DAIFUKU | Daifuku Intralogistics America

Berkshire Grey, Inc.

Mt Juliet, TN
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Revision History

REV	DATE	BY	DESCRIPTION
0.0	02-06-2024	GCT	General Specification, First Draft

1.0	03-08-2024	GCT	BG Callouts:
			• 1.2.5 Scanners
			  ○ Clarify Scanner Count
			• 2.2.2 Single Phase
			  ○ Clarify Facility provided and installed Scanner Outlets.
			• 3.4.4 Lift Gates
			  ○ Clarify 5 seconds automatic timer to restart the system after gate is closed.
			• 3.5.4 Product Jam
			  ○ BG Request for auto jam clear provided.
			• 4.1.3 Empty Inbound
			  ○ Round Robin Divert
			  ▪ Provision added for priority logic.
			• 5.1.2 Estop Zones
			  ○ Table 12 and Figures 40, 42: Recirculation is own E-Stop Zone
			• General UDT and System naming update in affected sections.
			  ○ Figures updated: 21, 32-34, 56-60, 62-63, 66.
			  ○ Tables updated: 13, 14.
			• Figure Image Quality updated.
			  ○ Figures: 61, 67

1.1	3-13-2024	GCT	BG:
			• BG provided updated 4-SPAN Figure with Labeling
			  ○ Figure 56
			• Figure 42 updated
			  ○ Gap in Estop Zone corrected.

1.2	04-05-2024	GCT	• Annotate Revision # on Cover Page and Footnote.
			BG:
			• 1.3.3 Barcode Specifications
			  ○ Figure 5 and 8 updated.
			• 3.5.5 Merges
			  ○ Clarify Merge operation.
			• 3.6 Scanner Operations
			  ○ MultiRead Symbol Corrected.
			• 4.1.1 Donor Tote/Carton Inbound
			  ○ PUT Station Highway Loops
			  ▪ 4 Zones of Pick Zone Staging.
			  ▪ Divert Lane available and full conditions defined.
			  ▪ PUT Station Merge reference 3.5.5 Merges.

REV	DATE	BY	DESCRIPTION
			○ Gridlock Prevention ▪ Area Naming Correction ▪ Counting ▪ North and South logic clarified to operate independently. ▪ Figure 23 updated • 4.1.2 Donor Tote/Carton Outbound ○ Reference 3.5.5 Merges for outbound merge operation. • 4.1.3 Empty Tote Inbound ○ Round Robin Divert ▪ Figure 30 Updated ▪ Priority Logic Defined ○ Inbound Right-Angle Transfers ▪ Transfer accumulation clarification. ▪ Outbound Totes in 4-SPAN induct. tracking zones clarification. • 4.1.4 Completed Order Tote Outbound (Box Merge) ○ Reference 3.5.5 Merges for outbound merge operation. ○ Updated Box Merge callouts. • 4.1.5 Scanner Details ○ Research Scanner & Empty Tote Scanner Scope Updated. ○ Initial timeouts defined. ○ Figure 37 updated. ○ Figure 39 updated.

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1.0 General Information

This document provides a description of the controls system for the Customer material handling equipment (MHE) system. This section includes a description of the system areas and an overview of the system performance design parameters.

1.1 Definitions

Cartons – box of product worker to pick from, should have barcode.

Donor Tote – plastic tote of product worker to pick from, should have barcode.

Empty Tote – plastic tote void of product to replenish the 4-SPAN, should have barcode.

Completed Order Tote – plastic tote filled with completed order from the 4-SPAN.

RSPS – Robotic Shuttle Product Sortation is the entirety of the BG order fulfillment station/workstation.

4-SPAN – wings of conveyor controlled by Berkshire Grey where cartons are filled with desired product within the RSPS.

PUT Station – Station where totes/cartons stop at the pick zone where pick operators pick items from totes/cartons within the RSPS.

1.2 System Area Summary

To define functionality, the overall system layout has been subdivided into the following primary system areas. The functionality and operation of each area are described in greater detail in Section 4.0, Area-Specific Operation and Product Flow. Overall system naming and panel devices are identified in the electrical layout package.

1.2.1 Donor Tote/Carton Inbound

Refer to Section 4.1.1 for detailed descriptions for the Donor Tote/Carton Outbound and its corresponding areas outlined in this section.

Divert Into PUT Station Highway Loops

A research scanner will be located on the Existing System sorter before the existing sorter induct scanner to scan totes and carton barcodes to Berkshire Grey. Totes and Cartons will then enter the Donor Tote/Carton Inbound discharging from the Existing System sorter divert downlines 8 and 9 to feed the North PUT Station Highway Loops and South PUT Station Highway Loops, respectively. Four PUT Stations are located on the North Highway Loop, and four PUT Stations are located on the South Highway Loop. The Daifuku conveyors interlocks with the Existing System sorter diverts.

PUT Station Highway Loops

The North PUT Station Highway Loops consists of PUT Stations 5 through 8. The South PUT Station Highway Loops consists of PUT Stations 1 through 4. A divert with a scanner will be located before each of the eight PUT Stations. The instructions at the scan point determines whether to divert totes/cartons into the PUT Station. The totes/cartons that divert to the PUT Station Loop, queue and index into the pick zone when allowed. The pick zone is a one zone MDR section controlled by Daifuku. In the pick zone, Berkshire Grey gives the signals to move into the pick zone and to exit once the allotted product has been taken. After product is picked and the tote indexes out of the pick zone, the tote then merges back into the highway loop.

Recirculation

Totes/Cartons not diverted to Outbound (Refer to 1.2.2 Donor Tote/Carton Outbound) will continue straight and enter Recirculation. The North and South Inbound totes/cartons will merge on a single takeaway conveyor. A divert with a scanner will be located at the end of Recirculation. The instructions at the scan point determines whether to divert totes/cartons into the South PUT Station Highway Loops or continue straight into the North PUT Station Highway Loops.

1.2.2 Donor Tote/Carton Outbound

A divert with a scanner will be located after the 4th PUT Station Loop in both the North and South Tote/Carton Inbound Highway Loops. The instructions at the scan point determines whether to divert totes/cartons to the Outbound or continue straight to Recirculation as previously described. North and South Outbounds will merge on a single takeaway conveyor.

A designated section of the outbound, before exiting and interlocking with Existing System conveyor, will allow operators to pull off empty cartons. The Daifuku conveyor interlocks with the existing external conveyor line.

Refer to Section 4.1.2 for detailed descriptions for the Donor Tote/Carton Outbound area.

Lift Gate

A lift gate will be installed before the Existing System conveyor on the outbound to allow operator/maintenance walk-through access in the area. Packages are not expected to accumulate on the gate to allow the operation of the gate mechanism as needed.

Refer to Section 3.4.4 Lift Gates for detail description.

1.2.3 Empty Order Tote Inbound

Refer to Section 4.1.3 for detailed descriptions for the Order Tote Inbound area.

New Divert on Existing System

A new Existing System divert, spur and scanner will be installed on an Existing System line to replenish the 4-SPAN Stations with empty order totes. The installation and programming changes needed for the new divert will not be handled by Daifuku. The Daifuku conveyor interlocks with the existing external conveyor line after the new divert's spur. System Design in this area not finalized.

Lift Gate

A lift gate will be installed downstream of where the Daifuku Conveyor interlocks with Existing System Conveyor to allow operator/maintenance walk-through access in the area. Packages are not expected to accumulate on the gate to allow the operation of the gate mechanism as needed.

Refer to Section 3.4.4 Lift Gates for detail description.

Round Robin Divert

Empty Totes coming from the new divert on the Existing System will arrive at a divert point with no scanner; the totes will route to the North and South Inbound Order Tote accumulation sections alternating equally between the two divert lanes. Diverting will route empty totes to the South Order Tote Inbound and continuing straight will route empty totes to the North Order Tote Inbound.

Inbound Right-Angle Transfers (RAT)

After the round robin divert, empty totes travel to enter the empty order tote inbound accumulation line. This is a straight conveyor with 4 right-angle transfers; each one positioned to service one of the four 4-SPAN's. The empty totes stage on a single interconnecting MDR zone after the rat angle transfer divert that connects the inbound accumulation line with the shared 4-SPAN outbound line, waiting for the signal received from Berkshire Grey that a new empty tote is needed on 4-SPAN. Then when the carton enters 4-SPAN, new empty cartons queue up in the vacated space.

1.2.4 Completed Order Tote Outbound (Box Merge)

Completed order totes from 4-SPAN conveyor kick out when it is communicated that there is an empty space on the receiving takeaway conveyor. The outside two lines, from either side of 4-SPAN conveyor, then merge at a 2-to-1 merge point. The completed order totes continue to transport through the system where the North and South Completed Order Tote Outbound lines will merge onto a single takeaway conveyor. The single takeaway conveyor will exit into Existing System conveyor. The Daifuku conveyor interlocks with the existing external conveyor line.

Refer to Section 4.1.4 for detailed descriptions for the Completed Order Tote Outbound area.

1.2.5 Scanners

A total of twelve Cognex Cameras are required in the system and each scan point will require a single side read. The eleven scan points located on the Donor Tote/Carton Inbound, Donor Tote/Carton Outbound, and Recirculation conveyor, Daifuku communicates the barcode data to Berkshire Grey, and they respond with the destination instruction. No routing decisions are made directly by Daifuku. The twelfth scan point at the research scanner located upstream of the Existing System Sorter, Daifuku only communicates the barcode data to Berkshire Grey; no routing or Existing System decisions are made here by Daifuku.

Scan Points

- 1 Scan Point on the existing Sorter
    - Research scanner on existing sorter whose downlines feed the Donor Tote/Carton Inbound
- 8 Scan points in the Donor Tote/Carton Inbound,
    - One before each PUT Station Highway Loop.
- 1 Scan Point on Recirc
    - One before the divert to send Tote/Cartons to North or South Highway Loops
- 2 Scan points in the Donor Tote/Carton Outbound,
    - One before the North Outbound Divert.
    - One before the South Outbound Divert.

Refer to Section 4.1.5 for further scanner details and locations.

1.3 Product and Throughput Specifications

The MHE conveyor system has been designed to accommodate the product size and throughput requirements for the designated project. These requirements are defined as follows.

1.3.1 Carton Specifications

To ensure optimal system performance, it is recommended that Customer adhere to the following product specifications shown in Table **1**.

Table 1 Measurements of the distinct types of containers used in the system.

Description	Length	Width	Height	Weight
Donor Carton Maximum	28”	18”	16”	50lbs
Donor Carton Minimum	12”	9”	6”	1lb
Donor Carton Average (Rate Carton)	24”	14”	12.5”	30lbs
Order Tote	24”	15”	24”	1lb - 40lbs
Donor Tote	24”	15”	24”	2.2lbs – 50lbs

1.3.2 System Throughput

All throughput rates are measured in cartons per minute (CPM), or totes per minute (TPM). It should be noted that these design rates are “peak” rates. Actual throughput over a sustained period of operation is subject to a number of variables, including product mix and productivity of operations personnel. **Figure 1**, and **Figure 2** show the rates throughout the system, broken apart for clarity.

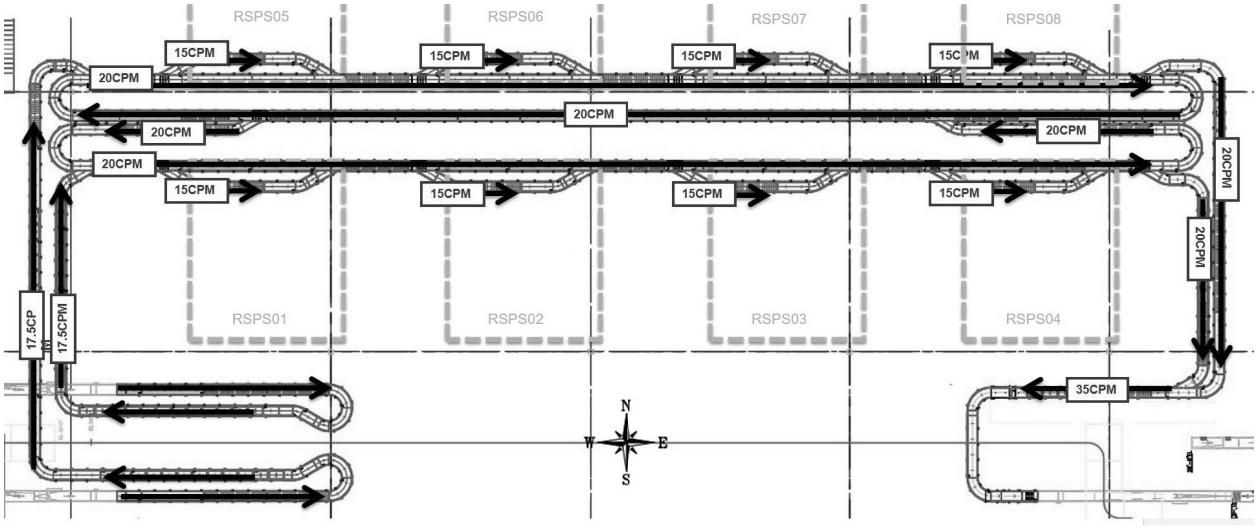


Figure 1 Rate for Donor Tote/Carton Inbound Tote Loops & Outbound.

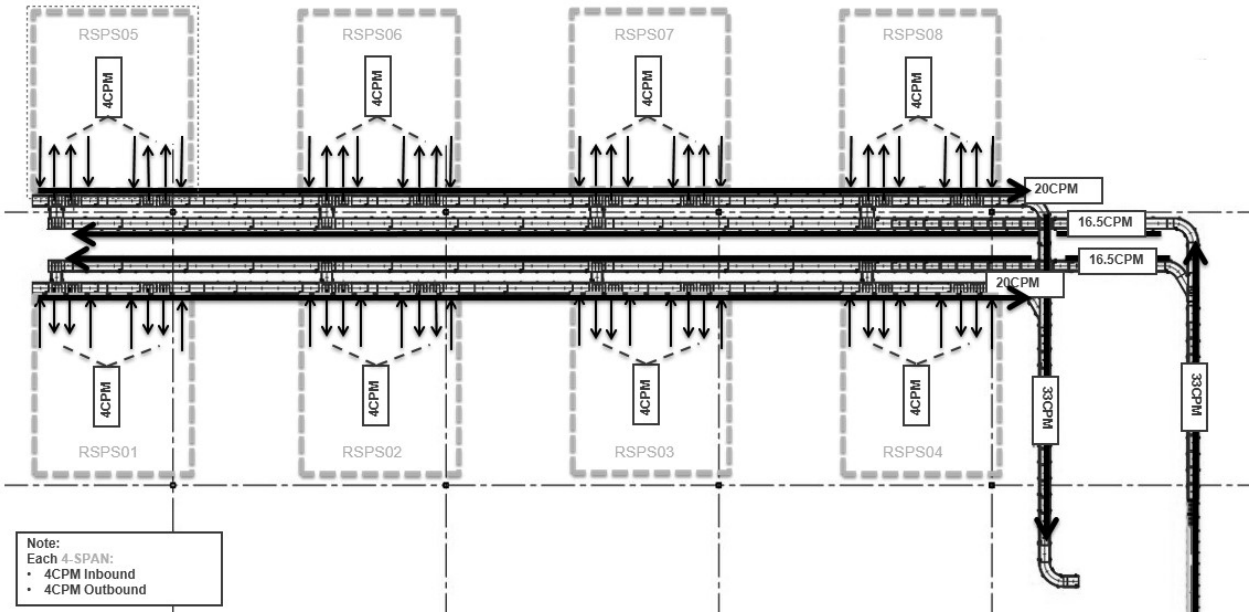


Figure 2 Rate for Empty Tote Inbound/Outbound Overview.

During the operational acceptance phase of the project, Daifuku personnel will demonstrate these rates to Customer personnel, with the rate case, carton, or tote appropriate to the location.

Disclaimer

- Daifuku reserves the right to test these rates in an exercise mode.
- The purpose of exercise mode is to demonstrate the throughput rate with the correct parameters and conditions for testing.
    - EX: Exercise mode often eliminates the dependance of messaging performance when testing rate throughput in the system.
    - EX: At 2 to1 merges, either merge lane may be disabled from merging to prove the upstream rate of the other current lane being tested.

Donor Tote/Carton Inbound & Outbound

- Testing the throughput from the Existing System sorter divert 8 & 9 to Donor Tote/Carton Inbound Downlines will require testing coordination with the customer and labor to load the Existing System with rate tote/cartons and alternating the diverting to both lanes to test rate throughput.
- All rates stated on the straight conveyor of the divert defined as all rate totes/cartons travelling straight through the divert.
- All rates stated on the divert side defined as all rate tote/carton diverting at the divert.
- Lanes on the Merges may be disabled to prove the upstream rate of the lane during testing.

Empty Order Tote Inbound

- The rate at each RSPS Station is 4CPM show in **Figure 3**.
    - Each entire Station has 4 Locations (AR1, AR2, BR1, BR2) in which product can induct from the right-angle transfer below each location on the outbound takeaway conveyor.

- The 4 CPM rate requirement can be satisfied by testing 4CPM into AR1 from the induction staging location indicated by location 1.
    - It is the furthest location from the induction location and will take the longest to travel and induct into the RSPS Station.
    - Satisfying the test at AR1 satisfies the testing requirements for the other 3 locations in the station since they are closer to the induction staging location and should take less time to induct the same number of totes.

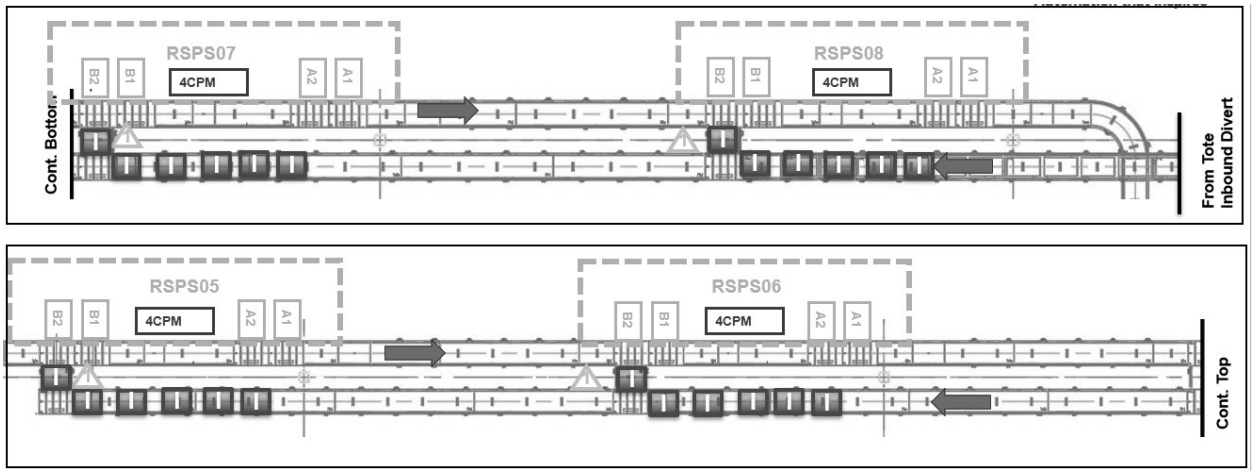


Figure 3 Rate for Empty Tote Inbound.

Completed Order Tote Outbound

- The rate at each RSPS Station is 4CPM shown in **Figure 4**.
    - Each entire Station has 4 Locations (AR1, AR2, BR1, BR2) in which product can release onto the outbound take away conveyor.
- The 20CPM indicated at location 1 is not the rate for the entire outbound take away conveyor. It is an accumulated rate.
    - Each station increases the rate at 4CPM as totes travel down the conveyor.
        - Locations 2 through 4 shows after each station the accumulated is increased by 4CPM.
    - To test the 20CPM at this location, labor will be required to load more totes onto the outbound conveyor to close to location 4 which is upstream of RSPS08. The four RSPS Stations on a single outbound takeaway line does not add up to 20CPM.

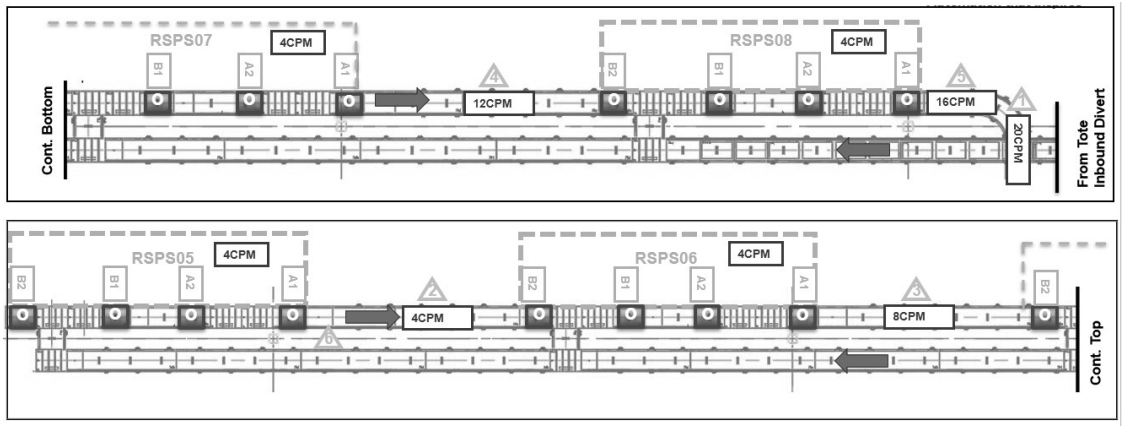


Figure 4 Rate for Completed Tote Outbound.

1.3.3 Barcode Specifications

Two types of barcodes that are expected to be used in the system.

Carton Barcode Information

Figure 5 below shows an example of the two types of carton barcode used and only placed on cartons.

Figure 5 Carton Barcode Type 1 (left) and Type 2 (right)

Attributes:

- 1.25”x 4.0” rectangle (Bar Height x Code Length)
- Ladder Orientation
- Code 128, 19.74 mil barcode size
- 20 digits

Placement:

Each barcode is a folded label placed on cartons with the 2nd folded labels showing on front left leading edge within the allowable window shown in **Figure 6**. Rate Carton shown as reference.

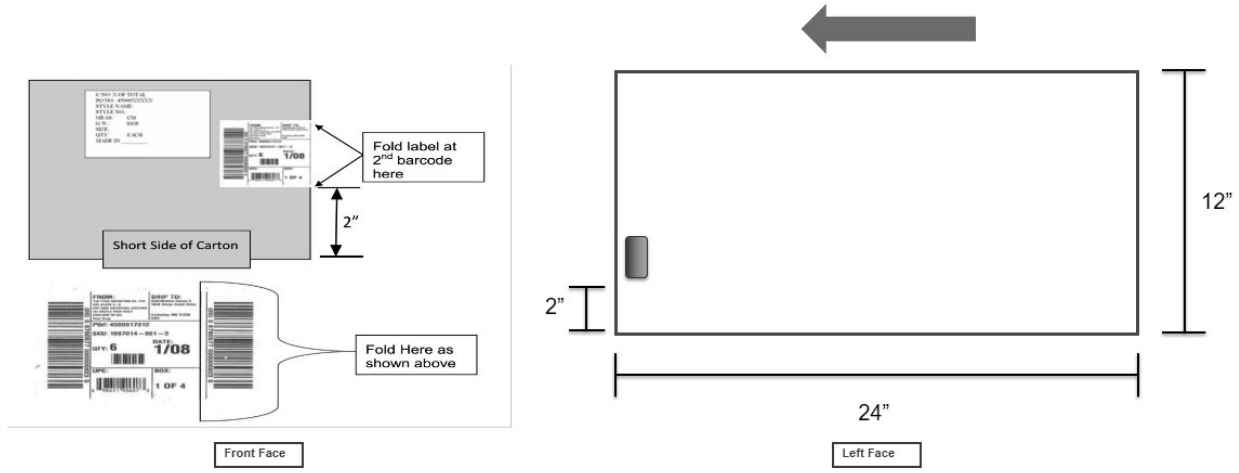


Figure 6 Allowable Carton barcode placement (shown on left face).

Under Armour Facility Tote Barcode Information

Figure 7 below shows an example of the facility tote barcode used and only placed on totes.

Figure 7 Tote barcode example.

Attributes:

- 3.5”x 1.0” rectangle (Bar Height x Code Length)
- Ladder Orientation
- Code 128, 19.74 mil barcode size
- 9 digits, pattern: “T:12345678”

Placement:
Each barcode is placed on totes within the allowable window on left face of tote shown on the right figure in **Figure 8**. See **Table 1** for tote dimensions.

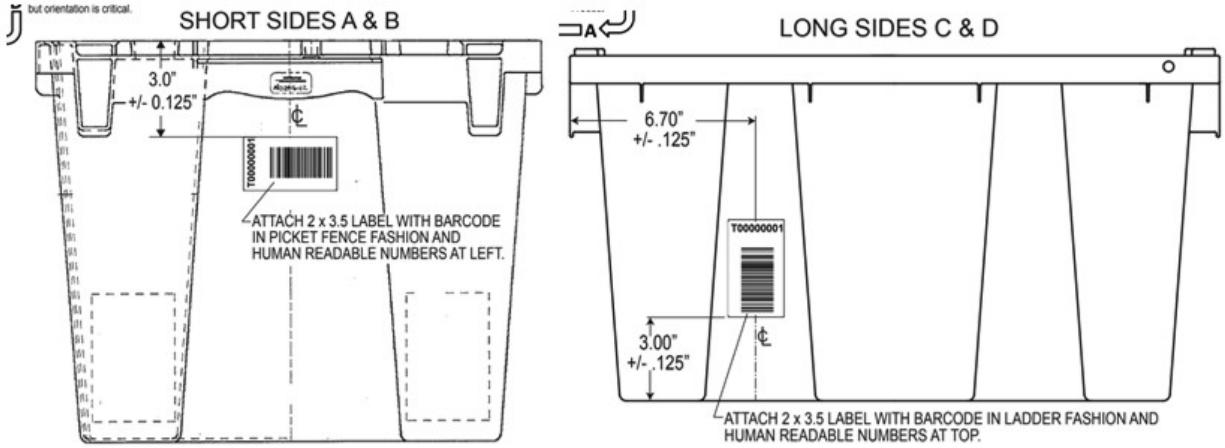


Figure 8 Allowable Tote barcode placement (right figure shown on left face).

2.0 Control System Architecture

This section provides an overview of the control system architecture for the Daifuku MHE system. This includes an explanation of the layers of control and descriptions of system power, control panels and network architecture.

2.1 Control Layer Overview

The Daifuku system is divided into two primary layers of control:

- Physical equipment control – Daifuku PLCs
- Data interface / product routing – Berkshire Grey Server

The physical control of the conveyor equipment is accomplished with a programmable logic controller (PLC) and includes motor control, sortation, and all other physical activation of control devices to affect product flow. Personnel safety and equipment protection are also incorporated into the PLC control layer.

The data interface and routing control layer is accomplished through messaging to and from Berkshire Grey PLC.

2.2 System Power

Three categories of electrical power are used for control of the Daifuku MHE system. They are 480V AC (three-phase), 120V AC (single-phase) and 24V DC.

2.2.1 Three-Phase 480V AC Power

Three-phase power is the principal means of power distribution for the system. All power distribution panels (PDP's) and motor control panels (MDP's) require 480V AC 3-phase power feeds, which are to be provided by Customer. Power feed requirements are located on the electrical and layout drawings identified in **Table 2**.

Panel	Power Source	Required Source Feed
PDP-A	Provided By Customer	250A
MCP01	PDP-A	N/A
MCP02	PDP-A	N/A

Table 2 Three Power Feed

PDP-A is a ten 30A Breaker panel. Eight circuits are utilized in the system with one spare and the 10th breaker is provisional. The required feed for the panel is 250A.

2.2.2 Single-Phase 120V AC Power

120V devices in this system are for the scanners. The power for these devices is provided by new facility installed outlets. These outlets are located on the highway loops and are extended to reach the scanner locations.

2.2.3 24V DC Power

24V DC control power is used for all parts of the MHE system. DC power is generally used for sensors and other control devices associated with higher-speed equipment such as sorters and induction equipment.

Motor-driven roller (MDR) conveyors require 24V DC power for operation. This power is delivered from distributed DC power supply panels located throughout the system. Each DC power supply panel requires an input of 480V, delivered from the PDP.

24V DC power for ArmorBlocks are provided from field-mounted DC power supplies. These power supplies require 480V input power, also delivered from the PDP.

2.3 Control Panels

The Daifuku MHE system includes two Motor Control Panels (MCPs), located near operator workstations. The MCPs contain circuit breakers and other associated devices necessary to accomplish equipment-level system control. Allen-Bradley ControlLogix PLCs are used for the system control logic. The Power Distribution Panel (PDP) is used to distribute large quantities of power from a central location. This panel contain distribution circuit breakers and may have a step-down transformer associated with them. MCPs and PDP will be located as needed.

