"Smart Connections" Intelligent Logistics Solution Applying ΣSynX®

Solution Business Department, Logistics, Thermal & Drive Systems
LTD_Solution_Sales@mhi.com

Mitsubishi Heavy Industries, Ltd. has developed "ΣSynX®" (Sigma Syncs) as its standard platform to synchronize and coordinate diverse machine systems. The ΣSynX core technologies were demonstrated using a prototype embodying the automated guided forklift (AGF) concept. To help solve logistical challenges faced by customers, including Japan's "2024 Problem in Logistics," Mitsubishi Heavy Industries, Ltd. has begun offering smart logistics solutions.

In our "automated picking solution," which is the first of its kind in Japan, ΣSynX has automated case picking operations in warehouses such as beverage warehouses. In December 2024, this solution was adopted by Kirin Beverage Co., Ltd. at its Ebina Logistics Center.

This report presents Mitsubishi Heavy Industries, Ltd. Group's ongoing projects to address a variety of logistical challenges faced on-site by customers, using ΣSynX's "smart connections" for smart logistics solutions.

1. Application of ΣSynX at logistics centers

ΣSynX represents Mitsubishi Heavy Industries, Ltd. (hereinafter referred to as MHI) Group's digital innovation brand. Based on the concept of "smart connections," it combines intelligence and technology to facilitate cooperation between humans and machines. Etymologically, ΣSynX consists of three parts: "Σ ("sigma," summation)," "Syn (synchronization/coordination)" and "X (future)." Four elements are incorporated by ΣSynX: Ecosystems, Products, Standard Tools and Security. MHI's technological foundation encompasses approximately 700 technical fields, more than 500 products, thousands of machine modules, 31 business sectors, and a diverse range of data and expertise, from development of complex machinery to operation and maintenance. ΣSynX is established on such technological foundation, which is further augmented by technologies and knowledge from around the world.

Application of ΣSynX is expanding as the standard platform in the field of logistics. Examples of this include group control to effectively manage Automated Guided Forklifts (hereinafter referred to as AGF) and Automated Guided Vehicles (hereinafter referred to as AGV), and "human-machine cooperation" using technology to avoid collisions by detecting the presence of humans or objects and non-verbal human interface technology to enable communication between humans and machines. Using ΣSynX core technologies, flexible management of logistics centers and providing solutions with high productivity and safety are possible.

2. Optimization of entire logistics operations by "smart connections"

Logistical challenges caused by Japan's "2024 Problem in Logistics" (e.g. shortage of logistics operators, improvement of working conditions and truck driver's working hours or waiting time) and other issues at logistics centers urgently need to be addressed. Under such circumstances, ΣSynX's "smart connections" for smart logistics solutions can optimize the entire sequence of operations at a logistics site and achieve efficient automation by integrating efficient operations and know-how supported by the experience of skilled workers into its software.

Conventional automation at logistics centers has focused on individual tasks. In most cases,

each piece of automation equipment is individually connected to the customer's management system. While optimization of each task automated by the equipment is ensured, this approach hinders improvement to the overall work process. Consequently, as shown in **Figure 1**, software to implement ΣSynX core technologies is introduced, connecting all automation equipment to the customer's management system, resulting in optimization of the entire logistics operations through "smart connections." As various automation equipment can be connected using the ΣSynX software, the optimal solution according to the operational environment and specific needs of each logistics center can be provided.

As shown in **Figure 2**, logistical challenges are analyzed based on the operational environment of the customer's logistics center, then followed by front-end engineering such as concept/basic design and preliminary assessment using logistics simulation. Customers are offered the optimal solutions with a high return on investment, ranging from short-term plans that can be immediately implemented, to medium-to-long term plans that include development and joint demonstrations.

