers. To show the heterogeneity in the choices of shippers, a mixed logit model with random parameters and a restricted triangular distribution was constructed. However, the overall accuracy of this model was not significantly better than that of the multinomial logit model, so the simpler and intuitive multinomial logit model was selected. The marginal rates of substitution between the characteristic variables were assessed. It was determined that the time value of all shipping in the Hangyong channel was 52.50 Chinese Yuan/(TEU-hour) (where TEU is twenty-foot equivalent units). The modal share of the waterway transport chain, particularly the chain using 500 DWT (deadweight tons) ships, gradually increases as the channel capacity is increased. Furthermore, the effect of the transportation time on the 500 DWT ship waterway transportation chain is much higher than that of the transportation cost. The increase in waterway modal share resulting from reductions in transportation time is approximately seven times that resulting from reductions in transportation cost of the same percentage. Moreover, for the same policy options, the changes in the modal share of 500 DWT/24 TEU ships and 300 DWT/16 TEU ships are very similar; that is, the competitiveness of the two ship types is very similar. Furthermore, the competitiveness of 500 DWT/30 TEU ships is higher than that of either of the smaller types.

**Costs**

**Economic Analysis of Inland Waterway Transport Chain Based on Multinomial Logit Model.** TRB96th Annual Meeting, Transportation Research Board, 2017, 13p

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**Transportation Research Record: Journal of the Transportation Research Board, Issue 2611, 2017, pp 19–31**

Intermodal container transportation is a growing market for soybean exports in the United States. In an effort to understand the optimal strategies for improving the United States' economic competitiveness in this emerging market, this research developed a detailed, multimodal transportation cost analysis model focusing on U.S. soybean container shipments. By using mode-specific transportation network and cost information, the model estimated and compared the "point-to-point" supply chain costs of alternative shipment routes from a domestic production site to a foreign port. For each candidate route, the analysis estimated the transportation time, distance, and cost of each modal segment. This cost analysis model is a building block for a larger research effort that aims to develop strategies to improve freight transportation infrastructure and operations in the context of existing and potential changes in the transportation industry and global market.

**Accounting for Fleet Management in Inspection of Towing Vessels Final Rule Cost Estimations: An Illustrative Example of the Importance of Capturing the Status Quo.** TRB 96th Annual Meeting, Transportation Research Board, 2017, 11p

Cost-benefit analysis is an important tool for both the public and private sectors to compare the outcomes of potential projects, decisions, or policies, and to choose the option that maximizes net benefits for stakeholders. However, the accurate estimation of the outcomes of a potential action can easily become confounded by an incomplete understanding of the status quo: of the way things currently are. Federal agencies performing cost-benefit analysis refer to building this understanding of the status quo as "forming the baseline." This paper illustrates the importance of properly forming the baseline by examining the effect of fleet management practices on the cost estimation for the Coast Guard’s Inspection of Towing Vessels Final Rule, which published in 2016.


In July 11, 2017, the National Academies of Sciences, Engineering, and Medicine Committee on Polar Icebreaker Cost Assessment released a letter report that advises the U.S. Congress on strategies to minimize life-cycle costs of polar icebreaker acquisition and operations. The Committee recommends the
number and type of polar icebreakers to fund and an acquisition strategy that achieves a lower cost. The Committee developed an independent cost estimate using available concept designs to determine if the U.S. Coast Guard’s (USCG) existing cost estimates for heavy and medium icebreakers are reasonable. It also compared operating costs of the current fleet to the prospective operating costs of new vessels. The Committee recommends a science-ready design for the new icebreakers and the use of an enhanced maintenance program to ensure continuity of operations for existing icebreakers. This letter report is mandated by the Coast Guard Authorization Act of 2015, and sponsored by the USCG.