In **Figure 9**, MCP01 & PDP-A is located between 4-SPAN Stations 6 & 7 on the North Donor Tote/Carton Inbound Loop. MCP02 is located between 4-SPAN Stations 2 & 3 on the South Donor Tote/Carton Inbound Loop

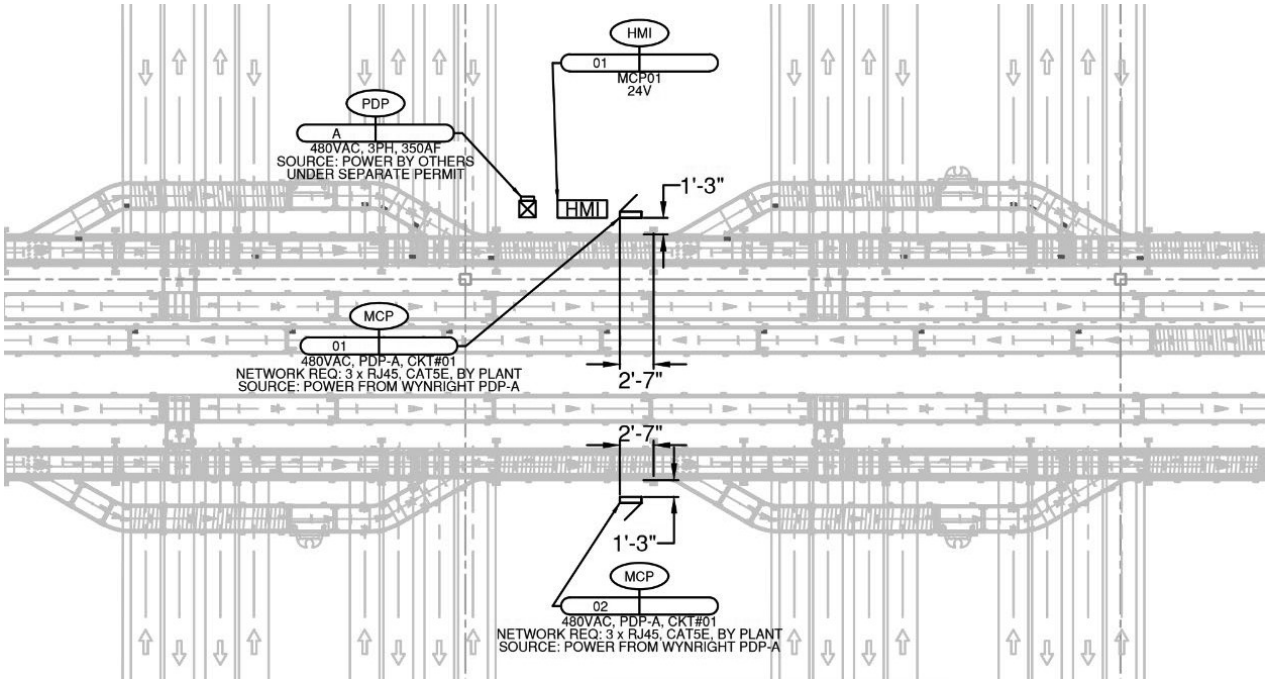


Figure 9 Locations of PDP, MCPs and HMI.

The following information in **Table 3** outlines where the pages for the MCPs and PDP begin on the electrical layouts.

Table 3 Electrical Layout reference pages for PDP and MCPs

Panel	Layout Page
PDP-A	PDP-A-01
MCP-01	MCP01-50
MCP-02	MCP02-50

2.4 Network Architecture

A dedicated Ethernet network is used for all communications between the field devices and conveyor-control PLCs. The customer provides ethernet drops at both panels, MCP01 and MCP02. Each panel has 3 drops, one for the PLC and two for spare. This amount does allow for remote PC connection for easier remote support access to the Daifuku system. Customer network restrictions states there will be no remote PC connection.

2.5 Distributed I/O Design

Control devices on the conveyor system are controlled via various forms of Distributed IO devices. These include Distributed IO blocks (1732E/ES Series), ERSC Controlled IO etc. Some devices and the encoder are connected to the MCP IO modules.

2.5.1 ArmorBlock I/O

ArmorBlock IO modules are used to connect to sensors and devices on the conveyor system. These blocks will be powered by 24V DC power supply located near the block. The modules connect to the network through a field mounted network switch, network switch located in the panel, or through another neighboring ArmorBlock. The safety and non-safety version of the ArmorBlocks used in the system are shown in **Figure 10**.

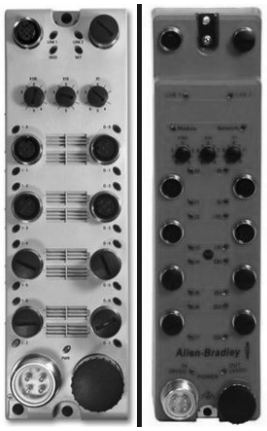


Figure 10 1732E/ES Series Armorblocks: non-safety (left), safety (right).

The safety ArmorBlock is generally used for safety devices, E-Stops, VFD Safe-off, Motor Starter, MDR feedback signal, etc., but the safety models can be used for non-safety devices and sensors. However, the non-safety ArmorBlock module *cannot* be used for safety devices.

3.0 Standard System Operation

The Daifuku conveyor system utilizes a variety of controls devices and components for system operation. This document describes the specific functions and operating characteristics of several standard system components. The locations of all associated devices within the Customer MHE system are indicated on electrical device layout drawings. There are various standardized common controls throughout the system described in this section. Area-specific functions and operator controls are described in greater detail in Section 4.0 *Area-Specific Operation and Product Flow*.

3.1 Safety Design

3.1.1 Safety Controller

The Daifuku system uses two 1756-L83ES GuardLogix controllers to control the system. Both devices are shown in **Figure 11**.

Figure 11 1756-L83ES GuardLogix Processor

3.1.2 Safety Devices

ArmorBlock Guard I/O Modules (1732-ES, shown in **Figure 12**) can only be used with the GuardLogix controller. These safety blocks are used to connect safety input devices and safety output devices. In this system, safety inputs can include E-Stop pull cords, E-Stop pushbuttons, MDR power supply “AUX” feedback signal, etc. Outputs can include VFD Safe Torque Off, MDR power output, E-Stop beacon lights, etc. The ArmorBlocks will connect to the system through N-TRON field-mounted ethernet switches. Some ArmorBlocks may connect directly to the MCP internal switches if close in distance.

Figure 12 ArmorBlock Safety I/O (1732-ES)

Refer to Appendix 5.1.2 for E-Stop Zone layout. These zones determine what safety outputs are inactive when a safety device is activated by an operator or unsafe condition monitored by the PLC. Daifuku ensures that the safety controller turns the Safety Outputs OFF as per the approved safety design.

3.2 Motor Control Panels (MCPs)

3.2.1 MCP Details

In addition to the plant floor lights and buttons, each MCP has an array of pushbuttons and indicator lights. The two MCPs in this project have the indicators shown in **Figure 13** and described in **Table 4**.

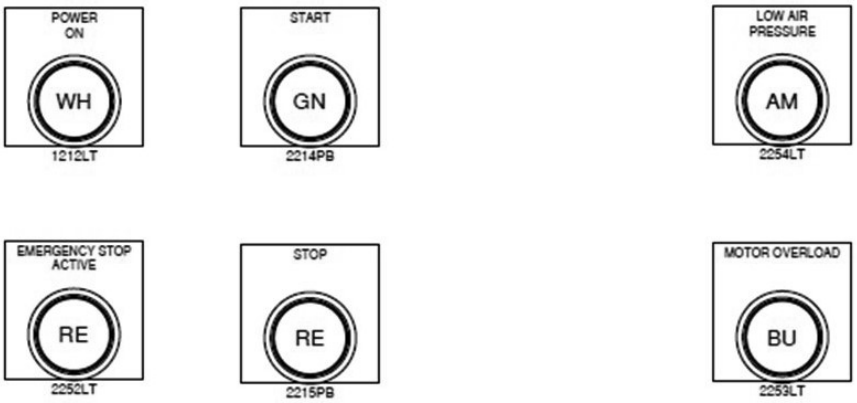


Figure 13 Motor Control Panel indicators and pushbutton controls, located on the front face of panel.

Table 4 Descriptions of the indicators and pushbuttons on the MCPs.

Control	Color	States
Panel Start PBLT: Starts all conveyor associated with the panel*	Green, Illuminated	**SOLID ON:** All the motors in the area are running. **OFF:** Conveyor associated with the PBS* has been stopped.
Panel Stop PB: Stops all conveyor associated with the panel*	Red	N/A
E-Stop Active: Indicates that one (or more) E-Stop device associated with the panel is active	Red	**FLASHING (1s ON/OFF):** Indicates that an E-Stop fault has occurred in the system, and the E-Stop device is active. **SOLID ON:** The affected safety device has been reset, but the system has not yet been reset through a reset button. **OFF:** E-Stop not active in the system.

Control	Color	States
Control Power On: Indicates the control panel power is ON	White	**SOLID ON:** The control panel power is ON. **OFF:** The control panel power is OFF.
Motor Overload: Indicates that there is a fault with one (or more) motor associated with the panel	Blue (1s ON/OFF pulse)	**FLASHING (1s ON/OFF):** One (or more) motor in the system has a fault. **OFF:** No motor faults present in the system.
Low Air Pressure:	Amber	**FLASHING (0.5s ON/OFF):** One (or more) motor in the system has a fault. **OFF:** No Air Pressure faults present in the system.

*Refer to Section 3.2.2 for start/stop zoning.

3.2.2 Conveyor Start and Stop

System start/stop control is accomplished using start/stop pushbuttons. The pushbutton pair consists of a green, illuminated start button and a red, non-illuminated stop button.

- The green start button is illuminated solid ON when the area is active, running, and there are no faults.
- The green start button flashes .5 Seconds ON / .5 Seconds OFF if there is a fault in the area that can be reset from that button.
- The green start button is OFF when the area is not running and there are no related faults in the area.

The MCP Start/Reset button is global to the subsystem controlled by that MCP with the following exceptions:

- The MCP Start/Reset button may work for others area MCP's that are in close proximity, or their systems work together to accomplish the functionality of the area.
    - EXAMPLE: In the system, the Donor Tote/Carton Inbound and Outbound are separated into North and South and controlled by MCP01 and MCP02, respectively. The entire area needs to start together to accomplish the functionality of getting totes/cartons inbound and outbound of the highway loops. MCP01 in the North Donor Tote/Carton Inbound Highway Loop can start MCP02 equipment in the South Donor Tote/Carton Inbound Highway Loop; MCP02 can start MCP01 equipment, so the entire area is running.
- When starting equipment remotely presents safety threats the MCP Start/Reset button is disabled.
    - EXAMPLE: Sorter jams can only be reset locally because unexpected energizing of a sorter could cause personal injury, and/or damage to equipment.

Startup Zones

There will be no startup zones broken up in this system. The entire system will start up with a start command from either MCP. As described later in the document, warning horns placed throughout the system will sound upon motor start command.

3.2.3 Motor Overload

Motor protection devices such as overloads and self-protected starters are monitored within the control panel. If there is a contactor on the motor, the contactor coil is hard-wired through an aux on the starter, and the contactor aux is monitored to determine when the protector is tripped. If the motor is controlled by a VFD utilizing a safe-off circuit, there is no contactor, and a protector fault is monitored directly through an aux contact on the starter.

- The blue light flashes .5 Seconds ON / .5 Seconds OFF when at least one motor protection device (overload or self-protected starter) in the panel is tripped.
- The blue light continues to flash .5 Seconds ON / .5 Seconds OFF after the motor protection device within the panel is reset.
- The blue light is OFF after the motor protection device is reset and the Conveyor Start button is pressed to reset the motor starter fault. Affected conveyors will restart using the standard startup sequence. The Conveyor Stop button or turning Control Power off will also turn the blue light off.

3.2.4 Low Air Pressure

Adequate air pressure is a key component for successful operation of most Automotion conveyor equipment. Without sufficient air pressure, the sorter diverts will not operate, and the accumulation conveyor will not drive product. Air pressure monitoring switches are installed on the system to provide air pressure status to the control system, ensuring that equipment is not operated when air pressure is below the minimum acceptable level. A Low Air Pressure pilot light on the door of each MCP provides indication when air pressure is inadequate to run the conveyor system. There is no local beacon indication for low air pressure.

- The amber light flashes .5 Seconds ON / .5 Seconds OFF when Control Power is ON and there is inadequate air pressure detected by the system.
- Inadequate air pressure acts like a stop request to the system to avoid damage and jam from air dependent conveyors and components.
    - The right-angle transfers in the system will finish their current action if possible before stopping.
- Pressing the start button is needed to start/reset the system when air pressure is restored.

3.2.5 E-Stop Active Pilot Light

The E-stop Active red pilot light is a global indicator for all E-stop devices wired to that MCP. This includes both the door Emergency Stop pushbutton and field-located E-stop pull cord switches and pushbuttons.

- The E-Stop Active pilot light flashes .5 Seconds ON / .5 Seconds OFF when at least one E-stop has been pressed somewhere in the area controlled by the MCP.
- The E-Stop Active pilot light is solid ON when ALL active emergency stops conditions have been corrected, ALL emergency stop switches and buttons have been reset.

- The E-Stop Active pilot light is OFF when the above conditions have been satisfied, and the reset and start PB(s) have been pressed.

3.3 User-Operated Field Devices

There are a variety of devices external to the control panel that an operator can use to interact with the control system. The following sections describe the common devices used in this system and their operations. For devices that are customized for a particular area, see Section 4.0 *Area-Specific Operation and Product Flow.*

3.3.1 E-Stop Pull Cords and Buttons

Emergency Stop pushbuttons and cord-operated switches (E-Stops) are located throughout the conveyor system in all areas where personnel have physical access to the conveyor. As a rule of thumb, E-Stops safely remove output power for anything immediately adjacent and within sight of the E-Stop. Certain exceptions may exist for operational isolation reasons. For an overview of E-Stop zoning, see Appendix 5.1.2.

Each E-Stop pull cord has a red beacon light that is illuminated when the E-Stop is actuated. The red E-Stop beacon light is located as close to the E-Stop pull cord switch as possible. Pulling the cable or cutting the cable (releasing all tension) will activate the switch. Reset the E-Stop module by pressing the button on the front face. Then, to reset the area fully, press the nearest reset button. Generally, there is a reset button, or start/stop station directly next to the pull cord/beacon light. The Lifeline 5 module used in most of the system is shown in **Figure 14**.

Figure 14 Lifeline 5 E-Stop pull cord module used in this system.

Each E-Stop mushroom-head button has an integrated red pilot light that is illuminated when the E-Stop is actuated. Push the button in to activate the E-stop. The button will stay depressed while activated. Reset the button by rotating and pulling out on the handle. An E-Stop button generates a signal while "OK" and pulled out (Normally Closed). The E-Stop pushbuttons have a reset button included in their assembly, this reset button must be pressed after pulling out the E-Stop button to fully reset the condition.

The process for an E-Stop condition is:

- The local red E-Stop indicator beacon flashes .5 Seconds ON / .5 Seconds OFF (standard flash) when the pull cord or button is tripped (integrated pilot light solid red ON).

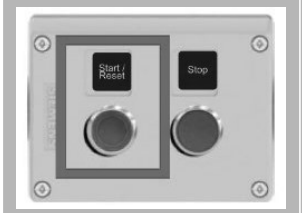
- The local red E-Stop indicator beacon is solid ON after the E-Stop condition has been corrected and the pull cord switch or button has been reset (integrated pilot light solid green ON).
- The local red E-Stop indicator beacon is OFF after the E-Stop condition has been corrected, the switch or button has been reset (integrated pilot light solid green ON), and the local reset button has been pressed.

3.3.2 START/STOP Pushbutton Station

Start/Stop Control Stations are located throughout the system to facilitate the operator to be able to start and reset without having to walk all the way to the main control panel. Each pushbutton pair consists of a guarded green illuminated Start/Reset button and a red, non-illuminated Stop button. The Start/Reset button generates a signal while pressed (Normally Open). The Stop button generates a signal all the time except when pressed (Normally Closed).

Table 5 Start/Stop Pushbutton Station below summarizes the detailed functionality of the start pushbutton, type of faults that are resettable by a start pushbutton on a Control Station, and push-button light states.

Table 5 Start/Stop Pushbutton Station details.

Control	Resettable Faults	Pushbutton Light States
Start PBLT:  Press to start the system, reset a fault, or restart the system.	Jam Fault E-Stop Fault Communication Fault Motor Overload Fault	**SOLID ON:** All the motors in the area are running. **FAST PULSE (100MS ON/OFF):** A nearby E-Stop zone is ready to reset. **OFF:** Conveyor associated with the PBS* has been stopped.
Stop PB:  Press to stop the system.	None	N/A

*Refer to Section Startup Sequence and Warning Horn for start/stop zoning.

3.3.3 Single Reset Pushbutton Station

Single reset pushbutton stations are also placed around the system. These are a single button, black, non-illuminated, with label “Reset”. See **Figure 15** for this station.

Figure 15 Single Pushbutton Station for reset locations.

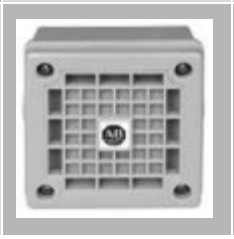
These could be used for resetting an E-Stop condition if the Start/Stop station is not desired. However, these single pushbuttons are most often used for resetting a Jam condition.

3.3.4 System Indicators (Beacons and Horns)

There are also devices external to the control panel that an operator can use to receive status from the control system. A list of common devices and their operations is shown in **Table 6**. For devices that are customized for a particular area, see Section 4.0 *Area-Specific Operations and Product Flow.*

Table 6 System Indicators and how to interpret them.

Indicator Type	Color	Indication
E-Stop Beacon	Red	**FLASHING (.5s ON/OFF):** Indicates that an E-Stop fault has occurred, and the E-Stop device is active. The Beacon continues to flash until the operator resets the E-Stop switch/pushbutton. **SOLID ON:** Once the E-Stop switch/pushbutton has been reset the beacon is solid ON. The operator must fully reset the condition through the nearby reset PB or panel PB. **OFF:** E-Stop not active at this spot.
Jam Beacon	Amber/Yellow	**FLASHING (.5s ON/OFF):** Indicates that a jam has occurred. Beacon continues to flash until operator clears the path of the jam photo-eye. **FLASHING (80ms ON / 100ms OFF)** Donor Tote/Carton Highway Loop Beacons fast flashing indicates when there is a lost to communication from the nearby Scanner. **FLASHING (250ms ON / 250ms OFF, 250ms ON / 1250ms OFF (double flashes)):** Empty Tote Inbound RAT Beacons indicates when the RAT has false box on it.

Indicator Type	Color	Indication
		SOLID ON: Once the path of the jam photo-eye is cleared, the beacon is solid ON until the conveyor is reset. Can be reset by a near reset PB, near start PB, or panel start PB. **OFF:** Jam not detected at this spot.
Full Beacon	Blue	**ON:** Downstream conveyor full **OFF:** Downstream conveyor not full **FLASHING (.5s ON/OFF):** Recirc Full Beacon Flashing indicates Donor Tote/Cartoon Loop is in Gridlock Prevention **FLASHING (250ms ON / 250ms OFF, 250ms ON / 1250ms OFF (double flashes)):** Donor Tote/Carton Highway Loop Beacons indicates when there is a lost to communication from BG to PLC.
Operational State Beacon **(Inbound Tote Divert)**	Green	**ON:** External System and Daifuku System interlocks are okay. **OFF:** Daifuku not ready to receive product **FLASHING (.5s ON/OFF):** External System not ready to divert product.
Startup Horn		**PULSE (1s ON/OFF FOR 5s):** Equipment is starting up.

3.4 Equipment Types

There are several distinct types of equipment in the system with different control requirements. Typical operations are listed below for specific equipment types.

3.4.1 Variable Frequency Drive

In areas where conveyors are frequently started and stopped, or where greater speed accuracy is required, select motors are equipped with variable frequency drives (VFDs).

If a VFD encounters a fault, the PLC activates an alert on the HMI to inform an operator of the problem. Before resetting the VFD fault, first investigate the nature of the fault by looking at the display screen on the drive. Once it has been determined that the drive is still functional, a local Reset pushbutton is used to reset the fault and initiate the standard start-up sequence.

3.4.2 LRPE Conveyor

Live roller photo-eye accumulation (LRPE) conveyors require local 480V AC 2 phase to 24V DC power supplies to operate. Up to two air zones are controlled by electronic controllers mounted on the conveyor side frame. The modules monitor one photo-eye per air zone; they remove the air from the zone upstream of a blocked photo-eye to allow products to accumulate. There are dipswitches on each module to select singulation/slug release modes and slug release timing. The only PLC control for an LRPE conveyor is the motor driving the rollers and the release signal at the exit end of the conveyor. Extra photo-eyes - separate from the photo-eyes used by the modules - are wired to the PLC for monitoring conveyor full conditions.

3.4.3 Motor Driven Roller Conveyor (MDR)

MDR stands for Motor-Driven Roller conveyor. These conveyors are made up of short sections of roller or belt, where each section is driven by an individual 24V DC motor. These conveyors have photo-eyes at each section and are used for accumulation, transport, and any other area-specific needs.

The MDR system is controlled through ERSC cards, where ERSC stands for Ethernet Roller Speed Controller. Accumulating MDR conveyor uses one ERSC card to control up to two rollers in a conveyor bed. The cards communicate to each other through shielded Ethernet cables. ERSC cards can be controlled with the PLC via Ethernet/IP (limitations apply). Power to ERSC cards are only turned off when an E-stop condition is triggered through activating the appropriate emergency pull cord, switch, or similar safety device.

ERSC cards can be controlled under their own logic with some PLC input known as Zero Pressure Accumulation (ZPA) mode. ERSCs in ZPA mode have their own internal logic when to run, stop and sleep. This means ERSCs in ZPA may continue to run and finish its internal logic during a stop command until the product has reached a point controlled by the PLC. A PLC control point could be anywhere the box needs to stop before the next process logic takes place such as transitioning from MDR to another conveyor type or a divert point.

PLC/IO mode allows PLC logic to control the full functionality of the card and follows Standard Automatic Logic Section 3.5.

3.4.4 Lift Gates

<u>Automatic Lift Gate Operation:</u>

The state of the gate is monitored by a proximity sensor signal. A normally closed signal is used for when the gate is in the closed/down position. An operator can lift the gate without any other input. Lifting the gate opens the normally closed proximity sensor signal and is effectively sending the system a stop command.

Once the lift gate is returned to a closed/down position and the normally closed proximity signal is restored, the system can be restarted in two ways. First, the operator can hit the system start button to send a start command to the system. Second, if the gate is in the closed position, the proximity signal is restored, and an operator has not pressed a start button within 5 seconds, then an automatic start command will be sent to start to the system again.

3.4.5 Right-angle Transfers

A Right-Angle-Transfer (RAT) sorter brings product in one at a time. It may divert only left, only right, or be bidirectional and do both. A straight exit point is also possible depending on conveyor layout requirements. After diverting left or right, in an "H" configuration the flanking conveyor may roll forwards or backwards to result in 5 possible destinations: left-forward, left-reverse, right-forward, right-reverse, or straight.

Photo-eyes configured in a square pattern around the perimeter of the transfer bed provide destination confirmation and jam detection.

The transfer will bring product in on rollers driven by an ERSC Motor-Driven Roller. For a product that is not destined straight, when the back end of the product lines up with the first band, an air cylinder lifts the sideways band assembly above the rollers. The product is now resting on the bands. The bands are then driven forwards or backwards to send the product left or right. No new product can be brought into the transfer until the bands are lowered or a straight-destined product has exited the transfer area.

The Automotion "Light-Duty" transfer uses MDR to drive the bands.

3.5 Standard Automatic Logic

This section describes standard logic that is used throughout the system. Any control logic not specifically called out in Section 4.0 Area-Specific *Operation* and Product Flow section can be expected to conform to the descriptions in this section.

3.5.1 Startup Sequence and Warning Horn

When an operator starts a section of conveyor (system start, E-stop reset, fault reset, jam reset, motor overload reset), a 5-second horn pulse is initiated. After the 5-second time delay has expired, the conveyors start up in a cascading sequence, beginning with the furthest downstream. This sequence of events represents Daifuku's standard startup sequence.

Individual MDR zones have integrated sleep logic and, after the initial startup sequence, may wake up without a horn.

When conveyors are not running due to Line Full or other flow controls, they are considered to be in "active standby" mode and can turn back on at any time without the horn sounding.

Refer to Section 3.2.2 for the startup zones.

3.5.2 Energy Conservation

Energy conservation logic limits power usage by turning off conveyors when they are not actively being used and is also referred to as sleep logic. When the system detects that a conveyor is entirely clear and has not seen any product for a period of time, the motor is automatically turned off. A photo-eye located upstream of each conveyor (generally at the discharge end of the conveyor immediately upstream) is used to "wake up" the line when new product is detected.

As a general standard, this logic is employed system wide. However, there are certain exceptions. Most notably, "manual load" conveyors are never automatically shut off. This includes pick modules, manual processing stations, or any other lines where associates manually place product onto the conveyor. Depending on the sorter type and the effect of speed on diverting, a sorter may have its speed reduced during low-throughput times instead of turning off entirely.

Another exception occurs within MDR conveyor. In general practice, the majority of MDR is ran under its own logic in the ERSC card (ZPA mode). They have their own logic when to run, stop, and sleep between zone to zone and horns will not sound for the start/stop of its normal function.

The standard start-up sequence does apply when conveyors are awakened from energy conservation mode, but only when 480 VAC motors are affected. If only MDR conveyors have been affected, the horn will not sound.

3.5.3 Flow Control

The control system for basic transport conveyor will meter product automatically based on downstream availability. When a location becomes unavailable to receive more product (Line Full or stopped), the upstream conveyors will stop releasing product either by stopping or activating a hold-back devices such as a brake. When a location becomes available, product flow from upstream is automatically resumed, typically without a horn.

Line Full

An accumulating or gravity conveyor is considered full if a photo-eye near the infeed end is constantly blocked. If no gap between products is detected by the photo-eye for a certain period of time, it is assumed that product is not actually moving in that area. The conveyor is considered full, and product flow from upstream is halted. The time used to consider a conveyor full depends on the conveyor and product type, and the speed the product moves through the area.
The same location is automatically considered clear when the photo-eye is constantly clear for a certain period of time. This time varies based on the conveyor and product type, and the speed the product moves through the area. If operators are required to manually clear the area (such as a gravity hospital lane on a sorter), the clear time may be additionally extended to give the operator time to exit the area after removing product.

Run Up

Non-accumulating conveyors will typically stop immediately upon the downstream conveyor becoming unavailable. If a photo-eye is present at the exit end of the conveyor, the conveyor may continue running until the photo-eye is blocked.

3.5.4 Product Jam

A conveyor is considered to contain a product jam if a photo-eye in a transition location is constantly blocked while the area is running. If no gap between products is detected by the photo-eye for a certain period of time, it is assumed that product is not actually moving in that area. The conveyor is considered jammed, and the immediate area is halted. Product flow from upstream is also halted. The time used to consider a conveyor jammed depends on the conveyor and product type, and the speed the product moves through the area.

The same location is considered clear when the photo-eye is cleared but will not restart until a reset button is pressed. Certain locations may be allowed to reset with the photo-eye blocked, but equipment that could be damaged by unintended reset (such as a sorter) will always require an operator or maintenance person to go to that specific location and clear the photo-eyes manually before resetting via local Start/Reset or Reset pushbutton.

If any non-standard conveyor access (crawling under/over, poor visibility, etc.) is required, the operator or maintenance person should activate an E-Stop before clearing the jam and reset the E-Stop only after ensuring all personnel working on the jam have safely exited the area.

When a jammed location is successfully reset, the area will restart using the standard startup sequence, including the warning horn.

Berkshire Grey requests an auto-jam reset function for the entire system. When the jam is cleared, the jam photo-eye is unblocked, and an operator has not pressed a Reset pushbutton within 10 seconds of clearing the jam, then the jam will auto clear. The auto-jam reset function will apply to all system jams except the mechanical divert up/down jams of 30 degree diverts and right-angle transfers. This ensures the operator clearing the jam is clear of the conveyor and resetting the jam with intent before the divert or right-angle transfer is allowed to mechanically operates its divert function.

3.5.5 Merges

The typical two-to-one merge receives product from two inbound conveyors, each inbound is equipped with either an air brake or short belt conveyor at the end. The braking device quickly starts and stops the movement of product as necessary, based on the release priority of each lane. Each line generally has a photo-eye at the end of the braking device, located such that cartons can be reliably stopped, if necessary, when the eye is broken.

Release priority is assigned to a lane when product is sensed by the brake photo-eye, so long as the opposite lane is not already releasing product and neither lane is full. If a carton blocks a brake photo-eye and product is already releasing from the other lane, the box will immediately stop and wait for the other lane to complete its release. There is a safety timer that runs while the release is being shifted from one lane to the other, ensuring that cartons from the two lanes do not clip one another and cause a jam.

If a lane runs out of product while releasing, the brake photo-eye senses that no product is present, and release is shifted to the other lane. If the non-releasing lane goes full and current releasing lane is not full, the release will shift to the other full lane. If both lanes are full, the release will shift back and forth as if no lanes are full.

3.6 Scanner Operations

The induction will halt with an alarm on the HMI and the local beacon indicator based on certain scanning faults detailed in **Table 7**. The number of instances is defined by the number of consecutive instances the fault occurs.

Table 7 Faults to halt flow of totes and their barcode that will be sent.

Fault	# of Instances	Barcode Message
No Read	5	???????
Multi-Read	5	#######
No Scanner Data	5	!!!!!!!
Divert Failure	3	n/a

No Read

The barcode scanner detects a carton but is not able to decode a valid barcode. The scanner transmits "?" characters instead. Products with this error are usually sent to the Error Lane by the host system.

Multiple Read

The barcode scanner detected more than one valid barcode on the same carton or scan trigger. The scanner transmits "#" characters instead. Products with this error are usually sent to the Error Lane by the host system.

No Scanner Data

The barcode scanner did not provide any information for a carton within the designated scanner response window. The PLC will report the barcode as "!" characters. Products with this error are usually sent to the recirculation path by the host system to try reading again. Potential causes:

- Misaligned scanner photo-eyes
- Failure of the scanner encoder or encoder mounting, when applicable
- Delay in the scanner communications that put the message outside the normal tracking window.
- Badly formatted message from the scanner, such as an unexpected number of characters
- Scanner hardware failure

4.0 Area-Specific Operation and Product Flow

This section provides an area-by-area description of system operation and product flow. The overall MHE system has been divided into several subsystems, as defined in Section 1.2 System Area Summary. For detail functionality of messaging, see Appendix 5.1.4.