Figure 1 ΣSynX's "smart connections" for smart logistics solutions

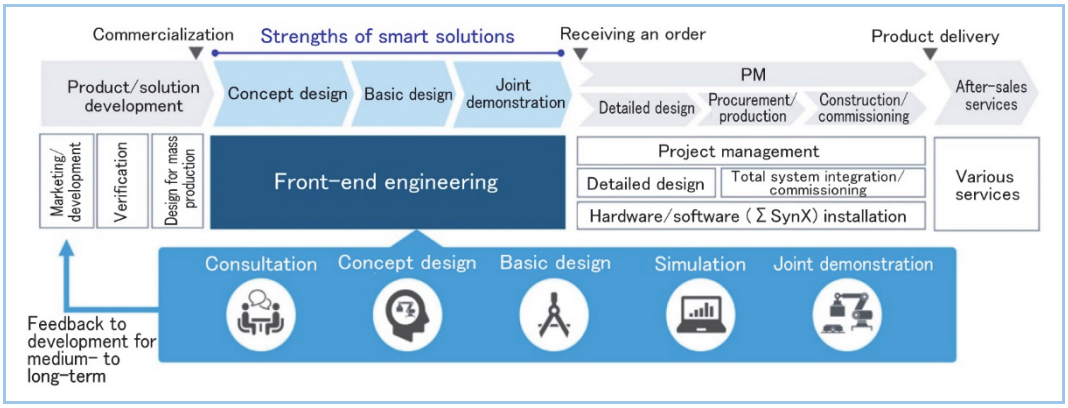

Figure 2 Value-chain of introduce a smart logistics solution

3. Characteristics of smart logistics solutions

3.1 Overview

Conventionally, safety and efficiency at a logistics center are managed by the workers with know-how and skilled techniques. Three domains have been categorized, namely "picking," "material handling intra-warehouse" and "truck loading/unloading," as shown in **Figure 3**. The goal is to convert a series of processes, from unloading the truck, to handling material in the warehouse, to loading products onto the truck, into intelligent/automated processes. The following sections present the characteristics of each solution.

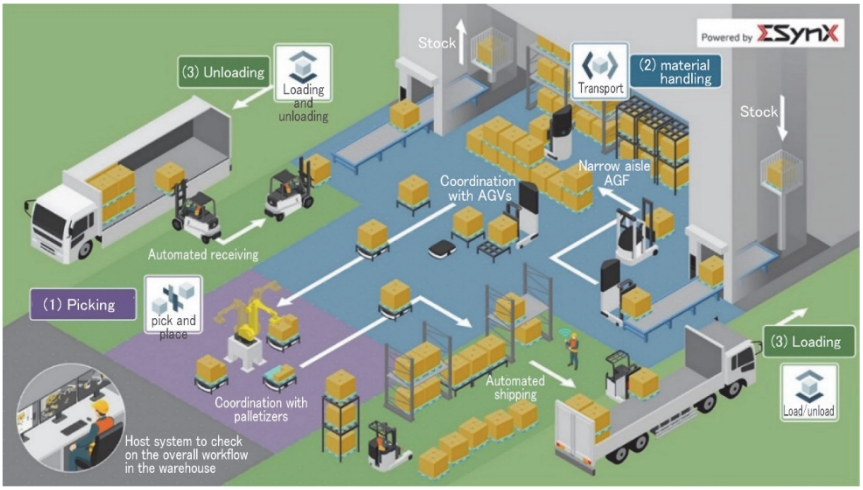

Figure 3 Automation of a series of individual processes, from unloading to warehouse , material handling and picking to loading

3.2 "Picking"

Regarding "picking," the "automated picking solution" enables the coordination of AGFs, AGVs and palletizers and has been in operation at the Ebina Logistics Center of Kirin Beverage since December 2024. Images of the actual facility using this solution are shown in **Figure 4**.

The ΣSynX software in the automated picking solution integrates worker insights and know-how, such as how to change the order of picking to enhance efficiency. MHI's originally developed optimization engine and integrated control system enable AGFs, AGVs and palletizers to efficiently coordinate with each other, resulting in fewer transport/picking operations and avoiding AGV traffic, as shown in **Figure 5**. This leads to higher throughput (improved processing capacity). The automated picking solution achieves efficient, smart automation, while eliminating heavy lifting such as picking up cases and reducing human error.

