Operational measures to mitigate and reverse the potential modal shifts due to environmental legislation

On 1 January 2015, the sulphur upper limit for marine fuels used within sulphur emission control areas was lowered from 1% to 0.1%, with which vessels can comply only through using pricier ultra-low-sulphur fuel, or investing in abatement technologies. A potential increase of fuel prices could lead to closures of services due to the combined effects of loss of market due to higher freight rates, and increased operational costs. This paper builds on previous work allowing the modelling of modal shifts between sea and land-based options, and assesses the potential of operational measures that ship-owners can deploy to cope with the threat of the low-sulphur requirements. The measures include speed reduction, change of service frequency, use of alternative fuels such as liquefied natural gas, investments in scrubber systems, and improved fleet assignment. The proposed measures are tested on a set of case studies for services that are part of a short sea shipping network of a leading Ro-Ro operator. The results of this work can be useful to practitioners seeking to design new strategies that improve the resilience of their network, as well as to regulatory bodies designing new regulation that could have negative implications on certain sectors.
Decarbonization of maritime transport: to be or not to be?

International shipping is at a crossroads as regards decarbonization. The Paris climate change agreement in 2015 (COP21) was hailed by many as a most significant achievement. Others were less enthusiastic, and more recently American President Trump decided to take the U.S. out of the agreement. Four years earlier, the International Maritime Organization (IMO) had adopted the most sweeping piece of regulation pertaining to maritime greenhouse gas (GHG) reduction, in the name of the Energy Efficiency Design Index (EEDI). In addition, one year after COP21, the IMO adopted a mandatory data collection system for fuel consumption of ships and agreed on an initial strategy and roadmap on the reduction of GHG emissions from ships. This paper takes a critical look at the above and other recent developments and focuses on the challenges faced by the industry if a path to significant CO2 reductions is to be successful. Difficulties and opportunities are identified, and the paper conjectures that the main obstacles are neither technical nor economic, but political.

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**Green Liner Shipping Network Design**

Green Liner Shipping Network Design refers to the problems in green logistics related to the design of maritime services in liner shipping with a focus on reducing the environmental impact. This chapter discusses how to more efficiently plan the vessel services with the use of mathematical optimization models. A brief introduction to the main characteristics of Liner Shipping Network Design is given, as well as the different variants and assumptions that can be considered when defining this problem. The chapter also includes an overview of the algorithms and approaches that have been presented in the literature to design such networks.

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**Policy measures to avert possible modal shifts caused by sulphur regulation in the European Ro-Ro sector**

The 0.1% limit in sulphur content within Sulphur Emission Control Areas as of 1st January 2015 requires that ship operators either use pricier ultra-low sulphur fuel oil, or alternatively install abatement technologies through substantial capital investments. A part of the resulting higher operating costs are passed on to shippers resulting in increased freight rates. These may lead to modal shifts towards rail or road options competing with Ro-Ro operators. Due to the unexpectedly low fuel prices in the period 2014–2016, Ro-Ro operators were relatively unharmed by the new limits, but nascent research has shown that if fuel prices increase some Ro-Ro services may not survive. This paper examines a set of policy options that can mitigate or reverse the negative effects of the low-sulphur regulation. The measures include internalizing external costs of transport, repaying fuel surcharges to shippers, subsidizing technological investments of ship operators, or increasing the land-based costs of transport via levies. To compare their efficacy, total costs are calculated for each measure. The results show that the proposed measures can successfully reduce the negative effects of the regulation but this would entail significant costs. A combination of subsidies towards shippers and ship operators is shown to be effective at reversing potential modal shifts and can be crucial in case of high fuel prices in the near future. The findings of this work can assist operators to develop new strategies and improve the resilience of their network, and regulators designing environmental policies that may have negative implications on certain sectors.

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Reducing GHGs: the MBM and MRV Agendas
The purpose of this chapter is to introduce the concept of Market Based Measures (MBMs) to reduce Green House Gas (GHG) emissions from ships, and review several distinct MBM proposals that were under consideration by the International Maritime Organization (IMO). The chapter then moves on to discuss the concept of Monitoring, Reporting and Verification (MRV) of CO2 emissions and the distinct mechanisms set up the European Union (EU) and the IMO for MRV. The reason the MBM and MRV subjects are treated in the same chapter is twofold: (a) the MRV discussion essentially started when the MBM discussion was suspended in 2013, and (b) MRV is a critical step for any eventual MBM implementation in the future.

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Reducing Sulfur Emissions: Logistical and Environmental Considerations
In recent years the issue of sulfur emissions from maritime transport has seen newfound attention. This chapter presents an overview of the main issues of sulfur emissions and the legislative framework that seeks to reduce the sulfur footprint of the maritime sector. It also analyzes potential modal shifts toward less efficient land-based modes which may happen as a result of sulfur regulations and investigates the related potential economic damage to ship operators. To that effect, this chapter presents findings from a recently finished project at DTU and the developed methodological framework that can be used to estimate such modal shifts, as well as to measure the efficacy of policy and ship operators’ measures to reverse such shifts.

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Reducing Sulphur Emissions: Logistical and Environmental Considerations
In recent years the issue of sulphur emissions from maritime transport has seen newfound attention. This chapter presents an overview of the main issues of sulphur emissions and the legislative framework that seeks to reduce the sulphur footprint of the maritime sector. It also analyses potential modal shifts towards less efficient land-based modes which may happen as a result of sulphur regulations, and investigates the related potential economic damage to ship operators. To that effect, this chapter presents findings from a recently finished project at DTU, and the developed methodological framework that can be used to estimate such modal shifts, as well as to measure the efficacy of policy and ship operators’ measures to reverse such shifts.
Speed Optimization for Sustainable Shipping
Among the spectrum of logistics – based measures for sustainable shipping, this chapter focuses on speed optimization. This involves the selection of an appropriate speed by the vessel, so as to optimize a certain objective. As ship speed is not fixed, depressed shipping markets and/or high fuel prices induce slow steaming which is being practised in many sectors of the shipping industry. In recent years the environmental dimension of slow steaming has also become important, as ship emissions are directly proportional to fuel burned. Win-win solutions are sought, but they will not necessarily be possible. The chapter presents some basics, discusses the main trade-offs and also examines combined speed and route optimization problems. Some examples are presented so as to highlight the main issues that are at play, and the regulatory dimension of speed reduction via speed limits is also discussed.

Speed Optimization vs Speed Reduction: the Choice between Speed Limits and a Bunker Levy
“Speed optimization and speed reduction” are included in the set of candidate short-term measures under discussion at the International Maritime Organization (IMO), in the quest to reduce greenhouse gas (GHG) emissions from ships. However, there is much confusion on what either speed optimization or speed reduction may mean, and some stakeholders have proposed mandatory speed limits as a measure to achieve GHG emissions reduction. The purpose of this paper is to shed some light into this debate, and specifically examine whether reducing speed by imposing a speed limit is better than doing the same by imposing a bunker levy. To that effect, the two options are compared. The main result of the paper is that the speed limit option exhibits a number of deficiencies as an instrument to reduce GHG emissions, at least vis-à-vis the bunker levy option.
Sustainable shipping: A cross-disciplinary view

International shipping is currently at a crossroads. The decision of the International Maritime Administration (IMO) in April 2018 to adopt an Initial Strategy so as to achieve by 2050 a reduction of at least 50% in maritime greenhouse gas (GHG) emissions vis-à-vis 2008 levels epitomizes the last among a series of recent developments as regards sustainable shipping. It also sets the scene on what may happen in the future. Even though many experts and industry circles believe that the IMO decision is in line with the COP21 climate change agreement in Paris in 2015, others disagree, either on the ground that the target is not ambitious enough, or on the ground that no clear pathway to reach the target is currently visible.

This book takes a cross-disciplinary view of the various dimensions of the maritime transportation sustainability problem. “Cross-disciplinary” means that a variety of angles are used to examine the book topics, and these mainly include the technological angle, the economics angle, the logistics angle, and the environmental angle. The book reviews models that can be used to evaluate decisions, policy alternatives and tradeoffs. For sustainable shipping, a spectrum of technical, logistics-based and market based measures are being contemplated. All may have important side-effects as regards the economics and logistics of the maritime supply chain, including ports and hinterland connections. The objective to attain an acceptable environmental performance, while at the same time respecting traditional economic performance criteria so that shipping remains viable, is and is likely to be a central goal for both industry and policy-makers in the years ahead. At the same time, policy fragmentation is likely to create distortions of competition and sub-optimal solutions. This book attempts to address these issues and identify better solutions.

Sustainable Shipping: A Cross-Disciplinary View includes chapters that cover many relevant topics. These include a general view of maritime transport sustainability, green ship technologies, information and communication technologies (ICTs) for sustainable shipping, green tramp ship routing and scheduling, green liner network design and speed optimization. Market based measures, oil pollution, ship recycling, sulphur emissions, ballast water management, alternative fuels and green ports are also covered. The book concludes by discussing prospects for the future, with a focus on the IMO Initial Strategy.

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The enforcement of the global sulphur cap in maritime transport

The global sulphur cap, introduced by the International Maritime Organization (IMO) and decided to be implemented by January 1st, 2020, sets the new sulphur limit to 0.5% not only in coastal areas, but in the high seas as well. The effective enforcement of this measure will ensure a level playing field for all operators in the shipping industry. The challenges expected to arise from this regulation and the available or potential enforcement schemes for the Emissions Control Areas (ECA) zones and the high seas are addressed in this paper. Different alternatives of the penalty policy that may discourage non compliance are analyzed. A model that calculates the profits from non compliance in the high seas is developed to help determine the level of fines that could be imposed in case of violation.
The profit maximizing liner shipping problem with flexible frequencies: logistical and environmental considerations

The literature on liner shipping includes many models on containership speed optimization, fleet deployment, fleet size and mix, network design and other problem variants and combinations. Many of these models, and in fact most models at the tactical planning level, assume a fixed revenue for the ship operator and as a result they typically minimize costs. This treatment does not capture a fundamental characteristic of shipping market behavior, that ships tend to speed up in periods of high freight rates and slow 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 line’s average daily profit. Departing from convention, the model is also able to consider flexible service frequencies, to be selected from a broader set than the standard assumption of one call per week. It is shown that this may lead to better solutions and that the cost of forcing a fixed frequency can be significant. Such cost is attributed either to additional fuel cost if the fleet is forced to sail faster to accommodate a frequency that is higher than the optimal one, or to lost income if the opposite is the case. The impact of the line’s decisions on CO2 emissions is also examined and illustrative runs of the model are made on three existing services.
The way ahead
The purpose of this chapter is to attempt to make an assessment on what may lie ahead as regards sustainable shipping. The focus of the chapter is the April 2018 decision of the International Maritime Organization (2018) on the formulation of an Initial Strategy to reduce maritime greenhouse gas (GHG) emissions. In that context, an assessment of the prospects for alternative fuels, which figure centrally in the Initial Strategy, is also included.

A taxonomy of carbon emission reduction measures in waterborne freight transportation
A wide range of measures has been proposed to improve vessel efficiency, reduce fuel consumption and lower emissions (1, 2). The classification of such measures is the subject of several publications. The Second GHG Study (3) of the International Maritime Organisation (IMO) is the most influential among them and identifies three fundamental categories of carbon emission reduction options: (i) energy efficiency improvements, which are further, sub-divided into the areas of ship design and operations; (ii) renewable energy sources; and (iii) fuels with lower lifecycle emissions per unit of work. Variations of this scheme have been proposed by Balland et al. (4) and Calleya, Pawling, and Greig (5). Classification schemes like the ones mentioned above are simple and practical but lack rigid theoretical foundations. On the other hand, schemes that attempt to capture the multiplicity of interrelations among all factors affecting emission volumes are often of low practical value due to their high level of complexity. IMO (3) provides such an example. Although it clearly acknowledges that, by definition, the CO2 emissions for most ships depend on the operational efficiency of the fleet and the transport work performed, when it comes to identifying the principal factors affecting the volume of emissions, the study presents a rather complex model including external and internal parameters that influence transport demand, modal split and fleet operations among others. McKinnon’s analytical framework for green logistics falls into this category, too (6).
Key performance indicators to assess and reverse the negative impacts of SECA policies for Ro-Ro Shipping

The 0.1% sulphur limit within Sulphur Emission Control Areas (SECA) has made compulsory the use of either pricier ultra-low sulphur fuel, or the installation of abatement technologies that require significant capital investments. Due to the unexpectedly low fuel prices, Ro-Ro operators have been able to cope with the new sulphur limits, but recent research has shown that if fuel prices increase some Ro-Ro services may face the risk of closure. This paper proposes three key performance indicators (KPIs) to enable the assessment of the impact of SECAs on Ro-Ro shipping. The KPIs are used on a set of case studies for services of a leading European Ro-Ro operator, and allow benchmarking of a series of operational and policy measures that aim to reverse the negative impacts of SECAs. The operational measures consider speed reduction, new sailing frequency, fleet reconfiguration, as well as investments in abatement technologies. Policy measures include the options of either subsidizing shippers or ship operators, or alternatively introducing new taxes on land-based options. The KPIs can be useful to ship operators seeking to improve the resilience of their network, as well as to regulatory bodies designing new environmental policies and understanding any negative implications these may have on ship operators.

Lessons on multi-level governance learned from the bottom-up corridor projects in the Baltic Sea Region

Since their introduction in 2013, the TEN-T core network corridors (CNCs) comprise the main implementation instrument for the EU transport infrastructure policy. In addition to three CNCs that cross the Baltic Sea Region, a number of bottom-up corridor projects have proliferated in this area. Most of these projects perceive transport corridors as a vehicle for strengthening economic and social cohesion and development through the promotion of cross-border trans-regional cooperation. In doing so, they have developed a number of different stakeholder cooperation schemes. Drawing on desk research and a series of interviews, the paper reviews the stakeholder management schemes that past corridor projects have designed, implemented or tested and maps the decision-making processes concerning stakeholder involvement. Special emphasis is placed on the engagement of businesses (manufacturing, transport and logistics industry) and the so-called lighter-weight players (smaller and rural regions/municipalities, NGOs and SMEs), which have been diagnosed as the least active in the CNC work.
Operational measures and logistical considerations for the decarbonisation of maritime transport

Maritime shipping is widely considered as the most fuel-efficient mode of transport. During the past decade, the relative share of CO2 emissions of the shipping sector has seen a slight reduction that has been attributed to the depressed market conditions that led to the resurfacing of the slow steaming practice. The sector has seen increasing regulatory pressure to further improve its environmental performance, not only in greenhouse gas (GHG) terms, but also in other pollutant types. Important regulation has been implemented with regards to the maximum allowable content of sulphur in marine fuel from the International Maritime Organization (IMO), whereas the introduction of MRV (monitoring, reporting, verification) in Europe will also assist in the efforts to reduce the environmental impacts of shipping. The European Union has also adopted the Transport White Paper that has set ambitious targets for reductions in GHG emissions compared to 1990 for all transport modes. At the same time, it is noteworthy that international shipping has been excluded from the COP21 climate change agreement in Paris. The discussion on possible pathways to achieve reductions in the maritime sector is currently in a stalemate. While certain Market Based Measures (MBMs) for GHGs have been contemplated at the IMO, a final decision has not been reached. In February 2017, the European Parliament voted to include shipping into the EU Emissions Trading Scheme (ETS) as of 2023, in the event that no global agreement is reached by 2021. This potential solution has met with criticism as there are concerns that the ETS could lead to distortions in trade, and actually not be an efficient method to reduce GHG emissions. Other measures have been submitted as potential solutions to the IMO such as the introduction of an additional levy on bunker fuel, as well as hybrid proposals that also take into consideration ETS type solutions, and the EEDI (Energy Efficiency Design Index). In this paper, the implications of these measures are examined in a quantitative context whereby the objective is to identify the potential for emissions reduction in different shipping sectors. In addition to estimations on emissions reduction, logistical considerations are thoroughly examined in the paper. For example, an introduction of a tax levy will result in a higher bunker price and thus operating costs for ship operators, which will de facto alter the optimal salling speed of the vessel to lower levels. This will result in lower emissions per trip, but may require the deployment of additional vessels to satisfy the total transportation demand, or lead to a modal shift towards other modes due to the shippers’ requirements for a faster service. This sort of distortion has already been observed due to the stricter fuel requirements within SECAs (Sulphur Emission Control Areas), but was rather anticlimactic due to the in general very low fuel prices observed in 2015. With regards to the EEDI, it is a well-established fact that while the rationale was to improve vessel and engine design, a potential alternative to comply with the limits would be to simply lower the salling speed, leading to underpowered vessels. In the case studies examined in this paper, a variety of vessel types, sizes, and deployed routes are considered to explore the impacts of the different decarbonisation pathways. This paper presents a new modelling framework that allows the quantitative estimation of the effectiveness of various MBMs in emissions reduction, also considering the total cost for the achieved reduction. The required tax on fuel to reduce emissions is calculated on a parametric analysis that considers desired reduction, salling speed, carrying capacity, fuel price, and freight rates. Case studies on liner shipping, Ro-Ro shipping, and tankers are considered, with a discussion on the role of the operating area of the vessel (ocean-going vs short sea shipping, outside vs inside SECAs). Finally, using data on the world fleet and the current trade volumes, a range of the potential reduction for CO2 emissions is performed for different values of levies on bunker fuel. The results can be useful in the way forward to decarbonising maritime transport, while also considering the economic and environmental trade-offs due to potential modal shifts, closure of services, and required fleet renewal. The constructed modelling framework is also able of assessing the impact of various other environmental regulation that may be proposed but may have a more local character (for example speed limits near the coastlines, requirements at the port etc.).
The profit maximizing liner shipping problem with flexible frequencies: balancing economic and environmental performance

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Best practice in multi-level cooperation for transport and growth in the BSR: Thematic study
The report presents the activities and main results of TENTacle Activity 5.1 ('Lessons learned'), which aims at supporting the implementation of core network corridors by transferring experience from multi-level governance (MLG) accumulated through bottom-up corridor projects and other cross-border transport initiatives in the Baltic Sea Region. It summarises the best practices identified in achieving stakeholder commitment to joint implementation of strategies and actions in selected transport corridors and provides recommendations on how this accumulated experience can be utilised in the CNC projects in a systematic and organised way.

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Model-based corridor performance analysis – An application to a European case
The paper proposes a methodology for freight corridor performance monitoring that is suitable for sustainability assessments. The methodology, initiated by the EU-funded project SuperGreen, involves the periodic monitoring of a standard set of transport chains along the corridor in relation to a number of Key Performance Indicators (KPIs). It consists of decomposing the corridor into transport chains, selecting a sample of typical chains, assessing these chains through a set of KPIs, and then aggregating the chain-level KPIs to corridor-level ones using proper weights. A critical feature of this methodology concerns the selection of the sample chains and the calculation of the corresponding weights. After several rounds of development, the proposed methodology suggests a combined approach involving the use of a transport model for sample construction and weight calculation followed by stakeholder refinement and verification. The sample construction part of the methodology was tested on GreCOR, a green corridor project in the North Sea Region, using the Danish National Traffic Model as the principal source of information for both sample construction and KPI estimation. The results show that, to the extent covered by the GreCOR application, the proposed methodology can effectively assess the performance of a freight transport corridor. Combining the model-based approach for the sample construction and the study-based approach for the estimation of chain-level indicators exploits the strengths of each method and avoids their weaknesses. Possible improvements are also suggested by the paper.
Report on the outcome of Task 3.2: Measures from policy makers
This report summarizes the main research findings of Task 3.2 (entitled "Measures from policy makers") of the RoRoSECA project. Task 3.2 falls under the umbrella of Work Package (WP) 3 (entitled "Measures to mitigate or reverse modal shifts"). Task 3.2 is focusing on the policy makers’ available options, and is using tools and models developed in Year 1 of the RoRoSECA project in order to quantify the implications of the examined measures. It is complementary to Task 3.1 ("Measures from the Ro-Ro operator") whose report has been delivered in month 19.

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Ship routing and scheduling: the cart before the horse conjecture
The literature on ship routing and scheduling has grown substantially over the last few decades, with many papers authored by top experts in this area and examining various versions of the problem. Many publication outlets have hosted these papers, with a broad variety of problem formulations, solution approaches, and application contexts. Equally broad is the range of angles of these papers, spanning the wide field from mostly theoretical analyses, focusing on specific methodological tools, all the way to applied studies, focusing on specific real-world applications. The basic hypothesis of this paper is that we are increasingly seeing papers that are more of theoretical than practical value, and in fact some of them often place the solution approach before real problem definition. As a result of this approach, the connection between these papers and reality is sometimes distant or elusive. To investigate this hypothesis, this paper tries to explain some misconceptions, refers to a limited sample of such papers, and suggests possible ways to rectify this situation in the future.
The implications of the new sulphur limits on the European Ro-Ro sector

In an effort to reduce the environmental impacts of maritime transportation, the International Maritime Organization (IMO) designated special Sulphur Emission Control Areas (SECAs) where ships are required to use low-sulphur fuel. In January 2015, the sulphur limit within SECAs was lowered to 0.1%, which can only be achieved if vessels are using pricier ultra-low sulphur fuel, or invest in abatement technologies. The increased operating costs borne by Ro-Ro operators in SECAs due to the stricter limits can result in the shutting down of some routes and a redistribution of cargo flows with land-based alternatives. The exact repercussions of the new sulphur limits are difficult to identify in the wake of significant recent reductions of the fuel prices for both low-sulphur and heavy fuel oil. This paper presents a modal split model that estimates modal shifts vis-a-vis competing maritime and land-based modes available to shippers. This allows examining the implications of the recent low prices to modal choice, and the influence a potential increase in fuel prices may have. The model is applied to seven routes affected by the regulation based on data from a leading European Ro-Ro operator. Sensitivity analyses on market share data, cargo values, freight rates, and haulers rates are conducted. Emissions inventories are constructed to assess the environmental efficacy of the SECA regulation. The novelty of the proposed model lies in the examination of the ex-post implications of shutting down a service and the redistribution of transport. Recommendations to mitigate and reverse the negative side-effects of such environmental legislation are proposed.
A Simple Synchro – Modal Decision Support Tool for the Piraeus Container Terminal

The concept of Synchro modality is effectively an evolution of a multimodal supply chain. It integrates different transport modes and gives shippers and logistics service providers the freedom to deploy different modes of transportation in the same chain and in a flexible way so as to gain the desired outcome according to their priorities in a certain trip. Time, costs and emissions are certainly the three most relevant parameters when talking about a multimodal transportation chain. In most cases the logistics provider has set priorities to conform with, and obviously above mentioned constrains influence each other in an adverse way. With the development of ICT technologies and systems installed on board and on shore and with a simple decision support system fed with input from tracking and tracing systems or traffic monitoring systems, one can easily and flexibly plan his transportation job and maintain his set priority while in parallel keeping the remaining two parameters in control. Down times for example could be eliminated and efficiency gains could be achieved with decreased environmental footprint.

