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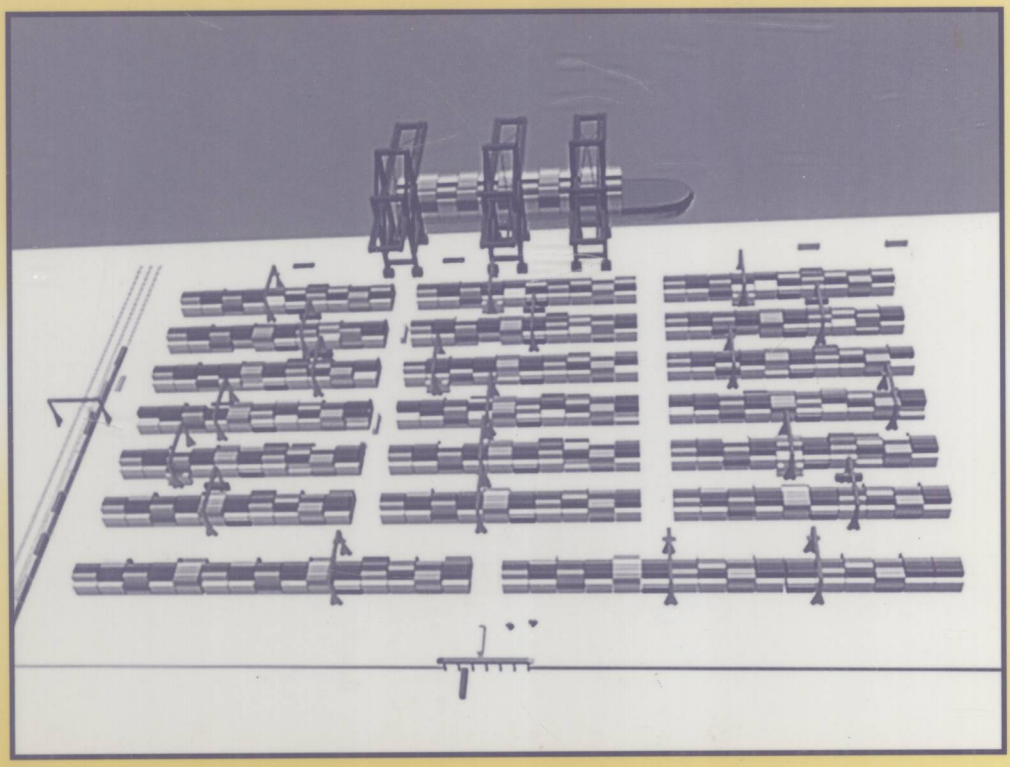

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Intelligent Freight Transportation

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Intelligent Freight Transportation

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A Series of Reference Books and Textbooks

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Preface

Freight transportation is vital to the functioning of societies. With globalization and relaxation of international trade barriers, the transportation chain has expanded considerably. The demand for goods has been increasing due to rising living standards, competition that lowers cost to consumers, and many other factors. This rising demand puts considerable pressure on all transportation nodes and links such as ports, ships, trucks, trains, airports, warehouses, roadway systems, and so on to improve their practices in order to keep pace with higher demand. The pressure comes at a time where in places such as metropolitan areas the freight transportation infrastructure is already saturated. Cost, social, and environmental constraints as well as lack of adequate space make it difficult, if at all possible, to expand the infrastructure using the traditional approach of "more land more capacity." The advances during the last three decades in electronics, computers, information technologies, and Internet as well as in optimization and software tools opened the way for alternative ways of improving the freight transportation system in order to keep pace with rising demand while meeting the constraints of the twenty-first century.

Intelligent freight transportation (IFT) is an area that deals with the use of advanced technologies and intelligent decision making in order to improve the freight transportation system by making the existing infrastructure more efficient. IFT is a multidisciplinary area with many complex problems, which in addition to technology include policy, socioeconomic, political, environmental, and human and other issues.

