**Designing efficient order picking systems: The effect of real-life features on the relationship among planning problems**

Reduce unproductive travel of narrow aisle order pick trucks compared to, for example, wide aisle order picking systems. However, narrow aisles cause wait times due to picker blocking, especially when multiple order pickers retrieve products in the same area. Moreover, multiple order pickers working in a small area increases the risk of accidents in the warehouse

(Venkitasubramony and Adil, 2017).

Although pick robots are upcoming because of their efficiency, manual picker-to-parts order picking systems are still predominantly used in practice (De Koster et al., 2007; Marchet et al., 2015), especially in for example spare parts warehouses; human order pickers can handle unexpected changes in the process, are flexible with respect to capacity, and can retrieve a large variety of SKUs in terms of size and weight, which is particularly applicable to spare parts (Marchet et al., 2015; Van Gils et al., 2017). Moreover, the high investment costs (Lamballais et al., 2017) and the risk of interrupting order picking operations during the implementation are additional barriers for using pick robots (Marchet et al., 2015).

While order picking costs account for the majority of all warehouse operations costs (Dijkstra and Roodbergen, 2017), the performance of the order picking process drives the customer service level.

A wide range of planning problems need to be solved to manage order picking processes efficiently. Dependencies among order picking planning problems further increase the complexity of managing order picking operations (Altarazi and Ammouri, 2018; Van Gils et al., 2018b). At an operational level, picker zoning, storage location assignment, order batching, and picker routing are the main drivers of order picking performance. Combining decisions on these planning problems is essential for designing an effective and efficient order picking process (Van Gils et al., 2018b).

**Robotized and Automated Warehouse Systems: Review and Recent Developments**

Based on the authors’ experience, in Western Europe alone, about 40 fully automated warehouses are in operation, and many are under development. Although these warehouses are large, they are much smaller (and supposedly more cost-efficient) than their conventional, manual counterparts. In addition to these fully automated warehouses, many partially robotized warehouses have been built. According to Buck Consultants International (2017), in the Netherlands alone, 63 large new warehouses were constructed in the period 2012–2016 using robot technologies. However, the majority of warehouse research still focuses on conventional storage and order-picking methods.