The Port of Piraeus is the largest Greek seaport and one of the largest ports in the Mediterranean Sea basin. It exhibits an impressive container traffic growth rate over the last 4 years triggered by its partial privatization and a recently completed hinterland connection to the rail network, which associated the port with the South-Eastern European corridor e.g. the route Far Eastern ports–Piraeus–Prague.

The current paper will present an easy to use simple tool to continuously assess even during the transportation event all the alternative modes for a given destination in terms of time cost and emissions. An analytical fully parameterized model will be the basis for this tool which will be run for the chain Shanghai–Piraeus–Prague. The overall scenario is as follows: A container ship is arriving from China to the Piraeus Container Terminal. One of its containers is destined to an inland Enterprise in Prague. The most common way for transportation to Prague is rail, but also truck could be an alternative solution and of course a combination of a Short Sea Shipping part to Thessaloniki and then truck or train to Prague. Emphasis in the calculations will be given to emissions for all the modes and relations will be shown with time and cost.

The tool developed is based on the case study above, being however open architecture software it can be expanded and applied to other ports and routes. The final outcome will be an easy and user friendly tool with the possibility to alter different input parameters and receive quickly a useful decision support system for the shipper or the logistics providers.

Finally, there are two loops foreseen for the runs of the program. The required input parameters at each stage are either directly fed to the program if available (e.g vessels ETA and position through GPS, VTS, ETC) or calculated if this is not the case.

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A Simple Synchro – Modal Decision Support Tool for the Piraeus Container Terminal

The concept of Synchro modality is effectively an evolution of a multimodal supply chain. It integrates different transport modes and gives shippers and logistics service providers the freedom to deploy different modes of transportation in the same chain and in a flexible way so as to gain the desired outcome according to their priorities in a certain trip. Time, costs and emissions are certainly the three most relevant parameters when talking about a multimodal transportation chain. In most cases the logistics provider has set priorities to conform with, and obviously above mentioned constrains influence each other in an adverse way. With the development of ICT technologies and systems installed on board and on shore and with a simple decision support system fed with input from tracking and tracing systems or traffic monitoring systems, one can easily and flexibly plan his transportation job and maintain his set priority while in parallel keeping the remaining two parameters in control. Down times for example could be eliminated and efficiency gains could be achieved with decreased environmental footprint. The Port of Piraeus is the largest Greek seaport and one of the largest ports in the Mediterranean Sea basin. It exhibits an impressive container traffic growth rate over the last 4 years triggered by its partial privatization and a recently completed hinterland connection to the rail network, which associated the port with the South-Eastern European corridor e.g. the route Far Eastern ports – Piraeus – Prague. The current paper will present an easy to use simple tool to continuously assess even during the transportation event all the alternative modes for a given destination in terms of time cost and emissions. An analytical fully parameterized model will be the basis for this tool which will be run for the chain Shanghai - Piraeus – Prague. The overall scenario is as follows: A container ship is arriving from China to the Piraeus Container Terminal. One of its containers is destined to an inland Enterprise in Prague. The most common way for transportation to Prague is rail, but also truck could be an alternative solution and of course a combination of a Short Sea Shipping part to Thessaloniki and then truck or train to Prague. Emphasis in the calculations will be given to emissions for all the modes and relations will be shown with time and cost. The tool developed is based on the case study above, being however open architecture software it can be expanded and applied to other ports and routes. The final outcome will be an easy and user friendly tool with the possibility to alter different input parameters and receive quickly a useful decision support system for the shipper or the logistics providers. Finally there are two loops foreseen for the runs of the program. The required input parameters at each stage are either directly fed to the program if available (e.g. vessels ETA and position through GPS, VTS, ETC) or calculated if this is not the case.

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Being green on sulphur: Targets, measures and side-effects

Green House Gas (GHG) emissions are not the only emissions of concern to the international transport community. SOx emissions are non-GHG emissions that are caused by the presence of sulphur in the fuel. As the maximum percentage of sulphur in automotive and aviation fuels is strictly regulated in most countries around the world, much of the attention in recent years has focused on maritime transport. The attention mainly stems from the fact that in marine fuels the percentage of sulphur can be very high: it can be as high as 4.5 % in Heavy Fuel Oil (HFO), which is the fuel typically used in all deep-sea trades. Even though the amounts of SOx produced by ships are substantially lower than CO2, SOx emissions are highly undesirable as they cause acid rain and undesirable health effects in humans and animals. To mitigate these adverse environmental effects, the international transport community has taken substantial policy measures. With the introduction of new limits for the content of sulphur in marine fuels in Northern European and North American sea areas, short-sea companies operating in these areas will face substantial additional cost. As of 1/1/2015, international regulations stipulate, among other things, a 0.1%limit in the sulphur content of marine fuels, or equivalent measures limiting the percent of SOx emissions to the same amount. As low-sulphur fuel is substantially more expensive than HFO, there is little or no room within these companies current margins to absorb such additional cost, and thus significant price increases must be expected. Unlike its deep-sea counterpart, in short-sea shipping such a freight rate increase may induce shippers to use landbased alternatives (mainly road). A reverse shift of cargo would go against the EU policy to shift traffic from land to sea to reduce congestion, and might ultimately (under certain circumstances) increase the overall level of CO2 emissions along the entire supply chain. The purpose of this chapter is to investigate the potential effect of sulphur regulations on the share of cargo transported by the waterborne mode vis-à-vis land-based alternatives.

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Dynamic vehicle routing problems: Three decades and counting

Since the late 70s, much research activity has taken place on the class of dynamic vehicle routing problems (DVRP), with the time period after year 2000 witnessing an areal explosion in related papers. Our paper sheds more light into work in this area over more than 3 decades by developing a taxonomy of DVRP papers according to 11 criteria. These are (1) type of problem, (2) logistical context, (3) transportation mode, (4) objective function, (5) fleet size, (6) time constraints, (7) vehicle capacity constraints, (8) the ability to reject customers, (9) the nature of the dynamic element, (10) the nature of the stochasticity (if any), and (11) the solution method. We comment on technological vis-à-vis methodological advances for this class of problems and suggest directions for further research. The latter include alternative objective functions, vehicle speed as decision variable, more explicit linkages of methodology to technological advances and analysis of worst case or average case performance of heuristics.

Green Maritime Logistics: The Quest for Win-win Solutions

By green maritime logistics we mean achieving an acceptable environmental performance of the maritime transport logistical supply chain while at the same time respecting traditional economic criteria. In this paper the environmental focus is on maritime emissions. Achieving such goal may involve several trade-offs, and win-win solutions are typically
sought. However, finding these solutions may be more difficult than may appear at first glance. The purpose of this paper is to provide a concise overview of the challenges of green maritime logistics and present some examples, both for greenhouse gas (GHG) and non-GHG emissions.

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Green Maritime Logistics

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Green maritime transportation: Market based measures
The purpose of this chapter is to introduce the concept of Market Based Measures (MBMs) to reduce Green House Gas (GHG) emissions from ships, and review several distinct MBM proposals that have been under consideration by the International Maritime Organization (IMO). The chapter discusses the mechanisms used by MBMs, and explores how the concept of the Marginal Abatement Cost (MAC) can be linked to MBMs. It also attempts to discuss the pros and cons of the submitted proposals.

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Green transportation logistics: the quest for win-win solutions

This book examines the state of the art in green transportation logistics from the perspective of balancing environmental performance in the transportation supply chain while also satisfying traditional economic performance criteria. Part of the book is drawn from the recently completed European Union project Super Green, a three-year project intended to promote the development of European freight corridors in an environmentally friendly manner. Additional chapters cover both the methodological base and the application context of green transportation logistics. Individual chapters look at the policy context; the basics of transportation emissions; Green Corridors basics; the concept of TEN-T (Trans-European Network); Green vehicle routing; Reducing maritime CO2 emissions via market based measures and speed and route optimization; Sulphur emissions; Green rail transportation; Green air transportation; Green inland navigation and possible areas for further research. Throughout, the book pursues the goal of "win-win" solutions and analyzes the phenomenon of "push-down, pop-up", where in a change in one aspect of a problem can cause another troubling aspect to arise. For example, speed reduction in maritime transportation can reduce emissions and fuel costs, but could require additional ships and could raise in-transit inventory costs. Or, regulations to reduce sulphur emissions may ultimately increase CO2 elsewhere in the supply chain. The book takes stock at the various tradeoffs that are at stake in the goal of greening the supply chain and looks at where balances can be struck.

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Payback Period for Emissions Abatement Alternatives: Role of Regulation and Fuel Prices

As of January 2015, the new maximum limit of fuel sulfur content for ships sailing within emission control areas has been reduced to 0.1%. A critical decision for ship owners in advance of the new limits was the selection of an abatement method that complies with the regulations. Two main options exist: investing in scrubber systems that remove sulfur dioxide emissions from the exhaust and switching to low-sulfur fuel when sailing in regulated waters. The first option would involve significant capital costs, while the latter would lead to operating cost increases because of the higher price of the fuel used. This paper presents a literature review of emissions abatement options and relevant research in the field. A cost–benefit methodology to assess emission reduction investments from ship owners is also presented. A study examined the effects of recent drops in bunker fuel price to the payback period of a potential scrubber investment. The results show that lower prices would significantly delay the payback period of such investments, up to two times in some cases. The case studies present the emissions generation through each option for representative short sea shipping routes. The repercussions of low-sulfur policies on large emission reduction investments including cold ironing are examined, along with implications of slow steaming for their respective payback periods. Recommendations are made for research in anticipation of future regulations and technological improvements.

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Performance assessment of a freight corridor on the basis of transport model results

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The implications of the new sulphur limits on the European Ro-Ro sector
In an effort to reduce the environmental impacts of maritime transportation, the International Maritime Organization (IMO) designated special Sulphur Emission ControlAreas (SECAs) where ships are required to use low-sulphur fuel. In January 2015, the sulphur limit within SECAs was lowered to 0.1%, which can only be achieved if vessels are using pricier ultra-low sulphur fuel, or invest in abatement technologies. The increased operating costs borne by Ro-Ro operators in SECAs due to the stricter limits can result in the shutting down of some routes and a redistribution of cargo flows with land-based alternatives. The exact repercussions of the new sulphur limits are difficult to identify in the wake of significant recent reductions of the fuel prices for both low-sulphur and heavy fuel oil. This paper presents a modal split model that estimates modal shifts vis-a-vis competing maritime and land-based modes available to shippers. This allows examining the implications of the recent low prices to modal choice, and the influence a potential increase in fuel prices may have. The model is applied to seven routes affected by the regulation based on data from a leading European Ro-Ro operator. Sensitivity analyses on market share data, cargo values, freight rates, and haulers rates are conducted. Emissions inventories are constructed to assess the environmental efficacy of the SECA regulation. The novelty of the proposed model lies in the examination of the ex-post implications of shutting down a service and the redistribution of transport. Recommendations to mitigate and reverse the negative side-effects of such environmental legislation are proposed.

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Transportation Emissions: some basics
Transportation is the backbone of international trade and a key engine driving globalization. However, there is growing concern that the Earth’s atmospheric composition is being altered by human activities, including transportation, which can
lead to climate change. Air pollution from transportation and especially carbon dioxide emissions are at the center stage of discussion by the world community through various international treaties, such as the Kyoto Protocol. The transportation sector also emits non-CO2 pollutants that have important effects on air quality, climate, and public health. The main purpose of this chapter is to introduce some basic concepts that are relevant in the quest of green transportation logistics. First, we present the basics of estimating emissions from transportation activities, the current statistics and future trends, as well as the total impact of air emissions and its contribution to climate change. In addition, this chapter presents the basics of environmental policy measures. In that context, we describe a way to measure the cost-effectiveness of various measures through the so-called Marginal Abatement Cost (MAC). Finally, the chapter deals with the topic of the energy efficiency gap and examines why governments and companies may forego cost-effective investments in energy efficiency, even though they could significantly reduce energy consumption at a lower cost.

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Cargo-mix optimization in Liner Shipping

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Cargo-mix optimization in Liner Shipping

International transportation constitutes one of the biggest challenges in limiting CO2 emission in the world: it is technically hard to find viable alternatives to fossil fuels, and due to the international nature, it is very difficult to regulate CO2 emission of intercontinental trade. Moreover, it is hard to motivate companies to pay for cleaner transport since transportation is not visible to end customers, and therefore cannot justify a higher cost. Hence, optimization may be one of the few options for limiting CO2 emission of international trade. A possible direction is to focus on vessels’ utilization. The more containers a vessel carries the smaller is the resulting CO2 emissions per transported ton of cargo. This is what can be seen as a win-win situation. Better vessel utilization will result both in cleaner transport and in better revenue margins for the shippers. Focus on vessel intake maximization is old news for liner shippers. Container vessels are delivered with a nominal capacity that ship owners know is only theoretical. Unless the cargo weight distribution is perfect, the nominal intake cannot be reached. Stowage coordinators fight this battle everyday. They are the planners of the cargo and have to find a load configuration (stowage plan) that both suits the current cargo to be loaded but also guarantees that the vessel can be utilized to its maximum in future ports. The size of nowadays vessels is, however, making this work harder and harder (Pacino et al. (2011)). Moreover, the cargo composition available in the different ports might not be suitable for the full utilization of the vessel. The focus of our work is the analysis of vessels’ cargo-mix, in particular finding what cargo composition is needed for a vessel to maximize its utilization on a given service. Such a model can have various
applications ranging from driving rate prices, improving fleet composition and network design ((Christiansen et al., 2007; Reinhardt and Pisinger, 2012; Brouer et al., 2014)).

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**Directions for further research**
Green transportation logistics is an area that combines the following: (a) it is relatively new in terms of research carried out thus far, (b) it has become increasingly important for both industry and society, and (c) it is rich in topics for further research, both basic and applied. In this final chapter of this book we discuss directions for further research in this area. We do so by taking stock of (1) related recommendations of project SuperGreen, and (2) related activities mainly in European research. Links between research and policy-making as two activities that should go hand in hand are also discussed.

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**Green corridors and their possible impact on the European supply chain**
The purpose of this chapter is to present the concept of green corridors and analyse their possible impact on the supply chain. The basis of this material is work conducted in the context of the EU SuperGreen project and therefore the geographical setting of the chapter is Europe. The general objective of the SuperGreen project has been to support the development of sustainable transport networks by fulfilling requirements covering environmental, technical, economic, social and spatial planning aspects. The chapter deals only with surface freight transport, including maritime transport, noting however that the quality of transport and logistics services is also affected by passenger transport competing for route capacity. Aviation is outside the scope of our analysis, as is the use of pipelines for liquid cargoes. In addition, the chapter provides examples of the corridor development approaches employed in Europe, and describes the performance monitoring methodology developed by SuperGreen. The deep sea service linking China to Europe is compared to the trans-Siberian rail link between Beijing and Duisburg as an example. Finally, the new transport infrastructure policy of the European Union is reviewed to investigate the relationship between green corridors and the recently introduced concept of TEN-T core network corridors in order to derive implications for corridor governance.

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Contributors: Panagakos, G., Psaraftis, H. N., Holte, E. A.
Green maritime transportation: Speed and route optimization

Among the spectrum of logistics-based measures for green maritime transportation, this chapter focuses on speed optimization. This involves the selection of an appropriate speed by the vessel, so as to optimize a certain objective. As ship speed is not fixed, depressed shipping markets and/or high fuel prices induce slow steaming which is being practised in many sectors of the shipping industry. In recent years the environmental dimension of slow steaming has also become important, as ship emissions are directly proportional to fuel burned. Win-win solutions are sought, but they will not necessarily be possible. The chapter presents some basics, discusses the main trade-offs and also examines combined speed and route optimization problems. Some examples are finally presented so as to highlight the main issues that are at play.

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Maritime routing and speed optimization with emission control areas

Strict limits on the maximum sulphur content in fuel used by ships have recently been imposed in some Emission Control Areas (ECAs). In order to comply with these regulations many ship operators will switch to more expensive low-sulphur fuel when sailing inside ECAs. Since they are concerned about minimizing their costs, it is likely that speed and routing decisions will change because of this. In this paper, we develop an optimization model to be applied by ship operators for determining sailing paths and speeds that minimize operating costs for a ship along a given sequence of ports. We perform a computational study on a number of realistic shipping routes in order to evaluate possible impacts on sailing paths and speeds, and hence fuel consumption and costs, from the ECA regulations. Moreover, the aim is to examine the implications for the society with regards to environmental effects. Comparisons of cases show that a likely effect of the regulations is that ship operators will often choose to sail longer distances to avoid sailing time within ECAs. Another effect is that they will sail at lower speeds within and higher speeds outside the ECAs in order to use less of the more expensive fuel. On some shipping routes, this might give a considerable increase in the total amount of fuel consumed and the CO₂ emissions.

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Maritime shipping and emissions: A three-layered, damage-based approach
Policy emphasis in ship design must be shifted away from global and idealized towards regional based and realistic vessel operating conditions. The present approach to reducing shipping emissions through technical standards tends to neglect how damages and abatement opportunities vary according to location and operational conditions. Since environmental
policy originates in damages relating to ecosystems and jurisdictions, a three-layered approach to vessel emissions is intuitive and practical. Here, we suggest associating damages and policies with ports, coastal areas possibly defined as Emission Control Areas (ECA) as in the North Sea and the Baltic, and open seas globally. This approach offers important practical opportunities: in ports, clean fuels or even electrification is possible; in ECAs, cleaner fuels and penalties for damaging fuels are important, but so is vessel handling, such as speeds and utilization. Globally we argue that it may be desirable to allow burning very dirty fuels at high seas, due to the cost advantages, the climate cooling benefits, and the limited ecosystem impacts. We quantify the benefits and cost savings from reforming current IMO and other approaches towards environmental management with a three-layered approach, and argue it is feasible and worth considering.

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On two speed optimization problems for ships that sail in and out of emission control areas
This paper deals with two speed optimization problems for ships that sail in and out of Emission Control Areas (ECAs) with strict limits on sulfur emissions. For ships crossing in and out of ECAs, such as deep-sea vessels, one of the common options for complying with these limits is to burn heavy fuel oil (HFO) outside the ECA and switch to low-sulfur fuel such as
marine gas oil (MGO) inside the ECA. As the prices of these two fuels are generally very different, so may be the speeds that the ship will sail at outside and inside the ECA. The first optimization problem examined by the paper considers an extension of the model of Ronen (1982) in which ship speeds both inside and outside the ECA are optimized. The second problem is called the ECA refraction problem, due to its conceptual similarity with the refraction problem when light travels across two different media, and also involves optimizing the point at which the ship crosses the ECA boundary. In both cases the objective of the problem is to maximize daily profit. In addition to mathematical formulations, examples and sensitivity analyses are presented for both problems.

Slow Steaming in Maritime Transportation: Fundamentals, Trade-offs, and Decision Models

Slow steaming is being practised in many sectors of the shipping industry. It is induced principally by depressed shipping markets and/or high fuel prices. In recent years the environmental dimension of slow steaming has also become important, as ship emissions are directly proportional to fuel burned. The purpose of this chapter is to examine the practice of slow steaming from various angles. In that context, a taxonomy of models is presented, some fundamentals are outlined, the main trade-offs are analysed, and some decision models are presented. Some examples are finally presented so as to highlight the main issues that are at play.
Speed Optimization for Green Maritime Logistics: Status and Prospects

The economic speed of an oceangoing vessel in a dynamic setting

The optimal (economic) speed of oceangoing vessels has become of increased importance due to the combined effect of low freight rates and volatile bunker prices. We examine the problem for vessels operating in the spot market in a tramp mode. In the case of known freight rates between origin destination combinations, a dynamic programming formulation can be applied to determine both the optimal speed and the optimal voyage sequence. Analogous results are derived for random freight rates of known distributions. In the case of independent rates the economic speed depends on fuel price and the expected freight rate, but is independent of the revenue of the particular voyage. For freight rates that depend on a state of the market Markovian random variable, economic speed depends on the market state as well, with increased speed corresponding to good states of the market. The dynamic programming equations in our models differ from those of Markovian decision processes so we develop modifications of standard solution methods, and apply them to small examples.
The National Technical University of Athens (NTUA) established a small Department of Naval Architecture and Marine Engineering in 1969, within the School of Mechanical and Electrical Engineering. Today, it is organized in four divisions, ship design and maritime transport, ship and marine hydrodynamics, marine structures, and marine engineering. To be awarded an engineering diploma in Greece, one has to spend a minimum of five years. The program at NTUA has also 10 semesters, out of which nine are dedicated to course study while the tenth is spend on the writing of a thesis. There is no tuition charge for European Union students, while a small fee is charged for students from other countries. In the first two years, the students are taught the fundamentals of engineering science. The core courses are taught in the third year. The wide spectrum of expertise that exists in school means that most research topics related to floating structures can receive supervision.