The purpose of this book is to bring together a number of experts working in different areas or disciplines to present some of their latest approaches and future research directions in the area of IFT. The field is so diverse that it is impossible for the seventeen chapters of the book to cover every single aspect of the area. The complexity of the problems involved, the issues raised, and proposed solutions will give the reader a clearer picture of the complexity of the problem as well as provide knowledge of the areas where progress could be made. The freight transportation system is an integrated system with many interconnected subsystems. While solving problems on the overall system level may be difficult, solutions on the subsystem level may be feasible. Such subsystem-level solutions are provided in several of the chapters of the book.

The book consists of seventeen chapters dealing with automation of container terminals, modeling of cross-border land transportation, port choice and competition, inland ports and alternative container transport systems, optimization techniques for efficient cargo movement, labor and environmental issues, and solutions.

The chapters present an indicative spectrum of the different areas and disciplines that can be classed as IFT. Many other important areas and aspects are omitted due to lack of space. The chapters are written by academicians, practitioners, and industry and labor union experts, giving the reader a very wide perspective of

the issues and solutions that arise in IFT. The diversity of the topics and that of the authors is a unique feature of the book, making it very useful to a very wide range of readers. Policy makers, researchers, practitioners, economists, environmentalists, and so on could benefit from the book, as they will be able to read about diverse yet very relevant topics in a single book. The book in itself emphasizes with its structure and content the multidisciplinary nature of IFT, whose understanding could lead to solutions of freight transportation problems that are so vital to society.

I thank all the authors for their valuable time and efforts in putting together this book, for their hard work, and for sharing their experiences so readily. I also thank the reviewers for their valuable comments in enhancing the contents of this book. Last but not least I thank my colleagues at the University of Southern California (USC) and California State University at Long Beach (CSULB) for their interaction that enriched my knowledge by indirectly letting me know how little I know of the complexity of freight transportation. Special thanks go to Professors James Moore, Genevieve Giuliano, Maged Dessouky, Randy Hall, Hossein Jula, Elliott Axelband, Berok Khoshnevis, and Anastasios Chassiakos; Marianne Venieris; Stan Whitley; Dr. Isaac Maya; and others. I also acknowledge the financial support of the transportation centers, CCDoTT at CSULB, METRANS at USC/CSULB, and CATT at USC, as well as of the National Science Foundation, which made it possible to do research in IFT and become more familiar with the field. Furthermore, the valuable help of several former Ph.D. students, which include Drs. Hossein Jula, Chin Liu, Jianlong Zhang, Baris Fidan, and Marios Lestas, as well as current Ph.D. students Yun Wang, Hwan Chang, Ying Huo, Matthew Kuipers, Nazli Kahveci, and Jason Levin, and past associate researchers Professors Katerina Vukadinovic and Elias Kosmatopoulos, and industry collaborator Edmond Dougherty, Jr., made the preparation of this book a much easier task.

Petros Ioannou

Editor

Petros Ioannou received MS and PhD degrees from the University of Illinois in 1980 and 1982, respectively. He is currently a professor at the Department of Electrical Engineering-Systems, University of Southern California, director of the Center of Advanced Transportation Technologies, and Associate director for research of METRANS. He has been an associate editor for the *IEEE Transactions on Automatic Control*, the *International Journal of Control, Automatica*, and *IEEE Transactions on Intelligent Transportation Systems.* Ioannou is currently associate editor-at-large of the *IEEE Transactions on Automatic Control* and chairman of the IFAC Technical Committee on Transportation Systems. His research interests are in the areas of adaptive control, neural networks, nonlinear systems, vehicle dynamics and control, intelligent transportation systems (ITS), and intelligent flight control. He is a fellow of IEEE, fellow of the International Federation of Automatic Control (IFAC), and author/coauthor of 8 books and over 150 research papers in the area of controls, neural networks, nonlinear dynamical systems, and ITS.