4.1.1 Donor Tote/Carton Inbound

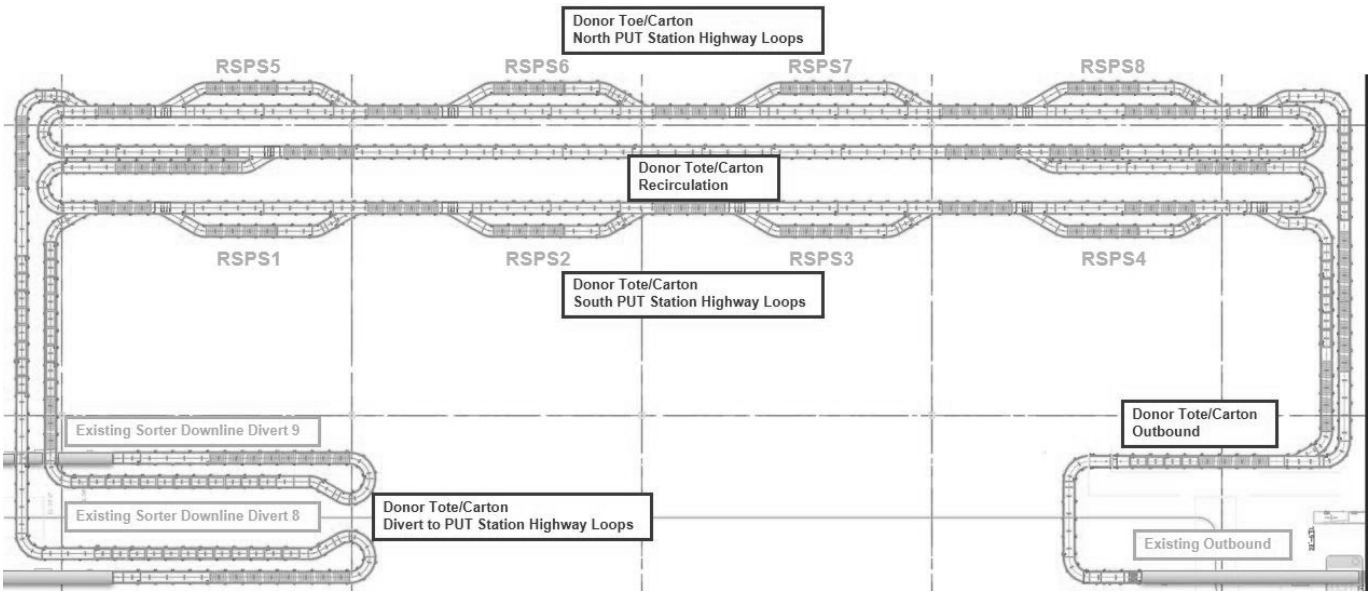


Figure 16 Donor Tote/Carton Overview.

Divert Into PUT Station Highway Loops

Daifuku downline conveyor interlocks with existing sorter diverts 8 and 9 to allow donor totes/cartons into the system shown in **Figure 18**. Suggested interlocks for both the External System and Daifuku System shown in **Table 8**. The *ReadytoRelease and OKtoFeed* manages the control flow between the two systems. *E-StopOK* interlocks the two safety systems and, the *RESET* allows the reset of the safety system from either system as long as the E-Stops are in a ready-to-reset state. *RESET* signal is a momentary 2 second pulse. Interlock relays TBD.

"Output to [System]" indicates the system outputting the interlock would drive an interlock relay for the signal. This relay would close a dry contact with the [System]'s own voltage to receive the input from the outputting system. For every output in the table, there is an expected matching input to the other system.

Table 8 Donor Tote/Carton Inbound Interlocks

External ILK's	Description	Daifuku ILK's	Description
ReadytoRelease (Output to Daifuku)	Sorter Downline is ready to release. (Control Flow)	**OKtoFeed** (Output to External)	Daifuku Downline is ready to receive product (Control Flow)
E-StopOK (Output to Daifuku)	E-Stop Zone Interlocks	**E-StopOK** (Output to External)	E-Stop Zone Interlocks
RESET	Reset for E-Stop Zone ILK	**RESET**	Reset for E-Stop Zone ILK

External ILK's	Description	Daifuku ILK's	Description
(Output to Daifuku)		(Output to External)	

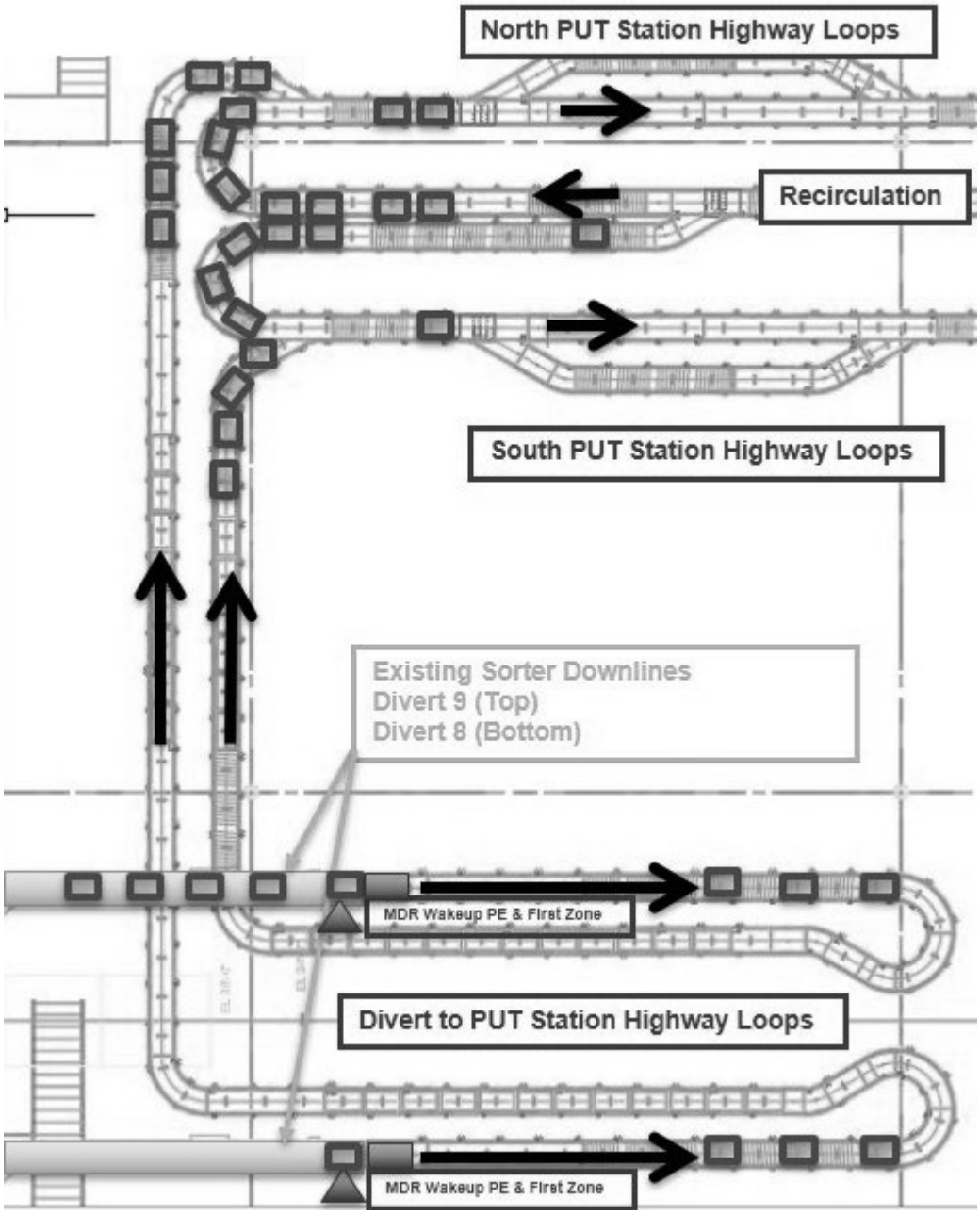


Figure 17 Existing Sorter Diverts 8 & 9.

The Existing System Sorter Divert in green can release totes/cartons and the Daifuku downline can receive totes/cartons shown in **Figure 17** if these ILK conditions are met:

- *E-StopOK* ILK both systems = true
- Daifuku *OktoFeed* = true
- Existing *ReadytoRelease* = true

If any condition goes false in **Figure 18**, the Existing System Sorter Divert in green is expected to stop releasing totes/cartons into the Daifuku System until all conditions are restored to true. The Existing

System *ReadytoRelease* ILK will wakeup/run the first Daifuku MDR Zone during initial start-up when Daifuku *OKtoFeed* ILK is also true in anticipation of receiving totes/cartons. After the initial startup state, a Daifuku MDR Wakeup Photo-eye mounted at the entry of the first MDR Zone or 6" into the Existing System Divert will wakeup/run the MDR Zone when an incoming tote/carton blocks the photo-eye.

If the *E-StopOK* ILK from either system is false, then both systems are expected to enter into the E-Stop state for the area. Once the E-Stop device(s) that tripped both systems is restored, then the reset for both E-Stop systems can be made from either system giving a momentary 2 pulse count reset signal. For example, if the operator resets the safety from the Daifuku system, then the Daifuku *RESET* ILK will send the momentary 2 pulse signal to the Existing System to reset their E-Stop condition as well.

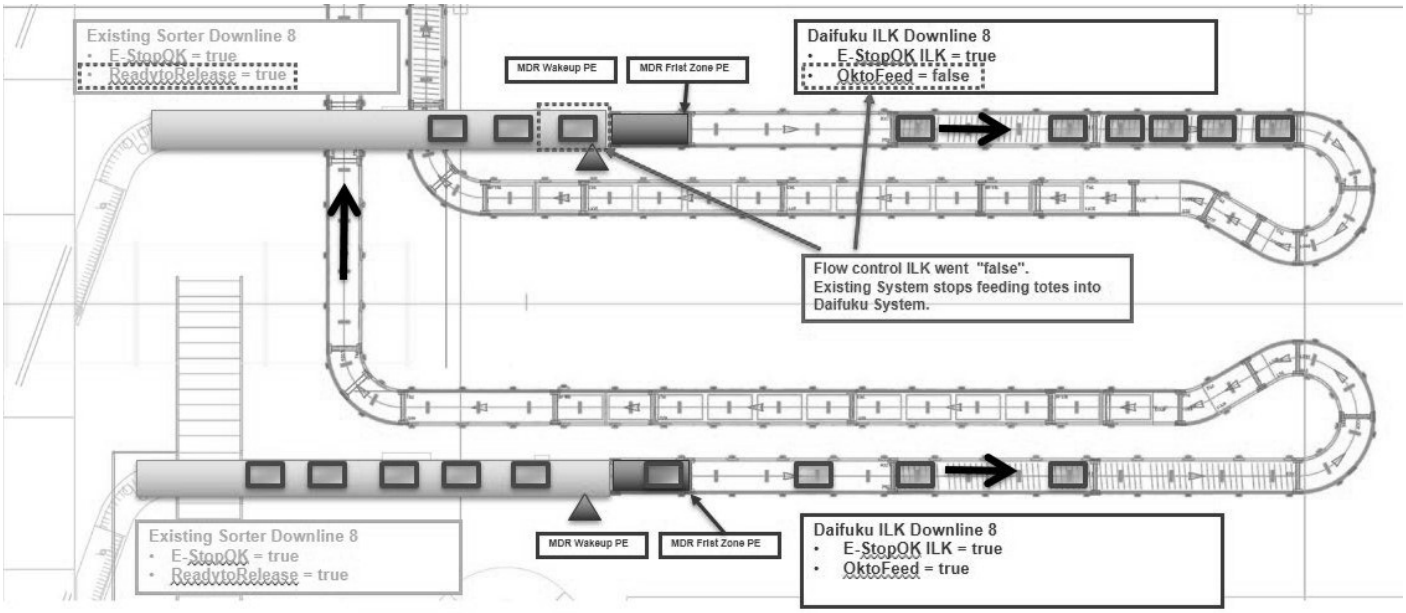


Figure 18 Existing Sorter Diverts 8 & 9 Interlocks

The "induct_available_no_tote" conveyor section status is monitored when *OKtoFeed = 1, ReadytoRelease =1* and no new totes/cartons entering the Daifuku System are detected by the Daifuku MDR First Zone Photo-eye. Daifuku will start a timer that is broadcasted on "udtPLCtoBG.aConvSectionSts[0]" tag when these conditions are met. The timer alerts BG the amount of time passed since a new tote has entered the Daifuku System. When a new tote/carton blocks the MDR First Zone Photo-eye, it will reset the timer. The timer restarts once the tote/carton clears the photo-eye.

From the discharge of the Existing System Sorter Diverts 8 & 9, totes/cartons will continue straight onto MDR downline until they turn left 180 degrees backwards toward the sorter up the incline and turn 90 degrees right towards the PUT Stations Highway. The totes/cartons will travel the to merge at a 2-to-1 merge point with the recirculation line for the North and South PUT Station Highways to enter the PUT Station Highway. Refer to Section 3.5.5 for detail description of merge operation.

PUT Station Highway Loops

The PUT Station Highway is the main straight MDR conveyor loop that connects all the PUT Station Highway Loops and feeds the outbound and recirculation conveyors. The PUT Station Highway Loops are where totes/cartons are diverted to the loop of MDR conveyor off the highway where the PUT Station

Operator receives and picks product in the Pick Zone. Totes/cartons then merges back with the highway. When a tote enters the highway loop, there are 4 zones of staging before the pick zone, shown in **Figure 20**.

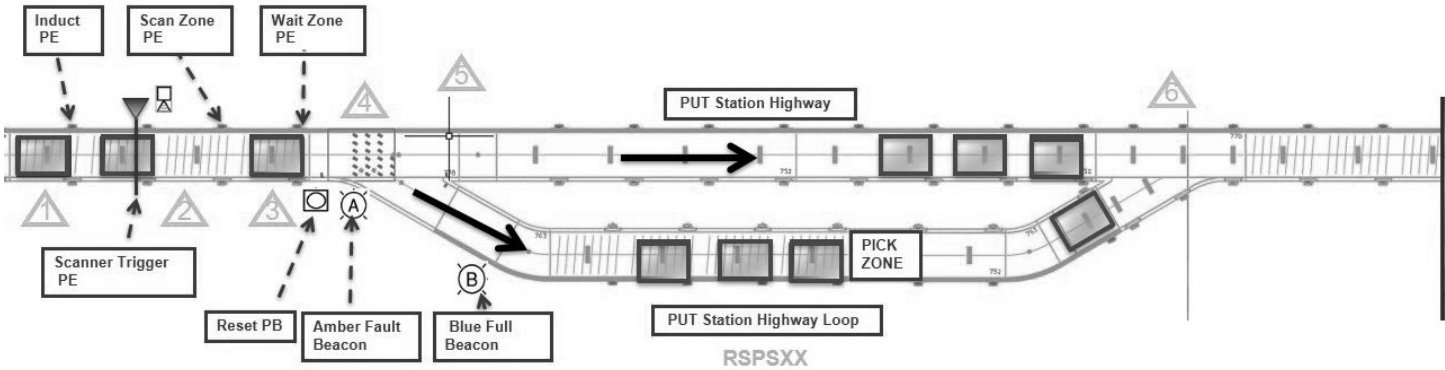


Figure 19 Highway loop tote staging example. South PUT Station Loop shown as reference.

- Location 1: Induct Zone
  - Tracking for each tote/carton starts when the tote/carton blocks the Induct photo-eye at location 1 (see Section 4.1.5 for scanner tracking zone details).
- Location 2: Scan Zone
  - From the Induct Zone, the tote/carton enters the scan zone blocking the Scanner PE and barcode information is scanned to the PLC from the scanner.
  - The barcode decision request from the PLC to BG starts as soon as we receive the barcode. (see Section 5.1.4 Scanners for Barcode Decision Details).
    - Reaching the Scan Zone photo-eye without barcode information for an "x" amount of time will result in no barcode data and the box will be routed straight.
    - "x" amount of time can be adjusted to system performance.
  - The tote/carton leaves the Scan Zone with barcode information and the Barcode Decision Request sent to BG.
- Location 3: Wait Zone
  - Totes/Cartons entering the Wait Zone is where the PLC expects the Barcode Decision Response from BG before hitting the wait zone photo-eye.
    - Reaching the Wait Zone photo-eye without a Barcode Decision Response BG for a set amount of time will send the tote/carton straight with "No Host Response" reason code.
- Location 4: Divert
  - The tote/carton will pass straight through or divert at location 4 based on BG's decision for that tote/carton.
  - Note:
    - In the best interest of keeping the highway tote/cartons flowing in the Highway Loop, the Divert will reassign and send divert assigned totes/cartons straight if the divert lane is unavailable for an "x" amount of time.
    - "x" amount of time can be adjusted to system performance.
    - These conditions include:
      - workstation not available: BG Station Status = 0.

- Divert Lane OKtoFeed: Divert Lane is ready to receive product and no full detected by MDR Zone photo-eye.

- Location 5: Confirmation and Reason Code
  - After the tote/carton exits the divert in either direction at location 5, the PLC sends Barcode Decision Confirmation to BG of where the tote physically traveled.
  - A BG tote/carton divert reason codes defined in "Facility Conveyance Tags" BG documentation to indicates whether the tote successfully traveled in the indicated path decided by BG or give reason it could not travel the correct path.
- Location 6: PUT Station Merge
  - The totes/carton that continue straight on the PUT Station Highway will travel to a 2-to1 merge that merges with the totes/cartons returning from the PUT Station Highway Loop.
  - See 3.5.5 Merges for merge details.

Totes/cartons that are diverted will enter the PUT Station Highway Loop and accumulate before the Pick Zone whose functionality is described in the next section. Totes/cartons that continue to travel straight will accumulate at the entry of the 2-to-1 merge that merges the highway loop tote/cartons back onto the highway. MDR zone photo-eyes will be used to detect full conditions for the highway loop and highway accumulation before the merge. The choice of the zone photo-eyes may be adjusted for system performance.

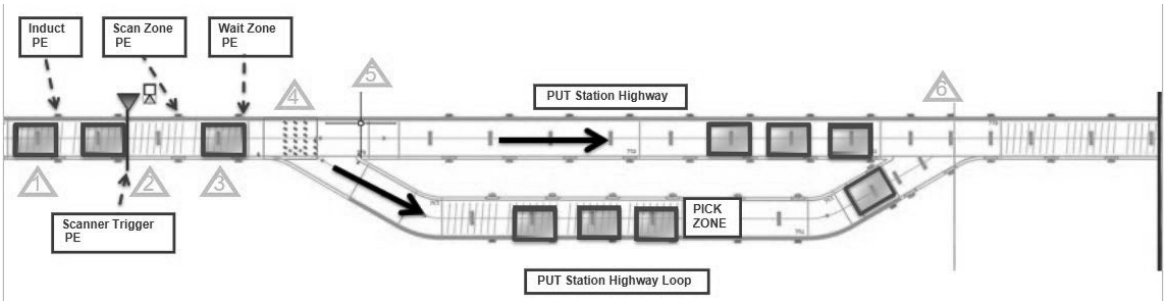


Figure 20 Highway loop tote staging example. South PUT Station Loop shown as reference.

Daifuku keeps track of the total totes/cartons in the entry of the highway loop starting after the divert to the entry of Pick Zone and reports it to BG with updating "aConvSectionTotalItems[XX]" tag. This is accomplished by a combination of monitoring ERSC card status and zone photo-eyes detecting totes/carton for those zones. In addition, Daifuku reports the conveyor status of the zones whether they are jammed in the highway loop monitoring ERSC card status zone photo-eyes shown in **Figure 21**. The jam status is updated in the "aStationConvZonesJammed[XX]" tag.

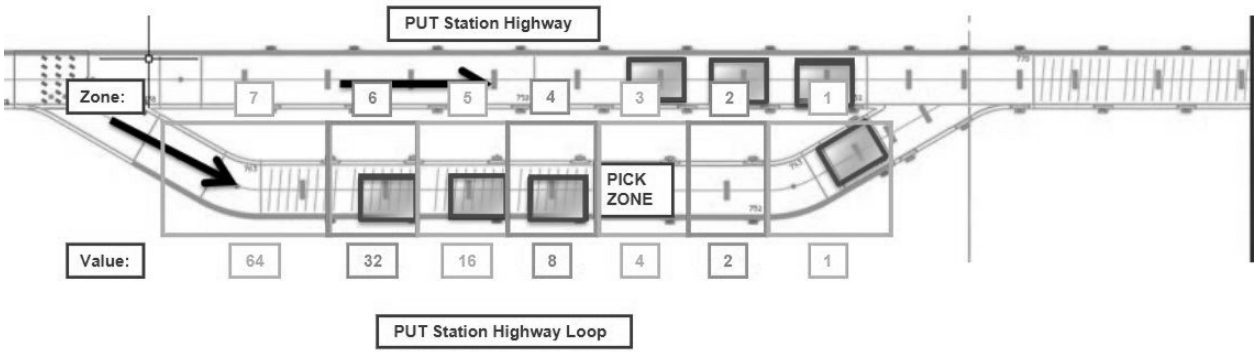


Figure 21 Highway loop Status Zone example.

PUT Station Pick Zone

The pick zone on each highway loop is single Daifuku MDR Zone controlled by BG where an operator stands to pick product from a tote/carton. Totes/cartons enter the highway loop by diverting from the highway with the BG decision made at the divert/scan point before each highway loop. The pick zone is shown in **Figure 20**.

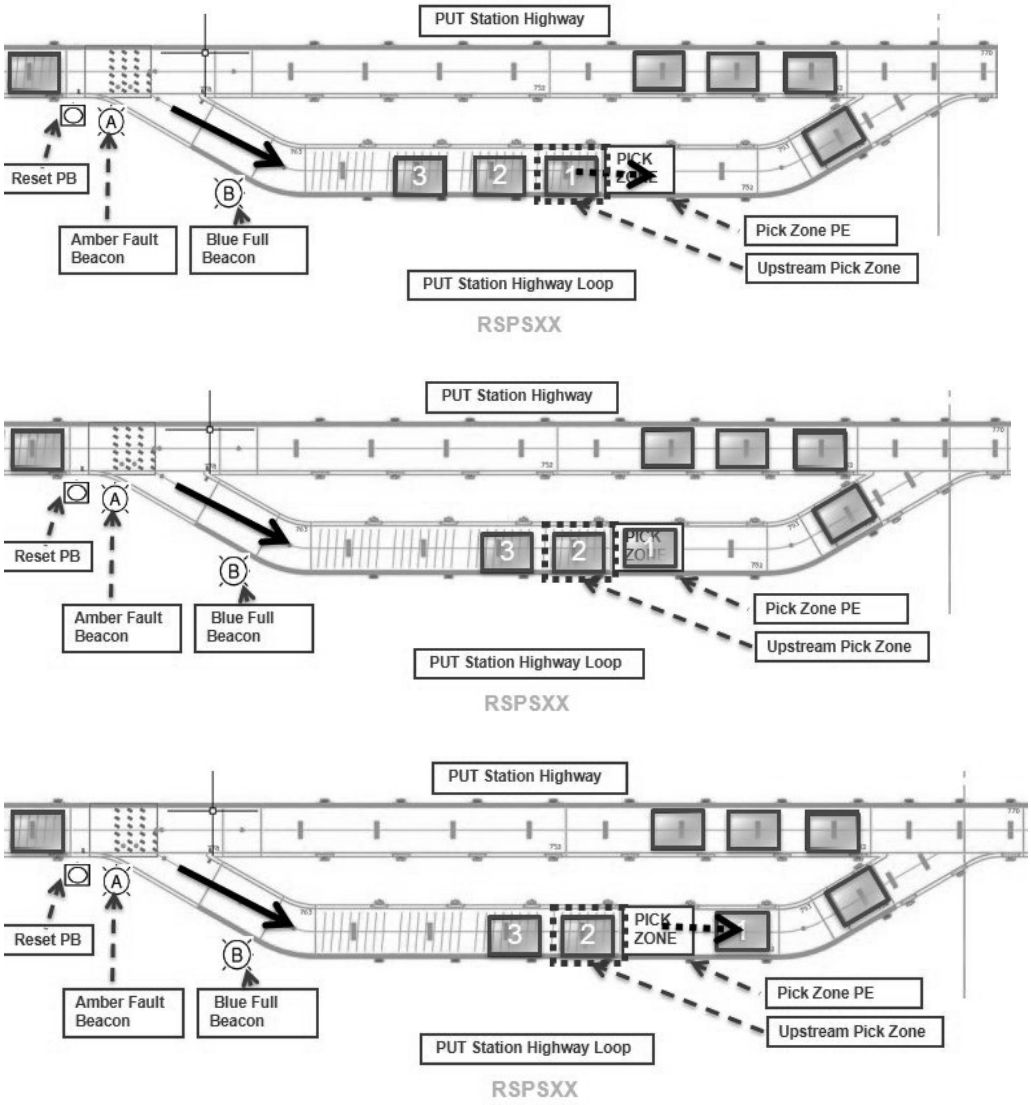


Figure 22 Highway loop Pick Zone Tote Index Example

High level functionality of the PUT Station Pick Zone is:

- Tote/carton Present and Conveyor Status (**Figure 22**, Top):
    a) Daifuku checks for pick zone to be clear and conveyor status of zone before the pick zone.
        - Daifuku sends tote present (tote_present = 0) if tote/carton not present.
        - Daifuku sends (aStationConvZonesJammed[8] =0) zone status not jammed before Pick Zone.

- Tote Index Start:
    a) Berkshire Grey sends an index start,
        - BG sends (aHandShakeStart = 1)
- Begin Tote Index (**Figure 22**, Middle):
    a) Daifuku begins the tote index with unlocking the pick zone and allows the tote/carton to enter until it blocks the photo-eye, then the zone is locked.
    b) Daifuku sends a transfer complete and waits for Berkshire Grey complete.
        - (aHandshakeComplete = 1)
- Tote Index Complete (**Figure 22**, Bottom):
    a) Berkshire Grey handles the decision of when the tote is completed.
        - (aHandshakeComplete = 1)
    b) Once Daifuku gets the complete, the tote is moved out and the process restarts for the next tote.

Refer to Section 5.1.4 Donor Tote/Carton Highway Loop Pick Zone (Tote Index) for detailed description of the Tote Index handshake.

Recirculation & Gridlock Prevention

The Recirculation line is how totes can be transported to one of the eight stations when needed more than once in more than one PUT Station, shown in **Figure 23**. The North and South Donor Tote/Carton Highway Loops will merge into the single recirculation take away line. Refer to Section 3.5.4 for merge operation detail. At the end of recirculation there is a scanner where the BG makes the decision to divert to the South Donor Tote/Carton Highway Loop or travel straight to the North Donor Tote/Carton Highway Loop.

Refer to Section 5.1.4 Donor Tote Inbound & Outbound Scanner for detailed description of Barcode Decision.

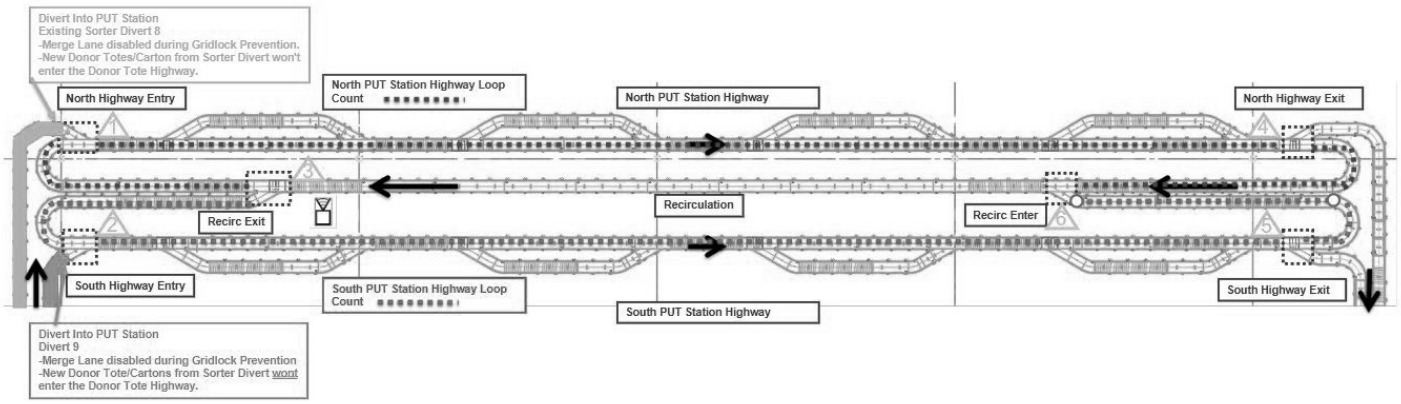


Figure 23 Recirculation and Gridlock Prevention

Gridlock Prevention is the preemptive system monitoring and action to prevent the entirety of the system to completely fill up with totes/cartons and create a gridlock state where totes/cartons can no longer travel in the system because there no open zones to travel. The only recovery from this gridlock state is operator intervention to remove totes/cartons from the system to free up zones for totes/cartons to start traveling again. This scenario is an undesirable outcome.

Gridlock Prevention will monitor the totes/cartons total count at the entry and exits to the North & South Highways and Recirculation. Separate total counts would exist for the North Highway, South Highway and Recirculation. If area monitored photo-eyes detect no totes/cartons for 10 minutes, the counts will renormalize to zero. Reference **Figure 23** Recirculation and Gridlock Prevention.

- North Highway Counting:
    - Add Count
        - Location 1 adds to the total when new totes/cartons from Divert 8 enter the merge.
        - Location 3 adds to the total when totes/cartons exit straight from Recirc Divert.
    - Subtract Count
        - Location 4 subtracts from the total when totes/cartons divert to outbound.
        - Location 6 subtracts from the total when totes/cartons enter the merge.
- South Highway Counting:
    - Add Count
        - Location 1 adds to the total when new totes/cartons from Divert 9 enter the merge.
        - Location 3 adds to the total when totes/cartons divert from Recirc Divert.
    - Subtract Count
        - Location 4 subtracts from the total when totes/cartons divert to outbound.
        - Location 6 subtracts from the total when totes/cartons enter the merge.
- Recirculation Counting:
    - Location 6 adds to the total when totes/cartons enter the merge.
    - Location 3 subtracts from the total when totes/cartons exit the divert.
    - Recirc counting is to help keep track of total tote/carton count in the Donor Tote Inbound.

