National Safety Council

Case Study

MSD Solutions Lab
an nsc program

Effective Use of Custom Pick Planning Software

What's the Risk?

The most common injuries at any warehousing company are musculoskeletal disorders (MSDs), more commonly known as a strain or sprain. Amazon has devoted considerable effort and resources to improve ergonomic conditions and reduce MSD injuries. This case study reviews an innovative technological solution Amazon developed in 2023 that specifically targets MSD risk reduction in robotic fulfillment centers.

In Amazon robotic fulfillment centers, employees stow, pick, pack, and ship orders to customers. Robots bring storage pods to employees to store (stow) and retrieve (pick) inventory. An employee in the stowing role takes inventory from a tote or box, scans it, and places it on an appropriately sized shelf in a 77- to 86-inch-tall storage pod brought to their workstation by a robot. Once a customer has ordered that item, the robot brings the storage pod to an employee working in the pick role to retrieve it from the shelf, scan it, and place it in a tote taken by conveyance to be packed and shipped to the customer. MSD risks associated with these roles result from variations in force and postures caused by repeatedly handling inventory with different weights and storage locations. The MSD risk associated with handling each piece of inventory differs with its location within the storage pod.

Implementation of Custom Pick Planning at Amazon

Amazon identified an opportunity to improve employee safety and ergonomics by strategically stowing inventory and planning pick assignments in select robotic fulfillment centers. To further incorporate ergonomic considerations into the pick planning algorithms and framework, an internal, cross-functional partnership was formed between the software development team responsible for stow and pick planning, design engineering, and safety.

The pick-planning process is highly complex. Amazon utilizes custom software for pick planning, which incorporates several factors to optimize resource utilization and customer needs. These factors include shipment prioritization, fulfillment center resource capacity, station staffing, and inventory distribution. To function well, the systems must be designed in such a way as to be reactive to changes in the state of the fulfillment center, capable of processing a large amount of data optimally, and flexible to incorporate new program objectives. The planning software has to be responsive and quickly adaptive to new customer orders and changes in inventory and staffing.

The team at Amazon worked to develop novel software innovations to prioritize employee ergonomic factors into stowing inventory logic and added a pick planning objective. These innovations focus on the interaction between the core ergonomic risk factors of force, posture, and repetition and where inventory is handled in the storage pod.

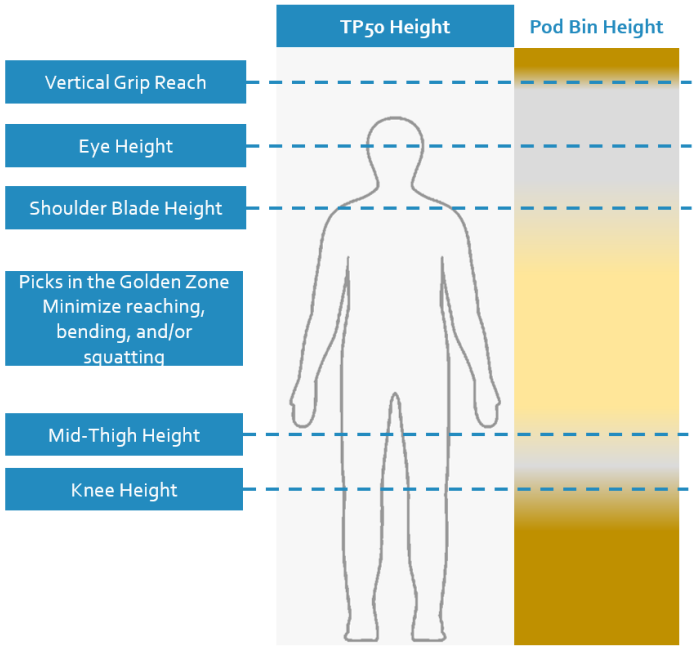
Two projects were initiated to achieve this: (1) the Stow Intelligence-Golden Zone (SI-GZ) project and (2) Ergonomic-Aware Pick-Assignments (ErgoPick). SI-GZ is a technology that reduces MSD risk to stow and pick employees through two mechanisms. First, SI-GZ directs employees to stow more common inventory into the ergonomic "Golden Zone" of the storage pod and more unique inventory to the top and bottom of the storage pod. This is intended to increase the proportion of items handled in the ergonomic "Golden Zone." The "Golden Zone" is between a person's mid-thigh and mid-chest (shown in light yellow; Figure 1).