Vessel Scheduling in Liner Shipping: A Multi-Objective Optimization Model for a Comprehensive Analysis of the Conflicting Objectives. TRB97th Annual Meeting, 2018, 7p

The international seaborne trade volumes have been continuously increasing over the last years. Many liner shipping companies started consolidation to form stronger alliances and attract new customers. In order to remain competitive and avoid potential monetary losses liner shipping companies have to improve efficiency of their vessel schedules. Some of the decisions that have to be made by liner shipping companies are conflicting in their nature. However, the existing vessel scheduling models generally combine the conflicting objectives into one objective function, which aims to minimize the total route service cost. Such approach imposes limitations for liner shipping companies in the analysis of tradeoffs between the conflicting objectives. To avoid the latter drawback this study proposes a multi-objective mixed integer nonlinear optimization model for the vessel scheduling problem, which accounts for all major route service cost components reported in the literature and separates them in two conflicting groups. The original mixed integer nonlinear model is linearized by discretizing the vessel sailing speed reciprocal, and the Global Multi-Objective Optimization Algorithm is developed to solve the linearized model. A set of numerical experiments are conducted for the Asia-Mediterranean Express Service liner shipping route. Results demonstrate that negotiation of both vessel service time windows and handling rates between liner shipping companies and marine container terminal operators may significantly reduce the total route service cost components.

The Profit Maximizing Liner Shipping Problem with Variable Frequencies. TRB 97th Annual Meeting, 2018, 5p

The literature on liner shipping is rich with many models on the problem of optimizing containership speed, frequently combined with fleet deployment, fleet size and mix, network design and other related facets of the problem. Many of these models assume a fixed frequency, typically one call per week. In this paper the authors consider service frequencies that belong to a broader set than the standard assumption of one call per week. This may conceivably yield better solutions. Models also typically assume a fixed revenue for the ship operator and usually minimize costs. This treatment ignores the freight rate’s influence upon the model’s results. In that sense, such models do not capture a fundamental aspect of shipping market behavior that ships tend to speed up in periods of high freight rates and slows down in depressed market conditions. This paper develops a simple model for a fixed route scenario which, among other things, incorporates the influence of freight rates, along with that of fuel prices and cargo inventory costs into the overall decision process. The objective to be maximized is the operator's average daily profit. Illustrative runs of the model are made on three existing services.


The U.S. Army Corps of Engineers (USACE) is responsible for the maintenance of federally authorized navigation channels and associated infrastructure. As such, USACE requires objective performance measures for determining the level of service being provided by the hundreds of maintained navigation projects nationwide. To this end, the U.S. Army Engineer Research and Development Center partnered with Texas A&M Transportation Institute to develop a freight fluidity assessment framework for coastal ports. The goal was to use archival automatic identification system (AIS) data to develop and demonstrate how ports can be objectively compared in relation to fluidity, or the turnaround time reliability of oceangoing vessels. The framework allows USACE to evaluate maintained navigation project conditions.
alongside port system performance indices, thereby providing insight into questions of required maintained channel dimensions. The freight fluidity concept focuses on supply chain performance measures such as travel time reliability and end-to-end shipping costs. Although there are numerous research efforts underway to implement freight fluidity, this is the first known application to U.S. ports. This paper covers AIS data inputs, quality control, and performance measures development, and also provides a demonstration application of the methodology at the Port of Mobile, Alabama, highlighting travel time and travel time reliability operating statistics for the overall port area. This work provides foundational knowledge to practitioners and port stakeholders looking to improve supply chain performance and is also valuable for researchers interested in the development and application of multimodal freight fluidity performance measures.

**The Prospects of Cold Ironing as an Emissions Reduction Option**, TRB 97th Annual Meeting, 2018, 6p

Cold ironing is the process of providing shore power to cover the energy demands of vessels calling at ports. This technological solution can eliminate the emissions of auxiliary engines at berthing, and result in a global reduction of emissions if the grid powering the vessel is environmentally friendly. This paper conducts a literature review of recent academic work in the field, and presents the status of this technology in California and Europe along with the current barriers for its further implementation. The use of cold ironing is mandatory in California and as a result terminal and ship operators were required to invest in this technology. Other regulations that target local emissions can have a significant impact on whether cold ironing is used in the future as a potential compliance solution. This paper constructs a quantitative framework for the examination of the technology from all stakeholders. The role of regulation is shown to be critical for the further expansion of this technology. Two case studies are presented that consider the perspective of a Ro-Ro operator and a container terminal. The results show that the cost of reducing one ton of CO$_2$ emissions through cold ironing, are much smaller than the external cost. The methodology can be useful to port and ship operators in examining the benefits of using cold ironing as an emissions reduction action.