Combining Speed and Routing Decisions in Maritime Transportation
We present recent results on the problem of combining ship speed and routing decisions. Speed is a key determinant of the economic and the environmental performance affecting variables such as trip duration, fuel costs, and air emissions, among others. It is seen that inputs such as fuel cost, ship charter costs and cargo inventory costs may impact both speed and routing decisions. We develop models that optimize speed for a spectrum of routing scenarios and we use a heuristic method to solve them. Some examples are presented so as to illustrate the various trade-offs that are involved.
Estimating the Operational Effect of a Bunker Levy: The Case of Handymax Bulk Carriers

Market based measures concerning air emissions from ships are very likely to be introduced in the next years, in an effort to cap Greenhouse Gas Emissions from ships. A lot of countries have presented their proposals to IMO and practically the majority of them are based on a form of a fuel price penalty for the existing ships. In this paper the proposal for a Global Emissions fund will be presented and discussed as the most appropriate, easy to implement and flexible solution for an enforcement of a market based measure. At a second stage and using the emissions calculation and speed optimisation tool developed within the Laboratory for Maritime Transport of the National Technical University of Athens, simulations will be performed for a specified Bulk carrier and the corresponding to its fleet segment. A bunker levy will be implemented in the program and its effects will be studied in terms of speed and transportation work. For this purpose the tool is run for both cases, i.e. single ship and fleet segment, and for two different years 2009 and 2010 with and without the bunker levy.

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Keywords: Speed optimization, Market based measures, Bulk carriers, Maritime transportation, Air emissions from ships, Greenhouse gas emissions

Green Maritime Logistics

Typical problems in maritime logistics include, among others, optimal ship speed, ship routing and scheduling, fleet deployment, fleet size and mix, weather routing, intermodal network design, modal split, transshipment, queuing at ports, terminal management, berth allocation, and total supply chain management. The traditional analysis of these problems has been in terms of cost-benefit and other optimization criteria from the point of view of the logistics provider, carrier, shipper, or other end-user. Such traditional analysis by and large either ignores environmental issues, or considers them of secondary importance. Green maritime logistics tries to bring the environmental dimension into the problem, and specifically the dimension of emissions reduction, by analyzing various trade-offs and exploring ‘win-win’ solutions. This talk takes a look at the trade-offs that are at stake in the goal of greening the maritime supply chain and takes stock at models that can be used to evaluate these trade-offs. The talk is based on recent research of the author and his colleagues.

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Organisations: Department of Transport, Transport optimisation and technique
Contributors: Psaraftis, H. N.
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How green are the TEN-T core network corridors?

“How green are the TEN-T core network corridors?” is a concept introduced by the European Commission to enhance the provision of sustainable freight transport logistics services by concentrating freight traffic between major hubs and by relatively long distances. SuperGreen, a Coordination and Support Action aiming at further defining this concept, identified the characteristics that distinguish a green corridor from an otherwise efficient one. The main thesis of this paper is that the “core network corridors” of the new TEN-T guidelines exhibit all these qualities and the vision of a green corridor network in Europe is close to reality. To support this thesis, and in continuation of the work of SuperGreen, the paper examines the proposed new „guidelines“ for the development of the TEN-T after presenting a brief history of transport network development in Europe.
Ship speed optimization: Concepts, models and combined speed-routing scenarios

The purpose of this paper is to clarify some important issues as regards ship speed optimization at the operational level and develop models that optimize ship speed for a spectrum of routing scenarios in a single ship setting. The paper's main contribution is the incorporation of those fundamental parameters and other considerations that weigh heavily in a ship owner's or charterer's speed decision and in his routing decision, wherever relevant. Various examples are given so as to illustrate the properties of the optimal solution and the various trade-offs that are involved.

Spotlight on the mediterranean

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Contributors: Gilmore, R. A., Psaraftis, H. N.
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The possible designation of the Mediterranean Sea as a SECA: A case study

In view of the ongoing discussions concerning the possible designation of the Mediterranean Sea as a Sulphur Emission Control Area (SECA), a modal split model was applied to a case involving the transportation of consolidated cargoes between Thessaloniki, Greece and industrial hubs of northern Germany. A road-only option was assessed against a combined-transport route involving a ferry (Greece-Italy) and a truck-on-train (Italy-Austria) service. The logit model used considers two variables as determinants of the modal selection: transport cost and time. The data are derived from interviews with a small transport service provider, typical for Greece, and are based on actual trips made (revealed preferences). The results predict that the designation of the Mediterranean as a SECA will cause a modal shift in favour of the road-only route by 5.2%, which under certain assumptions can reach 17.1%. However, the environmental implications of the resulting modal choices, calculated through the EcoTransIT World web based tool, are positive in relation to all emissions examined. This is attributed to the longer distance of the combined-transport option in comparison to the road-only one and, the poor environmental performance of the Ro-Pax vessels basically due to the need to maintain a relatively high speed.

General information

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Original language: English
Keywords: Sulphur Emission Control Areas, Mediterranean, Greece-Italy connection, Short-sea shipping, Freight mode choice, Ro-Pax vessel environmental performance
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Bridging the Energy Efficiency Gap in Shipping: The case of Principal-Agent Problems in operational emission reduction measures

Recent literature identifies several measures and practices that have a great potential to reduce ship air emissions. Interestingly enough, some of them have negative abatement costs, i.e. the use of such measures would lead to reductions in Greenhouse Gas (GHG) emissions and entail economic benefits leading to a win-win scenario. However, most of these measures are not adopted. Indeed, there is a vast amount of literature that tries to explain why companies fail to invest in energy efficiency even though it is, or is perceived to be, profitable - a "phenomenon" that is also commonly referred to as the "energy efficiency gap". In the shipping industry, most works have identified the so-called Principal Agent problem, or split incentives barrier as a fundamental one. The paper identifies the cases where this kind of problem may occur. Finally, the paper presents barriers and ways to overcome them (such as the "Virtual Arrival" Incentive) in the case of operational measures that are mainly related to slow steaming.
Green Corridors in European Surface Freight Logistics

In the European Commission's Freight Transport Logistics Action Plan of 2007, a number of short- to medium-term actions are presented that will help Europe address its current and future challenges, and ensure a competitive and sustainable freight transport system there. One action is the "Green transport corridors for freight". A Green Corridor is characterized by a concentration of freight traffic between major hubs and by relatively long distances of transport. Green Corridors should in all ways be environmentally friendly, safe and efficient. Green technologies and smart utilization of Information and Communication Technologies (ICT), where available, may even improve those corridors. Where not available, new R&D may be required to further develop what is needed. Given the above policy goals, project "SuperGreen" has been launched. This is Coordination and Support Action co-funded by the European Commission in the context of the 7th Framework Programme for Research and Technological Development, and coordinated by the National Technical University of Athens. The project involves 22 partners from 13 European countries. The purpose of this chapter is to address the key issues involved in the development of Green Corridors for European Freight Logistics, describe the SuperGreen project, and give an overview of main results to date.

Northern Sea Route: Effect on Modal Shift and Modal Choice

Since the beginning of shipping, the world's commercial routes have not changed very much. For most ships the main route which connects Europe and Asia, is the one through the Suez Canal. Climate Change has had a great effect on North Pole. The ice-covered areas are decreasing year by year, enabling sailing in North Pole for commercial purposes. Northern Sea Route connects north Europe to Far East in a distance sorter by 40% compared to the royal route via Suez. Shorter distance is not equal with a decrease in cost by the same factor and probably does not mean decrease at all. For a regular usage a of northern sea route many improvements need to be made such as ports, terminals, and a complete network to provide services like navigation and meteorological forecasts. For this paper, a multinomial logit function used to estimate the percentage of transported cargo among via ship through Suez Canal, via Trans-Siberia Railway and via ship through Northern Sea Route during the summer period. The extra costs for ice-breaking, navigation and other required services, needed for safe sailing, increase the operational cost and make NSR not a competitive solution. If NSR is going to be a trade revenue, all the above services will be offered at lower rates and generalized cost will fall. In the second part the multinomial logit function is used so as to estimate the rates of extra costs that make sailing via NSR a cost effective solution.
Speed models for energy-efficient maritime transportation: A taxonomy and survey

International shipping accounts for 2.7% of worldwide CO2 emissions, and measures to curb future emissions growth are sought with a high sense of urgency. With the increased quest for greener shipping, reducing the speed of ships has obtained an increased role as one of the measures to be applied toward that end. Already speed has been important for economic reasons, as it is a key determinant of fuel cost, a significant component of the operating cost of ships. Moreover, speed is an important parameter of the overall logistical operation of a shipping company and of the overall supply chain and may directly or indirectly impact fleet size, ship size, cargo inventory costs and shippers’ balance sheets. Changes in ship speed may also induce modal shifts, if cargo can choose other modes because they are faster. However, as emissions are directly proportional to fuel consumed, speed is also very much connected with the environmental dimension of shipping. So when shipping markets are in a depressed state and “slow-steaming” is the prevalent practice for economic reasons, an important side benefit is reduced emissions. In fact there are many indications that this practice, very much applied these days, will be the norm in the future. This paper presents a survey of speed models in maritime transportation, that is, models in which speed is one of the decision variables. A taxonomy of such models is also presented, according to a set of parameters.

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Source-ID: n:oai:DTIC-ART:bi/380431037::28964
Research output: Contribution to journal › Journal article – Annual report year: 2013 › Research › peer-review

An Updated Analysis of IOPCF Oil Spill Data: Estimation of the Disutility Cost of Tanker Oil Spills

Beyond any doubt, the cost of an oil spill is very difficult to be estimated. The approach used in this work is based on the assumption that the cost of an oil spill can be approximated by the compensation eventually paid to claimants. A series of regression analyses of the total costs have been carried out based on the latest available data. These analyses and their results can provide useful insights to the discussion on environmental risk evaluation criteria and in policy evaluation regarding the oil pollution of the marine environment by estimating the damage cost of oil spills and, thus, the benefit from relative regulations that deal with the prevention of oil pollution in cost effectiveness and cost benefit analysis.

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Contributors: Kontovas, C. A., Ventikos, N., Psaraftis, H. N.
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Concession of the Piraeus container terminal: turbulent times and the quest for competitiveness

This paper examines the recent concession of the Port of Piraeus (OLP) container terminal to Cosco Pacific. Serious discussions on how to transform the terminal to landlord status started in 2004 and, after an aborted tender, a concession award was approved by the Greek parliament in 2009. The contract is now operational after strong opposition by the port unions and a renegotiation phase in 2010. In this turbulent context, the economic implications of the particulars that dominated the negotiations and the provisions that were included in the final concession agreement (i.e. duration, conditions, competition issues, etc.) are worth examination. The analyses of the history, the design of the concession strategy that was endorsed by the relevant policy-makers (i.e. national ministry, port authority, etc.), and the implementation choices made provide an assessment of how the details of the concession might enhance/hamper the conclusion of the concession agreement and affect the organisation and the competitive position of the port.

Estimating the consequence costs of oil spills from tankers

In the last decade, both worldwide and in the United States, the number of oil spills and the total quantity of oil spilled into the seas have declined. However, further improvements are still desirable. Clearly, the cost of oil spills to be avoided is one of the most important parameters in evaluating ship designs, measures, and policies to reduce oil pollution. The approach used in this work is based on the assumption that the cleanup and the total cost of an oil spill can be approximated by the compensation eventually paid to claimants regarding the relative cost categories. To that extent, this paper reports on various analysis of oil spill cost data for spills. These analyses and their results can provide useful insights to the ongoing discussion on environmental risk evaluation criteria within Formal Safety Assessment (FSA). Additional uses are also suggested and some examples are given.
Formal Safety Assessment: an updated review

The method of Formal Safety Assessment (FSA) was devised several years ago with the intent to help the International Maritime Organization (IMO) and other policy makers formulate policies and regulations by the proper use of the scientific method in matters pertaining to maritime safety and the protection of the marine environment. A host of FSA studies have been submitted over the last several years and have been reviewed by the IMO. Also, progress has been recently accomplished as regards incorporating environmental risk evaluation criteria within FSA. On the basis of these developments, revisions of the FSA guidelines have been proposed and adopted. This paper presents a review of the FSA method in light of these developments. This review updates an earlier review of FSA by Kontovas and Psaraftis [Marine Technol 46(1):45–59, (2009)]. It also takes this opportunity to identify some deficiencies of FSA, either due to an incorrect application of the method or to the method itself, and makes some suggestions for further action in this area.

Green Corridors and the Trans-European Transport Network

“Green corridors” in freight transportation is a concept introduced in 2007 as an action of the “Freight Transport Logistics Action Plan” of the European Commission. It pursues a corridor approach in developing integrated, efficient and environmentally friendly transportation of freight between major hubs and by relative long distances. The National Technical University of Athens leads the EU-financed SuperGreen project, which aims at assisting the Commission in defining green corridors. One of the key activities of the project involves the selection of a number of European corridors...
and their performance benchmarking through a selected set of key performance indicators. The purpose of this paper is to present the most important project results with emphasis on transport policy issues. The paper will also include a comparison between the green corridor concept and the notion of "core network corridors", recently introduced by the Commission as an instrument for implementing what comprises the prioritised backbone of the multimodal mobility network in Europe.

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**Green Corridors in European Surface Freight Logistics and the SuperGreen Project**
"Green corridors" is an EU concept introduced in 2007 that aims at developing integrated, efficient and environmentally friendly transportation of freight between major hubs and by relative long distances. SuperGreen is a project co-financed by the European Commission to assist in further defining and developing the green corridor concept. A central activity of the project is the development of a corridor benchmarking methodology using a set of Key Performance Indicators that are suitable for monitoring the sustainable development goals of the European Union. The purpose of this paper is to present the SuperGreen project and the results achieved so far.

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**Market-based measures for greenhouse gas emissions from ships: a review**
The purpose of this paper is to review several distinct proposals for market-based measures (MBMs) that are under consideration by the International Maritime Organization (IMO) for greenhouse gases (GHGs). Thus far, some ten distinct MBM proposals have been submitted to the IMO. The paper discusses the general concept of an MBM, the mechanisms used by MBMs, and attempts to discuss the pros and cons of the submitted proposals, according to some specific criteria.

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Modelling tankers' optimal speed and emissions

With the increased quest for greener shipping, reducing the speed of ships has obtained an important role as one of the measures to be applied toward that end. Already speed has been important for economic reasons, as it is a key determinant of fuel cost, a significant component of the operating cost of ships. However, as emissions are directly proportional to fuel consumed, speed is also very much connected with the environmental dimension of shipping. So when shipping markets are in a depressed state and “slow-steaming” is the prevalent practice for economic reasons, an important side benefit is reduced emissions. Emissions estimation models typically assume fixed ship speeds. However, ships do not trade at predetermined speeds. Those who pay for the fuel may choose an operating speed as a function of the freight rate and bunker price, among others. Assuming a fixed speed may thus seriously miscalculate emissions. This paper incorporates ship speed into the analysis, and goes one step further by investigating the impact of optimizing speed on ship emissions. The study of the paper focuses on Very Large Crude Carriers (VLCCs), but some analysis for the Suezmax, and Aframax crude tanker segments is also presented, and some results for Panamax/Product, LPG, and LNG tankers are also reported. The paper's modeling approach has two goals: (a) the determination of the optimal operational speeds (laden and ballast) of a tanker as a function of fuel price, freight rate and other parameters, and (b) the estimation, among other outputs, of the emissions of the global fleet of a specific tanker segment. The modeling task comprises two steps. The first one optimizes the laden and ballast leg sailing speeds over reference trade routes for a specific (single) tanker. In a second step, we estimate annual emissions, and other operational attributes (e.g. fuel consumption) for the tanker fleet segment, based on the output of the previous optimization. Other outputs such as CO2, SO2, NOx and PM emissions are also produced. The policy implications of our work are finally discussed.

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Research output: Contribution to journal » Journal article – Annual report year: 2012 » Research » peer-review
proportional to fuel consumed, speed is also very much connected with the environmental dimension of shipping. So when shipping markets are in a depressed state and “slow-steaming” is the prevalent practice for economic reasons, an important side benefit is reduced emissions. Emissions estimation models typically assume fixed ship speeds. However, ships do not trade at predetermined speeds. Those who pay for the fuel may choose an operating speed as a function of the freight rate and bunker price, among others. Assuming a fixed speed may thus seriously miscalculate emissions. This paper incorporates ship speed into the analysis, and goes one step further by investigating the impact of optimizing speed on ship emissions. The study of the paper focuses on Very Large Crude Carriers (VLCCs), but some analysis for the Suezmax, and Aframax crude tanker segments is also presented, and some results for Panamax/Product, LPG, and LNG tankers are also reported. The paper’s modeling approach has two goals: (a) the determination of the optimal operational speeds (laden and ballast) of a tanker as a function of fuel price, freight rate and other parameters, and (b) the estimation, among other outputs, of the emissions of the global fleet of a specific tanker segment. The modeling task comprises two steps. The first one optimizes the laden and ballast leg sailing speeds over reference trade routes for a specific (single) tanker. In a second step, we estimate annual emissions, and other operational attributes (e.g. fuel consumption) for the tanker fleet segment, based on the output of the previous optimization. Other outputs such as CO2, SO2, NOx and PM emissions are also produced. The policy implications of our work are finally discussed.

New Regulations & Climate Change: Effect on Modal Split & Modal Choice
Since the beginning of shipping, the commercial routes have not changed at all. For most ships, except for the larger ones, the main route, which connects Europe and Asia, goes through the Gulf of Aden and the Suez Canal. Climate Change has had a great effect on the North Pole, creating a much shorter sea route between Europe and Asia, the Northern Sea Route (NSR). This alternative shipping route can offer a much shorter connection, even by 40%. On the other hand, the trans-Siberian railway is now connected to the national railway of Germany and some companies have been using it to transfer goods to and from China. The goal of this paper is to estimate the percentage of transported cargo that will be shifted to other carrying modes or routes. The model developed for the purpose of this paper, by using a multinomial logit function, shows the percentage of the transported cargo for every mode among ship via Suez or NSR, via trans-Siberian Railway and via airborne transportation. The factors, which were included in the function, were the generalized cost of transport, the transportation time (door-to-door) and the value of time.

Ship Emissions, Costs and Their Tradeoffs

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The Economics of Ships

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Source: PublicationPreSubmission
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Research output: Chapter in Book/Report/Conference proceeding » Book chapter – Annual report year: 2012 » Research » peer-review

The SuperGreen project and green corridor benchmarking

»Green corridors« in freight transportation is a concept introduced in 2007 by the »Freight Transport Logistics Action Plan« of the European Commission. It pursues a corridor approach in developing integrated, efficient and environmentally friendly transportation of freight between major hubs and by relative long distances. The National Technical University of Athens leads the EU-financed SuperGreen project, which aims at assisting the Commission in defining green corridors through the use of Key Performance Indicators (KPIs). A set of 9 European corridors have been selected by the project, based on their green characteristics or their greening potential, in order to be used as testing ground for the KPIs and the related benchmarking methodology. The paper presents the project’s preliminary results, namely (a) corridor selection, (b) benchmarking methodology and KPIs, and (c) corridor benchmarking results.

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A multi-commodity, capacitated pickup and delivery problem: The single and two-vehicle cases

We explore dynamic programming solutions for a multi-commodity, capacitated pickup and delivery problem. Cargo flows are given by an origin/destination matrix which is not necessarily symmetric. This problem is a generalization of several known pickup and delivery problems, as regards both problem structure and objective function. Solution approaches are developed for the single-vehicle and two-vehicle cases. The fact that for each cargo that goes from a node i to another node j there may be a cargo going in the opposite direction provides the motivation for the two-vehicle case, because one may conceivably consider solutions where no cargoes that travel in opposite directions between node pairs are carried by the same vehicle. Yet, it is shown that such scenarios are generally sub-optimal. As expected, the computational effort of the single vehicle algorithm is exponential in the number of cargoes. For the two-vehicle case, said effort is of an order of magnitude that is not higher than that of the single-vehicle case. Some rudimentary examples are presented or both the single-vehicle and two-vehicle cases so as to better illustrate the method.

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Web of Science (2011): Impact factor 1.815
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
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This paper looks at the implications of various maritime emissions reductions policies for maritime logistics. There can be important trade-offs that have to be made between the environmental benefits associated with such measures as reduction in steaming speed and change in the number of vessels in the fleet, and more conventional logistics attributes such as in-transit inventory holdings.

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Web of Science (2011): Impact factor 1.659
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Estimating the Consequence Costs of Oil Spills from Tankers
In the last decade, both worldwide and in the United States, the number of oil spills and the total quantity of oil spilled into the seas have declined. However, further improvements are still desirable. Clearly, the cost of oil spills to be avoided is one of the most important parameters inevaluating ship designs, measures, and policies to reduce oil pollution. The approach used in this work is based on the assumption that the cleanup and the total cost of an oil spill can be approximated by the compensation eventually paid to claimants regarding the relative cost categories. To that extent, this paper reports on various analysis of oil spill cost data for spills. These analyses and their results can provide useful
insights to the ongoing discussion on environmental risk evaluation criteria within Formal Safety Assessment (FSA). Additional uses are also suggested and some examples are given.

