This dissertation focuses on developing models to study the problem of searching and retrieving items in a dense storage environment. We consider a special storage configuration called an inverted T configuration, which has one horizontal and one vertical aisle. Inverted T configurations have fewer aisles than a traditional aisle-based storage environment. This increases the storage density; however, requires that some items to be moved out of the way to gain access to other more deeply stored items. Such movement can result in item location uncertainty. When items are requested for retrieval in a dense storage environment with item location uncertainty, searching is required.

Dense storage has a practical importance as it allows for the use of available space efficiently, which is especially important with the scarce and expensive space onboard of US Navy’s ships that form a sea base. A sea base acts as a floating distribution center that provides ready issue material to forces ashore participating in various types of missions. The sea basing concept and the importance of a sea base’s responsiveness is our main motivation to conduct this research.

We study two single-searcher search problems. In the first contribution we propose a search plan heuristic to search for a single item in an inverted T, k-deep dense storage system with the objective of decreasing the expected search time in such an environment. In this contribution, we define each storage environment entirely by the accessibility constant and the storeroom height. In addition, equations are derived to calculate each component of the search time equation that we propose: travel, put-back and repositioning. Two repositioning policies are studied. We find that a repositioning policy that uses the open aisle locations as temporary storage locations and requires put-back of these items while searching is recommended. This recommendation is because such a policy results in lower expected search time and lower variability than a policy that uses available space outside the storage area and handles put-back independently of the search process.

Statistical analysis is used to analyze the numerical results of the first contribution and to analyze the performances of both repositioning policies. We derive the probability distribution of search times in a storeroom with small configurations in terms of the accessibility constant and height. It was found that this distribution can be approximated for small configurations using a lognormal probability distribution with a certain mean and standard deviation. Knowing the probability distribution provides the decision makers with the full range of all possible probabilities of search times, which is useful for downstream planning operations.

In the second contribution we propose a search plan heuristic for multiple items in an inverted T, k-deep storage system. Additionally, we consider stacking multiple items over each other. Stacking items over each other, increases the number of stored items and allows for the utilization of the vertical space. We use the open-aisle repositioning policy that was illustrated to be superior in the first contribution. This contribution investigates a more general and a much more challenging environment than the one studied in the first contribution. In the second environment, to gain access to some items, not only may other items need to be moved out of the way, but also the overall number of movements for items within the system will be highly affected by the number of items stacked over each other. In addition, the searcher is given a task that includes searching and retrieving a set of items, rather than just one item.

For the second contribution, the performance of the search heuristic is analyzed through a Statistical Design of Experiments, and it was found that searching and retrieving multiple items instead of just a single item, can decrease the variability in search times for each storeroom configuration.
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The public is welcome to attend.