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1.1 INTRODUCTION/BACKGROUND

Economic restructuring and globalization have vastly increased the volume of commodity flows by all transport modes. Increased freight flows have had significant impact on metropolitan areas. Traffic at major freight generators (ports, airports, rail yards, warehouse/distribution nodes) has greatly increased, contributing to congestion, environmental pollution, and highway crashes. Economic forecasts are unanimous in predicting continued increases in international trade, with expectations that containerized cargo volume will increase considerably, leading to a commensurate increase in traffic at major import/export and distribution nodes. The U.S. highway, rail system, and ports are already struggling to keep pace with rising demand and deal with increased levels of congestion, environmental, and other issues. Increasing capacity at ports and goods movement supply chain in general, while satisfying environmental, economic, political, labor union, and other constraints, is a challenging problem that needs to be addressed.

Adding capacity by building new infrastructure is not a feasible short- or even medium-term alternative for managing increased cargo volumes, especially in metropolitan areas. Building new infrastructure faces numerous constraints: lack of funding, land scarcity, environmental concerns, community opposition, and others. The planning and review process for major projects can take a decade or more. Solving urban freight transportation problems will require better utilization of existing infrastructure and more efficient flows throughout the goods movement supply chain. Advances in information technology, telecommunications, data management, and computation tools, together with recent research in systems optimization and

control, make possible new approaches to the freight transportation problem. The term intelligent freight transportation represents an area where the use of advanced technologies and intelligent decision making can be integrated in order to come up with solutions that make better use of the existing infrastructure or introduce new transport ways in an effort to improve capacity and efficiency under environmental, economic, and other constraints.

The purpose of this book is to bring together experts from industry, academia, and other stakeholders to address freight transportation problems by raising issues, proposing solutions, discussing obstacles, and so forth from different points of view. In the following subsections we present the various areas covered by the chapters of the book.

1.2 AUTOMATION OF CONTAINER TERMINALS

Most terminals in metropolitan areas cannot meet increasing demand due to limited space and inefficient operations. Increasing capacity by using additional land is often a costly proposition due to the scarcity of land or its high cost. Advanced technologies and automation is an attractive way to increase capacity by replacing manual and often inefficient operations with automated ones that are optimized for efficiency.

In chapter 2, several automated container terminal (ACT) concepts are designed, analyzed, and evaluated. These concepts include the use of automated guided vehicles (AGVs) and different configurations of the terminals in an effort to save land while meeting throughput demand. Future demand scenarios are used to design the characteristics of each terminal in terms of configuration, equipment, and operations. Simulation models are developed to simulate each terminal system and evaluate its performance. In addition to performance, cost considerations are used to compare the different concepts. The results obtained demonstrate that automation could improve the performance of conventional terminals substantially and at a much lower cost.

Chapter 3 introduces a number of proposed container automation concepts and examines why some of them have been implemented and others not. The lessons learned from past successes and failures could lead to many more successful automated container terminals in the future. It points out that technology is often not the issue in implementing automation. Perceived need, funding, technical risk versus operational reward, and timing have been the key factors regarding terminal automation.

The trend in terminal operations is to minimize the time container vessels spend in ports. This can be achieved by improving the productivity of the various container handling operations by modernizing container terminals through the use of automated container handling facilities. Such changes introduce various new handling facilities and generate new research topics for efficient operations of terminals. Chapter 4 discusses the related decision-making problems that need to be explored by researchers.

1.3 MODELING OF CROSS-BORDER LAND TRANSPORTATION

The land transportation of containers between a container terminal and the origins or destinations of the containers may represent a very small portion of the global distribution network in terms of distance, but it could account for a significant portion

of the total transportation cost due to cross-border issues such as having different regulatory policies and information flow giving rise to shipment delays. The modeling of such a transportation problem is not trivial. In chapter 5, several modeling perspectives are introduced and used to formulate cross-border land transportation problems under different situations. These situations depend on the level of policy restrictions that govern cross-border activities and the level of information available for decision making. A number of models, ranging from coupling drivers and tractors to matching resources with transportation requests in a dynamic, stochastic environment, are reviewed. The case of Hong Kong is used as an example to illustrate the challenges of managing cross-border container transportation.

