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# PERFORMANCE OF AUTOMATED STORAGE/RETRIEVAL SYSTEMS UNDER STOCHASTIC DEMAND USING QUEUEING THEORY

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Abstract. *In this paper we offer a queueing theory-based method and some mathematical models for analyzing performance of automated storage/retrieval systems (AS/RS) under stochastic demand. With basic factors, we model the optimizing behavior of the AS/RS, establish queuing model to determine whether or not it meets throughput and offer easy-to-compute equations of AS/RS' utilization, the fraction of DC cycles and mean storage/retrieval time. According to the computational comparison with the simulation, the proposed models give satisfactory results with very high accuracy. Although the results are derived for a given system, they can also be used in the design or evaluation of new/proposed systems.*
**Keywords:** Automated storage/retrieval system, Queuing model, Performance estimation, Control policy

1. **Introduction.** An automated storage and retrieval system (AS/RS) is an important technology for improving productivity in modern manufacturing and distribution organizations. To enhance the flexibility of AS/RS, and to perhaps make them more useful components in the supply chain, attention should be directed toward finding an analytical approach to aid in easily evaluating the performance resulting from reasonable strategy [2].

AS/RS have been widely used not only as alternatives to traditional warehouses but also as part of advanced manufacturing systems. There are many instances of smaller-scale AS/RS now being used in warehouses (for order picking and similar applications) and in modern factories (for Work-In-Process, (WIP) management) jointly with the assembly lines as a buffer system [3]. The AS/RS served as a buffer system in WIP to assist the successful synchronization of the entire production/assembly processes [4], which is the case we treat in this paper. We assume that requests for storages and retrievals arrive randomly and independently, a storage request comes when an up-stream station completes work on a container, and a retrieval request occurs when a down-stream station is ready to work on the next container. The queueing theory-based model for utilization of AS/RS on this condition presented can be used to establish throughput standards on existing systems. The results are also quite useful in estimating throughput performance for first cut evaluations of AS/RS design configurations.