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Transportation Research Procedia 3 (2014) 621 – 630

Transportation Research Procedia

www.elsevier.com/locate/procedia

17th Meeting of the EURO Working Group on Transportation, EWGT2014, 2-4 July 2014, Sevilla, Spain

Performance indicators for planning intermodal barge transportation systems

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Abstract

Various indicators are used to qualify the performance of intermodal transportation systems. Some of these are found in public documents, usually providing global measures such as total flow volumes, profits, and share values. While of great interest, such measures are not sufficient to support a fine analysis of different operation strategies, commercial policies, and planning methods. Additional measures are used in the scientific literature to address these issues. Our first goal is to review the performance indicators found in scientific literature and to qualify them with respect to tactical planning of intermodal barge transportation systems. We extend this analysis to include revenue management policies, a topic generally neglected in freight transportation. We also discuss procedures to generate problem instances that provide the means to analyze planning methods and system behavior based on these performance indicators.

Selection and peer-review under responsibility of the Scientific Committee of EWGT2014

Keywords: freight intermodal transportation; barge transportation; performance indicators; tactical planning; revenue management

1. Introduction

Intermodal freight transportation is generally defined as moving cargo loaded into some type of boxes, the well-known containers, by a series of at least two transportation modes or carriers, without handling the cargo, containers being moved from one mode (vehicle) to the next in intermodal terminals, e.g., ports and rail yards (Bektaş and

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Selection and peer-review under responsibility of the Scientific Committee of EWGT2014
doi:10.1016/j.trpro.2014.10.041

Crainic, 2008; Crainic and Kim, 2007). It is a core economic activity supporting for a large part national and international trade. As such, it is a well-known and intensely investigated application field in operations research and transportation science. Planning and management of activities at the strategic (e.g., market development and location and dimensioning of facilities), tactical (e.g., service and capacity planning) and operational (e.g., dispatching and resource management) are both essential to the economic and operation efficiency of intermodal transportation systems and stakeholders, and complex processes in their own right. This resulted into a rather rich collection of models and methods aiming to optimize operations, service and resource utilization for intermodal freight transportation carriers. Not all components of the industry received equal treatment, however. We are thus particularly interested in such a less studied branch of the field, namely barge intermodal freight transportation systems (inland water transportation), which is gaining interest as a component of environment-friendly modal shifts.

The study we undergo, and the results presented here, focus on the tactical level decision-making problems and concern, in particular, the scheduled service network design (SSND) with asset management considerations. There are very few service network design models and methods proposed for barge transportation yet, but one observes raising interest for the topic, including within freight forwarders and carriers, mainly due to modal-shift public policies and increasing concerns in the public and shippers alike with respect to the environmental impact of other modes of freight transportation. This translates for barge carriers into a new motivation and willingness to have a higher level of competitiveness, to devise a different way of designing their services, and to explore new customer-service strategies offered by the revenue-management concepts.

Many studies assess existing decision-support tools, policies and practice or proposed service network design models and solution techniques, generally through comparison of optimization or numerical simulation results. The transportation system is generally modeled through network-based formulations with assumptions regarding the underlying physical network and infrastructure, characteristics of available assets (fleets of vehicles, terminal resources, capacities, etc.), and future demands (demand forecasts). Test instances are then generated, hopefully with reference to actual practice, the corresponding SSND formulations are solved, and solutions and characteristics of the corresponding operation plans are analyzed and performances are evaluated. Performance indicators thus play an important role in the analysis of models, methods, results, and corresponding policies.

Performance indicators are broadly used, in practice and research, to characterize the performance of a given transportation system under current (e.g., the annual activity and financial reports of carriers) or proposed (e.g., optimization and simulation studies) operating conditions. They are, of course, also widely used to validate and evaluate models and solution methods, as well as the corresponding results and strategies. Many such indicators are found in official documents and the scientific literature, as shown in the following. Yet, there is no general framework for analyzing the interest of particular performance indicators in the context of specific problem settings, generating appropriate problem instances, and choosing the most representative indicators. Nevertheless, it is commonly accepted that, some indicators give more insights than others when evaluating the performances of a transportation system or methodology, and some critical ones may be singled out. In the same time, the performance indicators can only be computed if specific information and data are collected for this purpose. Our goal is to contribute toward addressing this issue.

The contribution of the research presented here therefore is to propose a classification and analysis of the performance indicators generally used to evaluate tactical planning solutions in freight transportation, aiming to identify adequate ones for SSND with revenue management considerations. The performance indicators analyzed herein may be applied to assess performances of different modes (maritime, rail, etc.) supporting container transportation systems; we illustrate our study with an inland navigation system. We also give some insights in the way the necessary test instances are generated for a general network barge transportation system.

The structure of the paper is as follows. We give a brief description of the general SSND problem in Section 2, together with corresponding literature and specific issues related to the introduction of revenue management considerations in the tactical planning problem. Section 3 gives the first steps toward a general classification of performance indicators and identifies a number of particular ones related to the problem studied here. The description of a general procedure to generate problem instances for SSND models of general barge transportation networks is the focus of Section 4, followed by Section 5 where numerical results and an analysis of the different performance indicators are presented. The paper ends with conclusions about the presented study.