An initial Gridlock Prevention Threshold of 75% of total totes possible in the North or South Highway Loop separately will activate the Gridlock Prevention logic for that individual loop. The total totes possible in the Highway Loop is determined by the total individual zone's totes/cartons can accumulate in. The final threshold may be adjusted up or down depending on system performance. Merges and divert zones do not count because a tote/carton would not normally accumulate those zones.
The Gridlock Prevention Logic for North and South function independent of each other. The North Gridlock Prevention is enabled through the threshold condition pertaining to the North Donor Tote/Carton Highway (Brown dashes **Figure 23**) and the same is true for the South Gridlock Prevention in the South Donor Tote/Carton Highway (Pink dashes **Figure 23**).

The Gridlock Prevention would disable the Divert Into PUT Stations (Existing Sorter Divert(s) shown in Green for North and Blue for South **Figure 23**) merge lane at locations 1 & 2 preventing new totes/cartons from entering the highway loops and would not reenable the lane(s) until the count was under the threshold for a determined amount of time to ensure the system has cleared out sufficiently. Gridlock Prevention scenarios below.

- Scenario Example:

- If the North Highway Loop (Brown dashes **Figure 23**) has 113 total available zone for accumulation, then the threshold would be calculated as .75 x 113 = 85 totes/cartons (round up to next whole tote/carton).
- If the total tote/carton count meets or exceeds 85 in the North Highway Loop during operation, then the North Highway merge at location 1 would disable the merge lane fed by the Existing Sorter Divert 8 (Green), not allowing new totes/cartons to enter the North Highway Loop.
- The Existing Sorter Divert 8 merge lane would not be re-enabled until the total count was under the threshold for a determined amount of time ensuring enough totes/cartons have cleared the North Highway Loop through either the North Highway Exit diverting to outbound or exiting into Recirculation for new totes/cartons to enter.

- Gridlock Prevention Summary
  - The North and South Highway Loop Gridlock Prevention operate separately from the other loop.
    - One loop may be in Gridlock Prevention while the other Loop is not. Both can be in Gridlock Prevention from their own Gridlock Prevention Logic.
  - The total tote/carton threshold count may be adjusted higher or lower than 75% depending on system performance testing. The total tote/carton count is considering the optimum conditions where totes/cartons would be filling up the highway and highway loops equally.
  - The amount of time to latch the Gridlock Prevention before clearing under the threshold will be adjusted to system performance testing.
  - If no totes/cartons detected by MDR Zone photo-eyes or counting for a period of 10mn, then the count for the area will renormalize the count to zero.
    - This tote/carton monitoring and count reset is separate for each of the three areas of counting: North Highway Loop, South Highway Loop, and Recirculation.
    - The period of monitoring for no totes/cartons can be adjusted to system performance.

4.1.2 Donor Tote/Carton Outbound

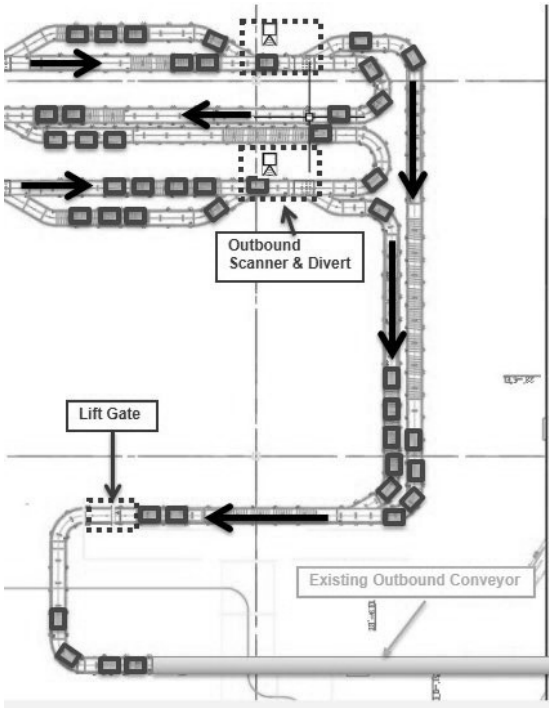


Figure 24 Donor Tote/Carton Outbound overview

After the 4th PUT Station in the highway loops in **Figure 24**, there is a scanner prior to each outbound divert in the North and South Outbound Loops (see Section 4.1.5). Totes/carton enters the outbound by diverting from BG's decision. The North and South Donor Tote/Carton Outbounds lines continue to a 2-to-1 merge (see Section 3.5.5 Merges). The totes/cartons continue to the lift gate that allows walkthrough access in the area and onward to the existing external outbound conveyor.

Daifuku outbound conveyor interlocks with Existing System outbound to allow donor totes/cartons to exit the system. Suggested interlocks for both the External System and Daifuku System shown in **Table 9**. The *ReadytoRelease and OKtoFeed* manages the control flow between the two systems. *E-StopOK* interlocks the two safety systems, the *RESET* allows the reset of the safety system from each system. Interlock relays TBD.

Table 9 Donor Tote/Carton Outbound Interlocks

External ILK's	Description	Daifuku ILK's	Description
OKtoFeed (Output to Daifuku)	External Outbound is ready to receive product. (Control Flow)	**ReadytoRelease** (Output to External)	Daifuku Outbound is ready to release. (Control Flow)
E-StopOK (Output to Daifuku)	E-Stop Zone Interlocks	**E-StopOK** (Output to External)	E-Stop Zone Interlocks
RESET (Output to Daifuku)	Reset for E-Stop Zone ILK	**RESET** (Output to External)	Reset for E-Stop Zone ILK

The Donor Tote/Carton Outbound can release totes/cartons and the Existing System outbound can receive totes/cartons shown in **Figure 24** if these ILK conditions are met:

- *E-StopOK* ILK both systems = true
- Daifuku *ReadytoRelease* = true
- Existing *OktoFeed* = true

If any condition goes false, the Donor Tote/Carton Outbound is expected to stop releasing totes/cartons into the Existing System outbound until all conditions are restored to true.

Daifuku will monitor the discharge of donor totes/cartons from the Donor Tote/Carton Outbound into the Existing System "udtPLCtoBG.aConvSectionSts_01" tag. This is the "discharge_1_not_RRR" conveyor section status. Whenever Daifuku is ready to discharge totes/cartons to the Existing System, but the Existing System is not giving *OKtoFeed*, a timer will start broadcasting on the "udtPLCtoBG.aConvSectionSts_01" tag and stopped when new tote comes in. To detect the conveyor section status, the last MDR zone photo-eye of the Daifuku outbound will detect if a tote/carton has accumulated into the last zone. If the *ReadytoRelease* status for the conveyor is true, the photo-eye is blocked and the Existing System interlock permissive signal is false, then timer will start. The timer will stop if any of these parameters are not met.

Lift Gate

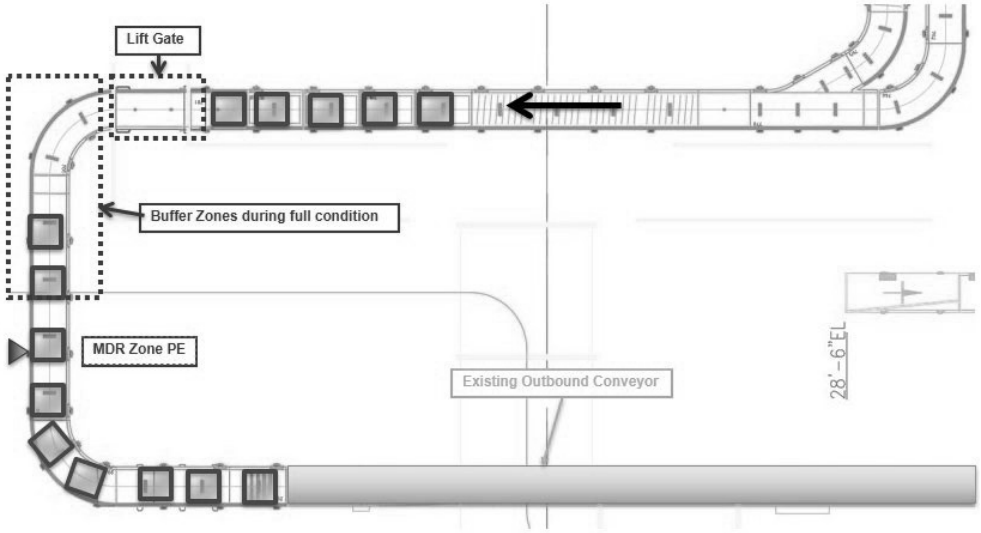


Figure 25 Donor Tote/Carton Outbound Lift Gate staging example.

After the 2-to-1 outbound merge, the totes/cartons pass through a lift gate that provides operators access to the area when needed. In general, Totes/Cartons are not expected to accumulate on the gate as shown in **Figure 25** Donor Tote/Carton Outbound Lift Gate staging example. This allows operator access when the conveyor line is full and totes/cartons have accumulated. During the non-full non accumulating condition, the operator must choose an appropriate time to lift the gate when totes/cartons clear the gate mechanism and before the next box reaches the gate. Opening the gate is the same as issuing a stop command to system. Upstream totes/cartons stop and accumulate before the gate and the MDR rollers in the gate will stop while it is in an open state.

During initial startup or anytime the gate changes from open to close, the downstream MDR Zone from the gate will wake up and run until clear before the gate is permitted to run and release totes. After the

initial startup or and the gate has been closed, the downstream MDR Zone will run or sleep with the gate MDR Zones. A MDR zone photo-eye will be determined far enough downstream of the gate to ensure when the downstream conveyor of the lift gate becomes full there will be enough buffer zones to accept any totes/cartons that are currently in transit across the gate. It will absorb any totes/cartons that may have just released after the full condition triggered. The lift gate rollers will operate long enough to ensure enough time was given for the totes/cartons to run out into the downstream conveyor. The operator may lift the gate once the totes/cartons are clear.

Refer to Section 3.4.4 for a detailed description on the Lift Gate.

4.1.3 Empty Order Tote Inbound

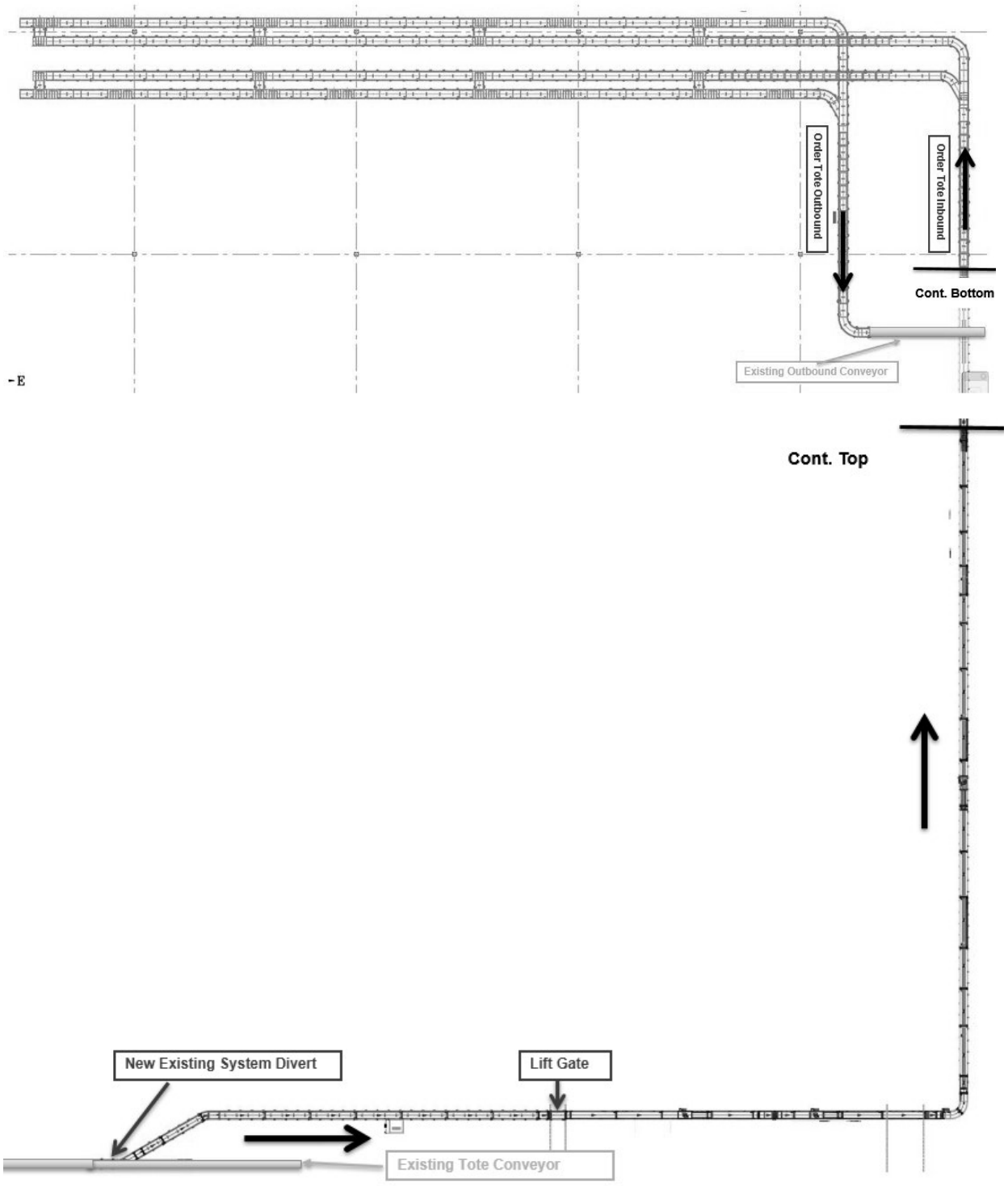


Figure 26 Order Tote Overview

New Divert on Existing System

A new divert, spur, and scanner will be installed on the Existing System line to replenish the Empty Order Tote Inbound. The installation and programming changes needed on the existing line will not be done by Daifuku.

The location of the divert shown in **Figure 27**. The instructions at the scan point determines to divert only BG Order Totes to the Empty Tote Inbound. A green operational beacon will place near the divert on the Daifuku takeaway conveyor to monitor the status between the External and Daifuku System at this point shown in **Table 6**.

Daifuku Empty Tote Inbound conveyor interlocks with Existing System divert line to allow empty totes to enter the system. Suggested interlocks for both the External System and Daifuku System is shown in **Table 10**. The *ReadytoDivert and OKtoFeed* manages the control flow between the two systems. *E-StopOK* interlocks the two safety systems, the *RESET* allows the reset of the safety system from each system. Interlock relays TBD.

Table 10 Empty Tote Inbound Interlocks

External ILK's	Description	Daifuku ILK's	Description
ReadytoDivert (Output to Daifuku)	External Outbound is ready to divert. (Control Flow)	**OKtoFeed** (Output to External)	Daifuku Outbound is ready to receive product. (Control Flow)
E-StopOK (Output to Daifuku)	E-Stop Zone Interlocks	**E-StopOK** (Output to External)	E-Stop Zone Interlocks
RESET (Output to Daifuku)	Reset for E-Stop Zone ILK	**RESET** (Output to External)	Reset for E-Stop Zone ILK

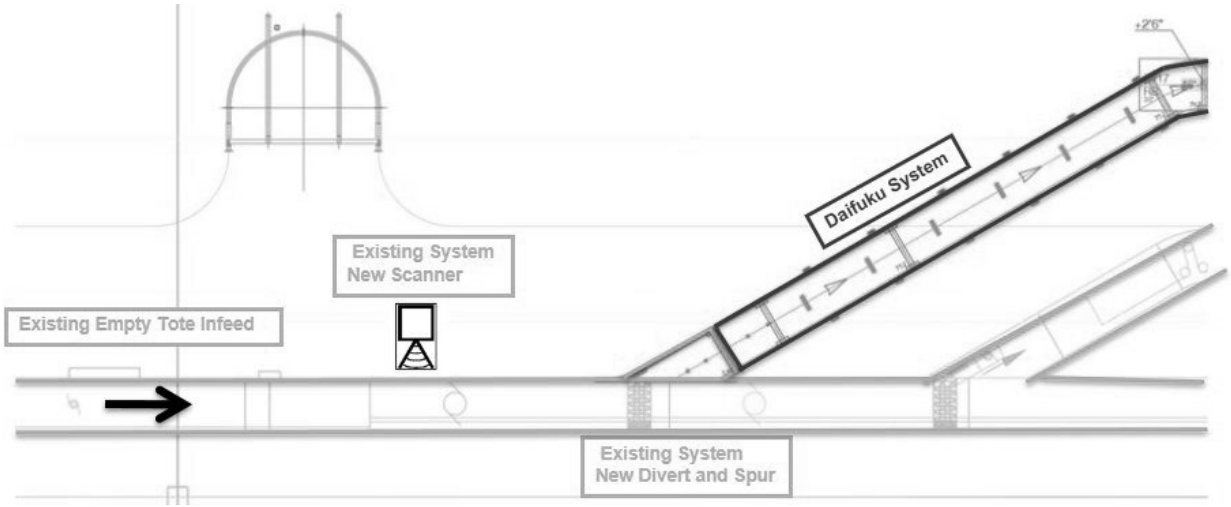


Figure 27 Empty Tote Inbound from New Divert and Spur in Existing System. Final design TBD.

The new installed Existing System Tote Divert in green can release totes/cartons and the Daifuku Empty Tote Inbound can receive totes/cartons shown in **Figure 17** if these ILK conditions are met:

- *E-StopOK* ILK both systems = true
- Daifuku *OktoFeed* = true

- Existing *ReadytoDivert* = true

If any condition goes false in **Figure 18**, the new Existing System Tote Divert in green is expected to stop releasing totes/cartons into the Empty Tote Inbound until all conditions are restored to true.

Lift Gate

After empty totes divert on the Empty Order Tote Inbound, the empty totes pass through a lift gate that provides operators access through the walking path. In general, empty totes are not expected to accumulate on the gate as shown in **Figure 28**. This allows operator access when the conveyor line is full and empty totes have accumulated. During the non-full non accumulating condition, the operator must choose an appropriate time to lift the gate when totes/cartons clear the gate mechanism and before the next box reaches the gate. Opening the gate is the same as issuing a stop command to system. The upstream empty totes will stop and accumulate before the gate and the MDR rollers in the gate will stop while it is in an open state.

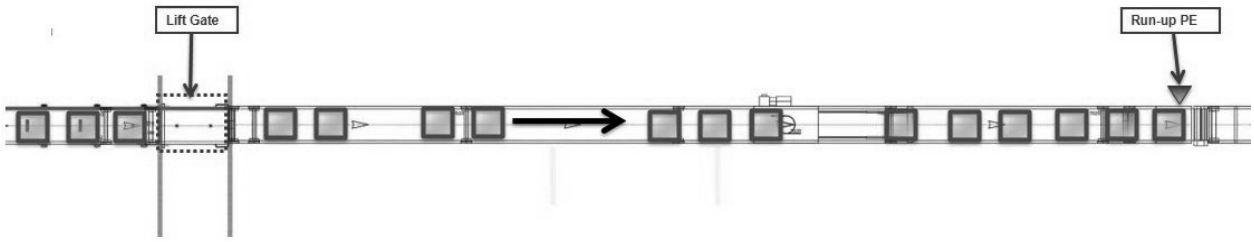


Figure 28 Empty Order Tote Inbound Lift Gate

The run condition of the belt conveyor downstream of the lift gate is the permissive condition to allow empty totes to release through and run the gate. When the belt conveyor run condition is false, empty totes upstream of the gate will stop and accumulate before the gate as expected. Because belt conveyor is not an accumulation type conveyor, the MDR zones on the gate must stop as well. There is opportunity for totes to be stopped on the gate section during these normal flow control conditions. The operator may need to wait until the system starts running again, and there is an opportunity to lift the gate when it is clear again. If the system is stopped for a prolonged period of time, the operator may need to slide the tote to belt conveyor before opening the gate.

Transportation

Empty Totes exiting the lift gate continue onto two sections of belt conveyor. At the end of each belt conveyor is a run-up photo-eye. When the downstream is not running, empty totes can continue running up to the end of the belt conveyor until the run-up photo-eye is blocked; the belt conveyor will then stop until the downstream is running again. The empty totes exit from the belt conveyor and turn 90 degrees through a v-belt curve.

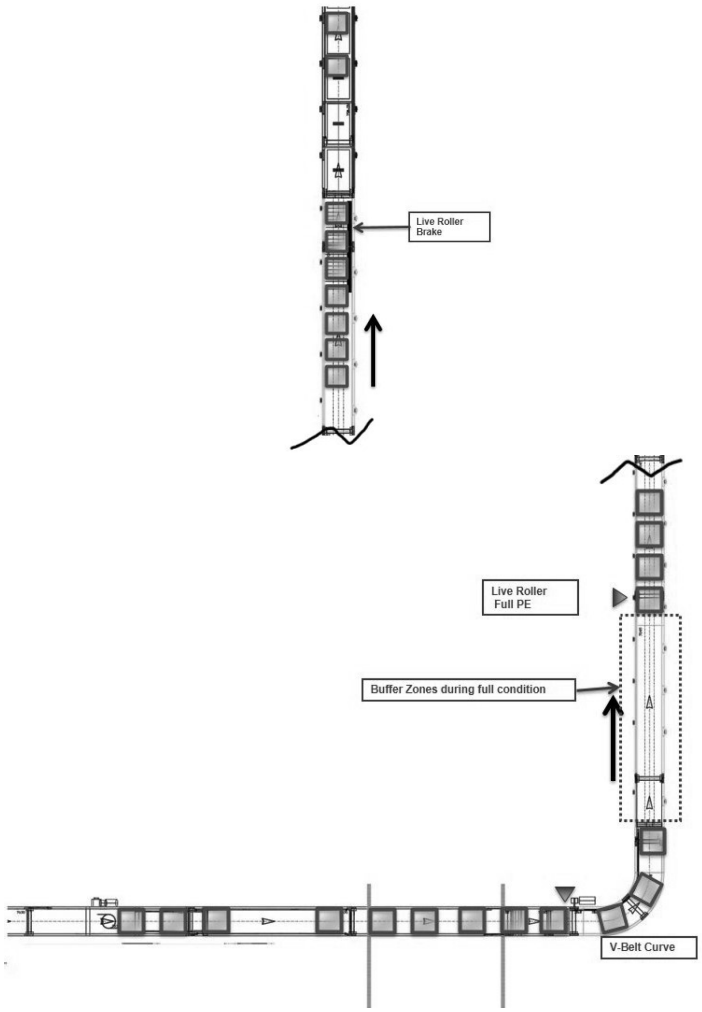


Figure 29 Empty Order Tote Transportation

The v-belt curve discharges onto the live roller accumulation. It is good practice to not accumulate on the v-belt curve. The live roller conveyor will have a photo-eye far enough downstream to detect the full condition early enough to stop empty totes at the belt conveyor before the v-belt curve and leave buffer zones for empty totes currently exiting the v-belt curve to accumulate on the live roller conveyor shown in **Figure 29** . At the exit of the live roller conveyor before discharging onto MDR conveyor, there is a live roller brake to regulate the control flow between the two conveyors.

The live roller brake is air operated and controlled through a solenoid by the PLC. When the downstream MDR is full, the brake will engage when the live roller zone photo-eye is blocked to stop empty totes and let them accumulate on the live roller conveyor until the downstream MDR is no longer full. The live roller brake can be pulsed to help create gap and better separation between empty totes providing better singulation onto the MDR zones if needed.

Round Robin Divert

Empty Totes exiting the live roller conveyor onto the MDR conveyor will arrive at a divert point with no scanner shown in **Figure 30** (A); the totes will route to the North and South Inbound Empty Order Tote inbound accumulation sections. Diverting will route empty totes to the South Order Tote Inbound and

continuing straight will route empty totes to the North Order Tote Inbound. If one of the two lanes is unable to receive totes for any reason, totes will default to the lane that is available to receive totes.

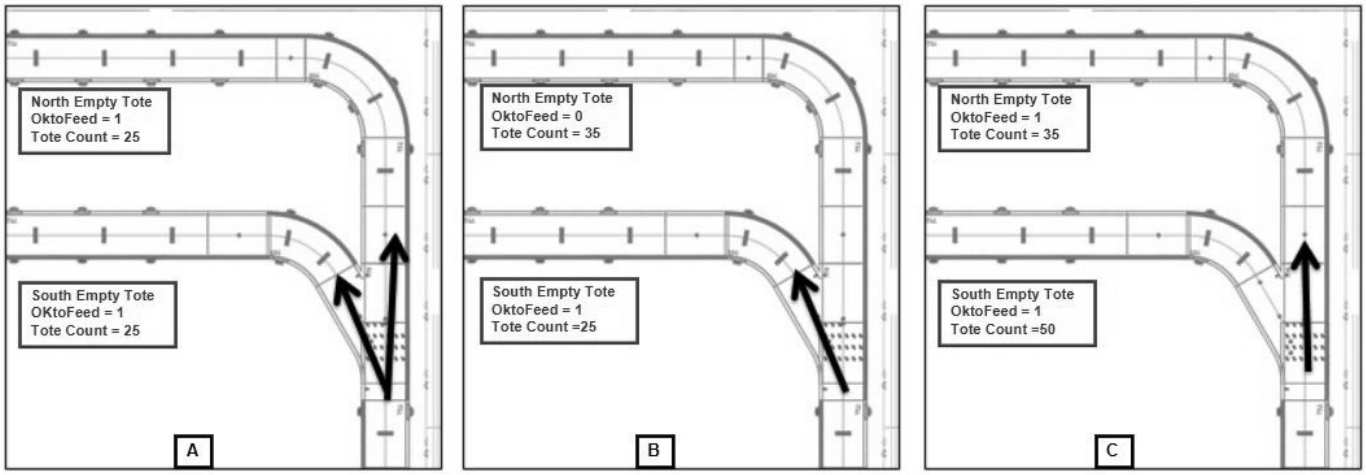


Figure 30 Round Robin Divert

The divert will equally distribute the empty totes to North and South Empty Tote Inbound accumulation conveyors round robin style and keep count how many empty totes the divert has sent to the North and the South Empty Tote Inbound Accumulation. If the North and South counts differ by more than 10 totes, the divert will prioritize the line with the lower count as the lane is "OktoFeed" cases. The North and South Total Tote Counts will renormalize and reset to 0 when Inbound Accumulation Line has not detected an empty tote in the North or Sout lines for 2mn.

- **Figure 30**(A) Normal Operation
    - North and South Lines OKtoFeed = true.
    - Tote Count between North and South Lines are less than 10 cases.
    - The Divert will round robin the totes between North and South Lines.
- **Figure 30**(B) Lane Not Available & Tote Count Threshold
    - North Line OktoFeed = false ; South Line OktoFeed = true.
    - Tote Count between North and South Line are at a 10 tote threshold. North has received 10 less totes than South.
    - Divert will continue to divert cases to South Line until the North Line OKtoFeed = true.
        - Once North Lane becomes available again, all cases divert North until North & South Tote Counts are equal again.
- **Figure 30**(C) Tote Count Threshold
    - North & South Line OktoFeed = true.
    - Tote Count between North and South Line are greater than 10 tote threshold.
    - Divert will divert cases to North Line until the North Count equals the South Count.

Inbound Right-Angle Transfers

The empty tote inbound accumulation line, for both North and South, will consist of four right-angle transfers on straight MDR conveyor; each will stage empty totes to feed one of the Berkshire Grey 4-SPAN induction conveyors. Location 1 indicates empty totes will stage on this interconnecting 1 zone MDR before the induct handshake between the PLC and BG determines which A or B wing induction of the 4-SPAN the empty tote is destined shown in **Figure 31**. The empty totes do not sit in the transfers, rather they are staged before and after the Inbound transfers. This allows the inbound transfer to remain open to c If all 4-SPANs wings are not available to receive totes or do not require totes, then the inbound will attempt to distribute and stage the incoming empty totes evenly as possible before the inbound right-angle transfers on the accumulation line. Otherwise, the empty totes will be distributed according to 4-SPAN need. As cartons transfer to the 4-SPAN on the shared empty tote inbound/outbound line, the empty totes on the accumulation line before the right-angle transfer will fill in the new empty space location 1. These staging positions are the same for both North and South lines of the empty tote inbound.

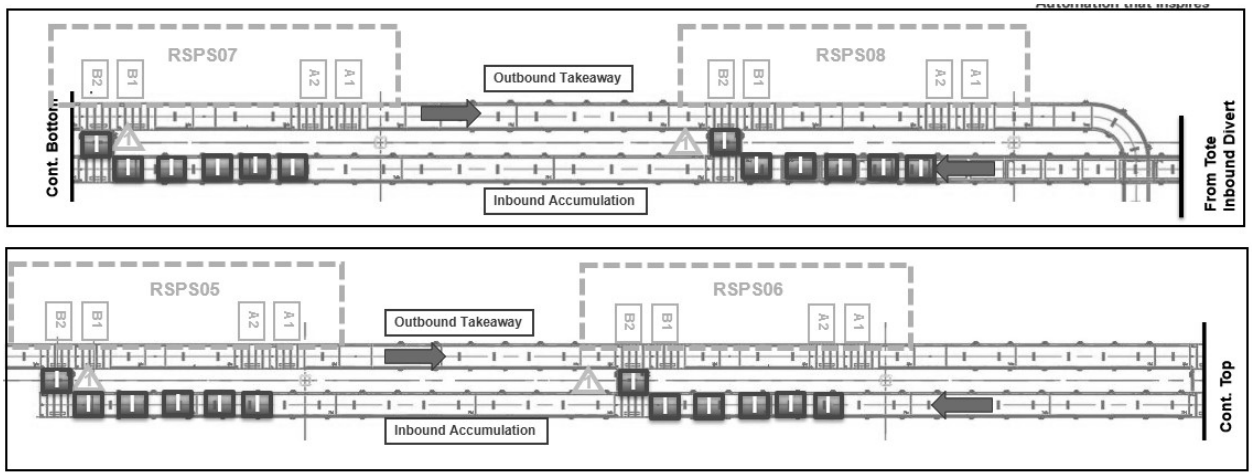


Figure 31 Staging positions of empty cartons on the empty carton inbound lines.