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Key performance indicators for green corridors in European freight Transportation

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Letter to the Editor

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Web of Science (2011): Impact factor 2.503
ISI indexed (2011): ISI indexed yes
Original language: English
DOIs: 10.1016/j.marpolbul.2011.02.019
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Research output: Contribution to journal › Letter – Annual report year: 2011 › Research

Liner shipping cycle cost modelling, fleet deployment optimization and what-if analysis
This article formulates the mathematical model of the liner shipping company cycle cost and attempts to optimize the operational profile of company assets in regards to specific network of routes of cargo flows and vessels portfolio. In other words it attempts to give a practical solution to the modern shipping company fleet deployment problem. This is achieved by developing a generic cost model methodology that aims to minimize total operating costs by using Genetic Algorithms in optimizing various predefined attributes such as operational speed. The finalized model could be applicable to liner shipping companies for optimization purposes of liner networks, as well as for simulation and examination of possible scenarios and what-if analysis. In the era of recession, a demand shock is examined and, interesting results are produced. In further research, this model can estimate the impact of environmental legislation intensification. In the what-if analysis, the model can depict how an initial design of a liner system can be optimized by modifying system attributes to dynamically meet new requirements.
The effects of regulatory changes on green freight corridors

General information
Publication status: Published
Organisations: National Technical University of Athens
Contributors: Panagakos, G. P., Psaraftis, H. N.
Pages: 807-814
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Host publication information
Title of host publication: Sustainable Maritime Transportation and Exploitation of Sea Resources
Publisher: CRC Press
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10.1201/b11810-120

The role of ports in Short Sea Shipping

This paper discusses the role of ports in Short Sea Shipping (SSS). To that effect a European perspective is mainly taken, as recently there have been numerous policy initiatives in Europe that deal with both sectors. The paper takes stock at the situation as regards European ports and SSS and discusses challenges and prospects for the future. The analysis looks into both ports and SSS in a strict sense and other sectors that are related, directly or indirectly, and that may have important ramifications. These other sectors include security and the environment. It is argued that the role of ports in removing bottlenecks and promoting SSS can be critical. This paper attempts to explain the causes of current problems, and makes some suggestions on how to remedy the situation. © 2011 Taylor & Francis Group, London.

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Organisations: Unknown
Contributors: Psaraftis, H. N.
Pages: 1429-1437
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Host publication information
Title of host publication: Marine Technology and Engineering
Publisher: CRC Press/Balkema
Balancing the economic and environmental performance of maritime transportation

This paper looks at the implications of various maritime emissions reductions policies for maritime logistics. There can be important trade-offs that have to be made between the environmental benefits associated with such measures as reduction in steaming speed and change in the number of vessels in the fleet, and more conventional logistics attributes such as in-transit inventory holdings.

Carbon dioxide emissions valuation and its uses

The purpose of this paper is to elucidate the frequently used definitions of the carbon price for one tonne of carbon dioxide avoided or reduced. This per unit cost plays an important role in estimating the benefit of avoiding greenhouse gas emissions or estimating the damage occurred when such gases are emitted. The economic valuation of carbon is essential for various purposes: designating environmental policies like optimal taxes and evaluating the economic efficiency of projects. Furthermore, the disutility cost can be used in cost benefit analysis and therefore in risk assessment. A framework called Formal Safety Assessment (FSA) is currently, the major risk assessment tool that is being used for policy-making within the International Maritime Organization (IMO). Therefore the work can also be also viewed within the framework of FSA, Cost-Benefit Analysis and similar risk assessment and policy evaluation analyses.

Concession of the Piraeus Container Terminal: Turbulent times and the quest for competitiveness

General information
Publication status: Published
Organisations: University of the Aegean, National Technical University of Athens
Contributors: Psaraftis, H. N., Pallis, A. A.
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Peer-reviewed: Yes
Event: Paper presented at International Association of Maritime Economists Conference (IAME 2010), Lisbon, Portugal.

Container transportation as an interdependent security problem
This paper concerns container shipping transportation viewed as an interdependent security system. The methodological background is the use of game-theory in the investigation of how interdependence affects individual choices about security expenditures in so-called interdependent systems (IDS problems). Any agent’s incentive to adopt security measures depends on the actions of others because of the negative externalities created among them. In this context, we examine security questions in container transportation and more specifically we focus on investments in container checking systems at ports, considering the currently much debated 100% scanning requirement of containers destined to USA. It is obvious, that in such analysis there is a demand to balance the cost of investing in (installing) and operating such a system and the reduction in the risk of a potential damage from a “dangerous” container from a security point of view. A transferred “dangerous container”, which may pass through another agent / port (screening point), introduces an additional dimension of risk. Useful suggestions are reached from such a treatment of the subject and policy dimensions emerge, such as the potential need for coordinating mechanisms among ports.

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Contributors: Gkonis, K. G., Psaraftis, H. N.
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Source-ID: n::oai:DTIC-ART:springer/244279247::36155

Establishment of a system to compare Energy Usage and Emissions for all transport modes
This paper describes a methodology for calculating the energy consumption and the emissions for all transport modes (sea, road, rail, aviation) in a consistent and comparable way. And it establish good principles for how the energy used and emissions shall be matched with the actual goods transported, and how to allocate the energy used on repositioning (ballast legs) to the cargo transported.

General information
Publication status: Published
Organisations: Norwegian University of Science and Technology, SINTEF, National Technical University of Athens
Contributors: Lindstad, H., Mørkve, O. T., Psaraftis, H. N.
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Green maritime logistics: some simple models

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Contributors: Psaraftis, H. N.
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Publisher: Peter Lang
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ISBN (Electronic): 9783631609606
Research output: Chapter in Book/Report/Conference proceeding › Book chapter – Annual report year: 2010 › Research › peer-review

Life-cycle co2 emissions of bulk carriers: A comparative study
In order to maintain shipping capacity to serve seaborne trade, new ships have to be built to replace those scrapped. The cost of building, manning, operating, maintaining and repairing a ship throughout its life is borne by society at large through market mechanisms. Gratsos and Zachariadis (2005) had investigated through a cost/benefit analysis how the average annual cost of ship transport varies with the corrosion additions elected at the design stage. The results of that paper clearly indicated that ships built with sufficient corrosion allowances, truly adequate for the ship's design life, have a lower life cycle cost per annum despite the fact that such ships would carry a slightly smaller quantity of cargo. Furthermore the safety and environmental benefits due to the reduced repairs and extended lifetime of such ships were briefly discussed. The debate of how "robust" a ship should be was also transferred to IMO in the context of Goal Based Standards following a submission by Japan which stated that the increased steel weight of a more robust ship will result in increased CO2 emissions due to a reduced cargo carrying capacity. Greece replied by submitting a summary of the aforementioned paper and preliminary estimations on Life cycle CO2 emissions disputing the Japanese contentions. However, taking onboard the challenge, an update is provided in the present paper, using the final Common Structural Rules (CSR) of the International Association of Classification Societies (IACS) bulk carrier corrosion margins and taking into account the major environmental implications of the heavier ship scantlings for two bulk carrier size brackets, Panamax and Handymax. The results show that the more robust ships would produce less CO2 emissions over their lifetime. © 2010: The Royal Institution of Naval Architects.

General information
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Contributors: Gratsos, G. A., Psaraftis, H. N., Zachariadis, P.
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Research output: Contribution to journal › Journal article – Annual report year: 2010 › Research › peer-review

Modelling Security Aspects of Merchant Shipping: a Piracy setting
This paper concerns merchant shipping security and proposes a game theoretic model for modelling piracy threats and counteractions. Piracy has become a central concern for the international maritime community, especially after the recent
tremendous increase in the number of piracy attacks in the Gulf of Aden and adjacent waters, off Somalia and the eastern coasts of Africa. This phenomenon has forced governments around the world into political and military action. However, the pirates appear to have adapted their operations to these developments. The piracy phenomenon is basically a security problem, where on one side the international community is seeking for measures to restrain attacks on merchant ships, while on the other side, pirates develop tactics and assess the existing situation in order to successfully place hijacking attacks. An interaction setting (game) is examined in the present approach between two players, a defender and an attacker. The defender (player 1) is a naval force command and the attacker (player 2) is the pirates “headquarters” (where their leaders plan their attacks). Two potential target areas for the pirates (and respective areas for the development of the naval forces) are considered, each of which is defined within certain geographical limits. Technically, this is an incomplete information game with information asymmetry. Following a number of assumptions, the analysis reaches interesting suggestions for the side of the defender, given the behaviour of the attacker. For example, regarding the target areas which should be defended and the level of defense measures, as a function of the expected damage costs that the shipping community might suffer, budget considerations, and damage expectations for any given defense strategy. In general, parametric analyses can be performed to reach useful results, regarding the optimal allocation of ships - defense measures, for given expectations (and not knowledge) for piracy activity.

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Contributors: Gkonis, K. G., Psaraftis, H. N., Ventikos, N. P.
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Keywords: Shipping security, Piracy, Game theory
Research output: Contribution to conference > Paper – Annual report year: 2010 > Research > peer-review

Reduction of Emissions Along the Intermodal Container Chain
Emissions from commercial shipping are currently the subject of intense scrutiny. Among the top fuel consuming categories of ships and hence air polluters are container vessels. The main reason is their high service speed. Lately speed reduction has become a very popular operational measure to reduce fuel consumption and can obviously be used to curb emissions. This paper examines such an operational scenario. Since time at sea increases with slow steaming, there is a parallel and strong interest to investigate possible ways to decrease time in port. One way to do so is to reduce port service time. Another possible way to minimize disruption and maximize efficiency is the prompt berthing of vessels upon arrival. To that effect, a related berthing policy is investigated as a measure to reduce waiting time. The objective of reducing emissions along the intermodal container chain is investigated vis-à-vis reduction in operational costs and other service attributes. Some illustrative examples are presented.

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Keywords: Green Logistics, Ship Air Emissions, Container Transportation
Research output: Contribution to conference > Paper – Annual report year: 2010 > Research > peer-review

An Online Ship Emissions Calculator as a Decision-Making Aid and Policy Evaluation Tool
The broader analysis of greenhouse gases such as CO2, and of other, non-greenhouse gases, such as SO2 and NOx is already very high on the International Maritime Organization’s (IMO) agenda. Various analyses of many aspects of the problem have been and are being carried out and a spectrum of measures are being contemplated. The authors have developed a web-based tool that is freely available online for calculating the exhaust gas emissions (CO2, SO2 and NOx) of specific types of ships under a variety of operational scenarios. It can be used for example by ship owners who need to know both the amount of emissions that their ships produce, and, indirectly, the bunker consumption, in order to choose between alternative scenarios that are both economic and more environmental friendly. In this paper, the algorithm that is behind the web tool as well as the practical importance of this tool are presented. Actual scenarios based on data provided by shipping companies are used and possible ways to incorporate the web tool into actual decision-making are analyzed.

General information
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Organisations: National Technical University of Athens
Contributors: Kontovas, C. A., Psaraftis, H. N.
Number of pages: 8
A web-based open emissions calculator

Many organisations and governmental agencies offer online calculators to calculate the carbon footprint of industrial activities. Furthermore, airline companies offer online tools to estimate carbon footprint and promote the purchase of carbon offsets in order to make the trip carbon neutral. This paper presents a free online emissions calculator that computes various emissions-related statistics for a given ship and operational scenario. This web tool is the first publicly available calculator for the shipping industry.

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Source-ID: n:oai:DTIC-ART:inspec/211207845::28955
Research output: Contribution to journal › Journal article – Annual report year: 2009 › Research › peer-review

Caspian - Black Sea - SE European Gas Corridors and the LNG parameter: A scenario bundles approach

In this paper, national energy strategy issues are of concern in relation to gas supply and the role of LNG (Liquefied Natural Gas). The decision makers are countries and governments rather than private investors. The analysis level is strategic, in the sense that it recognises the geopolitical dimensions of energy-related security issues. It is not intended to examine technical and cost details regarding existing or future gas routes, but instead we focus on more high-level and strategic parameters and concerns. Our application refers to the Caspian - Black Sea - SE European Gas Corridors in the year 2015. The role of LNG is assessed in this context as a flexible gas supply source, influencing the strategies of the involved players.

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CO₂ emission statistics for the world commercial fleet

The purpose of this paper is to present an analysis of carbon dioxide (CO₂) emissions of the world commercial fleet. The analysis is based on the Lloyds-Fairplay world ship database for 2007 and produces various emissions statistics of the following major ship types: bulk carriers, crude oil tankers, container vessels, product/chemical carriers, LNG carriers, LPG carriers, reefer vessels, Ro-Ro vessels and general cargo ships. A separate analysis is carried out for small vessels under 400 GRT and for passenger vessels. The main outputs from this analysis for each ship type-size bracket are the emitted grams of CO₂ per tonne-km and an estimate of the total CO₂ produced in a year. The methodology for estimating these statistics is described, and a comparison with other studies is made.
Formal safety assessment: A critical review

Formal Safety Assessment (FSA) is the premier scientific method that is currently being used for the analysis of maritime safety and for the formulation of related regulatory policy. This paper conducts a critical review of the FSA methodology and proposes ways to improve it. All steps of the FSA approach are looked at, and possible pitfalls or other deficiencies are identified. Then proposals are made to alleviate such deficiencies, with a view to achieve a more transparent and objective approach. The results of this paper may be useful if a revision of the FSA guidelines is contemplated along these lines. Recent International Maritime Organizations (IMO) developments are also described.

Game Theory contributions to Terrorism in Merchant Shipping: an Application to Port Security

This paper concerns merchant shipping security and proposes a game theory framework for modelling terrorism threats and counteractions. First, the security considerations associated with merchant shipping in the post 9/11 era are reviewed, as well as the main current issues in maritime security, and the approaches developed in the academic literature. It is argued that game theory is suitable to address such security issues and its contributions to counterterrorism in other security settings are reviewed. The purpose is to identify the relevance to merchant shipping security of concepts and insights developed in other security settings, and then accordingly apply them to the former. In this context, such a game theoretic model is applied to a port security setting, where "port" and "ship" targets must decide on the level of their security measures and their associated costs, in order to respond to a potential attack by terrorists. The interaction settings involve the actors, their available options, their preferences and strategic goals, and other important parameters and assumptions.
Defensive measures and potential damages are associated with cost variables. The analysis considers on one hand the case where the targets decide independently about the deterrence measures each one will take, wishing to minimise its expected overall costs. This may result to an attack being diverted from one target to the other. On the other hand, the targets may reach defence measures decisions in coordination with each other, in order to achieve the game's social optimum. In this case, the aim is the collective best, while the players' actions may not be in their best private interests. Useful conclusions and suggestions are reached from such treatment of the subject through an appropriate numerical example.

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Keywords: Game theory, Merchant shipping, Security, Terrorism, Deterrence measures

Life cycle cost of maintaining the effectiveness of a ship's structure and environmental impact of ship design parameters: An update
In order to maintain shipping capacity to serve seaborne trade, new ships have to be built to replace those scrapped. The cost of building, manning, operating, maintaining and repairing a ship throughout its life is borne by society at large through market mechanisms. The original paper investigated through a cost/benefit analysis, how the average annual cost of ship transport varies with the corrosion additions elected at the design stage. The results of the study clearly indicated that ships built with sufficient corrosion allowances, truly adequate for the ship's design life, have a lower life cycle cost per annum (AAC) despite the fact that such ships would carry a slightly smaller quantity of cargo. Furthermore the safety and environmental benefits due to the reduced repairs and extended lifetime of such ships were briefly discussed. The debate of how robust a ship should be was also transferred to IMO in the context of Goal Based Standards following a submission by Japan which stated that the increased steel weight of a more robust ship will result in increased CO2 emissions due to a reduced cargo carrying capacity. Greece replied by submitting a summary of the original paper and preliminary estimations on Life cycle CO2 emissions disputing the Japanese contentions. However, taking onboard the challenge, the authors present here an update, using the final IACS CSR bulk carrier corrosion margins and taking into account the major environmental implications of the heavier ship scantlings for two bulk carrier size brackets, Panamax and Handymax. The results show that the more robust ships would produce less CO2 emissions over their lifetime.

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Liner Shipping Costs and Logistics: A Literature Survey and Taxonomy of Problems

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Ship Emissions: Logistics and Other Tradeoffs
This paper takes a look at various tradeoffs that are at stake in the goal for reduced ship emissions and may impact the costeffectiveness of the maritime logistics chain and presents some models that can be used to evaluate these tradeoffs.

The reason for investigating such tradeoffs is that measures to reduce such emissions may possibly have ramifications as regards the logistical supply chain, and vice-versa. The broad spectrum of measures that are involved in the drive to reduce emissions generally depends on the type of emissions that are studied. In this paper we focus on operational measures that have a direct link to logistical operations, and investigate related tradeoffs. The focus is mainly on CO2 and SO2 emissions. Measures such as reduction of speed, change of number of ships in the fleet, and possibly others, will generally entail changes (positive or negative) in overall emissions, but also in other logistics and cost-effectiveness attributes such as intransit inventory and other costs. Industry circles have also voiced the concern that low-sulphur fuel in SECAs (these are the so-called ‘sulphur emissions control areas’ that exist in some parts of the world- for instance the Baltic and the North Sea) may make maritime transport (and in particular short-sea shipping) more expensive and induce shippers to use land-based alternatives (mainly road), even though shifting cargo from land to sea is an important policy goal. A reverse shift of cargo from sea to land might ultimately increase the overall level of CO2 emissions along the intermodal chain. Models to investigate such problems are developed and some examples are presented.

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Speed Reduction as an Emissions Reduction Measure for Fast Ships
Ships that sail at high speeds emit a higher amount of air emissions on a per tonne-km basis than ships that go slower. As the goal of environment-friendly shipping is high on the agenda of the IMO, the European Commission and many individual coastal states, reduction of emissions, both from greenhouse gases (GHG)such as CO2 , and also from SOx, NOx , and other gases, is an important and urgent target. One of the obvious operational measures that is contemplated to reduce emissions is speed reduction. As there is a cube law between speed and fuel consumption per day, the higher a ship’s speed is, the more her emissions can be reduced byspeed reduction. This is particularly true for high speed craft but also for containerships, RoPax ferries and other ships that go faster than the average. However, a reduction in speed may have undesirable side-effects that may generally entail non-trivial costs. Such side-effects may include the need for more ships in the fleet, increased cargo inventory costs, and others, and collectively may render speed reduction not necessarily cost-effective. Alternatively, one may compensate by reducing port time, to the extent possible. This paper investigates such issues for a variety of ship types at the higher end of the speed spectrum and attempts to identify factors that are important and alternatives that are more cost-effective.

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The LNG market: A game theoretic approach to competition in LNG shipping
The Liquefied Natural Gas (LNG) trade is one of the most promising sectors in energy shipping. It is expected that competition will increasingly develop in the shipping segment of the LNG chain, which at least in its first phases will have the characteristics of an oligopolistic market. The LNG shipping market context is appropriate for the adoption of a (non-cooperative) game theoretic analysis framework to support decision-making. This paper focuses on oligopolistic competition in LNG shipping over the transportation capacity supplied to a trade route by competing shipping companies. It also examines the possibility of non-cooperative collusion among the competing parties, in order for them to share higher profits. The conclusions concern the optimal level of capacity supply by the competitors, under certain interaction settings, and the conditions under which they can sustain Pareto efficient equilibria.
A model-based approach for tactical decision making in oil spill response

In this paper we propose an integrated approach for tactical decision making in oil spill response based on information on the oil fate. The optimization problem is sequentially coupled with a dynamic mathematical model that provides estimates of the oil spill fate at the contact time of the spill with the response means. The model consists of a set of differential and algebraic equations that describe the spill dynamics as these are affected by spreading and weathering. To solve the tactical problem, an integer optimization problem is formulated where the objective is to minimize the total costs considering the response system costs and the resulting reduction in the spill damage. Appropriate constraints on equipment operability and capacity, response time, supply and mother vessel use are set. The use of the methodology is illustrated via its application in a realistic case where the response means considered is the EU-MOP system (Elimination Units for Marine Oil Pollution).

CO₂ Emissions Statistics for the World Commercial Fleet

Carbon dioxide (CO₂) emissions from commercial shipping are currently unregulated, but nevertheless they are a subject of intense scrutiny by the world shipping community. According to the Kyoto protocol, definite measures to reduce CO₂ emissions are necessary in order to curb the projected growth of greenhouse gases (GHG) worldwide. Shipping has thus far escaped being included in the Kyoto global emissions reduction target for CO₂ and other GHGs, but it is clear that the time of non-regulation is rapidly approaching its end, and measures to curb future CO₂ growth are being sought with a high sense of urgency. Various analyses of many aspects of the problem have been and are being carried out and a spectrum of measures are being contemplated. It is clear that a reliable emissions inventory is essential for both scientists and policy-makers in order to formulate and evaluate the implementation of relevant regulations. To contribute to this debate and possibly complement other studies on the subject, the authors of this paper have conducted their own analysis on emissions of the world fleet database and can herein present some preliminary results of the emissions statistics of the following major ship types: bulk carriers, crude oil tankers, container vessels, product/chemical carriers, LNG carriers, LPG carriers, reefer vessels, Ro-Ro vessels and general cargo ships. A separate analysis was carried out for small vessels under 400 GRT and for passenger vessels.
Early Commitment and Entry Deterrence in an LNG shipping market
The LNG (Liquefied Natural Gas) trade is one of the most promising sectors in energy shipping. An important characteristic of the LNG shipping market is its oligopolistic structure. The market actors make their decisions independently, yet knowing that these decisions are likely to influence the strategic positioning of the other players. This context is appropriate for the adoption of a (non-cooperative) game theoretic analysis framework to support decision-making. Two topics of strategic decision-making in LNG shipping are investigated in this paper, namely Early Commitment and Entry Deterrence. Early Commitment has to do with the rationale that may justify an early strategic investment commitment (it may also be encountered as "pre-commitment") . In an LNG shipping market such a pre-commitment could be an order of (uncommitted) LNG vessels to be launched in the market in a future point in time. Entry Deterrence is a strategic interaction between a monopolist LNG shipowner in a specific market (the incumbent) and a potential entrant or entrants in that market. The entrants offer identical or close substitute products (services), i.e. the LNG cargoes shipping service. If they enter the market, then the incumbent's profits are reduced, so the incumbent - monopolist tries to prevent other firms from entering the market. First, a traditional approach to such a strategic interaction is discussed and it is explained why it is unsatisfactory. Then, it is presented how game theory provides a more sophisticated treatment of the subject, and the previously developed early commitment concepts are also utilised for this purpose.