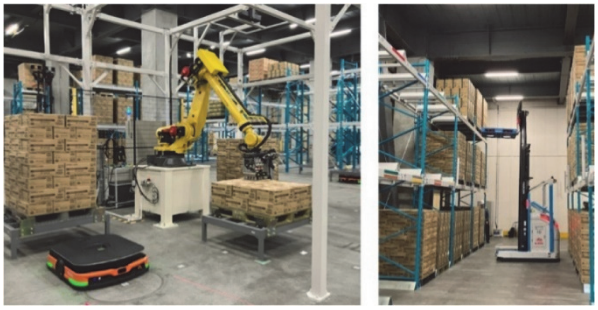

Figure 4 Automated picking solution operating at the Ebina Logistics Center

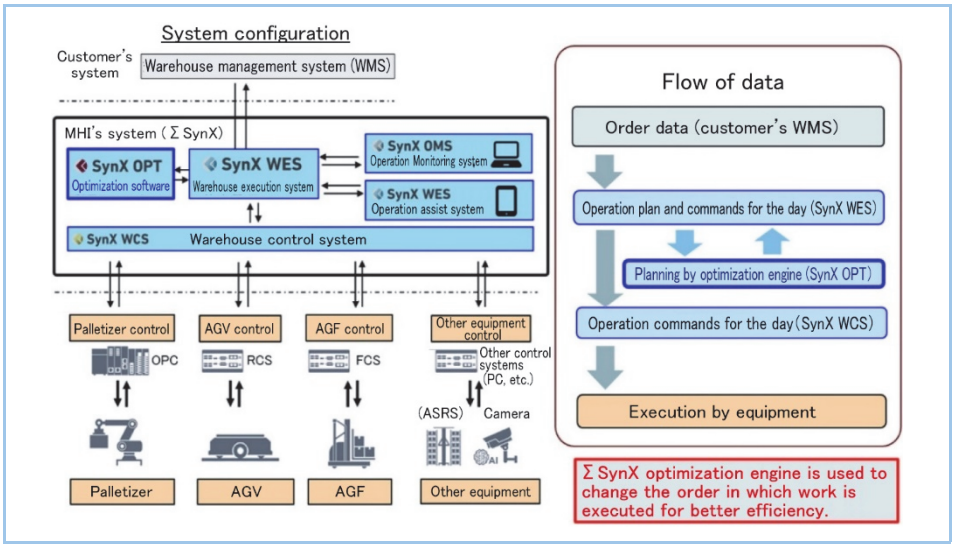

Figure 5 System configuration of the smart logistics solution

3.3 Material handling intra-warehouse

The "automated material handling solution" has addressed various challenges in warehouse operations, including improving storage efficiency, coping with seasonal fluctuations, enhancing the throughput, and reducing truck waiting time. Regarding software, similar to automated picking solution, ΣSynX optimization software integrates skilled forklift operator know-how to achieve efficient control of multiple automated machines such as AGFs and AGVs. By incorporating the techniques of skilled operators into new AGF models under development for commercialization, flexible autonomous operation of machines and their safe coordination with humans will also be possible.

Two major features of the automated material handling solution are "pre-staging" and "re-arrangement," as shown in **Figure 6**. "Pre-staging" involves moving goods from the storage warehouse to the staging area near truck berth in advance in preparation for loading. "Re-arrangement" is re-arranging goods in the truck berth or storage warehouse before the truck comes for unloading. This approach allows loading/unloading to commence immediately upon the truck's arrival, thereby reducing truck waiting time. Reducing truck driver working hours or truck waiting time is often attempted by directly shortening the time needed to load or unload the truck. ΣSynX optimization software implements into AGF with the insights and know-how of the setup tasks performed by experienced operators prior to receiving trucks, leading to a reduction in truck waiting times.

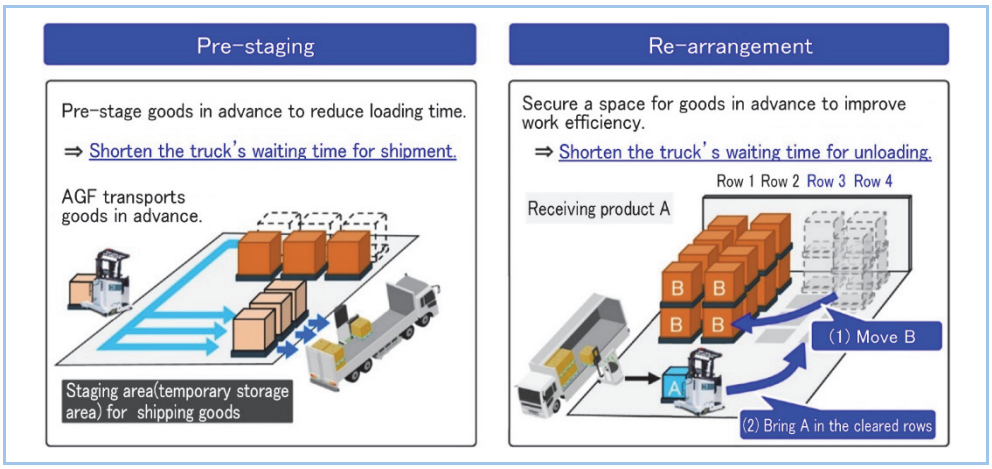

Figure 6 Functions of automated material handling solution (excerpt)

3.4 "Truck loading/unloading"

A prototype demonstrating MHI's next-generation truck loading/unloading AGF concept, which ΣSynX core technologies are incorporated, is currently under development. Achieving an automated truck loading/unloading system will contribute to address challenges such as the shortage of forklift operators and reduce truck waiting times.

