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GENERAL SIMULATION MODEL TO IMPROVE THE DESIGN AND OPERATION OF CROSS-DOCKING SYSTEMS

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ABSTRACT

Cross-docking operations involve receiving and unloading groups of incoming units and then disassembling, recombining each unit into groups that meet outgoing needs, and loading them onto outgoing containers. The primary objective of cross-docking is to reduce storage, handling, and lead time so as to minimize transportation and storage costs and maintain a high level of customer service.

This paper focuses on the development and application of a general cross-docking simulation model that is used to understand the stochastic and dynamic behavior of cross-docking systems. It is used to assess the performance of alternative physical arrangements and operational policies. In order to represent the most flexible designs, a key component of the model – a general door object – is presented. It is able to dynamically switch between inbound and outbound functions based on a specified set of operational rules. Example uses of the model are provided.

1 INTRODUCTION

Cross-docking is a material-handling process within the field of logistics that is used to reduce shipping and inventory costs. It is an intermediate transportation step that involves transferring units between incoming containers (e.g. cargo trailers) and outbound containers for continued transportation to a final destination. Cross-docking operations involve receiving and unloading groups of incoming units (e.g. pallet load of items) that arrive in containers, disassembling the groups into separate items within the cross-dock, and recombining each item into new groups that meet outgoing needs, such as grouping items according to final shipping destination. These groups are then loaded onto outgoing containers and shipped.

Cross-docking facilities are quite complex – they are large dynamic systems that inherently possess considerable variability and randomness with extensive interdependencies among system components. The design and operation of cross-docking facilities involve both tactical and strategic decision-making that can benefit from the application of operations research techniques. This is evidenced by the extensive literature review provided by Van Belle, Valckenaers, and Cattrysse (2011). They categorize the literature by decision-making level and approach used to address the problem.

Van Belle et al. (2011) include simulation as an analysis tool, but there are a small number of cited works. Much of the current research in cross-docking appears to be in mixed-integer programming formulations and algorithmic solutions. Van Belle et al. (2011) also suggest that the simplifying assumptions undertaken by much of the current research tends to limit their applicability in industry. A primary goal of our research is to develop robust tools that can be used to support design and operational decisions in industry. Simulation in general, and modern simulation software in particular (e.g. *FlexSim*), provide

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the means to develop effective decision-support tools for the design and operation of cross-docking systems.

2 APPROACH

Our research, and the development of a general cross-docking modeling and analysis tool, begins with a conceptual model of basic cross-docking operations. The conceptual model provides the basic operational logic, as well as the key variables that must be addressed in the effective design of cross-docking systems. It provides the foundation for the evolutionary development of general cross-docking system objects.

As part of this research, we are developing a comprehensive taxonomy of issues that need to be addressed in order to effectively design and operate cross-docking systems, as well as a succinct enumeration of the key drivers and parameters needed for cross-docking models. Similarly, we are developing a list of performance measures used to evaluate alternative cross-docking systems. A sampling of the issues and decisions that can be addressed by the simulation model include: policies for dynamically assigning available doors to inbound and outbound containers based on current operating conditions, scheduling inbound and outbound container arrivals, managing internal resource allocations (e.g. number and assignment of fork trucks), assessing cross-dock order processing policies, evaluating alternative overall facility design and layout configurations, etc.

The simulation model is developed in *FlexSim* and leverages its modern discrete-event, object-oriented development environment. The model is designed to be able to address both tactical and strategic issues and support a wide range of design and operational decisions. The flexible door object is considered agent-based since it configures itself based on embedded logic and current overall system conditions. The flexible door object contains a dock area that can be used for inbound or outbound containers, temporary storage space for inbound and outbound units, linkage to material handling devices that are used to move units to or from the container, and internal logic that communicates current local state information to a master system controller for use in determining configuration changes for all doors. Figure 1 provides a simple cross-docking system model using a preliminary version of the flexible door object. The model can thus be easily expanded by applying additional door objects to replicate existing or proposed cross-dock configurations. One planned enhancement to the modeling environment is a user interface that will generate base configurations, i.e. door objects and paths/connections between them.

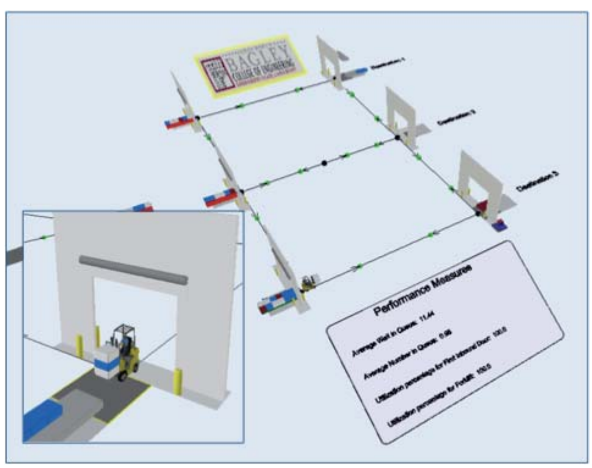

Figure 1: Preliminary version of flexible door object in a simple cross-dock system.

REFERENCES

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