Environmental risk evaluation criteria
This paper describes an approach to incorporating environmental risk evaluation criteria within IMO’s guidelines for Formal Safety Assessment (FSA). Such criteria are currently absent from FSA, and the discussion to include them has just started. Said criteria are relevant for evaluating on a cost-benefit basis Risk Control Options (RCOs) for reducing oil spill pollution risk. Oil pollution may come from any ship, including bunker spills from non-tank vessels. RCOs are not necessarily ship-based, and may include vessel traffic management information systems (VTMIS) and other options. The proposed approach may be useful in extending FSA to cover environmental risk evaluation criteria and combines such criteria with criteria already in use in FSA. It can also readily be extended to environmental consequences other than oil pollution. Recent IMO developments on this matter are also reported.
The role of Mediterranean short sea shipping in the EU transport chain: The case of Greece

The European Community has provided valuable support to short sea shipping through various programs and legislation. This paper analyses the situation while focusing on the Mediterranean Sea and suggests solutions for addressing the short sea shipping problems in this special region. The biggest challenge for all sides in the coming years will be the replacement of the existing fleet. The study presented herein gives an insightful and collective picture of the situation, while focusing on the Greek owned short sea vessels.

A decision-making model for oil spill response at the tactical level

The present paper addresses the tactical level of the oil spill response decision-making process, that determines the actions required to respond to a specific spill. In the broader area of the incident, a number of response facilities may exist. These facilities are equipped with known quantities and types of oil response equipment. The decision-maker needs to determine from which facilities to dispatch units to the spill site and, moreover, the types and quantities of the units to be dispatched. The objective is to respond to the specific spill in an optimal way; one approach is to respond optimally on a cost basis. The above tactical problem is modeled as an optimisation problem by applying the linear programming theory. An illustrative application of the model is finally presented.

Improvements FSA as a Prerequisite for Risk-Based GBS

The international shipping industry has begun to move from a reactive to a proactive approach to safety through what is known as “Formal Safety Assessment” (FSA). The recent “Goal Based Standards” (GBS) approach is focused towards being another proactive instrument. Much of the recent debate at IMO is whether the GBS should be “Risk-Based,” that is, whether it should use the full arsenal of risk-related methodologies that are already developed which includes FSA. The purpose of this paper is to outline possible improvements in the FSA process so that Risk-Based GBS can proceed
Improving FSA as a Prerequisite for Risk-Based GBS

The international shipping industry has begun to move from a reactive to a proactive approach to safety through what is known as “Formal Safety Assessment” (FSA). The recent “Goal Based Standards” (GBS) approach is focused towards being another proactive instrument. Much of the recent debate at IMO is whether the GBS should be “Risk-Based,” that is, whether it should use the full arsenal of risk-related methodologies that are already developed which includes FSA. The purpose of this paper is to outline possible improvements in the FSA process so that Risk-Based GBS can proceed smoothly without problems. To that end, a critical review of the FSA methodology is carried out with proposals on ways to improve it. All steps of the FSA approach are studied to identify possible pitfalls and/or other deficiencies. At this point some proposals are made to alleviate such deficiencies, with a view to achieve a clearer and more objective approach.

Investment Rules and Competition Patterns in LNG Shipping: A Game Theory Approach

The LNG market is experiencing a tremendous growth. It is expected that competition will increasingly develop especially in the shipping segment of the LNG chain, which at least in its first phases will have the characteristics of an oligopolistic market. The LNG shipping market is appropriate for the application of a (non-cooperative) game theoretic framework. This paper reviews the basic insights that game theory can offer to the analysis of the LNG shipping market and presents relevant game theoretic structures regarding competition and strategic investments. Game theory is a useful supplement to the intuition of a market player in the LNG shipping business, as it helps in identifying right strategies given certain conditions.
Public Financing and Charging in EU seaports: The Case of Greece
An international study commissioned by the European Commission has been recently completed on the subject of public financing and charging practices in EU seaports. This paper relates to this study by focusing on Greece and highlighting the special characteristics of the Greek port system and of Piraeus in particular, Greece’s largest port. The perspectives of port governance and of public financing and charging are looked at, together with financial flows to and from the port. Finally, the prospects for the future are discussed and some conclusions useful for policy formulation are attempted.

Radio Frequency Identification (RFID) Technology in the Ocean Container Transport
The central contribution of this paper is to present the status and the perspectives of RFID in ocean container transport. To accomplish this, we report the following: (a) the problem area and expected changes; (b) RFID and container ID fundamentals; (c) the RFID status quo in container transportation; (d) RFID perspectives in the ocean container industry; and (e) concluding observations and suggestions for consideration. We, preliminarily, note that the aforesaid tasks will be examined factoring the trend that ocean container carriers transform themselves from sea transport providers to total door-to-door logistics providers.

RFID-enabled Innovative Solutions Promote Container Security
In this paper we address the container security problem and we investigate RFID-enabled innovative solutions to confront it. To that end, initially we set the scene of the problem by reporting existing security problems in ocean container transport and container security-originated initiatives and regulations that affect seaborne containers transportation and handling. Afterwards, we accomplish our central objective by reporting RFID-enabled solutions and how they promote container security. In brief, our research unveiled that RFID-enabled IT systems can enhance container security. Specifically, as-yet RFID applications appear to assist in container identification and location tracking, in employee and vehicle access monitoring, and in regulatory adherence.
Risk based rulemaking and design - Proceed with caution

The trend towards a risk based regulatory framework at IMO and within classification societies is expanding while some voices claim that a full ship risk based scantlings design approach can be immediately implementable. This paper attempts to clarify some widely used, but confusing to many, notions such as Risk Based Rulemaking vs. Risk Based Design, and IMO's Goal Based Standards Traditional Approach vs. Safety Level Approach, and the implications of their use, or misuse, to future ship rulemaking, design and safety. The paper elaborates on some identified weaknesses of Formal Safety Assessment and the risk based approach which must be corrected. It further cautions on the over eagerness of some rule makers and designers to drop all prescriptive rule formulations and haphazardly adopt risk based formulations borrowed from other industries which may not be appropriate for ships. A reliable risk based approach involves avoidance to cut corners and thus avoidance on relying on a large number of arbitrary assumptions. To be applied properly, the risk based approach requires a significant amount of future research in order to reliably link from first principles the ship risk model with the desired acceptable Risk or Safety level.

The Two C's of the Risk-Based Approach to Goal based Standards: Challenges and Caveats

While it is generally accepted that the overall level of maritime safety has improved in recent years, further improvements are still desirable. It is fair to say that much of maritime safety policy worldwide has been developed in the aftermath of serious accidents (such as 'Exxon Valdez', 'Estonia', 'Erika' and 'Prestige'). Industry circles have questioned the wisdom of such an approach. The safety culture of anticipating hazards rather that waiting for accidents to reveal them has been widely used in other industries such as the nuclear and the aerospace industries. The international shipping industry has begun to move from a reactive to a proactive approach to safety through “Formal Safety Assessment” (FSA) and “Goal Based Standards” (GBS). FSA was introduced by the IMO as "a rational and systematic process for accessing the risk related to maritime safety and the protection of the marine environment and for evaluating the costs and benefits of IMO's options for reducing these risks". The recent GBS approach aims to be another proactive instrument, and there has been recent discussion in the IMO on the possible links between FSA and GBS. This paper attempts to clarify some widely used, but confusing to many, notions such as Risk Based Rulemaking vs. Risk Based Design, and IMO's GBS Traditional Approach vs. Safety Level Approach, and the implications of their use, or misuse, to future ship rulemaking, design and safety. The paper elaborates on some identified weaknesses of the risk based approach which must be corrected, with an emphasis on environmental risk evaluation criteria, which is an area in which further research is deemed necessary.
The Two C's of the Risk-Based Approach to Goal-Based Standards: Challenges and Caveats

While it is generally accepted that the overall level of maritime safety has improved in recent years, further improvements are still desirable. It is fair to say that much of maritime safety policy worldwide has been developed in the aftermath of serious accidents (such as ‘Exxon Valdez’, ‘Estonia’, ‘Erika’ and ‘Prestige’). Industry circles have questioned the wisdom of such an approach. The safety culture of anticipating hazards rather than waiting for accidents to reveal them has been widely used in other industries such as the nuclear and the aerospace industries. The international shipping industry has begun to move from a reactive to a proactive approach to safety through “Formal Safety Assessment” (FSA) and “Goal Based Standards” (GBS). FSA was introduced by the IMO as “a rational and systematic process for assessing the risk related to maritime safety and the protection of the marine environment and for evaluating the costs and benefits of IMO’s options for reducing these risks”. The recent GBS approach aims to be another proactive instrument, and there has been recent discussion in the IMO on the possible links between FSA and GBS. This paper attempts to clarify some widely used, but confusing to many, notions such as Risk Based Rulemaking vs. Risk Based Design, and IMO’s GBS Traditional Approach vs. Safety Level Approach, and the implications of their use, or misuse, to future ship rulemaking, design and safety. The paper elaborates on some identified weaknesses of the risk based approach which must be corrected, with an emphasis on environmental risk evaluation criteria, which is an area in which further research is deemed necessary.

General information
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Α Μεταβαλλόμενη Μεθόδος για την Καθοδήγηση Πλοίων σε Κολώνες

The central contribution of this paper is to provide a decision-support methodology for a broad class of inter-related problems in liner shipping. We aim at the optimization of liner networks by transforming the total network design into a sequential multi-stage optimization process in terms of Ship Routing & Scheduling, Fleet Deployment, and Transshipment. By fixing the various sources of non-linearity and by breaking down the total network design into the sequential solution of the aforesaid set of subproblems we have managed to accomplish our goals via the use of Linear, Dynamic and Integer Programming. The stages of the methodology are not completely autonomous; conversely, they interact in a dynamic way.

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Organisations: National Technical University of Athens, Massachusetts Institute of Technology
Contributors: Tsilingiris, P. S., Psaraftis, H. N.
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Publication date: 2006
**An Intelligent Robot System to Respond to Oil Spills: the EU-MOP Project**

This paper introduces a new EU research project called EU-MOP, which involves the design and evaluation of an intelligent robot system to respond to oil spills. The paper defines the objectives of the project, presents the underlying concept and discusses some preliminary results.

**General information**
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Organisations: National Technical University of Athens
Contributors: Psaraftis, H. N., Ventikos, N. P.
Number of pages: 10
Publication date: 2006
Peer-reviewed: Yes

**Maritime safety in the post-prestige era**

The Prestige accident is perhaps the last among a series of serious marine accidents that have significantly shaped the formulation of maritime safety policy worldwide. The main thesis of this paper is that in spite of recent progress in this area, there is still a long way to achieve a truly "proactive" maritime safety regime. A qualitative assessment on the nature of some major maritime safety policies and on the way that these are put forward is attempted, along with some opinions on possible pitfalls and on what needs to be done so that this process can be further improved.

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Contributors: Psaraftis, H. N.
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Publication date: 2006
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**Risk Limits of Oil Transportation in the Aegean Sea**

This paper presents an explorative analysis of tanker casualties in the Aegean Sea; thus, it is based on data derived from the records of a database specifically developed for this reason. This effort is a part of the Greek sponsored research project AEGEAN which aims to design and propose novel-"safe" tanker routes through the specific area and its main motivation is the continuous increase of oil quantities transferred through the Aegean Sea (e.g. due to the exploitation of the Caspian oil, or due to the forthcoming opening of new pipelines). Moreover, under the umbrella of safe oil movement across the Aegean Sea, a risk-driven approach is implemented in the outline of determining acceptable limits for local tanker safety: affordable (minimum) safety limits, since the proposed approach should not aggravate, in any case, the current situation/records and practices, from a marine safety point-of-view. This is achieved by using descriptive statistical techniques and selected risk models and by introducing corresponding risk indices that are able to support the adopted methodology and consequently provide sensible results and realistic conclusions. Hence, this paper may be regarded as a proactive-oriented effort to set acceptable safety levels for marine oil transport in the specific basin. It is noted that in the global maritime community there is no such thing as commonly accepted risk standards for any maritime transport procedure and activity; in this context, the key contribution of the paper lies in the initial study and the generic determination of current risk levels for marine (tanker) safety in the Aegean Sea.
Ship-Generated Oil Pollution in the Mediterranean Sea: the Situation and the EU-MOP Solution

This paper addresses issues of ship source oil pollution in the Mediterranean Sea. In this outline, it provides an overview of oil pollution records and patterns within the aforementioned area based on the statistical elaboration of numerous interesting parameters of the system and on the implementation of a risk oriented ranking scheme capable to identify and project high risk areas in terms of significant potential for ship generated oil spillage. Furthermore, the paper introduces a 6th Framework EC research project called Elimination Units for Marine Oil Pollution (EU-MOP) that deals with the design, evaluation and integration of a state-of-the-art autonomous swarm system that can provide an advanced, reliable and efficient solution with regards to oil confrontation and response. Hence, it defines the targets and objectives of the specific project, describes its ambitious concept and discusses some of its preliminary results. This paper is concluded with some interesting insights from the future work within the EU-MOP project.

Tanker accidents and environmental disasters: has the maritime industry acknowledged their connection to Human & Organizational Errors?

This paper introduces an ongoing EU research project called EU-MOP, which involves the design and evaluation of an intelligent and efficient robot system to respond to oil spills. The EU-MOP project addresses both unit and system level (i.e. unit design and emergency response topics) so as to draft a complete proposal/solution regarding oil spillage. The paper defines the objectives of the project, presents the underlying concept and discusses some of its up-to-date results.

The EU-MOP Concept: A Swarm Robotics Approach for Oil Spill Control

This paper introduces an ongoing EU research project called EU-MOP, which involves the design and evaluation of an intelligent and efficient robot system to respond to oil spills. The EU-MOP project addresses both unit and system level (i.e. unit design and emergency response topics) so as to draft a complete proposal/solution regarding oil spillage. The paper defines the objectives of the project, presents the underlying concept and discusses some of its up-to-date results.
A Generic Ship for the Shortsea Trades of the EU
The Union of Mediterranean Trading Shipowners of Greece with the technical assistance of ICEPRONAV of Romania have developed a generic ship type that can be constructed in such ways to serve the needs of a wide spectrum of transportation requirements, while ensuring significant economies for the builder in series. The need for this exercise has arisen in the context of ESYAN where clustering of various ship types around the six thousand tons mark had to be taken advantage of in a way to generate scale economies for both, the owners and the builders. While no serious technical innovation is involved, this type of application is novel and offers measurable savings in identifiable areas of the construction. If the matter of the replacement of the Greek Short Sea Fleet is seen as part of the overall strategy of Greece in the post cabotage era of the EU, a large number of such vessels are expected to be built. This paper describes the rationale behind this project and discusses the opportunities and challenges to promote it.

An Analysis of the European Union's Ports Policy
Less than a year after the Commission’s proposal for a Directive on the market access for port services was rejected in the European Parliament, the submission of a revised version of the ‘port package’ by outgoing EU Commissioner Loyola de Palacio in October of 2004 was met by a widespread lack of enthusiasm by the European port industry and by dockers unions. Many people fear that if there is inadequate consultation this revised draft Directive will have the same fate as its predecessor. At the same time, the advent of the ISPS code has put in place an impressive array of regulations to safeguard EU ports from acts of terrorism and other unlawful acts. Also, the ‘Prestige’ tanker disaster has triggered important legislation that may affect ports, on top of existing safety and environmental protection policies and other measure.

This paper takes stock at the broad spectrum of both current and proposed port safety, security, and environmental protection legislation, vis-à-vis the general policy thrust of the EU in the area of transport and discusses the situation faced by the port sector and EU intermodal transport in the new regime.
Specifically, this paper tackles the following question: If one takes all important portrelated policy initiatives under consideration, would he or she conclude that things are going well for the European ports sector? The impressive array of regulations that are in place or are planned for the EU port sector warrant an attempt to make an analysis of the collective effectiveness of such instruments. Without being encyclopedic, such an attempt is made in this paper, by trying to identify problems, challenges and opportunities, along with recommendations on how to improve the current situation.

A Review on the Integration of Human Factor in Marine Safety: The Sleeping Giant under the Spotlight

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Publication status: Published
Organisations: National Technical University of Athens
Contributors: Ventikos, N. P., Psaraftis, H. N.
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Peer-reviewed: Yes
Cost-Benefit Analysis for Ship Automation Retrofit: The Case of Icebreaker FREJ

EU ports policy: Where do we go from here?
With the advent of the ISPS code, an impressive array of regulations has been put in place to safeguard European Union (EU) ports from acts of terrorism and other unlawful acts. Also, the 'Prestige' tanker disaster has triggered important legislation that may affect ports, as regards safety and environmental protection. This paper takes a look at current port safety, security and environmental protection legislation, vis-a-vis the general policy thrust of the EU in the area of transport, and discusses the situation faced by the port sector and EU intermodal transport in the new regime. It is argued that we have a long way to go towards reaching policy goals as regards shifting cargo from land to sea. Challenges and opportunities are identified, and recommendations on how to improve the current situation are made.

Exploring for the risk limits of oil transport in the Aegean Sea: The current records and perspectives of tanker safety
This paper presents an explorative analysis of tanker casualties in the Aegean Sea; thus, it is based on data derived from the records of a database specifically developed for this reason. This effort is a part of the Greek sponsored research project AEGEAN which aims to design and propose novel-*safe* tanker routes through the specific area and its main motivation is the continuous increase of oil quantities transferred through the Aegean Sea (e.g. due to the exploitation of the Caspian oil, or due to the forthcoming opening of new pipelines). Moreover, under the umbrella of safe oil movement
across the Aegean Sea, a risk-driven approach is implemented in the outline of determining acceptable limits for local tanker safety: affordable (minimum) safety limits, since the proposed approach should not aggravate, in any case, the current situation/records and practices, from a marine safety point-of-view. This is achieved by using descriptive statistical techniques and selected risk models and by introducing corresponding risk indices that are able to support the adopted methodology and consequently provide sensible results and realistic conclusions. Hence, this paper may be regarded as a proactive-oriented effort to set acceptable safety levels for marine oil transport in the specific basin. It is noted that in the global maritime community there is no such thing as commonly accepted risk standards for any maritime transport procedure and activity; in this context, the key contribution of the paper lies in the initial study and the generic determination of current risk levels for marine (tanker) safety in the Aegean Sea.

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Introduction to an Innovative Crew Composition Approach Based on Safety/Operational and Financial Requirements
This paper proposes a tool to estimate crew composition based on safety/operational and financial requirements. As there is a tendency of ship owners to implement improved technologies on board their vessels, there is no systematic way to predict their potential effect on crew size and composition (typically determined by flag state authorities on a case-to-case basis) nor on the type and complexity of on board duties new technologies might dictate. The main aim of this paper is to develop a tool to assist in determining crew composition, by taking into account both administration’s and the ship owner’s point of view. Based on data collected from ship owners, a data mining technique is implemented in order to form a generalized framework that estimates crew composition as a function of ship type, size, and degree of automation. The agreement of model predictions with records from specific (vessel) cases is very good in terms of safety (for operations such as watchkeeping, mooring/unmooring, loading/unloading). The specific intended use of this tool is to help a ship owner decide whether it is cost-beneficial to retrofit a conventional vessel with advanced technologies that would potentially entail a reduced crew (probably dealing with different and more complex on board duties). Its main benefits are that it can be used to estimate crew composition before any vessel construction or upgrade has actually taken place and that it allows crew composition to be easily adapted to the technological evolution of ship systems even at their current rapid pace.

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Research output: Contribution to journal › Journal article – Annual report year: 2005 › Research › peer-review

Maritime Safety in the Post-Prestige Era

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Organisations: National Technical University of Athens
Contributors: Psaraftis, H. N.
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Optimizing shipping company operations using business process modelling

In order to identify the elements constituting quality in services, a business process modelling methodology has been applied in the case of a Greek liner shipping company. The company operations have been identified and analysed in order to assess the complete performance of service elements and thereafter identify how to match the service performance against the user requirements. A liner container service within Europe has to compete with the road transport which, in many cases, is an alternative to the sea transportation and not complementary to it. Thus, not only the ship has to be envisaged when aiming to improve quality in services but also the whole chain, namely port authorities, land transportation enterprises, subcontractors, agents, charterers and others. A set of potential improvements within this framework are thus suggested and time and cost (examined in a specific voyage scenario) are measured before and after the implementation of these measures. Very large time and cost savings are observed after the application of the technology improvements, allowing, in fact, the shipping company to even increase the number of round trips per year in the examined route. This indicates that very large benefits can be drawn by analysing and critically adjusting business processes in modern shipping companies.