High level messaging here will take place like this referencing **Figure 32**:
The empty tote stages at the inbound induct zone at location 1 and generates a tracking sequence ID that cycles from 1 through 9 once blocking the zone photo-eye. Only valid empty inbound totes will have a sequence ID in this range; any other tote in the tracking zone(s) will have sequence IDs outside this range indicate they are meant for pass through to the outbound. Berkshire Grey sends “Box Needed” (aInductAvailable=1) which can be present at more than one 4-SPAN Induct between the A and B Wings induct points. Daifuku will open the handshake with request a “Start Induct” to the 4-SPAN induct with a ‘Box Needed” having the highest “aInductSlotsAvailable”. In this example, AR1 In above Zone 7 has “Box Needed” and highest “aInductSlotsAvailable”. Daifuku would request “Start Induct” for this 4-SPAN induct location first and re-evaluate each subsequent handshake.

Berkshire Grey responds with “Induct Ready;” this means Berkshire Grey will be ready to accept the empty tote from the right-angle transfer as soon as it arrives. Once induct ready is indicated, Daifuku stops the upstream Outbound Induct Zone long enough for Zone 1 to be clear and transfer the empty tote from the Inbound Induct Zone into the outbound takeaway at Zone 1. The empty tote will travel along the tracking zones to the Zone 7 right-angle transfer. Daifuku transfers the empty tote as soon as it arrives and sends a “Complete” it is clear from the right-angle transfer. Once Berkshire Grey has successfully accepted the box, they send a “Complete” which is expected immediately after Daifuku

"Complete" signal. This will indicate the handshake for this inbound tote completed or closed. Refer to Section 5.1.4 Empty Order Tote Outbound for detailed description of the Tote Index handshake.

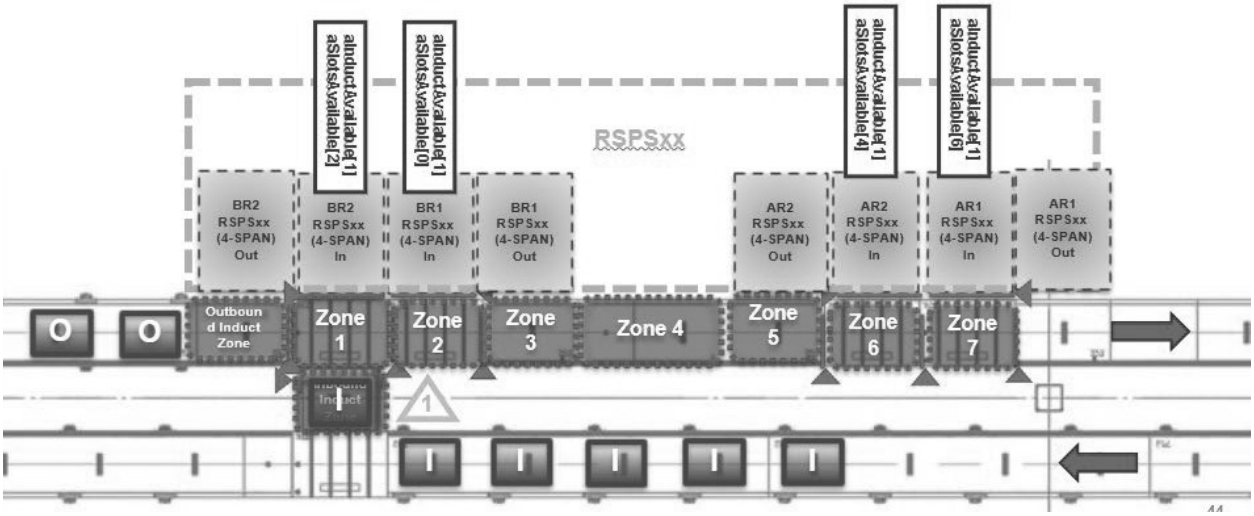


Figure 32 Empty Tote Inbound Operation.

Because the empty tote inbound is sharing some of its functionality on the same line as the completed order tote outbound takeaway, it is imperative to keep the outbound takeaway line clear as possible. The 2 sets of paired right-angle transfers with the MDR conveyor connecting in-between at each 4-SPAN will have tracking to differentiate between completed and empty order totes indicated in red zones above. Inbound totes will not enter the outbound takeaway unless it has a valid handshake open with a valid destination as described above.

Inbound totes will have priority to transfer onto the outbound takeaway once a valid handshake is open for them meaning the Outbound Induct Zone will be stopped or halted as soon as possible. The Outbound Induct Zone will be allowed to release again once the inbound tote has transferred onto the outbound takeaway line as long as another empty tote with a valid handshake is not ready to transfer over to the outbound takeaway after the initial empty tote. In addition, outbound totes wanting to merge from Zones 3 and 5 4-SPAN outbound will also not be permitted to merge when an inbound tote is detected in the upstream zone from it. Outbound totes can induct from upstream or from the 4-SPAN while empty totes induct as long as the downstream outbound conveyor from the 4-SPAN is able to receive the completed order outbound totes. Outbound Totes can temporarily accumulate in the Outbound Induct or Zones 1 through 6 if waiting for an empty tote to induct into the 4-SPAN and the outbound downstream conveyor is able to receive the outbound totes.

In the event any abnormalities occur after the start of the tote induction process, the inducted tote(s) that experience the abnormality in a tracked zone where the tracking is lost will be treated as an outbound tote(s) and sent straight through the system to the outbound when a reset is initiated. These abnormalities could include as power loss, jams, manual handling/pushing totes/placing totes in the induction zone, etc. If the abnormality occurs in a right-angle transfer, best recovery method is to completely clear the tote from the affected right-angle transfer before initiating a reset.

Inbound Right-Angle Transfers and Tracking Zone(s) Recovery

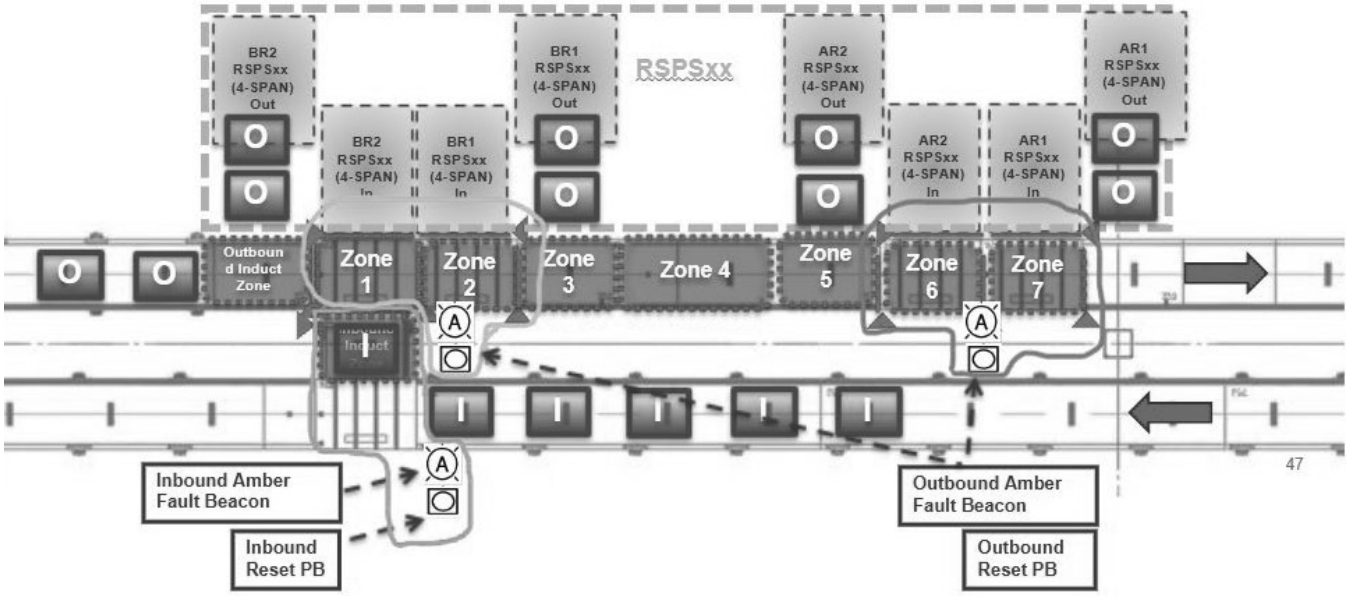


Figure 33 Empty Tote Inbound RAT and Tracking Recovery.

Each RAT or RAT pair in the 4-SPAN will have a local amber beacon and reset pushbutton station. These devices help operators to identify, correct and recover from conditions outside normal operating states aside from the HMI help screens. The amber beacon and reset pushbuttons shown above in **Figure 33** circle the local reset area for their respective RAT(s). When operating the reset, the operator will need to hit the correct reset pushbutton for the RAT he or she is recovering. Common recovery Identification and procedures below:

- RAT Jam
  - Cause:
    - A tote was unable to enter or exit the RAT successfully and has blocked a photo-eye for "x" amount of time indicating a jam has occurred in the RAT.
    - Photo-eye(s) could be misaligned.
  - Identification:
    - The RAT will halt its current process.
    - Tote will be blocking a set of photo-eyes.
    - The Amber beacon light will standard pulse .5s ON / .5s OFF
    - For misaligned photo-eyes, the photo-eye will only be showing a greenlight on the back instead of a green and amber light to indicate it is seeing the reflector.
  - Remedy:
    - Operator identities the RAT or RAT pair by the Amber Beacon Light flashing.
    - Remove the tote from the RAT.
      - If the tote is an empty inbound tote, it can be placed back onto the inbound accumulation line to be re-inducted again. Any current handshake messaging associated with the tote will be cancelled.
      - If the tote is a completed order tote, it can be moved downstream to a tracked zone. The tracked zone will assign the unexpected tote as an outbound tote.
  - Recovery

        - Once tote is removed and photo-eyes are unblocked, the amber beacon will stop flashing and go solid.
        - Press the reset pushbutton once to reset the jam condition clear.
        - The amber beacon will turn off after reset and the jam condition is still clear.
- "Ghost" or false Tote or inoperable state in RAT
    - Cause:
        - Wrong recovery from previous issue, missed flagged photo-eyes, photo-eye become unaligned, etc can cause a false or ghost tote to be seen in the RAT. The RAT registers a tote has entered the RAT when no tote is actually present.
    - Identification:
        - RAT processes will halt, and the upstream totes will accumulate in front of the RAT and not be able to enter the RAT.
        - Amber beacon will double pulse to indicate "ghost" tote in the RAT or RAT pair.
    - Recovery
        - Hold the reset pushbutton down for 5 seconds to clear out the tracking information for the RAT which clears the "ghost" tote information.
- Tracking Zone(s) Jam
    - Cause:
        - A tote releasing from a tracking zone(s) blocked the current zone photo-eye for "x" amount of time indicating the tote is jammed.
    - Identification:
        - Outbound Amber beacon will standard flash .5s ON / .5s OFF
        - Tote may be between two zones and could be visually identified.
    - Recovery:
        - If Completed Outbound Tote, then reposition tote back fully into one MDR Zone.
        - If the tote is an empty inbound tote, it can be placed back onto the inbound accumulation line to be re-inducted again. Any current handshake messaging associated with the tote will be cancelled.
        - Press reset pushbutton to clear jam.

4.1.4 Completed Order Tote Outbound (Box Merge)

Completed Order Tote Outbound is a shared line with the empty tote inbound that can receive the completed order totes from the 4-SPAN conveyor and empty totes to the 4-SPAN conveyor. The 2 sets of paired right-angle transfers with the MDR conveyor connecting in-between at each 4-SPAN will have tracking to differentiate between completed and empty order totes as described in the previous section. Completed Order Totes received on the outbound takeaway conveyor will be transported away from the 4-SPAN area and arrive at a 2-to-1 merge point where North and South Completed Order Empty Tote Outbound lines merge onto a single outbound takeaway conveyor. Refer to the standard 2 to 1 merge description in Section 3.5.5 Merges. Then the totes continue until exiting the system onto the existing external conveyor. The outbound path through a single 4-SPAN is shown in **Figure 34** and is expanded upon further in this section. The Daifuku conveyor interlocks with the existing external conveyor line. The label "Box" in this system means tote.

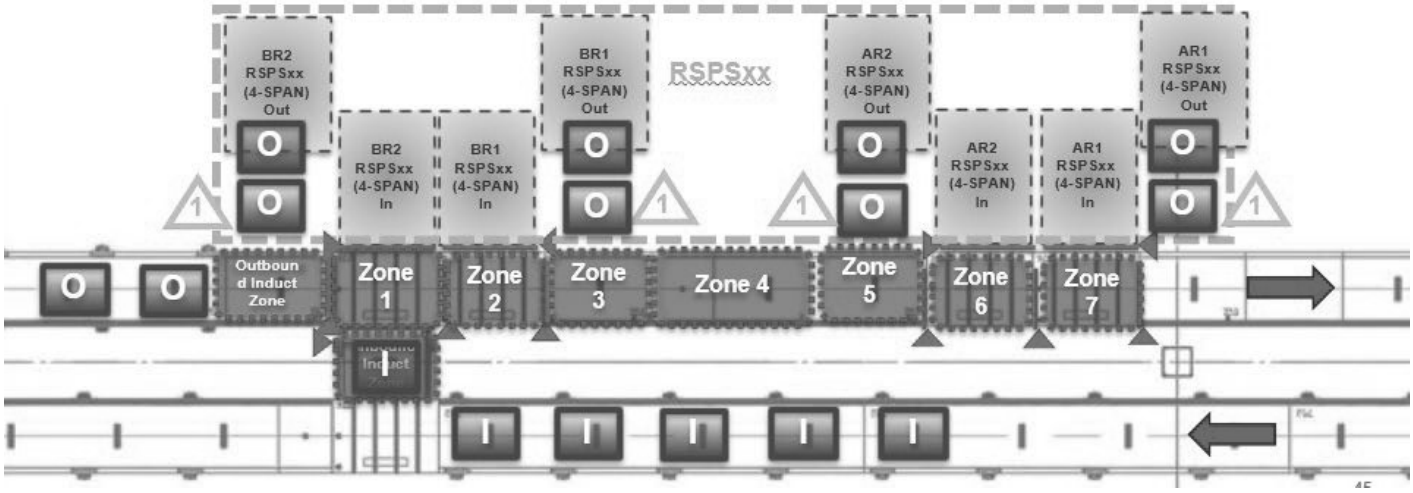


Figure 34 Flow of cartons through Order Tote Outbound Area

High level messaging process is as follows referencing **Figure 34**:

Berkshire Grey sends “Box Waiting” and “Boxes Available” indicating they have a completed order tote(s) at one or multiple location 1’s ready to discharge from the 4-SPAN Outbound and opening the Box Merge Handshakes. Daifuku will determine if there is an open window gap at the Outbound with the highest “Boxes Available” for the merge to occur by monitoring if the upstream zone is clear, no inbound totes are entering the upstream zone, the merge discharge zone is clear and downstream accumulation is not full. If all clear, Daifuku stops the release of the upstream zone before sending “Zone Ready”. Berkshire Grey sends a “Discharge Complete” when tote is successfully discharged from 4-SPAN system. Daifuku will generate a sequence ID outside the range 1 through 9 to indicate an outbound tote when it detects the tote with the MDR discharge zone photo-eye. Daifuku then sends “Discharge Complete” once the merge to conveyor has happened successfully and closes the handshake. This process applies to each 4-SPAN outbound merge point.

For example:

Berkshire Grey sends a “Box Waiting” and “Boxes Available” is the largest for the outbound tote in the BR1 4-SPAN above Zone 5. Daifuku would first check to see if Zone 4 contained an incoming Inbound Tote by looking for a valid sequence ID 1 through 9. An inbound tote present traveling into Zone 4 would mean Daifuku allows the inbound tote to pass through to its destination first. If no inbound tote is in Zone 4, then the discharge Zone 5 will be checked to be clear and the downstream accumulation after the 4-SPAN station is not full. When all parameters are met, Daifuku stops the release of the Zone 4 and sends “Zone Ready”. BG discharges the outbound tote onto outbound takeaway conveyor and sends “Discharge Complete” when finished. Daifuku detects the discharge outbound tote by running the discharge zone to index the outbound tote to the Zone 5 MDR zone photo-eye. Once detected, Daifuku generates a sequence ID outside of the empty tote range of 1 through 9 to indicate an outbound tote and sends “Discharge Complete”. Daifuku re-enables the release Zone 4 and Zone 5.

Once the completed order totes have released to Daifuku conveyor. The outbound totes travel downstream to the merge point. In the event any abnormalities in the tracking sections of the 4-SPAN outbound, the totes that experienced the abnormality will be treated as an outbound completed order tote and sent straight through the system to the outbound when a reset is initiated. These abnormalities could include as power loss, jams, manual handling/pushing totes/placing totes in the induction zone, etc. If the abnormality occurs in a right-angle transfer, best recovery method is to completely clear the

tote from the affected right-angle transfer before initiating a reset. Refer to Section 5.1.4 Completed Order Tote Outbound for detailed description of the Tote Index handshake.

The completed order totes merge onto a single takeaway conveyor until it exits to the existing external outbound. Daifuku outbound conveyor interlocks with the Existing System outbound to allow donor totes/cartons to exit the system. Suggested interlocks for both the External System and Daifuku System is shown in **Table 9**. The *ReadytoRelease and OKtoFeed* manages the control flow between the two systems. *E-StopOK* interlocks the two safety systems, the *RESET* allows the reset of the safety system from each system. Interlock Relays TBD.

Table 11 Empty Tote Outbound Interlocks

External ILK's	Description	Daifuku ILK's	Description
OKtoFeed (Output to Daifuku)	External Outbound is ready to receive product. (Control Flow)	**ReadytoRelease** (Output to External)	Daifuku Outbound is ready to release. (Control Flow)
E-StopOK (Output to Daifuku)	E-Stop Zone Interlocks	**E-StopOK** (Output to External)	E-Stop Zone Interlocks
RESET (Output to Daifuku)	Reset for E-Stop Zone ILK	**RESET** (Output to External)	Reset for E-Stop Zone ILK

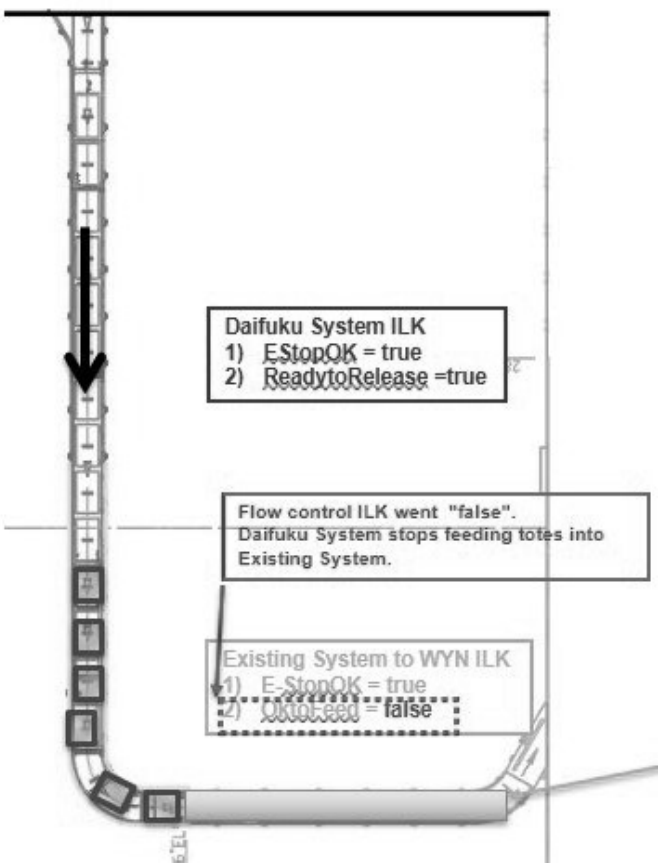


Figure 35 Empty Tote Outbound Interlocks

The Completed Order Tote Outbound can release totes/cartons and the Existing System Outbound can receive totes/cartons shown in **Figure 35** if these ILK conditions are met:

- *E-StopOK* ILK both systems = true
- Daifuku *ReadytoRelease* = true
- Existing *OktoFeed* = true

When any of the control flow conditions go "false", the Completed Order Tote Outbound will stop feeding the Existing System Outbound and totes are expected to stop on the last Daifuku MDR Zone before Existing System begins.

4.1.5 Scanner Details

Scanners for this project are Cognex equipment. Each scanner is 1-sided and positioned on the left-hand side of the conveyor. Each scanner communicates the barcode to the Daifuku PLC through ethernet connection. The barcode information is communicated from the Daifuku PLC to Berkshire Grey, and they give the destination instruction. Refer to Section 5.1.4 Scanner for Barcode Decision detail. Destinations based on barcode are not decided by Daifuku, and Daifuku does not provide barcode statistics or history. The scanners are powered by 120V outlets provided by new facility installed outlets. These outlets are located on the highway loops and are extended to reach the scanner locations. The scanners are connected to Daifuku local network, not Berkshire Grey corporate network.

Locations

Figure 36 and **Figure 37** shown below illuminate the locations of the scanners in the system.

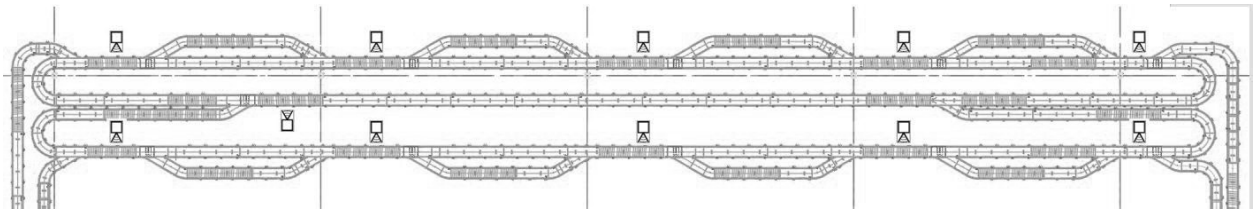


Figure 36 North & South Donor Tote /Cartoon Loop scanners, and Recirc Scanner

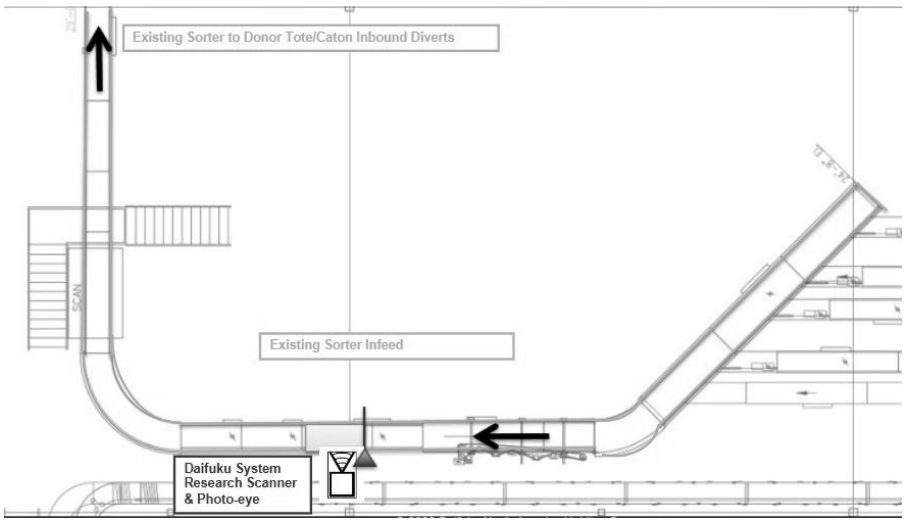


Figure 37 Donor Tote /Cartoon Loop Research scanners on existing sorter induct.

Scan Points

This section is a summary of the general process flow at each scan point in the Donor Tote/Carton Inbound shown in **Figure 38**. The Empty Tote Divert Scanner is not provided by Daifuku.

The Research Scanner on the existing system Sorter Induct Belt will consist of the scanner and scanner trigger photo-eye. It will be mounted at the 7' section of belt downstream of the merge highlighted green in **Figure 37** on the existing sorter induct. When a tote/carton blocks the scanner trigger photo-eye, the scanner reads the tote/carton barcode and sends it to the Daifuku PLC. Refer to 5.1.4 Functionality Details section Donor Tote Inbound & Outbound for the Barcode Decision Request process.

In the Donor Tote/Carton Inbound, a Tote/Carton entering the Induct Zone blocks the induct photo-eye to generate a tracking sequence ID assigned to that tote/carton. The sequence ID assigned to the tote/carton will have pertinent updatable information containing barcodes and decision-making information such as decision request, decision assignment, decision confirmation, and reason codes used throughout the scanning and diverting sequence. The sequence ID is tracked with the tote/carton as it moves through the scan point process.

As the tote/carton enters the Scan Zone next, the scanner photo-eye is blocked triggering the scanner to read the barcode on the tote/carton. The barcode information read is expected to be transmitted to the PLC within the time the tote/carton reaches the scan zone photo eye at the exit end of the zone. The new barcode received will trigger the decision request bar code decision handshake with BG. The barcode decision handshakes are described in section 5.1.4 Donor Tote Inbound & Outbound Scanner.

If no barcode data is received within a determined amount of time, the tote/carton is assigned no barcode data and sent to the wait zone. 500ms will be the default time-out but can be adjusted high/lower to match system performance during testing. The PLC expects the decision assignment from BG within the time the tote/carton leaves the scan zone until the tote/carton blocks the wait zone photo-eye. If no decision assignment is confirmed within a determined amount of time, the tote/carton is assigned to continue straight. 750ms will be the default timeout but can be adjusted higher/lower to match system performance during testing.

At the divert, the tote/carton will either divert or continue straight according to the decision assignment associated with its sequence ID. The decision confirmation will be triggered by a photo-eyed blocked downstream or timer based to confirm the direction the tote/carton traveled along with applicable reason codes.

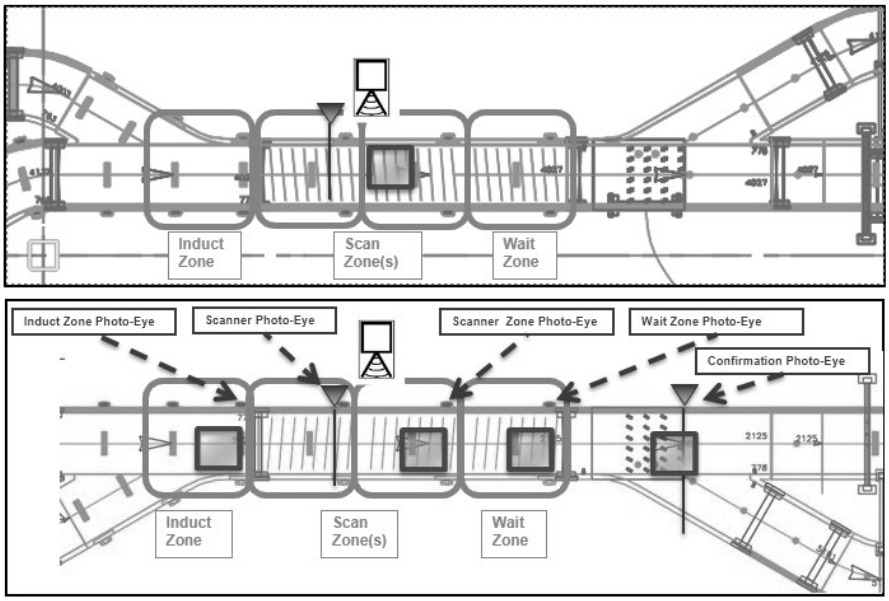


Figure 38 Scanning Operation and stage example. North Loop Top & South Loop Bottom as example.

In the event any abnormalities occur after the induction zone that interrupts the tracking of the sequence IDs of totes/carton in this process, the totes with loss or no sequence id associated with them will be treated as an unknown case and sent straight through the system. These abnormalities could include as power loss, jams, manual handling/pushing boxes in the zone, etc.

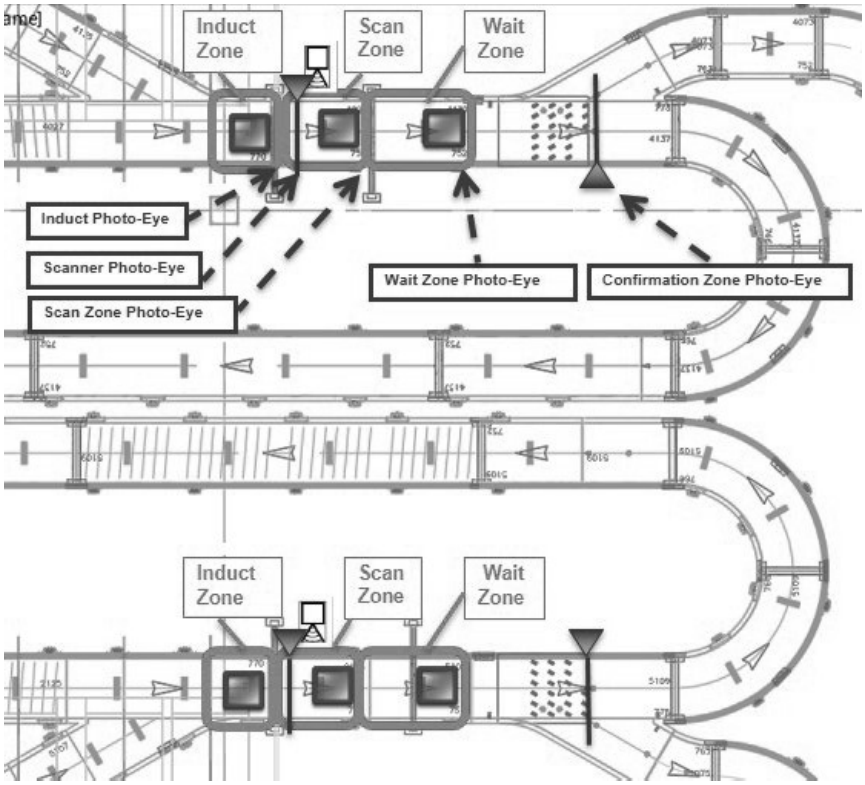


Figure 39 Scanning Operation North and South Donor Tote/Carton Outbound shown as example.