As shown on the left side in **Figure 7**, the prototype of the next-generation AGF concept is characterized by the capability to detect and respond misalignment of the truck or goods by itself. Moreover, another feature, all-wheel steering enables the forklift to turn around in close proximity to the truck (turning in place) and move sideways. This functionality enables efficient loading and unloading is possible, even in challenging environments, like narrow spaces.

During loading, the truck driver may need perform additional tasks such as installing physical buffers in view of quality maintenance during transportation (shown in Figure 7, right side). The system is being developed in which the AGF will continue loading goods onto the truck only when permitted by the driver via a portable terminal such as a smartphone or tablet. "Human-machine coordination" in which humans and machines can work together safely is thus realized.

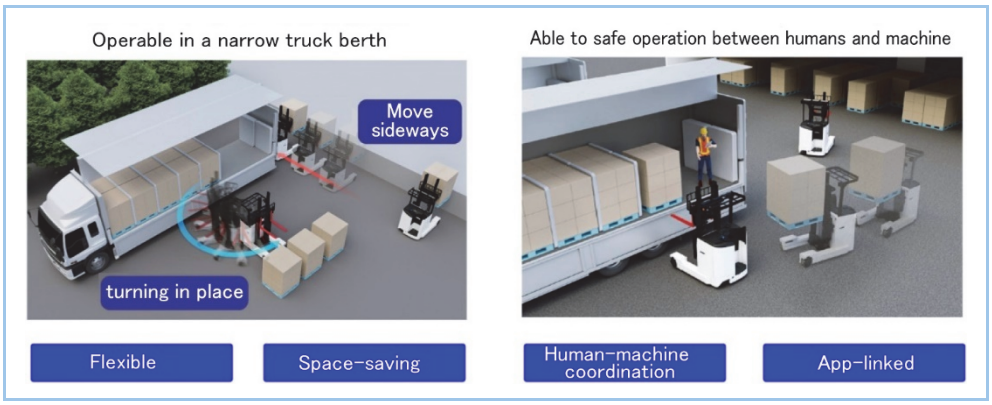

Figure 7 Major functions of the truck loading/unloading solution

3.5 Concept of "no roots"

One key idea in the implementation of the ΣSynX-based smart logistics solutions is the concept, "no roots."

In many cases, logistics centers such as factories and warehouses must be able to flexibly cope with changes in the quantity or type of goods handled due to seasonal fluctuations or product replacement, and future increases or decreases in production. However, managing more goods than initially expected is difficult for facilities with fixed equipment such as automated warehousing systems. In cases experiencing a downward trend, capacity of the equipment becomes excessive, and an equitable balance between maintenance costs and the amount of goods stored may be lost. In the case of rental properties such as multi-tenant warehouses, for which demand has grown in recent years, introducing fixed equipment may be difficult from the standpoint of later returning the property to its original state or due to the owner's preferences.

To address these challenges, MHI offers AGFs, AGVs, logistics equipment and auxiliary systems are either autonomously mobile or easily installed and reconfigurable. Adopting the concept of "no roots" promotes flexibility and enables logistics centers to adapt to any changes.

Development and demonstration of these smart logistics solutions are carried out at MHI's "LogiQ X Lab," a demonstration facility at the "Yokohama Hardtech Hub (YHH)," a co-creation space operated by MHI in Yokohama, Japan. Customers are invited to visit this facility, MHI can support them in finding automation and labor-saving solutions for their logistics centers. In addition to the "automated picking solution," "automated material handling solution" and "truck loading/unloading" introduced here, development of new solutions addresses customer challenges.

4. Future directions

Leveraging the collective strengths of the MHI Group, MHI and Mitsubishi Logisnext Co., Ltd. will continue to develop products such as smart logistics solutions using ΣSynX's "smart connections," to provide optimal solutions to various issues in the logistics industry.

Plans are in place to incorporate technologies demonstrated through the prototype of the next generation AGF concept (including group control, human coordination and remote monitoring) into new AGF models being developed by Mitsubishi Logisnext Co., Ltd. for commercialization.

MHI Group will continue to unite, and make full advantage of its comprehensive strengths. Through agile development that flexibly handle alterations such as in the specifications in the middle of the development process, MHI seeks to provide solutions that can directly lead to solving customer's problems in a timely manner.

ΣSynX® is a registered trademark of Mitsubishi Heavy Industries, Ltd. in Japan and other countries.