**Policy**

**Economic Analysis of Inland Waterway Transport Chain Based on Multinomial Logit Model**

The primary goal of this study was to determine appropriate policies to increase the proportion of freight transported by water on the Hangyong (Hangzhou-Ningbo) canal, thus improving the economic efficiency of the canal. The appropriateness of the policies depends on the preferences of shippers. This study examined Hangzhou-to-Ningbo shipping container usage. Factors such as the transportation chain time and cost, the characteristics of the shippers (number of employees and annual freight tonnage), and the value of the freight were used to construct a transportation chain utility function. Through surveys, data on shipper choices for transportation were obtained to model the decision process. It was determined that the transportation chain time and cost are the most significant factors in the decisions of Hangyong canal freight shippers.

**TRB Special Report 315: Funding and Managing the U.S. Inland Waterways System: What Policy Makers Need to Know**

U.S. inland waterways include more than 36,000 miles of commercially navigable channels and roughly 240 working lock sites. Funding and managing this extensive and historic navigation system is a continuing challenge. In 2014, the TRB Executive Committee initiated a consensus study of the inland waterways system in response to reports of deteriorating and aged infrastructure, levels of capital investment perceived as inadequate, a growing backlog of capital needs, and the decline in federal appropriations for inland navigation. This article presents findings from the June 2015 report and outlines four conclusions arrived at by the TRB consensus committee: (1) Inland waterways are an important component of the national freight system; (2) The most critical need for the inland waterways system is efficiently maintaining reliability and performance with limited resources; (3) A greater reliance on user-
pays funding for commercial navigation is feasible and would generate new revenue; and (4) Asset management is crucial in prioritizing maintenance spending and determining necessary funding levels.

**Developing a Port Energy Management Plan: Issues, Challenges, and Prospects**

Raising the environmental profile of European ports and promoting excellence in port environmental management and performance are key priorities for European ports policy. This paper presents a structured approach for developing a port energy management plan (EMP) that highlights the main issues, challenges, and prospects that should be taken into account.

**Ship to Shore: Integrating New York Harbor Ferries with Upland Communities**

Following decades of underutilization, New York Harbor is now in the midst of a ferry renaissance. New services whisk commuters and tourists across the Hudson and East Rivers, and, perhaps most significantly, the Mayor recently announced an unprecedented system expansion to restore ferry service to all five boroughs by 2018 but ferries in New York possess a marked disconnect from landside transit and community life, limiting their effectiveness as an extensive and equitable transportation system. This paper synthesizes data and qualitative information from interviews, case studies, academic papers, and government reports and proposes 15 actionable steps toward forging stronger connections—both physical and psychological in nature—between New York’s ferries and the upland communities they serve.

**Optimal Inspection Policy for Port State Control**

To protect their territorial seas against oil pollutions and accidents, authorities around the world have intensified their inspection efforts on arrival ships. However, the side effect of a full inspection of arrival ships includes: a) affecting the efficiency of the global logistics and trade, b) adding public spending on inspection costs. In this paper, the authors firstly develop a model to decide on the optimal inspection policy with an aim to save costs on inspection whilst keeping deterrence pressure on potential wrongdoers. A bi-matrix game is built between the authorities and the ship operators, in which two types of errors are considered. Then, the authors test whether the punishment of delay caused by inspection is strong enough to deter potential violations, or whether a cost of detention should be imposed on the wrongdoers so as to force ship operators to engage in self-correction before sailing their ships out to the high seas. Based on deterrence theory, an optimal penalty (cost of detention) is derived. A theoretically optimal inspection rate that mixes penalties is derived. To characterize the optimal enforcement strategy, the authors use numerical techniques to show the optimal inspection strategy. A comprehensive dataset was built to estimate the parameters of the bi-matrix game. The optimal inspection rate about different type vessels and the effects of changing parameters on the optimal inspection rate is examined in the light of the empirical results. It is shown that the optimal inspection rate obtained from the model can yield a significant saving, as well as prevent potential violations by ship operators.