Figure 39 Is an example how the scan zone is reduced to 1 MDR Zone due to space and installation restrictions. This occurs in both the North & South Donor Tote/Carton Outbound. The process remains the same. Tote/Cartons exiting the merge will block the Induct Zone photo-eye generating a sequenceID assigned to the tote/carton. As the tote/carton enters the Scan Zone, it will block the Scanner Trigger photo-eye triggering the scanner to read the barcode information within 1 MDR Zone. The rest of the Scan Zone and Wait Zone processes are as described above.

5.0 Appendix

This section contains various additional documents, notes, and detail items helpful to the project.

5.1.1 Supporting Documents

The supporting documents mentioned throughout is referenced from the “Berkshire Grey Interface Specifications Reference Documents V-23.4”.

5.1.2 E-Stop Zoning

Below, in **Figure 40**, **Figure 41**, **Figure 42** and is an outline of the E-Stop zones. **Table 12** is the E-Stop Zone Key. Zone boundaries may overlap based on actual footprint of MDR circuits. E-Stop Devices stop at the end of Daifuku Conveyor at the transition point where Daifuku Conveyor Interlocks with Existing System Conveyor.

Table 12 E-Stop Zone Key

E-Stop Zone	Color	Area
Zone 1	PURPLE	Existing Sorter Downline 8 to Donor Tote/Carton North Loop Highways
Zone 2	RED	Existing Sorter Downline 9 to Donor Tote/Carton South Loop Highways
Zone 3	GREEN	Donor Tote/Carton North Loop Highways Empty Order Tote North Inbound
Zone 4	BLUE	Donor Tote/Carton South Loop Highways & Recirc Empty Order Tote South Inbound
Zone 5	ORANGE	Donor Tote/Carton Outbound Completed Order Tote Outbound
Zone 6	TAN	Empty Order Tote Inbound Transportation Area
Zone 7	PINK	Empty Order Tote Divert Takeaway
Zone 8	YELLOW	Empty Order Tote Divert
Zone 9	BROWN	Donor Tote/Carton Recirculation

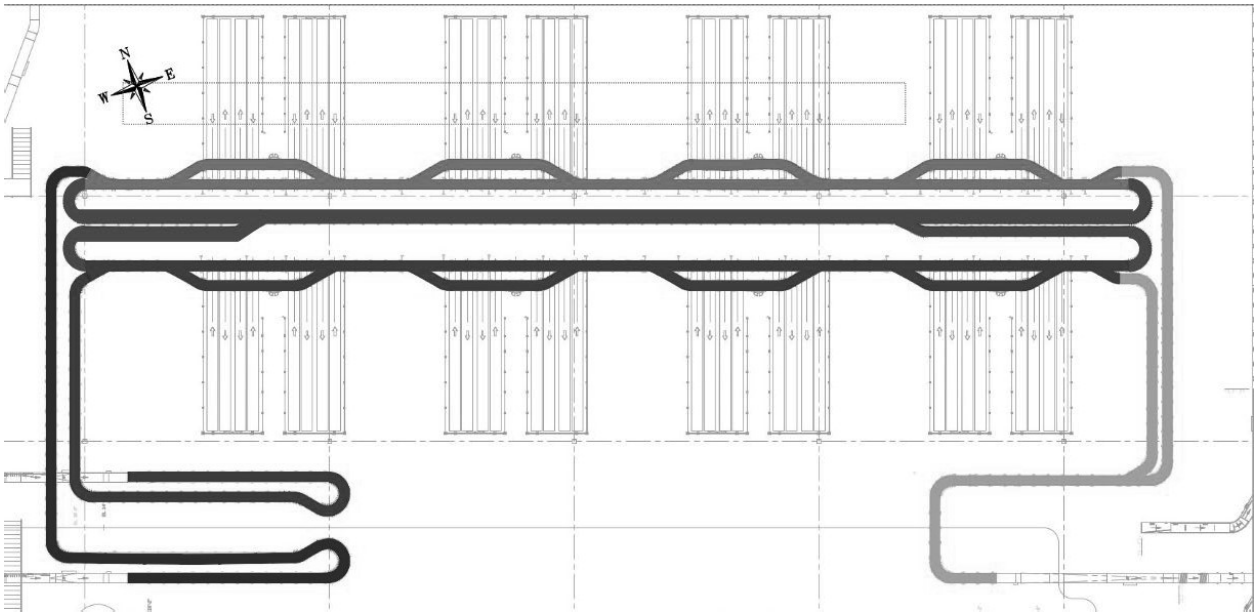


Figure 40 E-Stop Zones Donor Tote/Carton outline

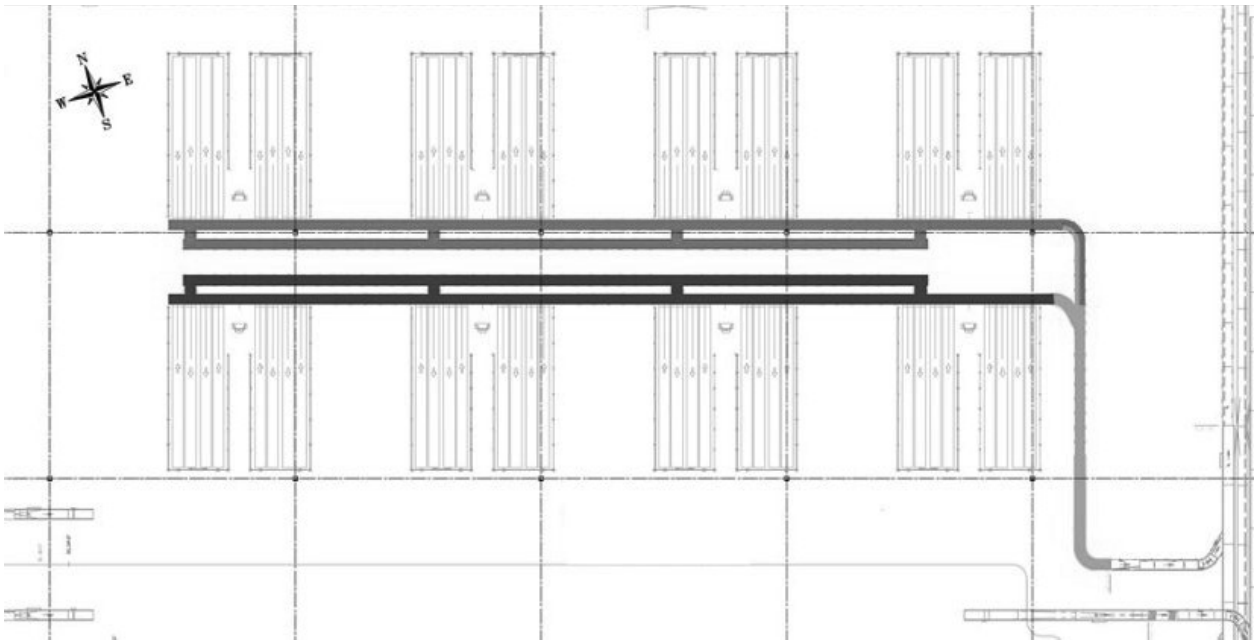


Figure 41 E-Stop Zones Empty Order Tote outline

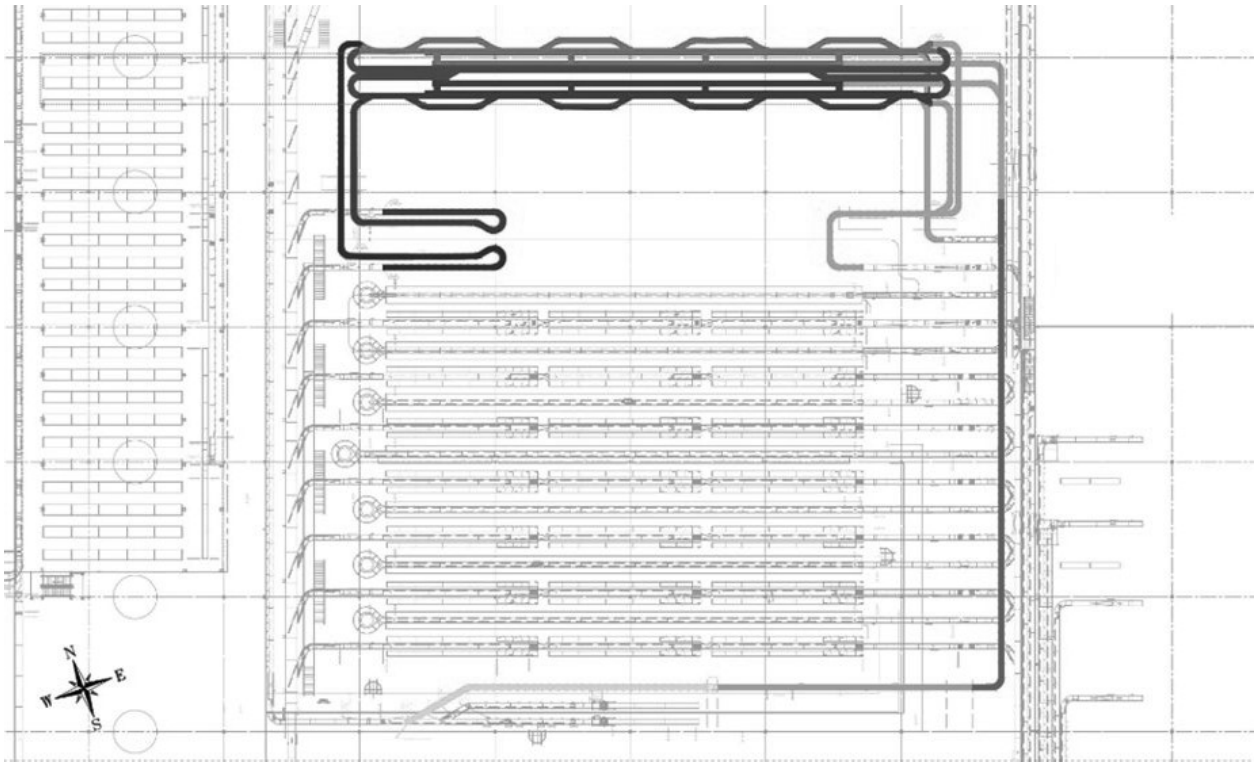


Figure 42 E-Stop Zones Empty Order Tote Inbound

5.1.3 HMI

The HMI consists of an Allen-Bradley 10” PanelView Plus 7 unit named HMI-01. It is powered by a 24VDC power supply. The HMI included is in pages HMI01-01 to HMI01-97 of the Conveyor System drawing set. The purpose of this device is to provide an interface which helps operators and maintenance staff to understand and observe the state of the conveyor system. The Graphics and Alarms included in the unit allow the user to become informed with any items which may require attention or corrective action.

The HMI will be mounted on a stationary pedestal at the location shown in **Figure 43**.

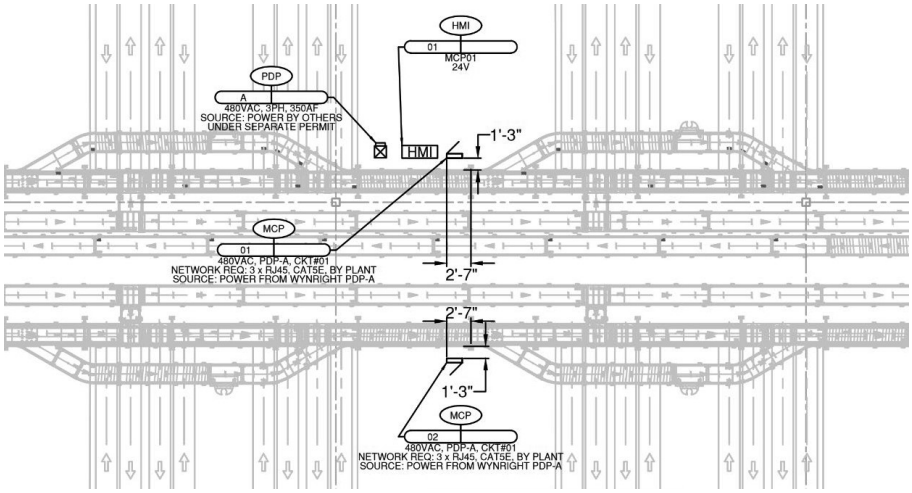


Figure 43 HMI location

Functionality

The HMI will include conveyance mapping, status indication, and alarms. The status indicators and alarms include, jams, lane full, E-Stops, etc. There will not be any speed control capabilities.

Features

The following statement contains features described in the original agreed upon Description of Operations:

“The HMI will include conveyance mapping, status indication, and alarms. The status indicators and alarms include, jams, lane full, E-Stops, etc. There will not be any speed control capabilities.”

The following features will be included with the HMI Unit:

*Note: All HMI Displays shown in this document are from a programmatic informational view, not a connected, running version of the program. Final displays to be updated with actual system information and graphics.

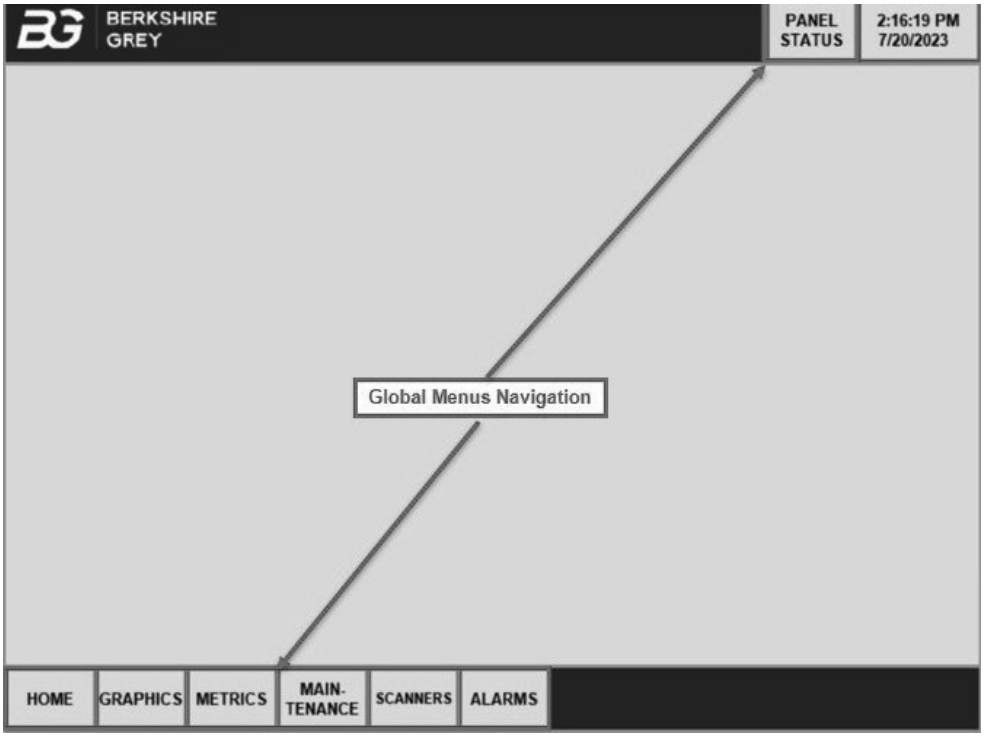


Figure 44 HMI Global Header and Footer

- GLOBAL Header and Footer (**Figure 44**)
    - The overall global object allows operator navigation between the Global Menus and Displays of the HMI.
    - Shows Date and Time

Figure 45 HMI HOME Screen

- HOME Menu (**Figure 45**)
    - HOME screen displays upon start-up of the HMI and is the home base for the HMI Program.
    - Displays Date and Time upper right-hand corner.
    - CONFIGURATION MODE
        - Allows operator access to the overall HMI menu outside of the BG HMI program.
        - Here the operator can switch HMI programs (if applicable), change the HMI device IP, adjust date/time settings, etc.
    - SHUTDOWN DISPLAY
        - Allows the operator to shut down the HMI display.

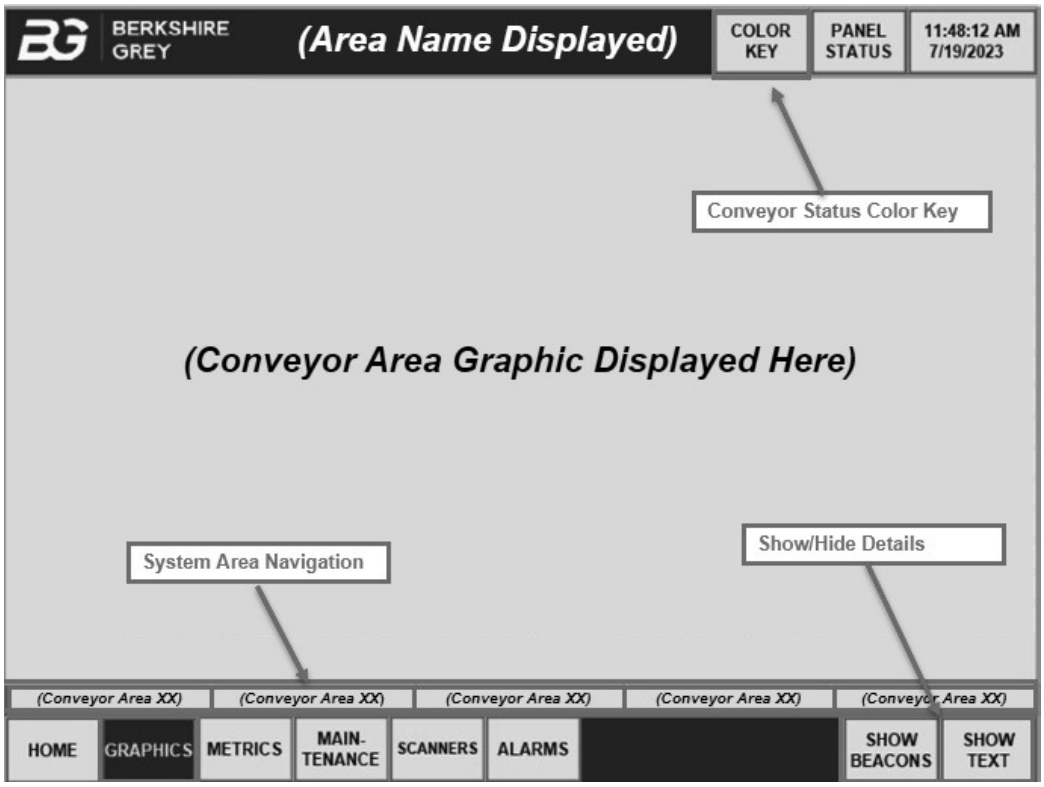


Figure 46 HMI Graphics Screen

- GRAPHICS Menu (**Figure 46**)
    - A default System area will open and graphically display when selecting the Graphics Menu.
    - System Area Navigation
        - Along the bottom of the display the graphic screen navigation tabs allow seamless switching between the different areas of the system.
        - Amplified section zone views for greater detail available
        - Conveyor grouping sections with device numbering.

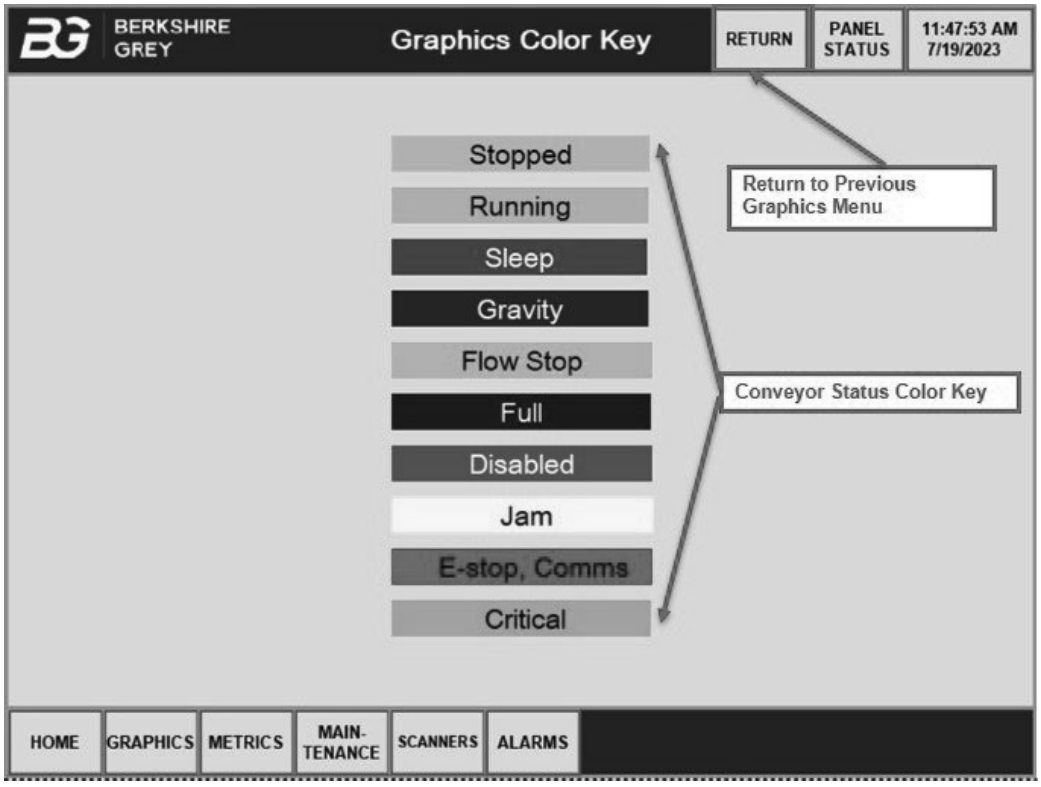


Figure 47 HMI Conveyor Status Color Key Screen

- Conveyor status COLOR KEY (**Figure 47**)
  - Located on the top right corner of the Graphics screen.
  - The color key indicates the conveyor statuses shown in the System Area graphics.
  - RETURN button replaces COLOR KEY button to allow navigation back to the previous graphics screen.

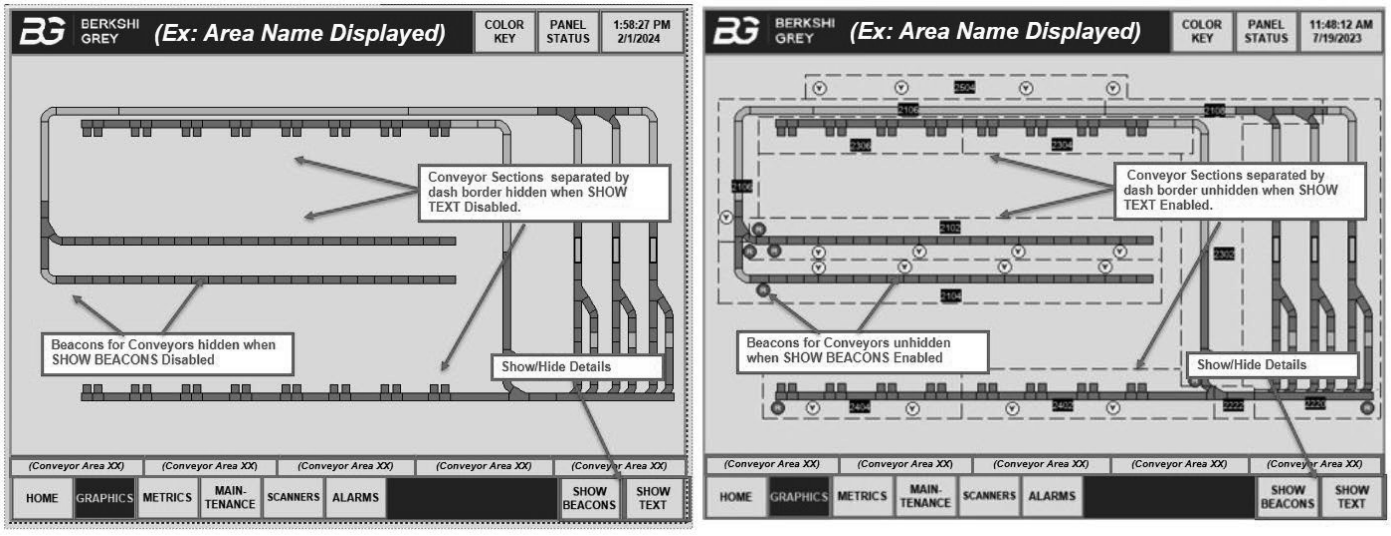


Figure 48 HMI SHOW/HIDE Details: HIDE (Left) & SHOW (Right)

- Show/Hide Details (**Figure 48**)
    - Bottom right-hand corner of the Graphics Screen is SHOW BEACONS and SHOW TEXT buttons. Enabling either feature will remain enabled even when navigating to a new System Area screen. Disabling either feature will remain hidden when navigating to a new System Area Screen
    - SHOW BEACONS
        - Enabling this feature shows the beacons (RED, AMBER, GREEN, BLUE) and illuminate according to their current operational state on the GRAPHICS Screen for the System Area currently displayed.
    - SHOW TEST
        - Enabling this feature shows the Conveyor Sections and Section Devices using a dashed line as the border.

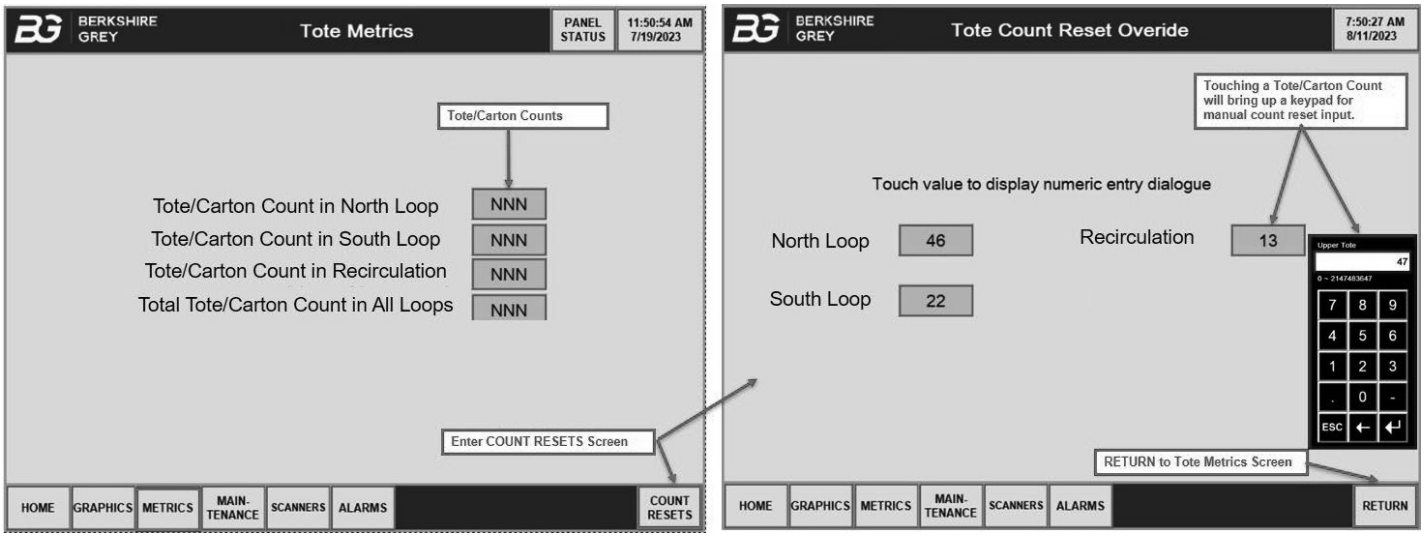


Figure 49 HMI Tote Metrics Screens: METRICS (Left) & COUNT RESET (Right)

- METRICS Menu (**Figure 49**)
    - Tote Metrics Screen Display the number of totes/cartons in the Donor Tote/Carton Highway Loop part of the system. It displays the tote/carton counts for the individual North, South and Recirculation areas as well as the total in entire area.
    - COUNT RESET
        - In the Tote Count Reset Override screen, Operators are allowed to manually change/correct/amend tote/carton counts by tapping on the count value. A Keypad will popup.
        - Press ESC to exit without making any changes to the count.
        - Press the numbers on the Keypad to desire count and press ENTER ↵ to accept new input value.
    - RETURN

- Return to Tote Metrics Screen

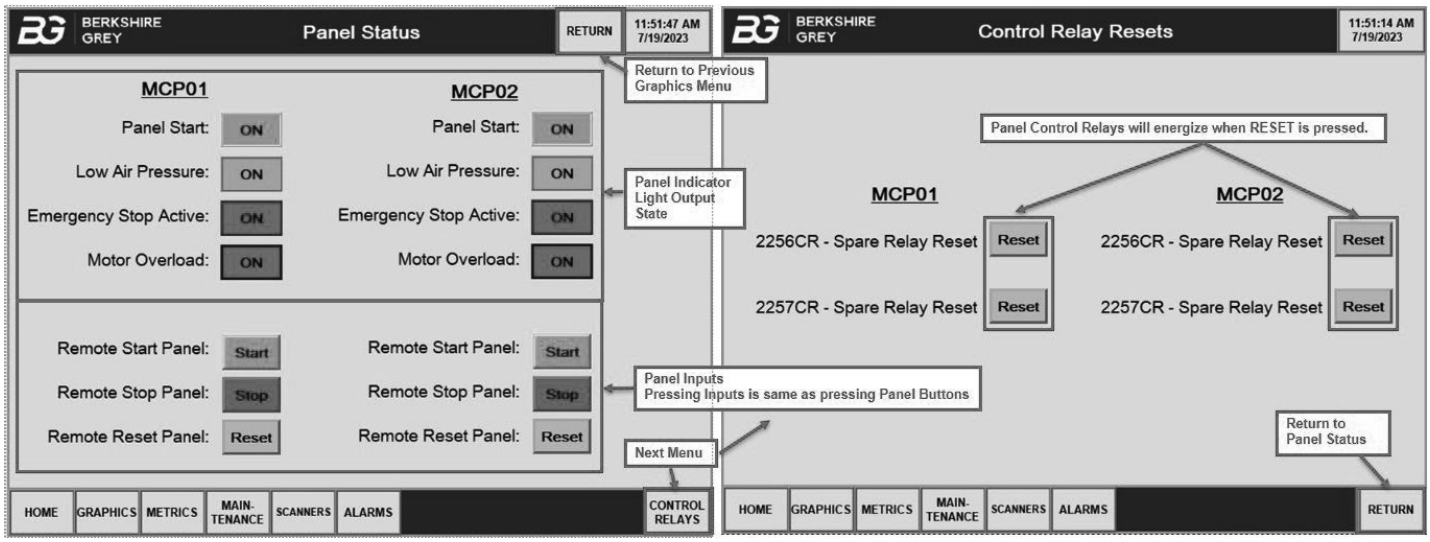


Figure 50 HMI Panel Status Screens: PANEL STATUS (Left) & CONTROL RELAYS (Right)