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Scopus rating (2005): SJR 0.657 SNIP 0.877
Web of Science (2005): Indexed yes
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Tariff reform in the Port of Piraeus: A practical approach

This paper gives an overview of the main elements of the tariff reform that took place in the port of Piraeus during the last decade. The process of 'structural' revisions in many of the port's tariffs took place mainly between 1996 and 2001, which is the period during which, among other developments, container traffic through Piraeus more than doubled. Focusing on the above period and on container tariffs, the paper highlights the motivation for the changes and some of the practical difficulties associated with the process of port rate making in this major Mediterranean port. The tariff reform in some eight other categories that took place in that period is also briefly outlined, and some success and failure stories are described.

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Web of Science (2005): Indexed yes
Original language: English
Keywords: Port pricing, Tariff reform, Container terminal, Port of Piraeus, OLP
A high-level synthesis of oil spill response equipment and countermeasures
This paper presents an operational synthesis of major oil spill response methods (mechanical, chemical, etc.) and the corresponding oil response equipment for sea context (booms, skimmers, etc.). We focus on important features of oil spill response, in order to formulate a decision-based database, capable of supporting the development of a complete oil spill response operation. Moreover, we classify these findings and introduce simple formatting and standards to supply predictive tools for oil spill models. The actual goal of this paper is to come up with a decision-driven process, which can provide for a realistic choice of oil spill response equipment in the design of the primary oil response phase. This is intended to lead to a prompt, logical, and well-prepared oil spill response operation satisfying time and cost criteria and protecting the marine environment.

Analysis of the Greek Coastal Shipping Companies with a Multi-Criteria Evaluation Model

An Evaluation Model for Forecasting Methodologies in the Port Industry
Critical Analysis of Tanker Op-Ex Adjusting Crew Synthesis, Automation Level and Maintenance

In this paper we will present a critical analysis concerning tanker operating expenses. In this context, we try to explore various possibilities for the combined adjustment of automation level and crew synthesis, in order to fulfill maintenance (operational) needs of tankers. Precedent research results have shown that by increasing vessel automation level a substantial decrease of crew synthesis is feasible, in terms of watchkeeping and safety redundancy; hence, a potential window for decrease of op-ex is produced. The crucial issues/constraints regarding the analysis for the operational viability are maintenance man-hours in accordance with policy issues on on-board workload and fatigue, and external costs in order to cover all corresponding tanker needs. This paper examines all recorded aspects of the specific problem and proposes a methodological framework. This is achieved by using certain statistical, analytical and simulation techniques so as to come up with solid results and conclusions. Main motivation for this paper is the oncoming increase of tanker build-in technological innovations versus the slowly changing policy for vessel crew synthesis. Finally, we will conclude this paper with interesting comments arisen from the aforementioned tasks.

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Contributors: Lyridis, D. V., Ventikos, N. P., Zacharioudakis, P. G., Psaraftis, H. N.
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Keywords: Maritime economics, Human aspects, Simulation models, Maritime policy, On-board operations


In this paper, we present the relationship between an oil spill-assessing approach, namely the event-decision network (EDN) and the formal safety assessment (FSA) of the International Maritime Organization (IMO). We focus on various points at which the Network incorporates basic features of the FSA in order to formulate a state-of-the-art, original strategic tool. In keeping with a safety–friendly effort, we developed the EDN, which implements a scenario-driven, generic tree framework. Moreover, the IMO, under the umbrella of decision-making, has introduced FSA, which is a systematic methodology for enhanced maritime safety by using risk and cost/benefit criteria. It is of interest to describe the introduced spill-scenario analysis/simulation and to pinpoint its interconnections with the aforementioned official instrument. Among other things, the goal of such a task is the enhancement of marine safety and the subsequent protection of seas from oil spills.

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The introduction of highly integrated and automated technology into navigation systems, aiming, amongst others, to decrease personnel onboard the ship, calls for efficient tools to assess the possible impacts of this new trend on the safety levels associated with the operation of the ship. This trend has lead in recent
years to the investigation of the adoption of advanced risk assessment techniques. The scope of the paper is to present a quantified safety assessment methodology that can be applied while retrofitting navigation systems. The methodology is based on the review of the IMO Formal Safety Assessment technique and consists in the development of a Safety Prediction Model for the safety assessment of the different automation/ integration levels subject of a retrofit. The application presented in the paper is part of the work performed under the ATOMOS IV research project, partly funded by the DGTREN Directorate of the European Commission.

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Peer-reviewed: Yes
Research output: Contribution to conference > Paper – Annual report year: 2002 > Research > peer-review

**Introducing E-brokerage in European Transport Services: the Case of the PROSIT Project**
The use of advanced telematic solutions in the transport sector is already a market trend as well as a policy choice of the European Commission (EC), aiming to improve mainly the overall efficiency of waterborne transport. The R&D project PROSIT, co-funded by the EC, is an effort to introduce telematic technologies in the traditional field of the shipbroker. As middlemen tend to be excluded in an era of “new economy”, PROSIT aims to explore the substitution of an actual commercial procedure with web-based tools. PROSIT has been developed through four major case-studies (scenarios), involving different states of technology, market needs, and organizational structures. In this paper all scenarios are described, discussed and evaluated. Given the results of PROSIT some qualitative issues of e-brokerage and the future of such services are discussed in view of the modular structure of modern enterprises.

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Keywords: Waterborne transport, Intermodal transport, E-brokerage, Validation, Logical framework method
Research output: Contribution to conference > Paper – Annual report year: 2002 > Research > peer-review

**Maritime safety: To be or not to be proactive**
The purpose of this paper is to address important issues regarding policy formulation in the maritime safety area. The main thesis of the paper is that there is some way to achieve a truly proactive maritime safety regime, and there even seems to be recent progress toward this end. A qualitative assessment on the nature of maritime safety policies and on the way that these are put forward is attempted, along with some opinions on the possible pitfalls and on what needs to be done so that this process can be further improved.

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Optimizing Manpower On-Board Ships Targeting to the Increase of the Competitiveness of the EU Fleet the Case of a Ship Oriented Automation Electronic Tool (ACOSTOS™)

In general, the problem of the EU flagged ships' competitiveness is considered to be of extreme importance for the whole marine industry. In this paper we will present a new electronic tool for the calculation of the benefits that a shipowner may have, if the ports in which his vessel operates, would implement automated loading/discharging systems in order to achieve smaller port turnaround times. The electronic tool can also calculate the benefit that a shipowner may have by implementing automated loading/discharging onboard his vessel.

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The Usage of Tree Analysis in the Context of a Strategic Approach Concerning Incidents of Oil Marine Pollution: Introduction of the Event-Decision Network

In this paper, we present the development of a tree analysis approach for the strategic level of handling and confronting oil pollution incidents-matters. We describe its basic structure (levels of factors) and the way it can formulate the local oil pollution. The paper is concluded with the presentation of an indicative example.

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Research output: Contribution to conference

A Review Analysis of International and Greek Databases Concerning Oil Spills: The Case of a New Greek Oil Spill Database

In general, the problem of oil marine pollution is considered to be of extreme importance for the marine environment. It is a wellknown fact, that detailed databases concerning oil spill incidents, are the necessary means for a realistic statistical analysis. In this paper, we will present the findings from a review analysis of databases, which include oil spill data. Then we will focus on the way that the Greek oil spill database was developed. We will conclude the description of the aforementioned database by defining some basic points of its statistical analysis and by exhibiting some corresponding indicative results.

General information
Publication status: Published
Organisations: National Technical University of Athens
Contributors: Ventikos, N. P., Dilzas, K. P., Psaraftis, H. N.
Number of pages: 5
Publication date: 2001
Peer-reviewed: Yes
A Statistical Approach on Oil Pollution in Greek Seas
In general, the problem of oil pollution is included amongst the most important threats for the marine environment. Moreover, Greece has a nodular position in Southern Europe's oil trade and transportation network; therefore it is only natural to expect some incidents of oil pollution that might affect the Greek seas and their shores. In this paper, we present the development of a Greek oil spill database. Then we focus on its statistical analysis and on some corresponding indicative results. We will conclude the paper with a brief description of the proposed strategic analysis with the presentation of a flexible network approach into matters of oil marine pollution.

General information
Publication status: Published
Organisations: National Technical University of Athens
Contributors: Ventikos, N. P., Psaraftis, H. N., Lyridis, D. V.
Number of pages: 10
Publication date: 2001
Peer-reviewed: Yes
Research output: Contribution to conference › Paper – Annual report year: 2001 › Research › peer-review

A synthesis algorithm for responding to oil spills using complementary locations on networks
This paper develops a synthesis algorithm on networks for the problem of (a) locating appropriate levels and types of cleanup capability to respond to oil spills that may occur in a given area, and (b) allocating such capability among points of high oil spill potential in that area. The heuristic algorithm takes into account frequency of spill occurrence, variability of spill volumes, differing cleanup technologies, equipment efficiency and operability, fixed costs of opening facilities, equipment acquisition, transportation and operating costs, and costs of damage as functions of spill volume and level of response. The algorithm can also accept stipulations on response times. The results of the heuristic algorithm have been compared with results obtained by a Linear Programming (LP) formulation, and the highest deviation observed was around 1%. The advantage of the developed algorithm is apparent in real-life oil spill problems which are large-scale in nature and which cannot be solved by the LP procedure.

General information
Publication status: Published
Organisations: Technion-Israel Institute of Technology, The World Bank Group, National Technical University of Athens
Contributors: Ceder, A., Tharakan, G. G., Psaraftis, H. N.
Pages: 269-285
Publication date: 2001
Peer-reviewed: Yes
Publication information
Journal: Applied Mathematical Modelling
Volume: 25
Issue number: 4
ISSN (Print): 0307-904X
Ratings:
Scopus rating (2001): SJR 0.745 SNIP 1.01
Web of Science (2001): Indexed yes
Original language: English
DOIs: 10.1016/S0307-904X(00)00046-9
Research output: Contribution to journal › Journal article – Annual report year: 2001 › Research › peer-review

Contribution of Telematics in the Management of Oil Spill Issues

General information
Publication status: Published
Organisations: National Technical University of Athens
Publication date: 2001
Peer-reviewed: Yes
Research output: Contribution to conference › Paper – Annual report year: 2001 › Research › peer-review
Implementation of a Multi-Level Statistical Analysis on a New Database Covering Oil Pollution in Greek Seas: Definitions & Results

General information
Publication status: Published
Organisations: National Technical University of Athens
Contributors: Ventikos, N. P., Psaraftis, H. N.
Publication date: 2001
Peer-reviewed: Yes
Event: Paper presented at International Conference of Environmental Statistics 2001 (EMA’01), Cadiz, Spain.
Research output: Contribution to conference › Paper – Annual report year: 2001 › Research › peer-review

The Port of Piraeus Enters the New Millennium

General information
Publication status: Published
Organisations: National Technical University of Athens
Contributors: Psaraftis, H. N.
Number of pages: 4
Publication date: 2001

Host publication information
Title of host publication: 10,000 Years of Greek Shipping
Publisher: T&T publishing
Edition: 1
Research output: Chapter in Book/Report/Conference proceeding › Preface/postscript – Annual report year: 2001 › Research › peer-review

Πειραιας - Κεντρο Ναυτιλιας και Πολιτισμου

General information
Publication status: Published
Organisations: Piraeus Port Authority S.A.
Contributors: Psaraftis, H. N.
Number of pages: 1
Publication date: 2000

Host publication information
Title of host publication: Πειραιας - Κεντρο Ναυτιλιας και Πολιτισμου
Publisher: Efesos Publications
Research output: Chapter in Book/Report/Conference proceeding › Preface/postscript – Annual report year: 2000 › Research › peer-review

An Analysis of Maritime Transportation Risk Factors
This paper presents an analysis on the factors that are important determinants of maritime transportation risk. The analysis has been part of an international, multi-partner project. The purpose of the project has been to identify technologies and other measures to improve maritime safety, mainly in the context of European waters.

General information
Publication status: Published
Organisations: National Technical University of Athens
Contributors: Psaraftis, H. N., Panagakos, G., Desypris, N., Ventikos, N. P.
Number of pages: 7
Publication date: 1998
Peer-reviewed: Yes
Keywords: Risk analysis, Maritime safety
Research output: Contribution to conference › Paper – Annual report year: 1998 › Research › peer-review

A Prototype Statistical Approach of Oil Pollution in the Mediterranean Sea
In this paper, we present a detailed statistical survey of oil pollution in the greater area of the Mediterranean Sea (with a preference in the Greek Seas: e.g. the Aigean Sea or the Iloanian Sea and the respective Greek fleet). The Mediterranean
Sea exhibits a noticeable increase of oil pollution within the last 15 years as documented by data presented within this work. A new electronic data base tool with a multitude of operational capabilities that utilizes data from the REMPEC Organization in raw format is introduced. We further present a statistical analysis of the data which differentiates each incident according to the volume of spilled oil and we conclude with some interesting results and comments.

**General information**
Publication status: Published
Organisations: National Technical University of Athens, University of Miami
Contributors: Ventikos, N. P., Psaraftis, H. N., Iakovou, E.
Number of pages: 10
Publication date: 1998
Peer-reviewed: Yes
Research output: Contribution to conference • Paper – Annual report year: 1998 • Research • peer-review

**A Statistical and Strategic Survey of Oil Pollution in the Mediterranean Sea**
In this paper, we present the results of a statistical analysis (for the time period 1978-1995) and a relative strategic survey of the magnitude of oil pollution from ships in the Mediterranean Sea. The Mediterranean Sea is a very sensitive and closed ecosystem which makes the need of protection from oil pollution imperative. The electronic tool of "SPILLASE" which administrates in a multi-fold manner the data base from the REMPEC Organization in Malta, is a contribution to that direction. We then present the results of a statistical analysis that cover the area of the Mediterranean Sea and all the corresponding fleet. Finally, we present a strategic survey which reveals a stable dependence of the fluctuation of the volume of spilled oil (from naval accidents of Greek ships) in the Mediterranean Sea (1978-1995) from a newly introduced term called "accident product".

**General information**
Publication status: Published
Organisations: University of Miami, National Technical University of Athens
Contributors: Ventikos, N. P., Psaraftis, H. N., Iakovou, E.
Number of pages: 10
Publication date: 1998
Peer-reviewed: Yes
Research output: Contribution to conference • Paper – Annual report year: 1998 • Research • peer-review

**Strategies for Mediterranean Port Development**
In this paper we discuss development strategies that may be used by ports in the Mediterranean as we are about to enter the new century. Increased integration of ports within intermodal transport chains is expected to play a key role in that development. Issues such as infrastructure and superstructure improvement, financing, pricing, and optimal use of port resources are seen as critical factors that will influence future port competitiveness and performance. The container market is used as the main context of this paper, although other sectors are also mentioned.

**General information**
Publication status: Published
Organisations: National Technical University of Athens
Contributors: Psaraftis, H. N.
Number of pages: 8
Publication date: 1998
Peer-reviewed: Yes
Research output: Contribution to conference • Paper – Annual report year: 1998 • Research • peer-review

**The Human Element as a Factor in Marine Accidents**
The purpose of this paper is to present a comprehensive analysis of the human element as a factor in marine accidents. This analysis has been part of project SAFECO (for Safety of Shipping in Coastal Waters), sponsored by the European Commission, Directorate General for Transport (DGVI). The analysis investigates relationships between the various probable causes of an accident and the final outcome of the accident.

**General information**
Publication status: Published
Reduced Manning to Increase Fleet Competitiveness

The merchant fleets of many countries worldwide have experienced a significant decline of competitiveness over the years. Phenomena such as national fleet shrinkage and "flagging out" have been the main manifestations of such a decline. Realizing that manning costs are frequently a major percentage of ship operating costs, one of the measures that has been contemplated in order to reverse this trend has been the design, development, and operation of highly automated ships manned by reduced crews. The purpose of this paper is to present the results of an analysis that addresses the question to what extent and under which scenarios can advanced technologies that reduce manning improve merchant fleet competitiveness. The analysis is the product of a European Commission project, and, as such, focuses on the fleets of European Union member states. However, we also attempt to generalize the conclusions to other fleets of the world.

General information
Publication status: Published
Organisations: National Technical University of Athens
Contributors: Psaraftis, H. N.
Publication date: 1996
Peer-reviewed: Yes
URLs:
Research output: Contribution to conference › Paper – Annual report year: 1996 › Research › peer-review

Research in European Shortsea Shipping: the State of the Art

There has been an explosive growth in shortsea shipping related research during the last six years. In this period there have been about 80 papers presented at the three European Research Roundtable on Shortsea Shipping conferences to date (1992, 1994, and 1996). In addition, the three FAST international conferences on fast waterborne transport (1991, 1993, and 1995) presented close to 300 papers, of which about 70 directly focus on shortsea shipping. Various projects, national and international, have been also initiated in this area. In the context of the 4th Framework Programme, the European Commission/ Directorate General for Transport (DGVII) has launched in early 1996 several shared cost projects, as well as a concerted action explicitly targeted to shortsea shipping. Other directorates such as DG XII and DG XIII have also launched related projects in early 1996. In view of such a boom of research activity, it becomes imperative to critically survey such work, and also make a taxonomy of it, so that all this work is sorted out, and the baseline for further research becomes clear. Failure to do this will inevitably result in duplication of effort, gaps in research, lack of vision on what is needed, and other negative ramifications. The purpose of this paper is to carry out a critical survey and taxonomy of such work. The survey has involved a European-wide solicitation of input on related work, and also attempts to identify common trends on research topics. Without claiming that the contents of the paper are encyclopaedic, or that each and every piece of material collected has been reviewed in depth, we can at least claim that the 442 entries catalogued represent an unprecedented compilation of material in this area. Perhaps the most important trend identified within this vast collection the material is a significant degree of "fragmentation" of R&D effort in the SSS field, in the sense that problems that are methodologically similar in many contexts have been typically addressed in isolation. The most obvious consequence of this fragmentation is that the impact of R&D efforts to serve the real needs of European SSS has been so far limited. Commission-sponsored activities such as the SSS Roundtable Conferences, the Concerted Action on SSS, the collaborative R&D projects under way, and other related activities are expected to alleviate this situation in the future.

General information
Publication status: Published
Organisations: National Technical University of Athens
Contributors: Psaraftis, H. N., Schinas, O. D.
Number of pages: 30
Publication date: 1996
Peer-reviewed: Yes
Research output: Contribution to conference › Paper – Annual report year: 1996 › Research › peer-review
The link between Greece and the rest of EU countries: Status and prospects
The purpose of this paper is to critically investigate the transportation link between Greece and the rest of European Union (EU) countries. Greece is the only non-island EU country which is not adjacent to the rest of the contiguous EU countries. Since the breakout of the war in the territory of the former Republic of Yugoslavia, the main land link through the Balkan peninsula has become dangerous and inadequate to carry the continuously growing transport load. The other link of Greece to the rest of the EU is intermodal: it connects western Greek ports with eastern Italian ports via the Adriatic Sea. Under the present circumstances, and in spite of many problems, this particular link represents the only promise for a viable connection between Greece and the rest of the EU. The volume and value of the trade between Greece and the rest of EU countries are continuously growing. However, the existing network has reached its capacity, and problems of insufficient land traffic interconnections are now becoming more complex, demanding immediate action. The paper has two major objectives: the first is to describe the network by analysing the statistical data provided by public and private sources and by making references to the institutional framework. All land and sea connections, including port infrastructures, are also described. Extensive analysis of data provides an image of the traffic in ports and an ability to make aggregate projections of the traffic in the future. The second objective is to foresee what may happen in the near future. As new fast ships may enter the routes of the Adriatic, and a new institutional environment is taking shape by EU rules and regulations, this trade will never be the same again. In order to achieve this objective, the paper estimates the transport cost and performs a modal split analysis. The new technology fast ships are technically and economically investigated. The analysis shows that a major problem is the economic viability of the fastships, which leads to a higher required fare and thus prohibits some carriers to use them. To the best of our knowledge, this is the first time such an analysis has been performed for the Adriatic Sea link. The paper ends with several conclusions and recommendations, which point to the inadequacies of the system and can suggest ways for a better performance of nodes, modes, branches and the whole network in general.

Dynamic vehicle routing: Status and prospects
Although most real-world vehicle routing problems are dynamic, the traditional methodological arsenal for this class of problems has been based on adaptations of static algorithms. Still, some important new methodological approaches have recently emerged. In addition, computer-based technologies such as electronic data interchange (EDI), geographic information systems (GIS), global positioning systems (GPS), and intelligent vehicle-highway systems (IVHS) have significantly enhanced the possibilities for efficient dynamic routing and have opened interesting directions for new research. This paper examines the main issues in this rapidly growing area, and surveys recent results and other advances. The assessment of possible impact of new technologies and the distinction of dynamic problems vis-à-vis their static counterparts are given emphasis.
Greek Coastal Shipping System: Impact of New Technologies and Market Deregulation on Modal Split
The purpose of this paper is to investigate the problem of modal split for passengers and vehicles in a specific context, that of the Greek coastal shipping system. The transport modes considered are conventional passenger/car ferries (P/C vessels), fast (30-50 knot) vessels, and air transport. For a variety of reasons, monumental changes are about to take place within this system over the next decade. These center primarily on the deregulation of the market that is a result of the European Union integration, and on the introduction of vessels capable of carrying passengers and cars at high speeds. By EU directive, the Greek coastal market shall be fully deregulated by the year 2004. This means that owners would be able to set up routes with minimal governmental interference. The question is of course how passenger demand will evolve within such a new environment, and how the various competing modes of transport will fare. This paper is an attempt to systematically analyze scenarios that might be the possible outcomes of these changes.