**Modeling Marine Transportation Policies**

U.S. and international shipping industry and marine fuel markets are undergoing a period of significant change. These changes are driven by new environmental regulations, enacted by the International Maritime Organization (IMO) in “MARPOL Annex VI (revised),” which place significant and progressive limits on emissions of nitrous oxides (NOx), sulfur oxides (SOx), and particulate matter (PM) from marine engines. Current worldwide limit on sulfur content in marine fuels is 3.5% or 35,000 ppm, which is subject to further reduction to 0.5%, or 5,000 ppm starting in 2020, with an option to extend the compliance date to 2025. Countries-signatories to the IMO have an option to designate their coastal waters under MARPOL Annex VI as Emissions Control Area (ECA), where more stringent emission standards apply. Current sulfur limit in ECAs is 1%, which will be reduced to 0.1% sulfur content, or 1,000 ppm, starting on January 1, 2015. The United States has designated two ECAs—North American ECA, which extends 200 miles from shore around the U.S. and Canadian waters, and the U.S. Caribbean ECA, which extends 50 miles offshore around Puerto Rico and the U.S. Virgin Islands. New environmental regulations are expected to have a major impact on marine fuel consumption in the United States due to the designation of ECAs, particularly with respect to fuel choice in maritime freight travel, with expected shift from heavy
bunker fuels toward distillate grade marine oils. In order to measure impact of the upcoming regulatory
changes on fuel choice, modeling methodology should include the key drivers—emissions regulations
and new technologies—on the projected marine fuel energy use. This paper discusses a modeling
methodology that accounts for regulatory changes and provides a modeling framework to estimate fuel
use by fuel type (residual and distillate) when ECA is in place. The methodology provides a framework
for a dynamic forecast of the residual and distillate fuels and allows to measure a change in consumption
of these fuels in response to regulatory changes.

**Public Private Partnerships – P3**

**Study on Profit Distribution and Stability of P3 Network Alliance Based on Game Theory** this paper takes
the P3 for example, adopts Nash equilibrium and Pareto equilibrium methods, based on the profit
distribution and stability of kernel solution of cooperative game theory, and proposes an improved
Shapley distribution model modified by three impact factors of risk taking, market competitiveness and
investment to analyze the 3-member alliances in detail. The results have shown that, the P3 could obtain
greater profits and reduce capacity, effectively to ease the downturn shipping market situation of supply
and demand imbalance. In the meanwhile, a more reasonable approach of the profit distribution is
proposed to ensure the efficient operation of the P3. 2015 Annual Meeting

**Private–Public Partnerships as Strategic Alliances: Concession Contracts for Port Infrastructures**
A new approach to the design of concession contracts of port infrastructures that adapts some of the
methods used in the design and start-up of strategic alliances is presented. From a cost–benefit analysis
of the project, based on the industry benchmarks, a revenue-sharing model dependent on the investment
interest and the risk undertaken or transferred by each partner was formulated. This model aids in the
calculation of the amount of the canons (lease and royalty charges) that should be stated in the contract.

**Ports and Waterways**
This collection of 9 papers on ports and waterways examines: public-private partnerships for port
infrastructures; the productive efficiency of world container ports; evaluating productivity improvement at
a seaport coal terminal; critical infrastructure at U.S. west coast intermodal terminals; an equilibrium
model to evaluate maritime infrastructure investments; barge terminals and the competitiveness of barge
transport; optimal transport routes for inland waterway container ships; scheduling waterway projects;
and grain shippers’ transportation demand and volume sensitivity.

**China’s Port Reform and Development: Policy Analysis**
Report reviews the evolution of China’s port reform and policy changes supported by port statistics,
examined a brief case study of port development in Shanghai, China, and analyzed policy changes in
port governance, legal framework, and funding mechanisms

**NASEM Gulf research Program Consensus Studies**

**Building and Measuring Community Resilience: Actions for Communities and the Gulf Research
Program** 2019

**Effective Monitoring to Evaluate Ecological Restoration in the Gulf of Mexico**