- Panel Status
  - Panel Inputs
    - Start function of each panel
    - Stop function of each panel
    - Reset function of each panel
  - Ability to view Panel Indicator Lights
    - Panel Start
    - Low Air Pressure
    - Emergency Active
    - Motor Overload
  - CONTROL RELAYS
    - Ability to Trigger Control Relays (CRs included w/ panels for future additions)

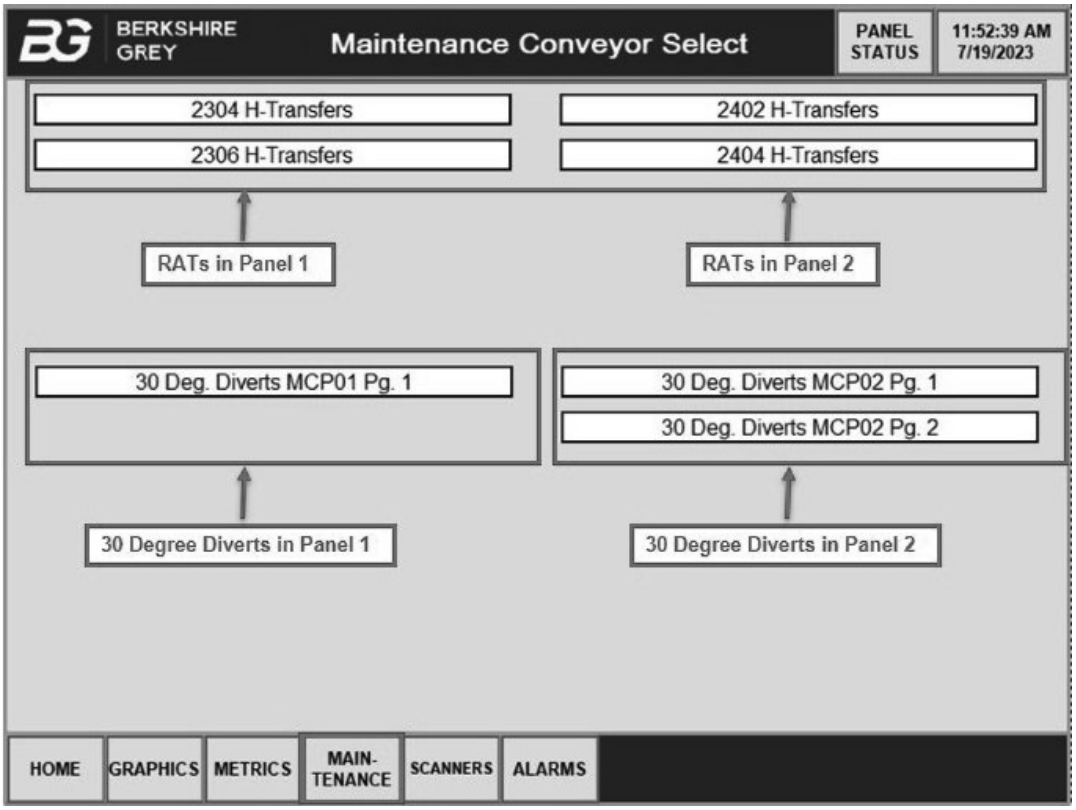


Figure 51 HMI MAINTENANCE Screen

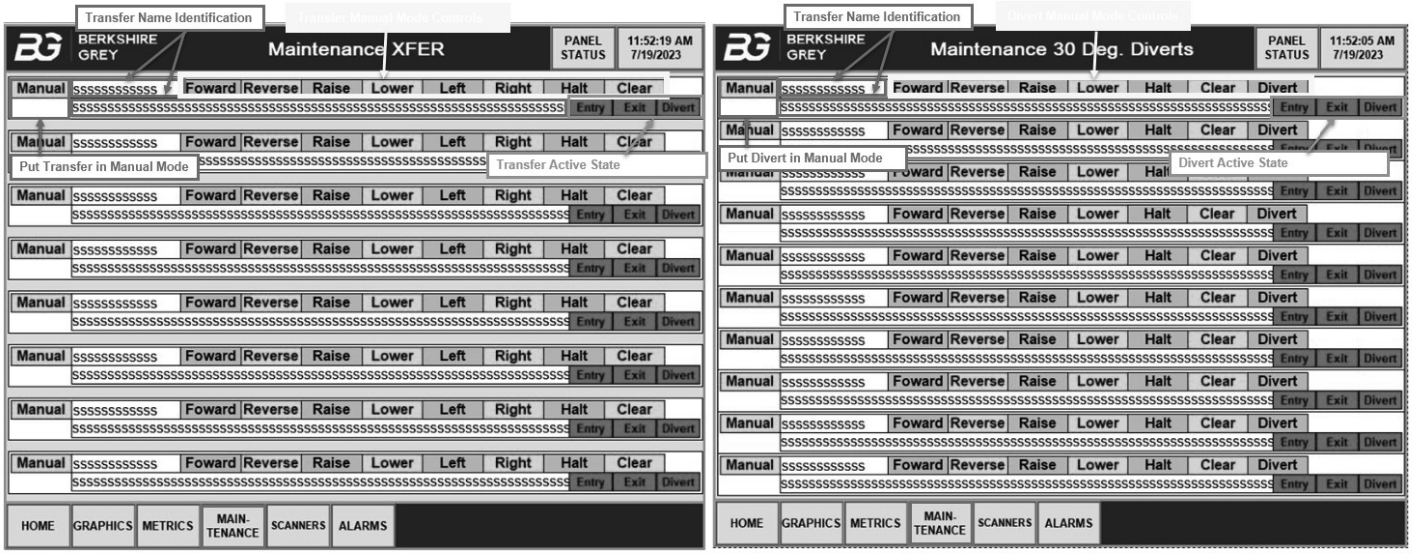


Figure 52 HMI MAINTENANCE Screen: XFER (Left) & DIVERT (Right)

- MAINTENANCE Menu (**Figure 51**)
    - Menu allows maintenance to navigate to the manual control pages of the 90 Degree H-Transfers and 30 Degree Diverts.
    - Manual function of 90 Degree H-Transfers (**Figure 52**, Left) & 30 Degree diverts (**Figure 52**, Right).

- Manual: Puts the Transfer into Manual mode
- Manual Controls:
  - Forward: Manually moves the Belts in the forward direction.
  - Reverse: Manually moves the Belts in the Reverse direction.
  - Raise: Raises the divert rollers
  - Lower: Lowers the divert rollers
  - Left: Runs the divert rollers in the left direction (when looking downstream)
  - Right: Runs the divert rollers in the right direction (when looking downstream)
  - Halt: Manually halts product on the Divert when BG allows via Handshake.
  - Clear: Input to Clear all stored Divert bits when Cycle Stop is on.
- Equipment Active State:
  - Entry, Exit, Divert PE: Output indicator shows Red when blocked, Green when un-blocked.

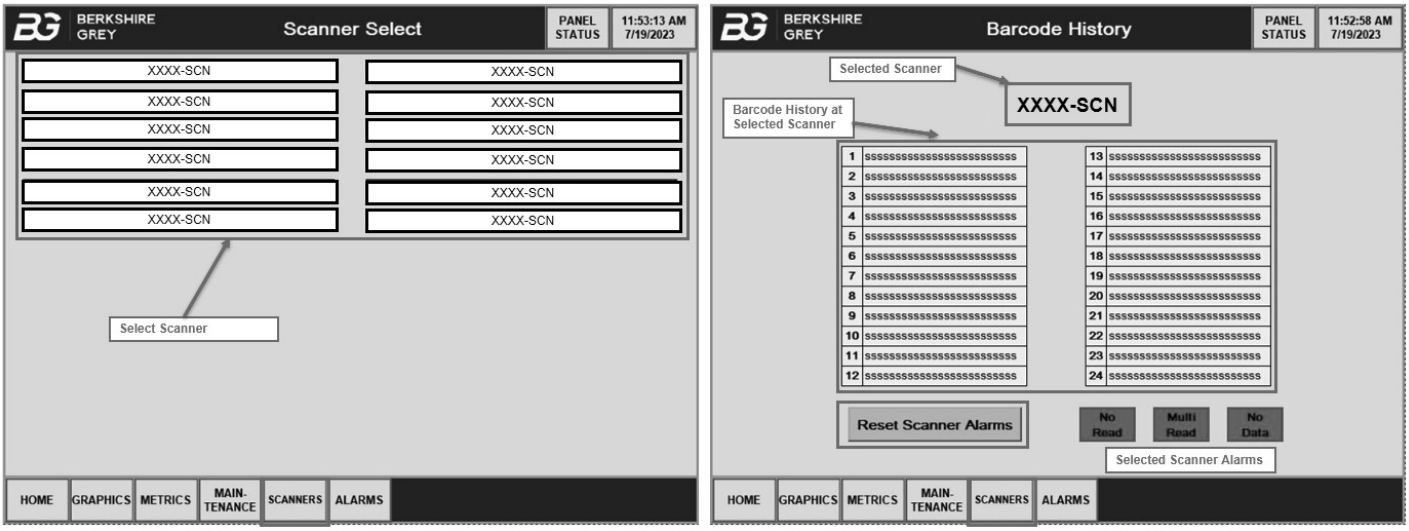


Figure 53 HMI SCANNERS Screen: Scanner Select (Left) & Barcode History (Right)

- SCANNERS Menu
  - Scanner Select Screen (**Figure 53**, Left)
    - Allows operators to select a barcode scanner in the system. Each button goes to the scanner display which the button is named after.
  - Barcode History Screen (**Figure 53**, Right)
    - View Barcode History of the selected Scanner
    - View Scanner Alarms Statuses
    - Reset Scanner Alarms

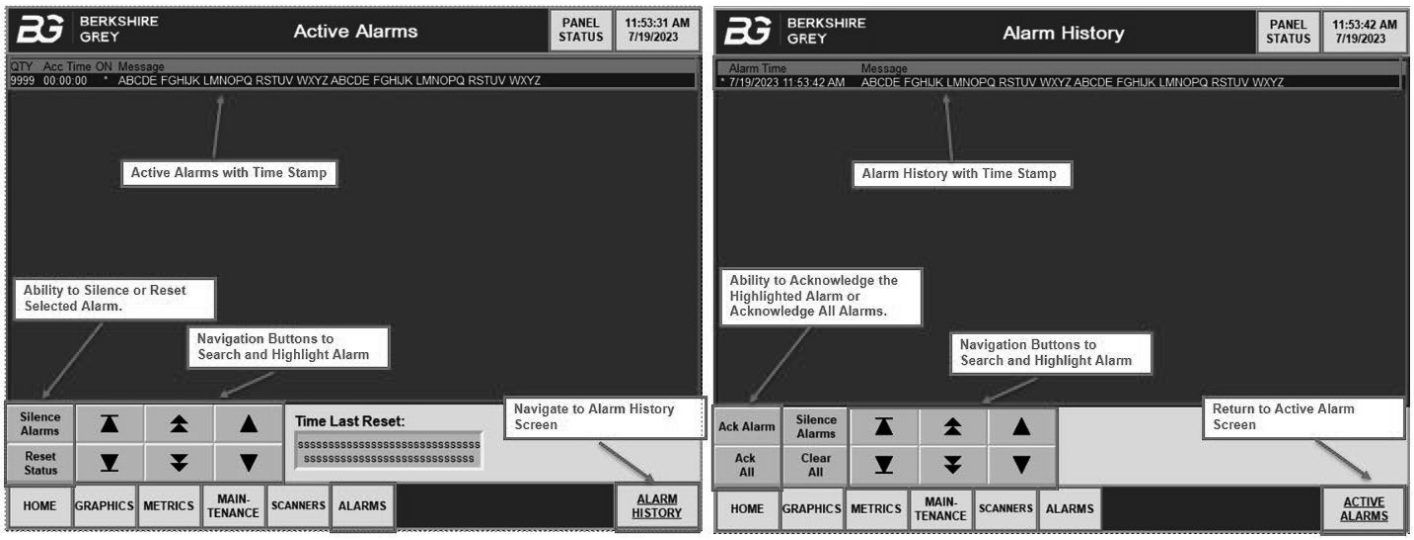


Figure 54 HMI ALARMS Screen: Active Alarms (Left) & Alarm History (Right)

- ALARMS
  - Active Alarms (**Figure 54**, Left)
    - This display shows all alarms active in the PLC. The PLC is sending that there is an alarm, it will always show on this screen. The alarms show a description of the alarm, if it is still ON, Quantity, and Accumulated time since the alarm.
    - Users may use the Navigation Buttons beneath the alarm list to navigate throughout the existing alarms.
    - Reset Status will clear any alarms which have been corrected and move the reset time into the "Time Last Reset" text box. The alarms will still remain in the Alarm History display until cleared from that display.
    - Silence Alarm is used to turn off any internal beeper or configured audio. This button is a standard alarm display feature and is reserved for any future modifications or additions.
  - History of Alarms (**Figure 54**, Right)
    - This display shows the history of all alarms in the system that have occurred and been reset. It has similar functionality as the Active Alarms Screen with Navigation Buttons and Silence Alarms.
    - The alarms in Alarm History show alarm description and the date & time the alarm occurred. This differs from the accumulated time in Active Alarms. It shows this instead of accumulated time since Alarm History may be more extensive since the customer may want to keep a longer record of alarm occurrences.
    - Ack Alarm allows the user to acknowledge the occurred alarm(s) but still allow the user to keep the alarm on the history screen.
    - Clear All allows the user to completely clear the alarm history.
  - Alarms Monitoring:

- Jams
- Fulls
- Scanner Faults
- Estop Faults
- Power Faults
- Ethernet Switch Faults
- Communication Faults
    - ERSC MDR Cards
    - SIO and IO Armorblocks
- VFD Faults
- Proximity Sensor Faults
- Motor Overload Faults

5.1.4 Functionality Details

Refer to "3rd Party Payload" document (Appendix 5.1.1) for tag details referenced in this section.

Refer to "3rd Party Common Handshake Components" document (Appendix 5.1.1) for common elements of the handshakes mentioned in this section. These common components include: Heartbeat Monitoring, Startup Sequence, Cancellation Monitoring, Reset Sequence, and Ack Timeout.

System Naming

Preliminary "RSPS" 4-SPAN naming shown in **Figure 55**. Each pair of shuttles is referred to as "RSPS XX". See Figure 56 for the 4-SPAN section specific naming.

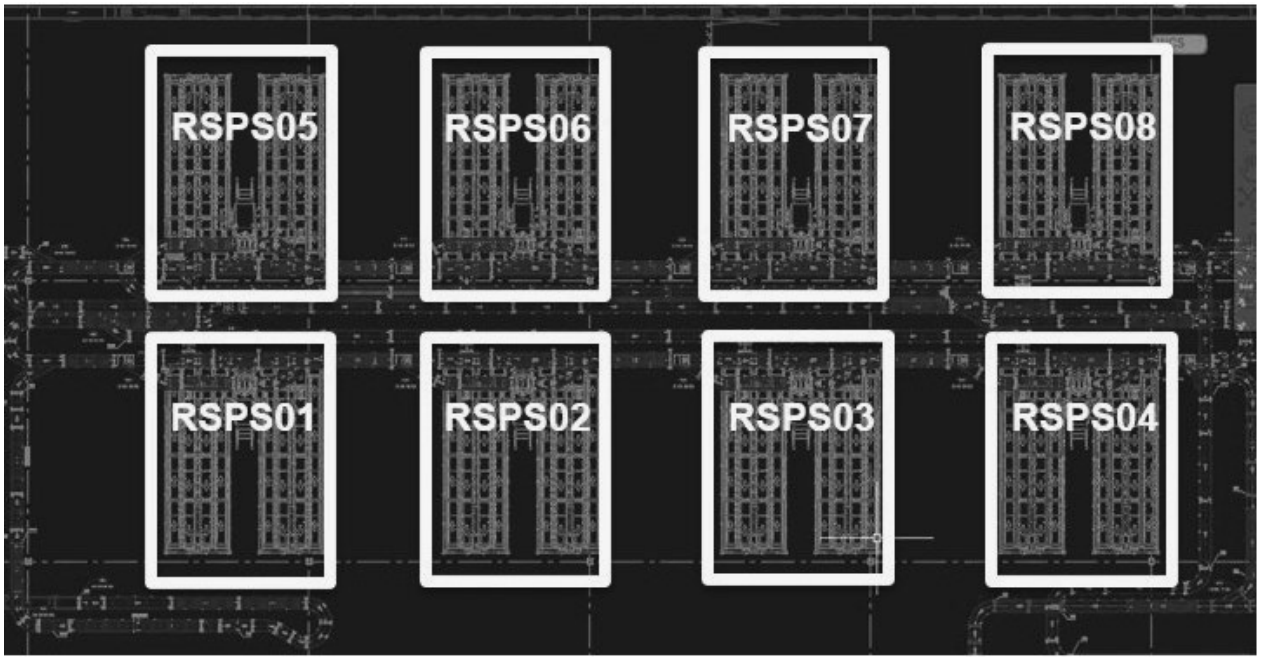


Figure 55 Naming of RSPS 4-SPAN Stations

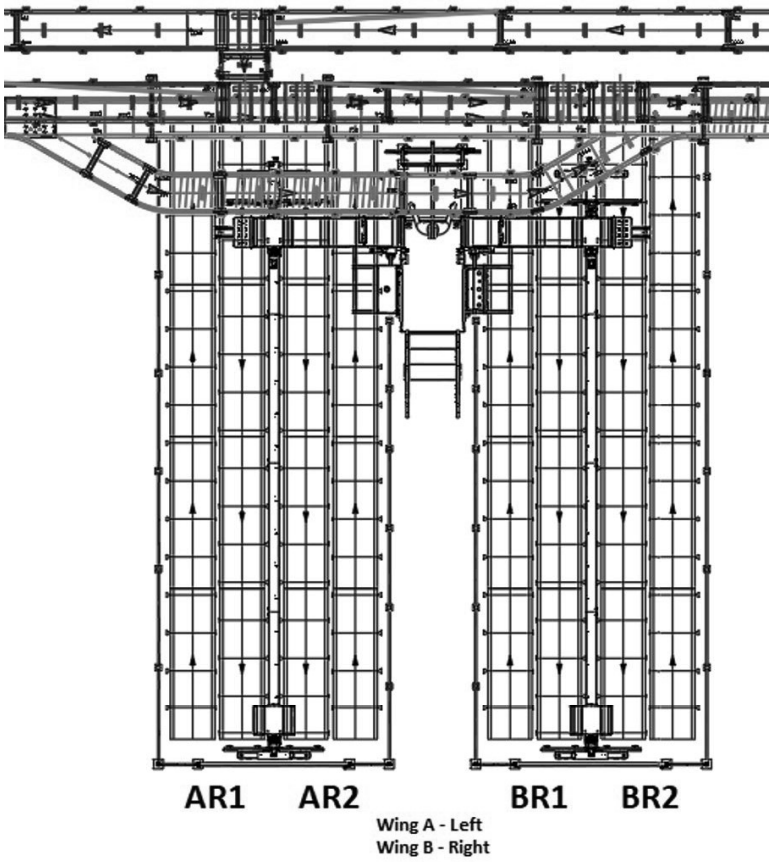


Figure 56 4-SPAN section labelling

System Status

Both Daifuku and Berkshire Grey have a tag called "wSystemSts" that is part of the different message UDTs. This tag is used as a heartbeat between the two systems. If a timeout is detected in the heartbeat signal from either side this indicates a communication error between the two parties. All handshakes will be cancelled, and operators are alerted that there is a problem in the system communication.

Empty Tote Inbound and Completed Order Tote Outbound Seq ID Key

The Berkshire Grey Handshake does not require sequence IDs in this area. A range of Seq IDs are needed here for Daifuku to track and distinguish between inbound and outbound totes. The Seq IDs chosen to help with routing and troubleshooting tracking are unique ranges to the tote origin for North 4-SPAN Station in **Table 13** and South 4-SPAN Station in **Table 14** Empty Tote Inbound/Outbound SOUTH Sequence ID Table. **Figure 57** is the graphical key of the seq ID assignment. A north 4-SPAN station shown in the example. The south shuttle 4-SPAN station will mirror the north 4-SPAN station.

Table 13 Empty Tote Inbound/Outbound NORTH Sequence ID Table

Area of Tote Origin	Inbound Tote	Outbound Tote BR2	Outbound Tote BR1	Outbound Tote AR2	Outbound Tote AR1	Unknown Tote
Seq ID Range	1 to 9	11 to 19	21-29	31-39	41-49	51-59

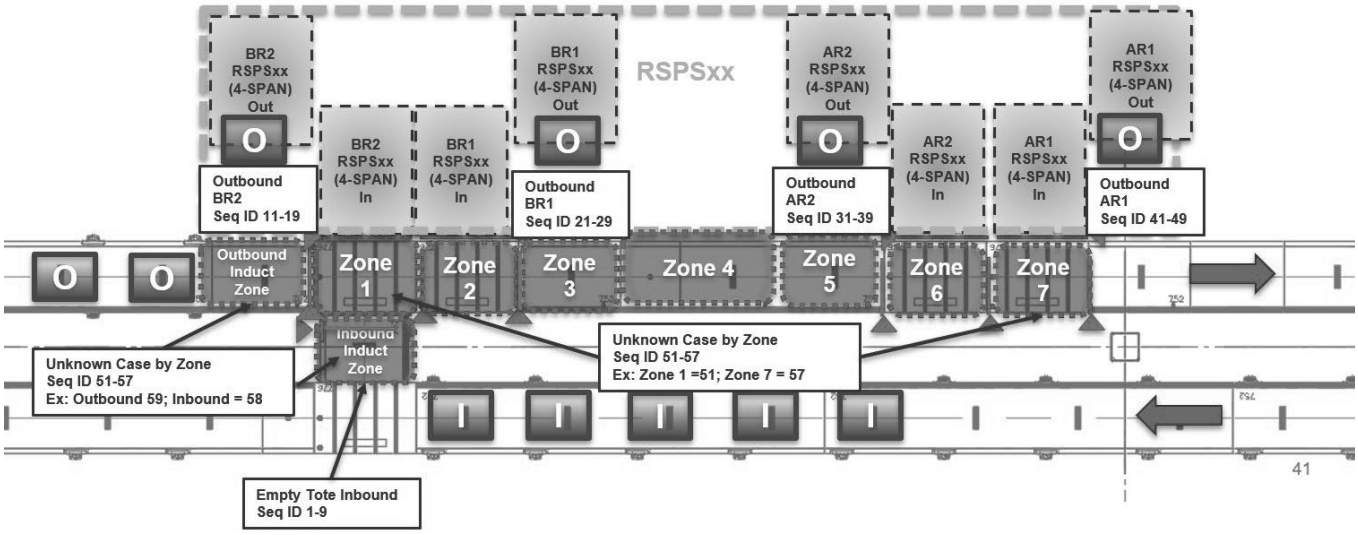


Figure 57 Empty Tote Inbound/Outbound Seq ID NORTH 4-SPAN Graphical Key

Table 14 Empty Tote Inbound/Outbound SOUTH Sequence ID Table

Area of Tote Origin	Inbound Tote	Outbound Tote AR1	Outbound Tote AR2	Outbound Tote BR1	Outbound Tote BR2	Unknown Tote
Seq ID Range	1 to 9	11 to 19	21-29	31-39	41-49	51-59

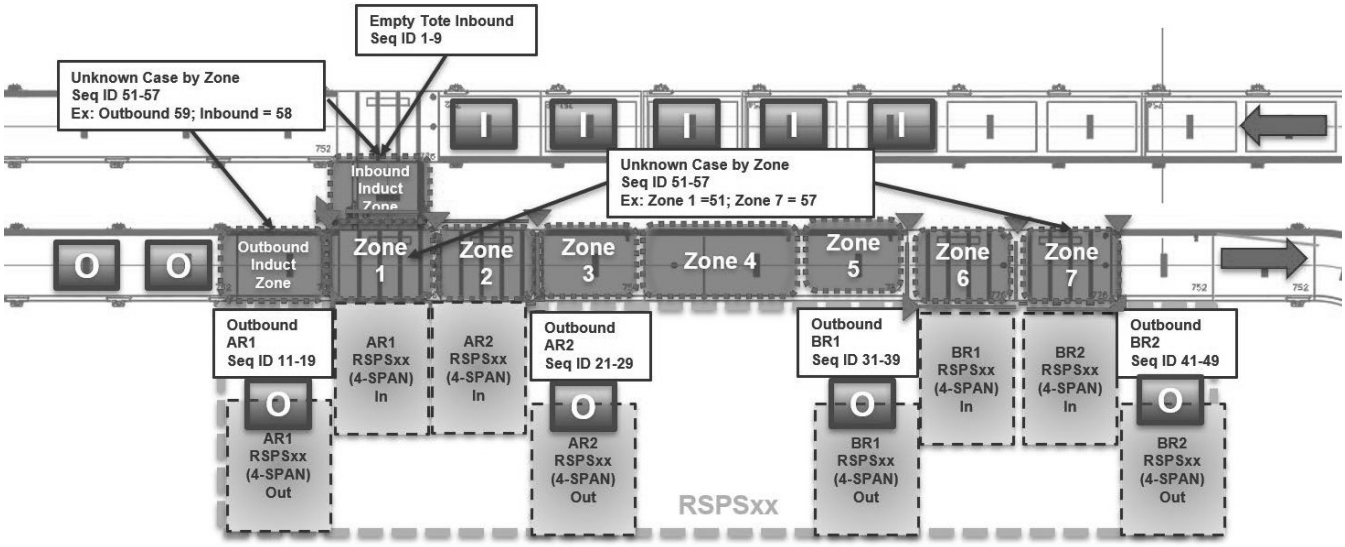


Figure 58 Empty Tote Inbound/Outbound Seq ID SOUTH 4-SPAN Graphical Key

Completed Order Tote Outbound (Box Merge)

All tags used for this area are from "udtPLCtoBG" and "udtBGtoPLC" for Daifuku and Berkshire Grey, respectively. All tags in both UDTs starting with "aHandshake…" are an array of 160 booleans. The same tags are used for the induct and discharge, where the discharge utilizes the key index array 40-79 in the "3rd Party Payload" document.

The process is described next, and graphically represented in **Figure 61**.

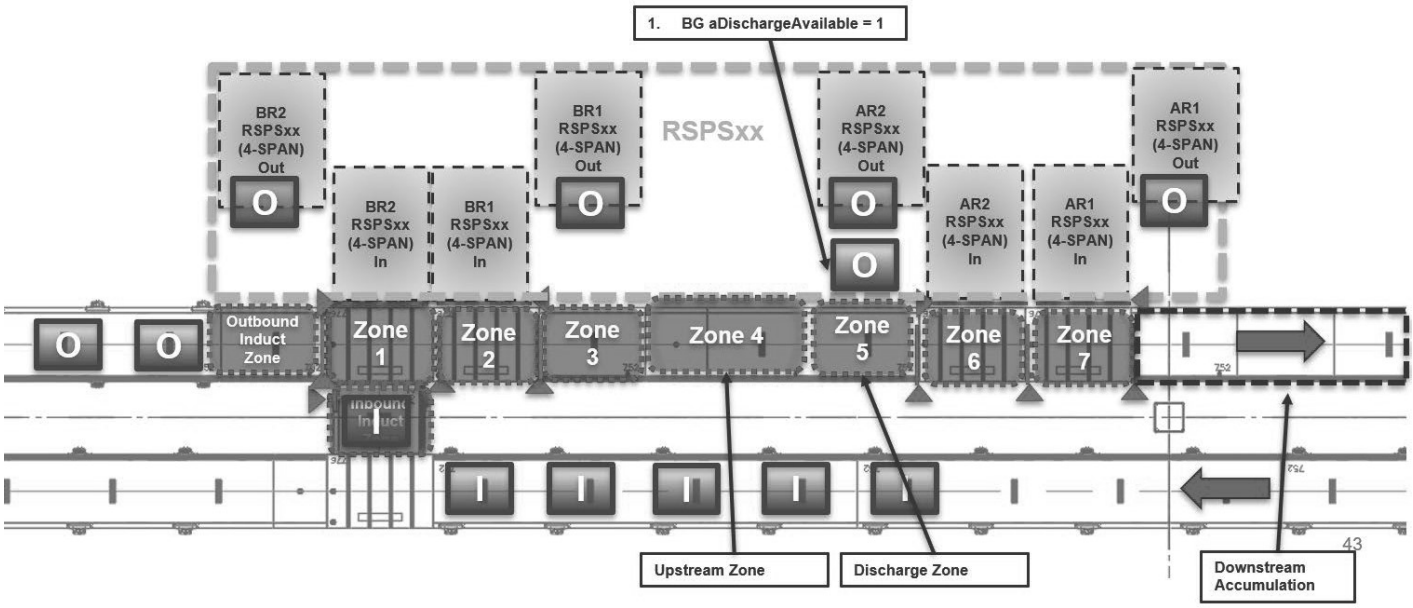


Figure 59 Box Discharge Handshake: Discharge Available.

- BG Request Discharge Start (**Figure 59**)
    a) BG sends (aDischargeAvailable = 1) to indicate that a completed order tote is ready to discharge, Daifuku first checks if an inbound tote is entering the upstream zone by looking for tote inbound seq ID range indicated in **Table 13**.
    b) If an inbound tote is entering or is currently in the upstream zone, then it will be allowed to pass through first. When an inbound tote is not initially detected, Daifuku stops the release of zone upstream of the merge zone (discharge zone) stopping any tote that arrives anytime during the merge. Daifuku ensures the merge zone photo-eye is not blocked, the zone is stopped, and the downstream accumulation is not full and can receive the tote. When these 3 conditions are true Daifuku sends (aHandshakeReady) indicating that the merge zone is ready shown in **Figure 60**.