General information
Publication status: Published
Organisations: National Technical University of Athens, Athens University of Economics and Business, Attiko Metro AE
Contributors: Psaraftis, H. N., Nellas, G. J., Magirou, E. F., Nassos, G. C.
Number of pages: 24
Publication date: 1994
Peer-reviewed: Yes
Event: Paper presented at Tristan II: Triennial Symposium on Transportation Analysis, Capri, Italy.
Research output: Contribution to journal › Journal article – Annual report year: 1995 › Research › peer-review

Institutional and Socioeconomic Issues in Greek Ferry Services
This paper aims at presenting the main issues concerning institutional and socioeconomic problems in Greek coastal shipping. In particular, issues concerning the implementation of the EU Regulation on maritime cabotage are given emphasis and discussed throughout the paper. It is seen that many changes will have to take place to harmonize existing national legislation with the new regime that will take place in 2004.

General information
Publication status: Published
Organisations: DAS Hellas SA, National Technical University of Athens
Contributors: Sturmey, S. G., Panagakos, G., Psaraftis, H. N.
Number of pages: 19
Publication date: 1994
Peer-reviewed: Yes
Research output: Contribution to conference › Paper – Annual report year: 1994 › Research › peer-review

Modal Split in Greek Shortsea Passenger/Car Transport
The purpose of this paper is to investigate the problem of modal split for passengers and vehicles in a specific context, that of the Greek coastal shipping system. The transport modes considered are conventional passenger/car ferries (P/C vessels), fast (30-50 knot) vessels, and air transport. For a variety of reasons, monumental changes are about to take place within this system over the next decade. These center primarily on the deregulation of the market that is a result of the European Union integration, and on the introduction of vessels capable of carrying passengers and cars at high speeds. By EU directive, the Greek coastal market shall be fully deregulated by the year 2004. This means that owners would be able to set up routes with minimal governmental interference. The question is of course how passenger demand will evolve within such a new environment, and how the various competing modes of transport will fare. This paper is an attempt to systematically analyze scenarios that might be the possible outcomes of these changes.

General information
Publication status: Published
Organisations: National Technical University of Athens, Athens University of Economics and Business, Attiko Metro AE, DAS Hellas SA
Number of pages: 27
Publication date: 1994
Peer-reviewed: Yes
Dynamic shortest paths in acyclic networks with Markovian arc costs
We examine shortest path problems in acyclic networks in which arc costs are known functions of certain environment variables at network nodes. Each of these variables evolves according to an independent Markov process. The vehicle can wait at a node (at a cost) in anticipation of more favorable arc costs. We first develop two recursive procedures for the individual arc case, one based on successive approximations, and the other on policy iteration. We also solve the same problem via parametric linear programming. We show that the optimal policy essentially classifies the state of the environment variable at a node into two categories: green states for which the optimal action is to immediately traverse the arc, and red states for which the optimal action is to wait. We then extend these concepts for the entire network by developing a dynamic programming procedure that solves the corresponding problem. The complexity of this method is shown to be $O(n^2K + nK^3)$, where $n$ is the number of network nodes and $K$ is the number of Markov states at each node. We present examples and discuss possible research extensions.

Probabilistic Ship Structural Analysis: An Incorrect Way to Compute the Probability of Failure
There has been a recent paper in the probabilistic ship structural analysis literature that describes an incorrect way of calculating the probability of failure. This short technical note points out this fallacy and suggests the correct way to calculate this probability.

Impact of New Technologies on Shortsea Shipping in Greece
This paper describes the current situation of shortsea shipping in Greece and discusses the possible role of new technologies within the context of coastal transport in this country in the years ahead. By "new technologies" this paper mainly refers to vessels of new design and operating characteristics (such as "fast" vessels capable of making 30-50 knots). In addition, the term "new technologies" also includes the broader spectrum of technological advances that would increase the efficiency of the present system, such as computerized passenger reservation systems, advanced communications systems, etc.

With respect to ship technology, the coastal shipping system in Greece has already experienced a significant transformation in the last 20-30 years, and is most likely to experience another one in the years ahead. The first such
transformation concerns the gradual substitution of ferry vessels for the more
traditional passenger-only vessels sailing in the Aegean and Ionian seas. The second transformation concerns the
potential role of fast vessels of new design, whose appearance in the system has already started.
If one combines such a development with other technological advances in information systems and telecommunications,
as well as the likelihood of increased deregulation of the shortsea market in the near future, it is likely that the picture of
shortsea shipping in Greece in the years ahead will be dramatically
different from what it has ever been. The paper presents some speculative scenarios as to how this picture might evolve.
This paper also includes a section on policy recommendations so as to improve the efficiency of the system and aim
toward a better EC transport integration.

General information
Publication status: Published
Organisations: National Technical University of Athens
Contributors: Psaraftis, H. N., Papanikolaou, A.
Number of pages: 20
Publication date: 1992
Peer-reviewed: Yes
Research output: Contribution to conference › Paper – Annual report year: 1992 › Research › peer-review

Routing and Scheduling on a Shoreline with Release Times
In this paper we examine computational complexity issues and develop algorithms for a class of "shoreline" single-vehicle
routing and scheduling problems with release time constraints. Problems in this class are interesting for both practical and
theoretical reasons. From a practical perspective, these problems arise in several transportation environments. For
instance, in the routing and scheduling of cargo ships, the routing structure is "easy" because the ports to be visited are
usually located along a shoreline. However, because release times of cargoes at ports generally complicate the routing
structure, the resulting routing and scheduling problem is nontrivial. From a theoretical perspective, this class of problems
lies on the borderline between problems in P and those that are NP-complete. For the straight-line case (a restriction of
the shoreline case), our analysis shows that the problem of minimizing maximum completion time can be solved exactly in
quadratic time by dynamic programming. For the shoreline case we develop and analyze heuristic algorithms. We derive
data-dependent worst-case performance ratios for these heuristics. We also discuss how these algorithms perform on
practical data. Finally, we examine the computational complexity of other problem variants involving alternative objective
functions and different types of time window constraints.

General information
Publication status: Published
Organisations: Kion Technology Inc., Northeastern University, Massachusetts Institute of Technology
Pages: 212-223
Publication date: 1990
Peer-reviewed: Yes
Publication information
Journal: Management Science
Volume: 36
Issue number: 2
ISSN (Print): 0025-1909
Original language: English
Electronic versions:
Routing_and_scheduling_on_a_shoreline_with_release_times.pdf
Source: FindIt
Source-ID: 228053512
Research output: Contribution to journal › Journal article – Annual report year: 1990 › Research › peer-review

Dynamic Vehicle Routing Problems
The purpose of this paper is to put dynamic vehicle routing into perspective within the broader are of vehicle routing, as
well as provide a flavor of recent progress in this area. We identify the important issues that delineate the dynamic case
vis-a-vis the static one, comment on methodological issues, review generic design features that a dynamic vehicle routing
procedure should possess, discuss the adaptation of static approaches to a dynamic setting, and describe an algorithm for
the dynamic routing of cargo ships in an emergency situation. We conclude by recommending directions for further
research in this area.

General information
Publication status: Published
Organisations: Massachusetts Institute of Technology
Oil Spill Risk Management: The Strategic Response Case
The purpose of this paper is to examine some important aspects of oil spill risk as they relate to the strategic problem of providing adequate response capability to cope with oil spills that may occur in a certain geographical area. The paper explains the rationale of the methodology developed and discusses an illustrative application in the U.S. New England region.

A heuristic algorithm for the multivehicle advance request dial-a-ride problem with time windows
A heuristic algorithm is described for a time-constrained version of the advance-request, multivehicle, many-to-many dial-a-ride problem. The time constraints consist of upper bounds on the amount of time by which the pick-up or delivery of a customer can deviate from the desired pick-up or delivery time and on the time that a customer can spend riding in a vehicle. The algorithm uses a sequential insertion procedure to assign customers to vehicles and to determine a time schedule of pick-ups and deliveries for each vehicle. A flexible objective function balances the cost of providing service with the customers' preferences for pick-up and delivery times close to those requested, and for short ride times. Computational experience with the algorithm, is described, including a run with a real database of 2600 customers and some 20 simultaneously active vehicles. The scenario for the application of the algorithm is also discussed in detail.
Optimal response to oil spills: The strategic decision case
Develops a model for the problem of (a) locating appropriate levels and types of cleanup capability to respond to oil spills and (b) allocating such capability among points of high oil spill potential. The model takes into account frequency of spill occurrence, variability of spill volumes, different cleanup technologies, equipment efficiency and operability, fixed costs to open a facility, equipment acquisition, transportation and operating costs, and costs of damage as functions of spill volume and level of response. The model can also accept policy stipulations on response times. An illustrative application of the model in the New England region is presented and its possible uses within existing and alternative policy environments are discussed.

General information
Publication status: Published
Organisations: Technion-Israel Institute of Technology, World Bank, Massachusetts Institute of Technology
Contributors: Psaraftis, H. N., Tharakan, G. G., Ceder, A.
Number of pages: 15
Pages: 203-217
Publication date: 1986
Peer-reviewed: Yes

Publication information
Journal: 4 O R
Volume: 34
Issue number: 2
ISSN (Print): 1619-4500
Original language: English
Electronic versions:
Optimal_response_to_oil_spills_the_strategic_decision_case.pdf
DOIs:
10.1287/opre.34.2.203
Source: FindIt
Source-ID: 17138709
Research output: Contribution to journal › Journal article – Annual report year: 1986 › Research › peer-review

Scheduling Large-Scale Advance-Request Dial-A-Ride Systems
This paper examines the scheduling of large-scale advance-request dial-a-ride systems, describes two algorithms that have been developed recently to solve problems in this area, and provides analysis and insights into how these algorithms are expected to perform under various operational scenarios and in comparison with one another. The algorithms examined are the GCR (Grouping/Clustering/Routing) and ADARTW (Advanced Dial-A-Ride with Time Windows) procedures. The paper gives an overview of both algorithms, emphasizes the differences in their operational scenarios, describes computational experience with both procedures and includes worst-case considerations for ADARTW. Extensions and directions for further research are also discussed.

General information
Publication status: Published
Organisations: Massachusetts Institute of Technology
Contributors: Psaraftis, H. N.
Pages: 327-367
Publication date: 1986
Peer-reviewed: Yes

Publication information
Journal: American Journal of Mathematical and Management Sciences
Volume: 6
Issue number: 3-4
ISSN (Print): 0196-6324
Original language: English
DOIs:
10.1080/01966324.1986.10737199
Research output: Contribution to journal › Journal article – Annual report year: 1986 › Research › peer-review
A tactical decision algorithm for the optimal dispatching of oil spill cleanup equipment

We develop an optimization procedure for assisting decision-makers in the allocation of resources for cleaning up a specific oil spill. The objective function is to minimize a weighted combination of spill-specific response and damage costs. Inputs to this problem include information about the outflow of oil, availability and performance of spill cleanup equipment, as well as costs of equipment transported and on-scene operation. A general (albeit separable) damage function is assumed. The algorithm is deterministic and is based on a dynamic program within which a series of 0-1 knapsack problems are solved repeatedly. Although this algorithm is approximate, its worst-case performance is quantified and we argue that under realistic inputs the procedure can be expected to produce solutions very close to optimality. Under prescribed conditions we prove that the algorithm produces optimal solutions. A realistic example based on the Argo Merchant oil spill is presented to provide insight into the structure of this problem. Finally, we discuss possible uses of this model within the existing and alternative operational and policy environments.

General information
Publication status: Published
Organisations: Massachusetts Institute of Technology
Contributors: Psaraftis, H. N., Ziogas, B. O.
Number of pages: 17
Pages: 1475-1491
Publication date: 1985
Peer-reviewed: Yes

Publication information
Journal: Management Science
Volume: 31
Issue number: 12
ISSN (Print): 0025-1909
Original language: English
Electronic versions:
A_tactical_decision_algorithm_for_the_optimal_dispatching_of_oil_spill_cleanup_equipment.pdf
DOIs:
10.1287/mnsc.31.12.1475
Source: FindIt
Source-ID: 17385190
Research output: Contribution to journal › Journal article – Annual report year: 1985 › Research › peer-review

A sequential hypothesis testing, optimal stopping problem in underwater acoustic detection

A sequential hypothesis testing, optimal stopping problem in underwater acoustic detection is formulated and solved using dynamic programming. The problem calls for deciding whether acoustic signals being received over long ranges in the ocean are due to a source or to ambient noise alone, so as to minimize the expected value of a specified cost function over a given time horizon. The cost function incorporates a constant cost per observation as well as terminal costs for false acceptance of either hypothesis. According to previous work by the authors, and without loss of generality, modeling the acoustic signals assumes a two-state discrete-time Markov process for each of the two hypotheses, the state of the process depending on whether the intensity of the signal at the receiver is above a specified threshold or not. The decision process presented is based on observations of the signal’s “interarrival times,” that is, the time intervals between two successive detection events. The algorithm is then extended into more than two alternative hypotheses (several “false” targets) and results using both simulated and experimental acoustic data for the two and three hypotheses cases are presented. Computational issues in implementing the algorithms as well as possible extensions of this work are finally discussed.

General information
Publication status: Published
Organisations: University of Michigan, Ann Arbor, Massachusetts Institute of Technology
Contributors: Psaraftis, H. N., Perakis, A. N.
Pages: 859-865
Publication date: 1984
Peer-reviewed: Yes

Publication information
Volume: 75
Issue number: 3
ISSN (Print): 0001-4966
Original language: English
DOIs:
10.1121/1.390569
On the practical importance of asymptotic optimality in certain heuristic algorithms
This article presents an informal discussion of the issue of asymptotic optimality of heuristics from the viewpoint of the operations research practitioner. It is suggested that certain heuristics belonging to the above class are likely to perform questionably in practice, with regard both to relative error and to computational tractability. Possible explanations of this phenomenon are offered and suggestions for further research toward a better understanding of this problem are presented.

General information
Publication status: Published
Organisations: Massachusetts Institute of Technology
Contributors: Psaraftis, H. N.
Number of pages: 10
Pages: 587-596
Publication date: 1984
Peer-reviewed: Yes

Publication information
Journal: Networks
Volume: 14
Issue number: 4
ISSN (Print): 0028-3045
Original language: English
DOIs: 10.1002/net.3230140409
Source: FindIt
Source-ID: 17828229

Analysis of an O(N^2) heuristic for the single vehicle many-to-many Euclidean dial-a-ride problem
We develop an O(N^2) heuristic to solve the single vehicle many-to-many Euclidean Dial-A-Ride problem. The heuristic is based on the Minimum Spanning Tree of the nodes of the problem. The algorithm's worst case performance is four times the length of the optimal Dial-A-Ride tour. An analysis of the algorithm's average performance reveals that in terms of sizes of single-vehicle problems that are likely to be encountered in the real world (up to 100 nodes) and in terms of computational complexity, the O(N^2) heuristic performs equally well, or, in many cases, better than heuristics described earlier by Stein for the same problem. The performance of the heuristic exhibits statistical stability over a broad range of problem sizes.

General information
Publication status: Published
Organisations: Massachusetts Institute of Technology
Contributors: Psaraftis, H. N.
Pages: 133-145
Publication date: 1983
Peer-reviewed: Yes

Publication information
Journal: Transportation Research. Part B: Methodological
Volume: 17B
Issue number: 2
ISSN (Print): 0191-2615
Original language: English
Electronic versions: Analysis_of_an_O_N2_heuristic_for_the_single_vehicle_many_to_many_Euclidean_dial_a_ride_problem.pdf
Source: PublicationPreSubmission
Source-ID: 102496872

An Exact Algorithm For The Single Vehicle Many-To-Many Dial-A-Ride Problem With Time Windows
This paper modifies the exact dynamic programming algorithm developed by the author for the single vehicle many-to-many immediate request Dial-A-Ride problem. Each customer has specified upper and lower bounds for his pickup and delivery times and the objective is to minimize the time needed to service all customers. The major difference between the two algorithms is the substitution of backward recursion with forward recursion. The new algorithm requires the same computational effort as the old one (O(N^23^N) for N customers) and is able to recognize infeasible problem instances.
Detection Modelling of Unsaturated and Partially Saturated Ocean Acoustic Signals

The basic problem in ocean detection of narrowband acoustic signals is studied for unsaturated sound propagation, whereas considerable progress has been made towards modeling the more general case of partially saturated acoustic detection process. In this paper, a two-state, discrete-time Markov model is first derived for the unsaturated ocean acoustic detection process. Closed-form expressions for the probability mass functions (PMF's) of the number of time steps separating either two successive detections (interarrival time) or one detection and the first subsequent downcrossing (holding time) are presented. Another Markov model is next derived for partially saturated narrowband acoustic signal propagation, and closed-form expressions for the PMF's for the relevant interarrival and holding times are presented.

Discrete-Time Detection Modelling for Unsaturated Ocean Acoustic Propagation

The basic problem in ocean acoustic detection is formulated under the assumption of unsaturated sound propagation. The latter essentially amounts to a constant signal plus Gaussian noise. Detection is defined as occurring whenever \( \rho \), the root mean square pressure at the receiver, exceeds a specified threshold level \( \rho_0 \). A two-state, discrete-time Markov model is derived, and closed-form expressions for the probability mass functions of the number of time steps separating two successive detections (interarrival time) or one detection and the first subsequent “downcrossing” (holding time) are presented. Expressions for the joint probability density function of \( \rho \) at two different points in time are obtained and used to determine the relevant one-step transition probabilities of the Markov model. Sample results using the model are finally presented.
First Experiences with the Massachusetts Institute of Technology Oil Spill Model

A research group at the Massachusetts Institute of Technology has completed the first phase of development of a computer-assisted model for analyzing complex decisions and policies regarding oil spill cleanup. The model is the product of an ongoing MIT Sea Grant project sponsored by a consortium of government and industry organizations. The model can be used, among other things, in “strategic” planning for the long-term oil spill response needs of a region, in assisting on-scene coordinators in responding to a specific spill (“tactical/operational” setting), in evaluating the environmental and economic damages of a spill versus the cost of cleanup, in simulation and training, and in the analysis of various policy and regulatory issues such as delays, use of dispersants, and liability and compensation. The model is described in detail, with a focus on its potential uses. Some illustrative applications in the New England region are presented and applications of the model for the solution of Petro-Canada’s dispersant logistics problem are discussed briefly.

General information
Publication status: Published
Organisations: Petro-Canada, Massachusetts Institute of Technology
Contributors: Psaraftis, H. N., Nyhart, J. D., Betts, D. A.
Number of pages: 6
Publication date: 1983
Peer-reviewed: Yes
Research output: Contribution to conference > Paper – Annual report year: 1983 > Research > peer-review

K-Interchange Procedures For Local Search In A Precedence-Constrained Routing Problem

We develop k-interchange procedures to perform local search in a precedence-constrained routing problem. The problem in question is known in the Transportation literature as the single vehicle many-to-many Dial-A-Ride Problem, or DARP. The DARP is the problem of minimizing the length of the tour traveled by a vehicle to service N customers, each of whom wishes to go from a distinct origin to a distinct destination. The vehicle departs from a specified point and returns to that point upon service of all customers. Precedence constraints in the DARP exist because the origin of each customer must precede his/her destination on the route. As in the interchange procedure of Lin for the Traveling Salesman Problem (TSP), a k-interchange is a substitution of k of the links of an initial feasible DARP tour with k other links, and a DARP tour is k-optimal if it is impossible to obtain a shorter tour by replacing any k of its links by k other links. However, in contrast to the TSP where each individual interchange takes O(1) time, checking whether each individual DARP interchange satisfies the origin-destination precedence constraints normally requires O(N^4) time. In this paper we develop a method which still finds the best k-interchange that can be produced from an initial feasible DARP tour in O(N^3) time, the same order of magnitude as in the Lin heuristic for the TSP. This method is then embedded in a breadth-first or a depth-first search procedure to produce a k-optimal DARP tour. The paper focuses on the k = 2 and k = 3 cases. Experience with the procedures is presented, in which k-optimal tours are produced by applying a 2-opt or 3-opt search to initial DARP tours produced either randomly or by a fast O(N^2) heuristic. The breadth-first and depth-first search modes are compared. The heuristics are seen to produce very good or near-optimal DARP tours.

General information
Publication status: Published
Organisations: Massachusetts Institute of Technology
Contributors: Psaraftis, H. N.
Number of pages: 12
Pages: 391-402
Publication date: 1983
Peer-reviewed: Yes

Publication information
Journal: European Journal of Operational Research
Volume: 13
Issue number: 4
ISSN (Print): 0377-2217
Original language: English
Electronic versions: K_Interchange_Procedures_For_Local_Search_In_A_Precedence_Constrained_Routing_Problem.pdf
Source: FindIt
Putting an Oil Spill Cleanup Computer Model to Work for the Navy

A research group at the Massachusetts Institute of Technology has completed the first phase of the development of a computer assisted model for analyzing complex decisions and policies regarding oil spill cleanup. The model is the product of an ongoing MIT Sea Grant project, sponsored by a consortium of government and industry organizations, including the National Oceanic and Atmospheric Administration, the U.S. Coast Guard, the U.S. Navy, the Commonwealth of Massachusetts, the Spill Control Association of America, JFB Scientific Corporation, the Doherty Foundation, Petro-Canada and Texaco.

The model can be used, among other things, in strategic planning for the long-term oil spill response needs of a region, in assisting On Scene Coordinators in responding to a specific spill (tactical/operational setting), in evaluating the environmental and economic damages of a spill versus the cost of cleanup, in simulation and training, and in the analysis of various policy and regulatory issues such as the effects of delays, the use of dispersants and the investigation of liability and compensation issues.

The paper describes the model in detail, focuses on its potential uses and presents experience with its application in conjunction with pollution control efforts of the U.S. Navy. Specifically, we outline the application of the model in the Port of Charleston, South Carolina, an ongoing project sponsored by the Naval Facilities Engineering Command. The difficulty of gathering data for such an application is discussed.