This solution was designed to minimize the number of times employees need to bend, kneel, or squat to reach the bottom bins and reach upward or use the ladder for the top bins of the storage pods. Second, SI-GZ prevents the storage of heavier inventory in the bottom bins of the storage pod. The heavier weight threshold is designed to mitigate interactions with the storage pod that would cause higher peak low back compression.

ErgoPick is a technological solution that increases the proportion of assigned picks in employees' ergonomic "Golden Zone." The team incorporated objective logic into the pick planning software to ensure employees pick the desired item from the "Golden Zone" when available. This technology reduces ergonomic risk to the pick employee.

Software innovations were evaluated for feasibility and impact through small-scale proof-of-concept pilots. Once proven, Amazon could move quickly to deliver these innovations to improve employee experience and safety.

Figure 1. Optimal heights to handle inventory



Impacts

SI-GZ and ErgoPick have led to MSD risk reduction in the stow and pick processes. MSD risk is generally tied to exposure to risk factors, including repetitive motion, force, vibration, and awkward positions. Therefore, it is appropriate to measure the success of these interventions by quantifying the change between the baseline MSD risk and the intervention MSD risk as measured using advanced ergonomics assessment tools.

ErgoPick has had the following health and safety benefits:

- Reduced low bin picks by 11% and high bin picks by 2.3%. This shows that the software solution directs picks, as expected, to ergonomically optimal bins and away from the less optimal bins.
- These have led to an average 0.5% improvement in the peak forces per pick acting on the low back, a 0.6% improvement in cumulative compression forces per pick, and an average 0.64% increase in the cumulative forces per pick acting on the upper extremity.

SI-GZ has had the following health and safety benefits on top of the ErgoPick benefits:

- Reduced low back compression forces per transaction and cumulative hand load per transaction in both stow and pick.

- In stow, SI-GZ reduced peak low back compression per transaction by 0.8%, cumulative low back compression per stow by 2.0%, and cumulative hand load per stow by 3.3%.
- By increasing the inventory stored in the Golden Zone, SI-GZ simultaneously benefits employees in both the stow and the pick roles. SI-GZ reduced peak low back compression per transaction by 0.4%, cumulative low back compression per stow by 0.6%, and cumulative hand load per stow by 3.4%.

Across the scale of Amazon's operations, these changes deliver real improvement in the amount of material handled in more ergonomically friendly storage locations. The success of SI-GZ and ErgoPick has been used to build additional investment into a collaborative framework to improve safety and ergonomics using advanced technologies. In 2025, a cross-functional team is dedicated to building additional software-based solutions to improve safety in these roles.

Lessons Learned

A pilot project mechanism was critical to the success of this endeavor. The software innovations implemented in these projects were novel MSD risk reduction approaches. The algorithms that control the pick and stow processes at Amazon are very complex and must function in a highly dynamic work environment. Incorporating another factor into the system was a technical challenge. To overcome this challenge the team used small scale pilots to test solutions prior to full network rollouts. The team was then able to quickly iterate the software algorithms and test their ergonomic and operational impacts.

Adopting the use of cutting-edge data analysis techniques and tools was also vital to this project. Accurately quantifying the MSD risk reduction effects of these interventions was challenging due to the variable nature of inventory storage locations, the weight of inventory handled by each employee, and the scale of the intervention to Amazon fulfillment centers around the globe. To address this challenge, the team developed novel data analysis techniques that used digital human models and custom analysis software that incorporated machine learning to scale the analysis across the business.

Amazon is guided by four principles: customer obsession rather than competitor focus, passion for invention, commitment to operational excellence, and long-term thinking. Amazon strives to be Earth's most customer-centric company, Earth's best employer, and Earth's safest place to work. Customer reviews, 1-Click shopping, personalized recommendations, Prime, Fulfillment by Amazon, AWS, Kindle Direct Publishing, Kindle, Career Choice, Fire tablets, Fire TV, Amazon Echo, Alexa, Just Walk Out technology, Amazon Studios, and The Climate Pledge are some of the things pioneered by Amazon.