1.4 PORT CHOICE AND COMPETITION

The containerized trade market is growing rapidly due to globalization and increased international trade with the Far East giving rise to port competition among the European ports in the Le Havre–Hamburg range for more capacity. The port of Amsterdam in an effort to meet such competition developed the Ceres Paragon Terminal in 2002. Characterized by a revolutionary concept known as an indented berth, served simultaneously by nine ultramodern post-Panamax gantry cranes, high productivity levels and low turnaround times can be obtained. Although the odds seemed favorable for the new terminal, enthusiasm was replaced by vexation as the terminal experienced a dramatically slow start. For years it was barely operational with only an incidental test run and some feeder and barge movements. Finally the first carriers were contracted in July 2005. In chapter 6 relevant main port choice and port performance criteria identified in literature are studied. Some of these criteria are applied to the port of Amsterdam in order to study the port's and terminal's chances for structural establishment in the competitive West European port arena.

1.5 INLAND PORTS AND ALTERNATIVE TRANSPORT SYSTEMS

The lack of sufficient storage capacity in terminals due to lack of adequate land as well as the increasing level of congestion associated with cargo movement within and outside the terminals motivates different approaches to deal with the situation. The concept of inland port, where containers are handled at a remote place where land is cheaper and the traffic network less congested before transferred from/to the terminal is one way to ease the pressure on terminals for more capacity. The use of alternative methods of cargo movement without disturbing the traffic network, especially in metropolitan areas, is another way of managing congestion and improving efficiency.

In chapter 7 existing inland port operations and port planning are studied and used to predict future development trends. Inland port operations are classified by the type and method of cargo handling to provide transportation and distribution planners sufficient information to begin the process. A review of concepts being considered for future inland port development is provided. The emerging efforts to develop an integrated inland port system within the United States are evaluated and summarized.

In chapter 8 the basic operational concepts reflected by the existing terminal types, mainly in terms of logistic activities, are studied. Furthermore, a number of

innovative technological concepts proposed for the enhancement of inland terminal performance are presented.

Chapter 9 deals with a new approach of moving containers based on a magnetic levitation technology. The system is referred to as the Maglev Freight Conveyor System. This approach utilizes a proven Maglev "conveyor belt" technology that shows promise for both short-haul urban freight movement and interstate-bound containers. The application of this technology to container freight movement inside the port and beyond its confines is expected to reduce both highway congestion and pollution throughout the Los Angeles area.

1.6 OPTIMIZATION TECHNIQUES FOR EFFICIENT OPERATIONS

The application of advanced technologies, especially information technologies and automation, will open the way for the use of advanced optimization techniques in order to optimize performance and improve efficiency. Furthermore, the way practices are carried out could be changed or modified to make full use of technological developments that would lead to additional capacity, less congestion, and many other benefits.

In chapter 10, the time window appointment system, which has recently been introduced as a way to reduce congestion at the terminal gates, is investigated. With this system the trucks are assigned a window of time to show up at the terminal gates to be served. Given that trucks have to perform other delivery/pickup tasks associated with warehouses, customers, and so on using the road network, the overall problem can be formulated as an optimization problem with limits where trucks have to complete their tasks with minimum cost subject to time window and other constraints. In this chapter, the container movement by trucks in metropolitan areas with time constraints at origins and destinations is modeled as an asymmetric multi-traveling salesman problem with time windows (m-TSPTW) with social constraints. Different variations of the m-TSPTW are studied, and solution methods are reviewed and evaluated.

Intermodal drayage truck routing and scheduling problems represent a special class of vehicle routing problems called full *truckload pickup and delivery problems.* Feasible routes in such problems are primarily constrained by time restrictions. In chapter 11, methods to improve container drayage truck routing and scheduling practices through the use of advanced systematic scheduling approaches based on information technology are presented and analyzed.

Loading ships as they are unloaded (double-cycling) can improve the efficiency of a quay crane and therefore container port. In chapter 12 the double-cycling problem is investigated and solution algorithms to the sequencing problem are developed. Furthermore, a simple formula is used to estimate benefits. The objective in this case is to reduce the turnaround time of the ship by completing the loading/unloading process as fast as possible. Several optimization techniques, which include the greedy algorithm based on the physical properties of the problem and the formulation of the problem as a scheduling problem and its optimum solution using Johnson's rule, are used and compared. The results demonstrate that double-cycling can create significant efficiency gains.