A Basic Problem of Resource Allocation in Target Tracking

Stochastic dynamic programming techniques are used to formulate and solve the problem of tracking two independent and stationary targets with one sensor in order to maximize a certain measure of performance. At any point in time, the sensor, usually a passive sonar array, can be allocated to only one of the two targets. Assuming the fluctuation process in the ocean to be governed by a phase-random multipath law, the sensor "holds" the target when \( p \), the root-mean-square pressure at the receiver, is above a user-specified threshold. Using discrete time models for the ocean acoustic detection process formulated in earlier papers, we solve the problem for a finite horizon of observations using several alternative objective and reward/penalty functions. Delays of user-specified magnitude in "switching" from one target to the other are also incorporated in our algorithms. Examples using both real and simulated data are presented and discussed. Finally, future research directions are suggested.
Myopic and Presbyopic Approaches to a Multi-Sensor, Multi-Target Resource Allocation Problem
This paper takes advantage of recent results on the probabilistic modeling of the ocean acoustic detection process to develop two approximate procedures for tackling a simplified version of the m-sensor, n-target resource allocation problem. The first procedure is termed "myopic" (short-sighted) and applies if we are interested to maximize the expected number of targets held in the short-run. This second procedure is termed "presbyopic" (far-sighted) and applies if we are interested to obtain the maximum expected number of targets held in the long-run, that is, when the system is in the steady state. Both approaches are suboptimal because they neglect, each in a different way, the interdependence of allocation decisions through time.
We formulate the myopic case as a Linear Programming "Assignment" optimization problem whose inputs are dynamically updated through time. Then we do the same for the presbyopic case. It is seen that if a presbyopic policy is followed, no switching decisions will ever occur. We then extend the myopic formulation to incorporate a general target-holding reward function as well as switching costs. We present some illustrative examples, applying both approaches to simulated data. We also present a comparison of both methods with an exact Stochastic Dynamic Programming approach we had developed earlier for problems of very small size.

A Critical Review of Oil Spill Risk Analysis
The literature on oil spill risk analysis is reviewed. Various results on the locational distribution of oil spills, spill frequencies and spill volumes are provided. A comprehensive methodological framework is developed for analyzing oil spill risk to a given geographical region.

Memory Detection Models for Phase-Random Ocean Acoustic Fluctuations

On a New Model for the Ocean Acoustic Detection Process

The Legal Environment Component of an Oil Spill Cleanup Model

A dynamic programming approach for sequencing groups of identical jobs
A dynamic programming solution to the single vehicle many-to-many immediate request dial-a-ride problem

When considering the static case intermediate requests that may appear during the execution of the route are not considered. A generalized objective function is examined, the minimization of a weighted combination of the time to service all customers and of the total degree of ‘dissatisfaction’ experienced by them while waiting for service. This dissatisfaction is assumed to be a linear function of the waiting and riding times of each customer. Vehicle capacity constraints and special priority rules are part of the problem. A dynamic programming approach is developed, and extended to solving the equivalent ‘dynamic’ case. In this case, new customer requests are automatically eligible for consideration at the time they occur. The procedure is an open-ended sequence of dates, each following every new customer request. The algorithm optimizes only over known inputs and does not anticipate future customer requests.

General information
Publication status: Published
Organisations: Massachusetts Institute of Technology
Contributors: Psaraftis, H. N.
Number of pages: 25
Pages: 130-154
Publication date: 1980
Peer-reviewed: Yes

Publication information
Journal: Transportation Science
Volume: 14
Issue number: 2
Original language: English
Electronic versions:
A_dynamic_programming_solution_to_the_single_vehicle_many_to_many_immediate_request_dial_a_ride_problem.pdf
DOIs:
10.1287/trsc.14.2.130
Source: FindIt
Source-ID: 18822411
Research output: Contribution to journal › Journal article – Annual report year: 1980 › Research › peer-review

National Response Capability to Oil Spills: A Systems Approach

The purpose of this paper is to describe a systems approach for the formulation of the overall problem of oil spill pollution response in the U.S. This formulation is part of an on-going MIT research project, sponsored by a consortium of government agencies and private organisations. The goal of the project is to create a model intended to be used as a tool for analysis of existing and alternative systems for oil spill response and to predict the economic impact of various response options. The paper discusses alternative objectives and provides a hierarchical framework for decisions for optimal oil spill response in three levels, strategic, tactical and operational. The financial and damage assessment aspects of the problem are also presented.

General information
Publication status: Published
Organisations: Massachusetts Institute of Technology
Contributors: Psaraftis, H. N., Baird, A. V., Nyhart, J. D.
Number of pages: 8
Publication date: 1980
Peer-reviewed: Yes
Event: Paper presented at OCEANS ’80 Conference (IEEE), Seattle, United States.
Research output: Contribution to conference › Paper – Annual report year: 1980 › Research › peer-review
Some New Aspects of Slamming Probability Theory

A systematic investigation of some probabilistic aspects of slamming is presented. This investigation includes the assessment of the unconditional probability of slamming at a random instant of time; the estimation of the conditional probability of slamming at a given instant after a particular slam; and the consequent rejection of the hypothesis that slamming is a Poisson process. In addition, a procedure to approximate the distribution of slamming interarrival times is presented. Finally, new slamming statistics, obtainable from the theory of this work, are presented and compared with the existing slamming criteria. The theory of this paper can be readily applied to other seakeeping events such as deck wetness, keel emergence, and propeller racing.

General information
Publication status: Published
Organisations: Massachusetts Institute of Technology
Contributors: Psaraftis, H. N.
Pages: 186-192
Publication date: 1978
Peer-reviewed: Yes

Publication information
Journal: Journal of Ship Research
Volume: 3
ISSN (Print): 0022-4502
Original language: English
Research output: Contribution to journal › Journal article – Annual report year: 1978 › Research › peer-review

Projects:

CyberShip: Cyber Resilience for the Shipping Industry (CyberShip)
The shipping industry has become more vulnerable to cyber-attacks in recent years, because of its dependence on information technology and increasingly complex networks. Cyber systems are incorporated into almost every facet of maritime operations, such as financial and human resources management, security systems, navigation (Global Navigation Satellite Systems (GNSS), Automatic Identification System (AIS), Electronic Chart Display Systems (ECDIS), etc.), communications, electronic certificates, cargo tracking, pre-arrival processing and other key systems and equipment. All maritime structures (including ships and offshore facilities) as well as the connected infrastructure (e.g. offices of shipping companies, ports etc) are vulnerable. Currently, the awareness regarding cyber security aspects is either at a very low level or completely disregarded. The issue of cyber security has been brought into the attention of the International Maritime Organization (IMO), and industry associations such as BIMCO and others. As a result of this guidelines for tackling cyber security problems have been developed.
This project is aimed at providing shipping companies and regulators with a reference framework and decision support model to better cope with disruptions originating from a cyber-attack.
Barfod, M. B., Project Manager, Department of Management Engineering, Management Science, Transport DTU, Operations Management
Psaraftis, H. N., Project Participant, Department of Management Engineering, Management Science, Transport DTU, Operations Management
Jensen, C. D., Project Participant, Department of Applied Mathematics and Computer Science , Cyber Security, Copenhagen Center for Health Technology
Sepúlveda Estay, D. A., Project Participant, Department of Management Engineering, Management Science, Transport DTU, Operations Management
Sahay, R., Project Participant, Department of Applied Mathematics and Computer Science , Cyber Security

01/09/2017 → 31/12/2019
Documents:
MSc. Thesis "Maritime Cyber Security: concepts, problems and models" by Sotiria Lagouvardou
MSc. Thesis "Cyber Risks in Supply Chains" by Pablo Guerra
MSc. Thesis "Analyzing the attack surface of ships" by Bartlomiej Hyra
Project: Research

ShipCLEAN: ShipCLEAN - Energy efficient marine transport through optimization of coupled transportation logistics and energy systems analyses
Psaraftis, H. N., Project Participant, Department of Management Engineering, Management Science, Transport DTU, Operations Management

01/09/2017 → 31/12/2019
Keywords: shipping
Project: Research
Smart Maritime: Norwegian Centre for improved energy efficiency and reduced harmful emissions
Psaraftis, H. N., Project Participant, Department of Transport, Transport optimisation and technique, Department of Management Engineering, Management Science
01/09/2016 → 31/08/2019
Project: Research

BlueSiros: BlueSIROS – Satellite Integrated Route Optimisation Service
Psaraftis, H. N., Project Participant, Department of Transport, Transport optimisation and technique, Department of Management Engineering, Management Science
01/05/2016 → 13/10/2016
Project: Research

SCANDRIA2ACT: Sustainable and Multimodal Transport Actions in the Scandinavian-Adriatic Corridor
Psaraftis, H. N., Project Participant, Department of Transport, Transport optimisation and technique, Department of Management Engineering, Management Science
20/11/2015 → 30/04/2019
Project: Research

TENTACLE: TENTacle- Capitalising on TEN-T core network corridors for prosperity, growth and cohesion
Psaraftis, H. N., Project Participant, Department of Transport, Transport optimisation and technique, Department of Management Engineering, Management Science
20/11/2015 → 30/04/2019
Project: Research

Liner shipping network design based on local optimization
Koza, D. F., PhD Student, Department of Management Engineering
Repke, S., Main Supervisor
Pisinger, D., Supervisor
Psaraftis, H. N., Examiner
Fagerholt, K., Examiner
Speranza, M. G., Examiner
Samfinansieret - Andet
01/09/2014 → 16/04/2018
Award relations: Liner shipping network design based on local optimization
Project: PhD

Cargo-mix optimisation
Christensen, J. M., PhD Student, Department of Management Engineering
Pacino, D., Main Supervisor
Psaraftis, H. N., Supervisor
Larsen, A., Examiner
Alvarez-Valdes, R., Examiner
Andersson, H., Examiner
Forskningsrådsfinansiering
01/09/2014 → 01/02/2018
Award relations: Cargo-mix optimisation
Project: PhD

Green corridors in freight logistics
Panagakos, G., PhD Student, Department of Management Engineering
Psaraftis, H. N., Main Supervisor
Larsen, A., Supervisor
Rich, J., Examiner
Cullinane, K., Examiner
Ojala, L., Examiner
Samfinansieret - Andet
15/08/2014 → 25/11/2016
Award relations: Green corridors in freight logistics
Project: PhD
Real Time Process Management for Error Correction and Maintenance in Railways
M. Pour, S., PhD Student, Department of Management Engineering
Rasmussen, K. M., Main Supervisor
Psaraftis, H. N., Examiner
De Causmaecker, P., Examiner
Hanbali, A. A., Examiner
Technical University of Denmark
15/06/2013 → 23/03/2017
Award relations: Real Time Process Management for Error Correction and Maintenance in Railways
Project: PhD

Efficient Algorithms for integrated Container Terminal Activities
Iris, C., PhD Student, Department of Transport
Larsen, A., Main Supervisor
Pacino, D., Supervisor
Repke, S., Supervisor
Psaraftis, H. N., Examiner
Vis, I. F. A., Examiner
Technical University of Denmark
01/02/2013 → 04/07/2016
Award relations: Efficient Algorithms for integrated Container Terminal Activities
Project: PhD

The Framework of phase-based planning of railway
Li, R., PhD Student, Department of Management Engineering
Larsen, A., Main Supervisor
Landex, A., Supervisor
Salling, K. B., Supervisor
Psaraftis, H. N., Examiner
Madsen, S. N., Supervisor
Preston, J., Examiner
Vicencio, A. A. N., Examiner
Technical University of Denmark
15/01/2013 → 21/09/2017
Award relations: The Framework of phase-based planning of railway
Project: PhD

Competitive Liner Shipping Network Design
Karstsen, C. V., PhD Student, Department of Management Engineering
Pisinger, D., Main Supervisor
Repke, S., Supervisor
Psaraftis, H. N., Examiner
Toth, P., Examiner
Christiansen, M., Examiner
Technical University of Denmark
15/12/2012 → 07/04/2016
Award relations: Competitive Liner Shipping Network Design
Project: PhD

Mitigating and reversing the side-effects of environmental legislation on Ro-Ro shipping in Northern Europe
The main objective of this project is to identify and assess possible technical, operational, regulatory and financial measures for the mitigation and reversal of the negative repercussions of environmental legislation to the market shares of Ro-Ro shipping in Northern Europe. The project builds upon prior research by the Principal Investigator and his colleagues in recent years and will be under the umbrella of Maritime DTU. The project is funded by the Danish Maritime Fund.
Psaraftis, H. N., Project Participant, Department of Transport, Transport optimisation and technique
Kontovas, C. A., Project Participant, Department of Transport, Transport optimisation and technique
Kronbak, J., Project Participant, Department of Transport, Transport optimisation and technique
Zis, T., Project Participant, Department of Transport
15/06/2015 → 14/06/2017
Keywords: Maritime Industry
**ConCoord: ConCoord**
The project focuses on the important area of city logistics. It investigates an integrated urban freight simulation environment, a unique measurement framework for the environmental footprint of transport and logistics, and the performance measurement of new innovative urban transport and logistics concepts. Specifically dealing with the different and important considerations of new transportation solutions, new mechanisms for execution and control of city logistics, and research on the urban distribution of goods reducing urban freight movements and its impact on residents and the environment.

The fundamental idea is to stop considering each shipment, actor (e.g. shippers, Logistics Service Providers, etc.) and vehicle in isolation, but as components of an integrated logistics system to be optimized. The keywords are CONsolidation and COORDination (CONCOORD) of the urban distribution flows that are currently fragmented. CONCOORD involves key players in the urban transportation field, both from leading European universities and world-class Europe-based companies, who have expertise and experience in city distribution and who have the willingness to explore this issue for the benefit of all those in Europe.

Olsen, A., Project Manager, Department of Transport, Transport optimisation and technique
Larsen, R., Project Participant, Department of Transport, Transport optimisation and technique
Larsen, A., Project Applicant, Department of Transport, Transport optimisation and technique
Psaraftis, H. N., Project Manager, Department of Transport, Transport optimisation and technique
Wen, M., Project Participant, Department of Transport, Transport optimisation and technique

01/01/2013 → 01/06/2016

**Activities:**

**Speed Optimization vs Speed Reduction in Maritime Transport: the Speed Limit Debate**
Period: 1 Apr 2019
Harilaos N. Psaraftis (Guest lecturer)
Department of Technology, Management and Economics
Management Science
Operations Management

**Description**
Talk at AORTA workshop, Bath University, UK.
https://www.bath.ac.uk/events/colloquium-on-advances-in-or-transportation-applications-aorta/
Degree of recognition: International
Documents:
AORTA 2019 Psaraftis

**Related event**

**Colloquium on Advances in OR Transportation Applications (AORTA)**
01/04/2019 → 01/04/2019
Bath, United Kingdom
Activity: Talks and presentations › Conference presentations

**Sustainable shipping: to be or not to be**
Period: 4 Mar 2019
Harilaos N. Psaraftis (Invited speaker)
Operations Management
Management Science
Department of Technology, Management and Economics
Degree of recognition: Local
Documents:
IDA seminar Psaraftis

**Related event**
The profit maximizing liner shipping problem with flexible frequencies: balancing economic and environmental performance
Period: 10 Jul 2018
Harilaos N. Psaraftis (Speaker)
Department of Management Engineering
Management Science
Operations Management

Description
Talk presented at the EURO 2018 conference, Valencia, Spain.
Documents:
EURO 2018 Psaraftis FINAL

Related event
EURO 2018 conference on Operational Research
09/07/2018 → 11/07/2018
Valencia, Spain
Activity: Talks and presentations › Conference presentations

Liner shipping with flexible frequencies: logistical and environmental considerations
Period: 28 Jun 2018
Harilaos N. Psaraftis (Speaker)
Department of Management Engineering
Management Science
Operations Management

Description
Degree of recognition: International
Documents:
Chios 2018 Psaraftis

Related event
European Port Policy Symposium
28/06/2018 → 29/06/2018
Chios, Greece
Keywords: liner shipping
Activity: Talks and presentations › Conference presentations

Sustainable shipping
Period: 31 May 2018
Harilaos N. Psaraftis (Other)
Department of Management Engineering
Management Science
Transport DTU
Operations Management
Degree of recognition: International

Related event
Sustainable shipping
31/05/2018 → 31/05/2018
Lyngby, Denmark
Keywords: Sustainability, shipping
Activity: Other

The profit maximizing liner shipping problem with flexible frequencies
Period: 29 May 2018
Harilaos N. Psaraftis (Speaker)
Department of Management Engineering
Management Science
Operations Management

Description
Some new stuff on container shipping.
Degree of recognition: International
Documents:
Psaraftis

Related event
ROUTE 2018: International Workshop on Vehicle Routing, Intermodal Transportation and Related Areas
27/05/2018 → 30/05/2018
Snekkersten, Denmark
Keywords: liner shipping, GHG emissions
Activity: Talks and presentations › Conference presentations

ROUTE 2018
Period: 27 May 2018
Harilaos N. Psaraftis (Other)
Department of Management Engineering
Management Science
Transport DTU
Operations Management

Description
ROUTE 2018 aims to provide a forum for scientific exchange and cooperation in the fields of vehicle routing, intermodal transportation and related areas.
Degree of recognition: International

Related event
ROUTE 2018: International Workshop on Vehicle Routing, Intermodal Transportation and Related Areas
27/05/2018 → 30/05/2018
Snekkersten, Denmark
Activity: Other

MBMs: the IMO discussion
Period: 8 May 2018 → 9 May 2018
Harilaos N. Psaraftis (Invited speaker)
Department of Management Engineering
Management Science
Operations Management

Description
A 3 minute presentation on the IMO discussion on Market Based Measures (MBMs)
Degree of recognition: International
Documents:
Psaraftis Cologne

Related organisation

**MBMs: the IMO discussion**
Harilaos N. Psaraftis (Invited speaker)
8 May 2018 → 9 May 2018
Activity: Talks and presentations › Conference presentations

**Decarbonization of shipping: status and prospects**
Period: 2 May 2018
Harilaos N. Psaraftis (Speaker)
Department of Management Engineering
Management Science
Transport DTU
Operations Management

**Description**
All you need to know on maritime GHGs
Degree of recognition: National

Related organisation

**Decarbonization of shipping: status and prospects**
Harilaos N. Psaraftis (Speaker)
2 May 2018
Activity: Talks and presentations › Conference presentations

**Maritime Logistics and Cybersecurity at DTU**
Period: 2 May 2018
Harilaos N. Psaraftis (Other)
Department of Management Engineering
Management Science
Transport DTU
Operations Management

**Description**
Workshop presenting topics on the subjects of maritime logistics and cybersecurity. DTU and external speakers.
Degree of recognition: Local

Related event

**Maritime Logistics and Cybersecurity at DTU**
02/05/2018 → 02/05/2018
Copenhagen, Denmark
Activity: Other

**The profit maximizing liner shipping problem with flexible frequencies: logistical and environmental considerations**
Period: 17 Apr 2018 → 19 Apr 2018
Harilaos N. Psaraftis (Speaker)
Department of Management Engineering
Management Science
Transport DTU
Operations Management
Description
Some new stuff on liner shipping.
Degree of recognition: International

Related organisation

The profit maximizing liner shipping problem with flexible frequencies: logistical and environmental considerations
Harilaos N. Psaraftis (Speaker)
17 Apr 2018 → 19 Apr 2018
Keywords: liner shipping
Activity: Talks and presentations › Conference presentations

Reducing emissions in maritime transportation (ii)
Period: 1 Feb 2018
Harilaos N. Psaraftis (Invited speaker)
Department of Management Engineering
Management Science
Transport DTU
Operations Management
Degree of recognition: Local
Documents:
Shanghai Jiao Tong Univ talk 01 02 2018

Related event

Seminar at Shanghai Jiao Tong University, Shanghai, China
01/02/2018 → 01/02/2018
Shanghai, China
Activity: Talks and presentations › Talks and presentations in private or public companies and organisations

Reducing emissions in maritime transportation
Period: 30 Jan 2018
Harilaos N. Psaraftis (Invited speaker)
Department of Management Engineering
Management Science
Transport DTU
Operations Management

Description
title says it all
Degree of recognition: Local
Documents:
Shanghai Univ talk 30 01 2018

Related event

Seminar in Shanghai University, Shanghai, China
30/01/2018 → 30/01/2018
Shanghai, China
Keywords: maritime emissions
Activity: Talks and presentations › Talks and presentations in private or public companies and organisations

Hong Kong Polytechnic University
Period: 22 Jan 2018 → 26 Jan 2018
Harilaos N. Psaraftis (Visiting researcher)
Department of Management Engineering
Description
My final visit as Departmental Academic Advisor, Department of Logistics and Maritime Studies. Term was 2012 to 2018.
Degree of recognition: International
Activity: Visiting an external institution › Visiting another research institution

Green Maritime Logistics
Period: 9 Aug 2017
Harilaos N. Psaraftis (Keynote speaker)
Department of Management Engineering
Management Science
Transport DTU
Operations Management

Description
An overview of what is Green Maritime Logistics
Degree of recognition: International
Documents:
IMAM 2017 Psaraftis v4.0

Related organisation
Green Maritime Logistics
Harilaos N. Psaraftis (Keynote speaker)
9 Aug 2017
Keywords: green logistics
Activity: Talks and presentations › Conference presentations

Transportation Science (Journal)
Period: 1 Jan 1987 → 1 Jan 2018
Harilaos N. Psaraftis (Editor)
Department of Management Engineering
Management Science
Transport DTU
Operations Management

Description
Associate Editor, Guest Editor (2 special issues)
Degree of recognition: International

Related journal
Transportation Science
0041-1655
Central database
Activity: Editorial work and peer review › Series editor › Communication