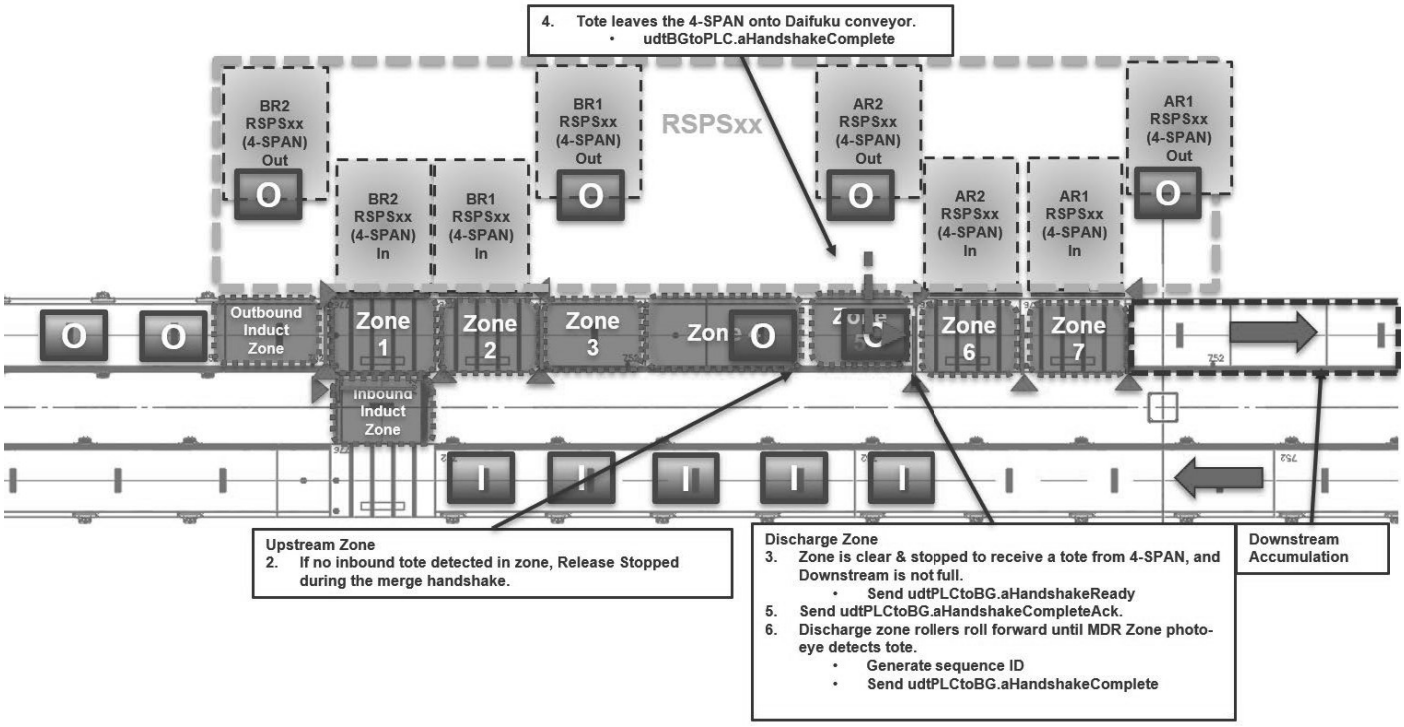


Figure 60 Box Discharge Handshake: Merge.

Once the discharging carton leaves the BG 4-SPAN, BG sends (aHandshakeComplete) in indicating that the merge is complete from the BG side. Daifuku responds with (aHandshakeCompleteAck) which is just for analytics related to timing between the Daifuku PLC and BG. Daifuku accepts the carton and waits x seconds to move the merge zone until the photo-eye is blocked. Then, the carton and any other cartons waiting upstream can move and resume normal behavior. When the carton reaches the merge photo-eye, Daifuku generates a sequence ID for the tote tracking according to **Table 13** and sends (aHandshakeComplete) indicating that the merge was successful. Then, both BG and Daifuku use (aHandshakeReset) from their respective UDT to reset the sequence. Note: through the entire sequence, there is cancellation monitoring (aHandshakeCancel) that each side is looking for throughout.

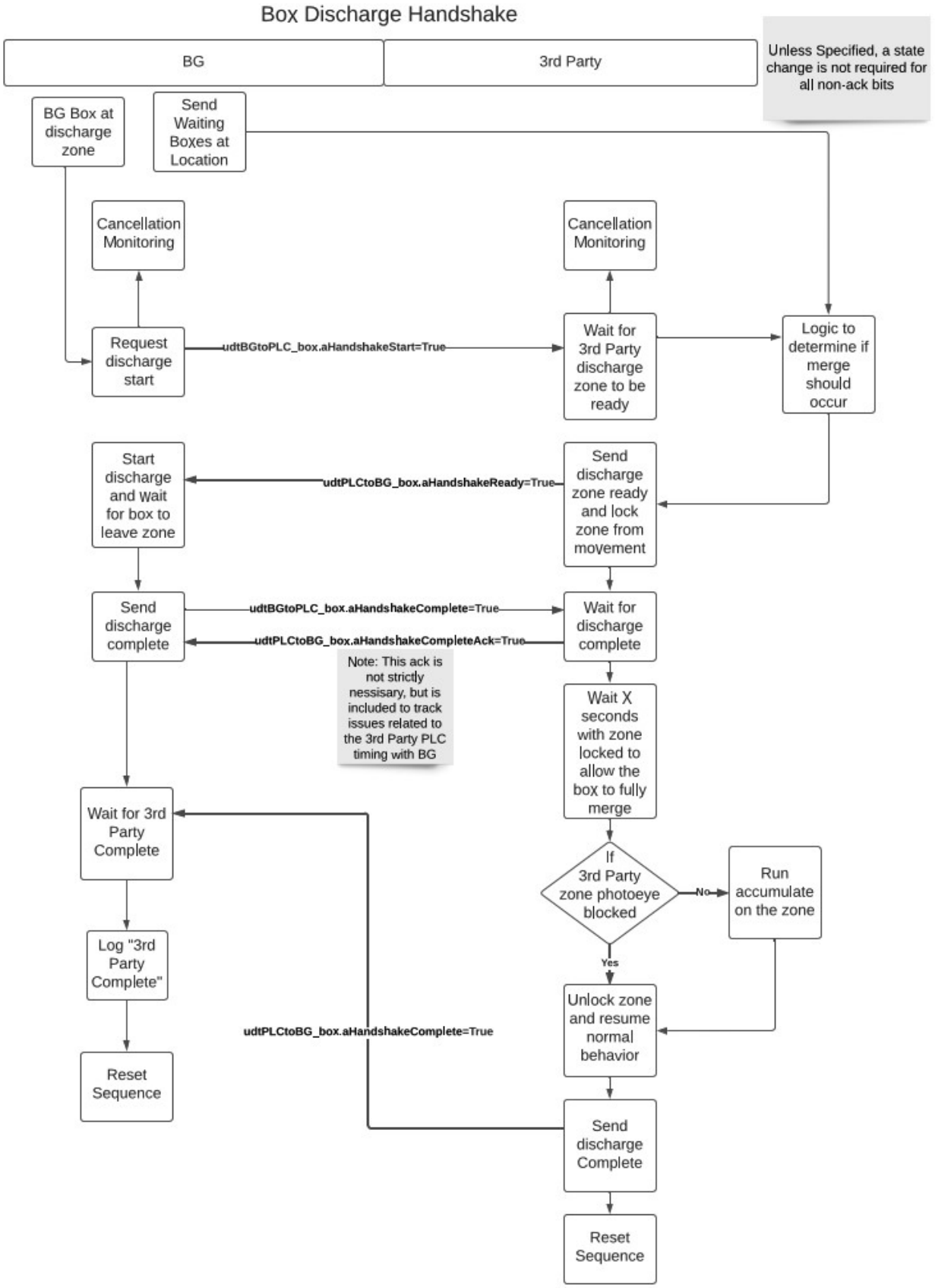


Figure 61 Box Discharge Handshake outline, labelled with tag names.

Empty Order Tote Inbound

All tags used for this area are from "udtPLCtoBG" and "udtBGtoPLC" for Daifuku and Berkshire Grey, respectively. All tags in both UDTs starting with "aHandshake…" are an array of 160 booleans. The same tags are used for the induct and discharge, where the induct utilizes index 0-39. "aInductAvailable" and "aInductSlotsAvailable" from BG are arrays of 64 where the key index array 0-39 are utilized for the induct. It is important to note that only 1 Handshake per tote per Induct is allowed. For example in **Figure *62***, if a handshake is open for AR1 inbound for a single tote to induct, then the single tote must make it to the induct to complete/close the handshake or the handshake is cancelled before a new handshake for Zone 7 can be opened for a new single tote. Multiple handshakes may be open at multiple inducts as long this 1 Handshake per tote per 4-SPAN induct is followed. This means the most handshakes that can be open at once at the 4-SPAN station is four because there are only four unique induct points (BR2, AR2, BR1, and AR1).

The process is described next, and the logic states are graphically represented in **Figure 64**.

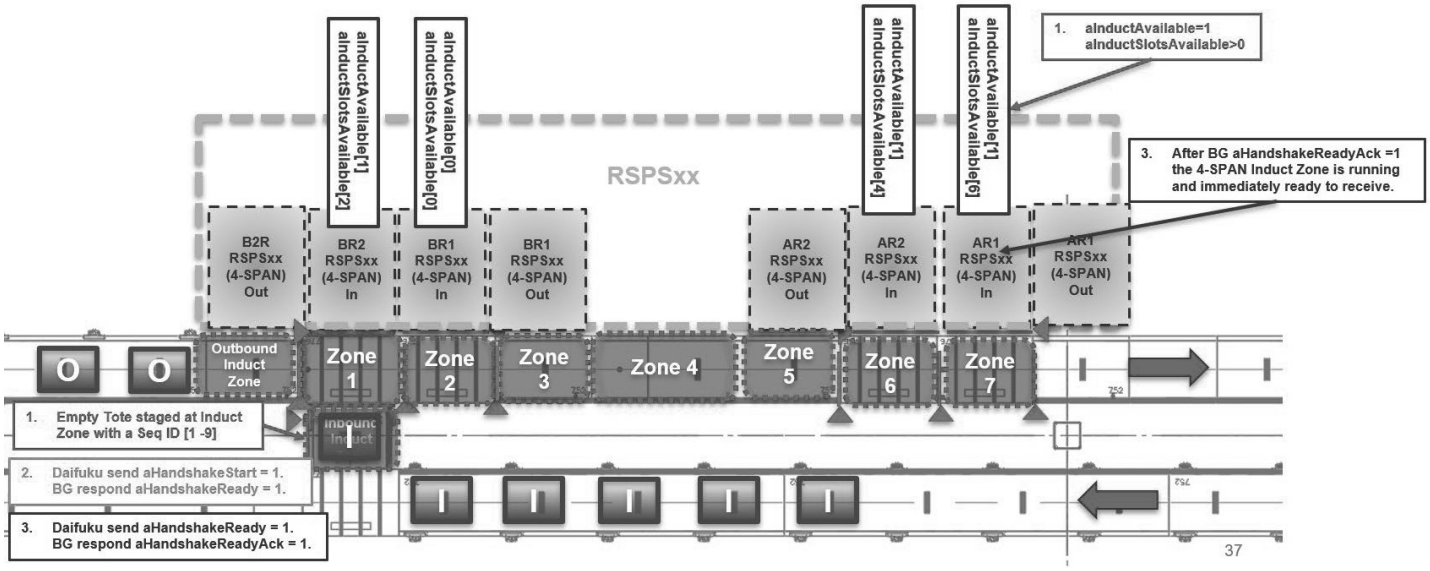


Figure 62 Box Induct Handshake State 1 through 3

- State 1: Initial Conditions
    a) Daifuku stages the empty inbound tote at the Inbound Induct Zone and generates a seq ID from 1 thru 9 indicating it is an inbound tote for tracking.
    b) BG sends the number of available slots (aInductSlotsAvailable>0) in the 4-SPAN and (aInductAvailable = 1) indicating that the 4-SPAN induct zone is ready to receive.
- State 2: Request to Start Induct Handshake
    a) Daifuku sends (aHandshakeStart = 1) to start the induction with the aInductAvailable>0 that has the most aInductSlotsAvailable. RSPSAR1's aInductSlotsAvailable[6] is the most in this example.
    b) BG responds with (aHandshakeReady = 1) to signal they are ready for the Induct Process.
- State 3: BG Induct is Ready
    a) Daifuku sends (aHandshakeReady = 1) to BG.

b) BG responds with (aHandshakeReadyAck = 1).

- Designated BG 4-SPAN Induct is running and ready to accept the inbound tote as soon as the RAT can divert the correct Tote to the correct 4-SPAN Induct.
- This last message is used to track errors in the BG process.

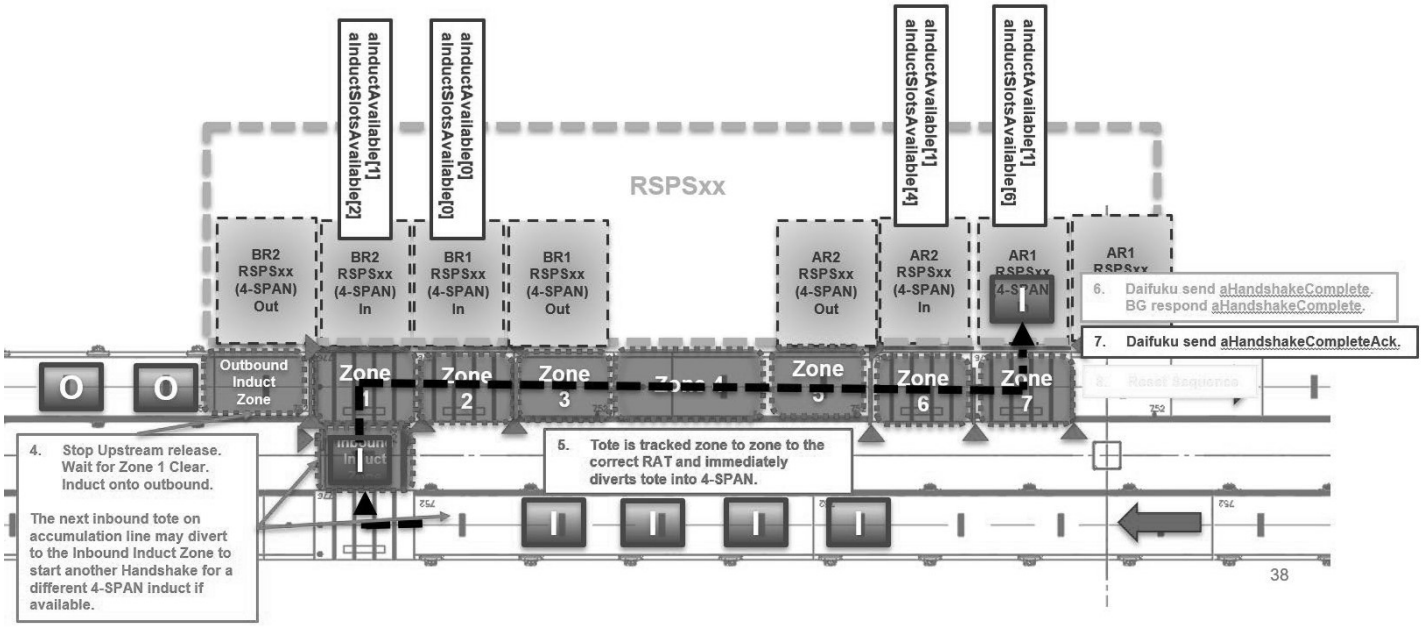


Figure 63 Box Induct Handshake State 4 through 8

- State 4: Start Physical Induct
  a) Daifuku stops the release of the Outbound Induct Zone and waits for Zone 1 to be clear.
  b) The empty inbound tote is allowed to induct onto the takeaway outbound conveyor tracking zone to zone to the RAT that is below the intended 4-SPAN induct.
     - Note: Inbound Totes have priority over Outbound Totes receiving from the upstream 4-SPAN stations and at the Outbound Box Merges within 4-SPAN Station.
  c) Another empty inbound tote on the accumulation line is allowed to be diverted next into the Inbound Induct Zone next once the tote with a valid handshake diverts onto the outbound conveyor. This tote may start the next handshake with the next available induct with the greatest need.
- State 5: Tote Diverts and Clears RAT
  a) Once the empty inbound reaches the correct RAT, the RAT will immediately divert the inbound tote into the 4-SPAN induct.
- State 6: Induct Complete
  a) Daifuku sends (aHandshakeComplete) to BG.
  b) BG expected to respond with (aHandshakeComplete) immediately.

- State 7: Close the Handshake
    a) Daifuku sends (aHandshakeCompleteAck) to BG.
- State 8: Reset Sequence
    a) Once both completes have been sent/received, both parties use (aHandshakeReset) from their respective UDT to reset the sequence. Note: through the entire sequence, there is cancellation monitoring (aHandshakeCancel) that each side is looking for throughout.

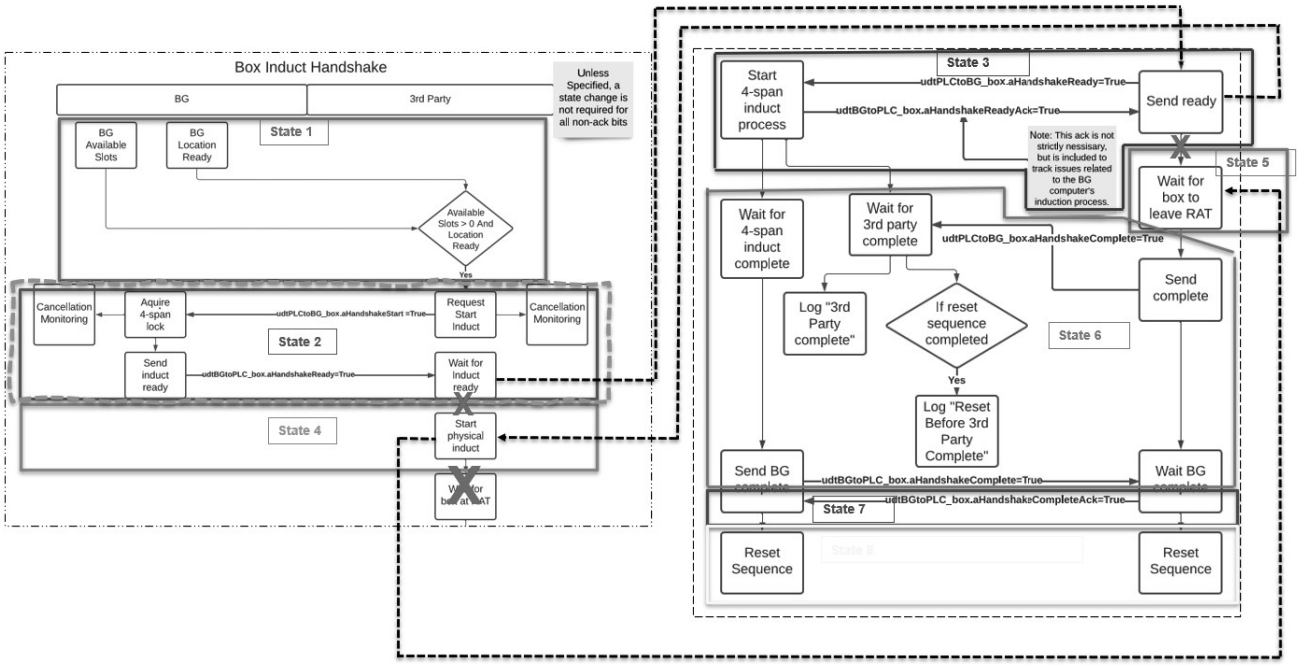


Figure 64 Box Induct Handshake, with labelled tag names.

Donor Tote/Carton Highway Loop Pick Zone (Tote Index)

All tags used for this area are from “udtPLCtoBG” and “udtBGtoPLC” for Daifuku and Berkshire Grey, respectively. All tags in both UDTs starting with “aHandshake…” are an array where the index corresponds to the RSPS numbering.

The process is described next, graphically represented in **Figure 67** and shown in **Figure 65**.

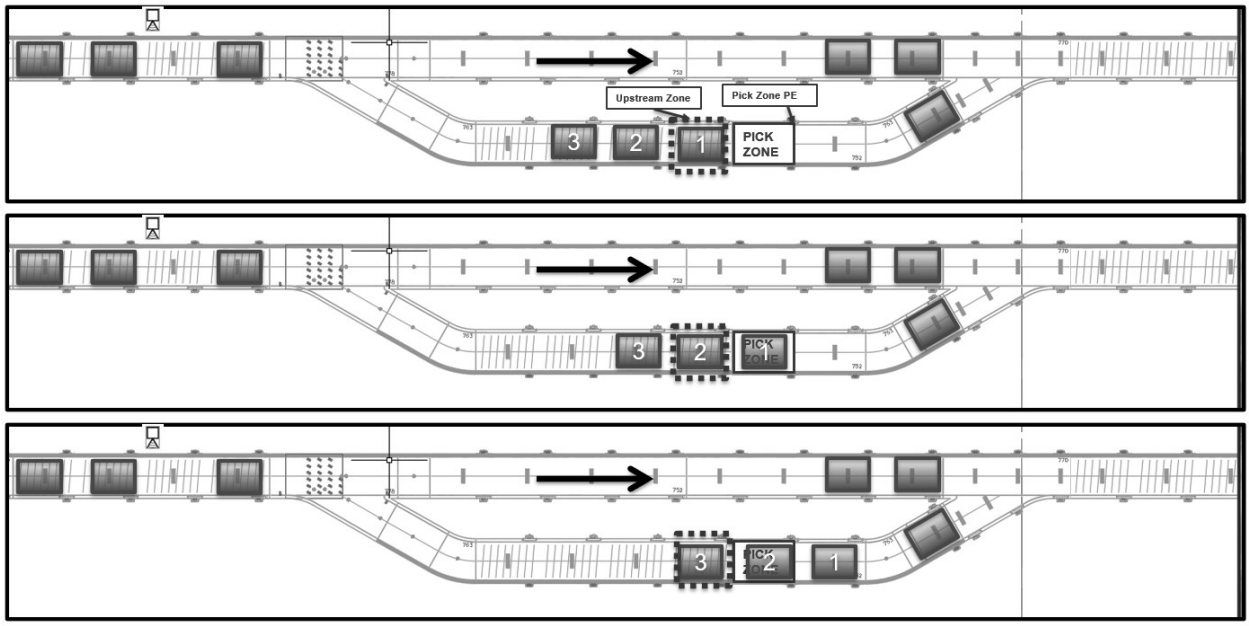


Figure 65 Donor Tote/Carton Highway Loop Pick Zone Example

In the top of **Figure 65**, Daifuku sends the status of the pick zone photo-eye indicating if a tote present. Throughout the sequence, Daifuku also monitors the highway loop for jams and sends (aStationConvZonesJammed) with corresponding index for the highway loop if a jam is detected shown below **Figure 66**. Daifuku does give the (aBarcode) information here.

In the middle of **Figure 65**, Berkshire Grey sends (aHandshakeStart = 1) to start the handshake. Daifuku allows the pick zone to release if a tote is currently present and allows a new tote (tote 1) to release from the upstream zone. When a new tote arrives detected by the Pick Zone photo-eye, Daifuku stops the pick zone and stops the next totes upstream (totes 2-3) of the pick zone. Daifuku reports the status of the zone directly upstream of the pick zone. Daifuku sends (aHandshakeComplete = 1) once the totes are stopped and waits for BG complete. Once BG complete (aHandshakeComplete) is received, both sides reset the sequence (aHandshakeReset = 1). Note: through the entire sequence, there is cancellation monitoring (aHandshakeCancel) that each side is looking for throughout.

The bottom of **Figure 65** show how the next handshake would progress the totes through pick zone. Berkshire Grey starts the next handshake. Daifuku allows the pick zone to release tote 1 and allows tote 2 to release from the upstream zone. When a tote 2 arrives in the pick zone, Daifuku stops the pick zone and stops the next totes upstream (tote 3) of the pick zone. The process continues as previously described.

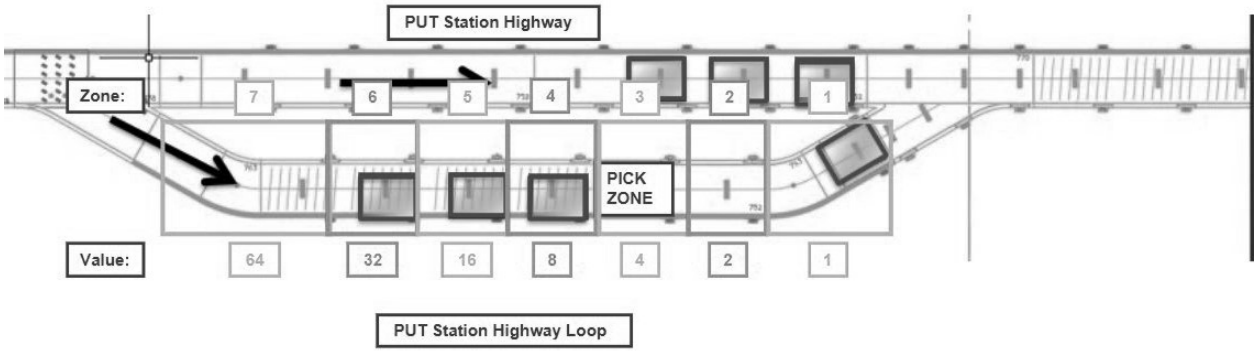


Figure 66 Tote aStationConvZonejammed example

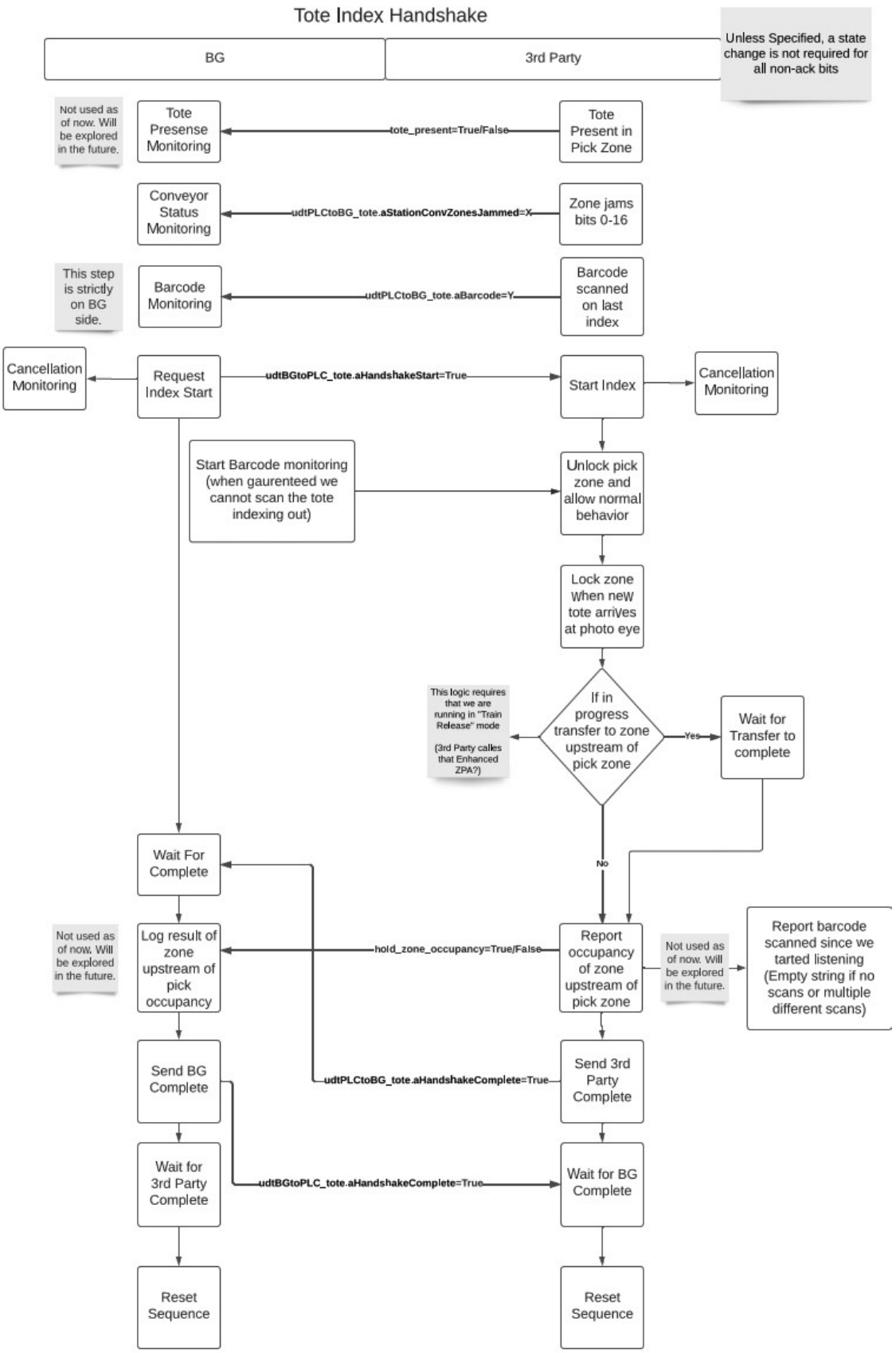


Figure 67 Tote Index Handshake, with labelled tag names

Donor Tote Inbound & Outbound Scanners

All tags used for this area are from "udtPLCtoBG" and "udtBGtoPLC" for Daifuku and Berkshire Grey, respectively.
The process is described next, and graphically represented in the figures at the end of this section.

The process for barcode decisions is broken into 3 processes, Decision Request (**Figure 70**), Decision Response (**Figure 71**), and Decision Confirmation (**Figure 72**). The barcode decision overview process is shown in **Figure 69**.

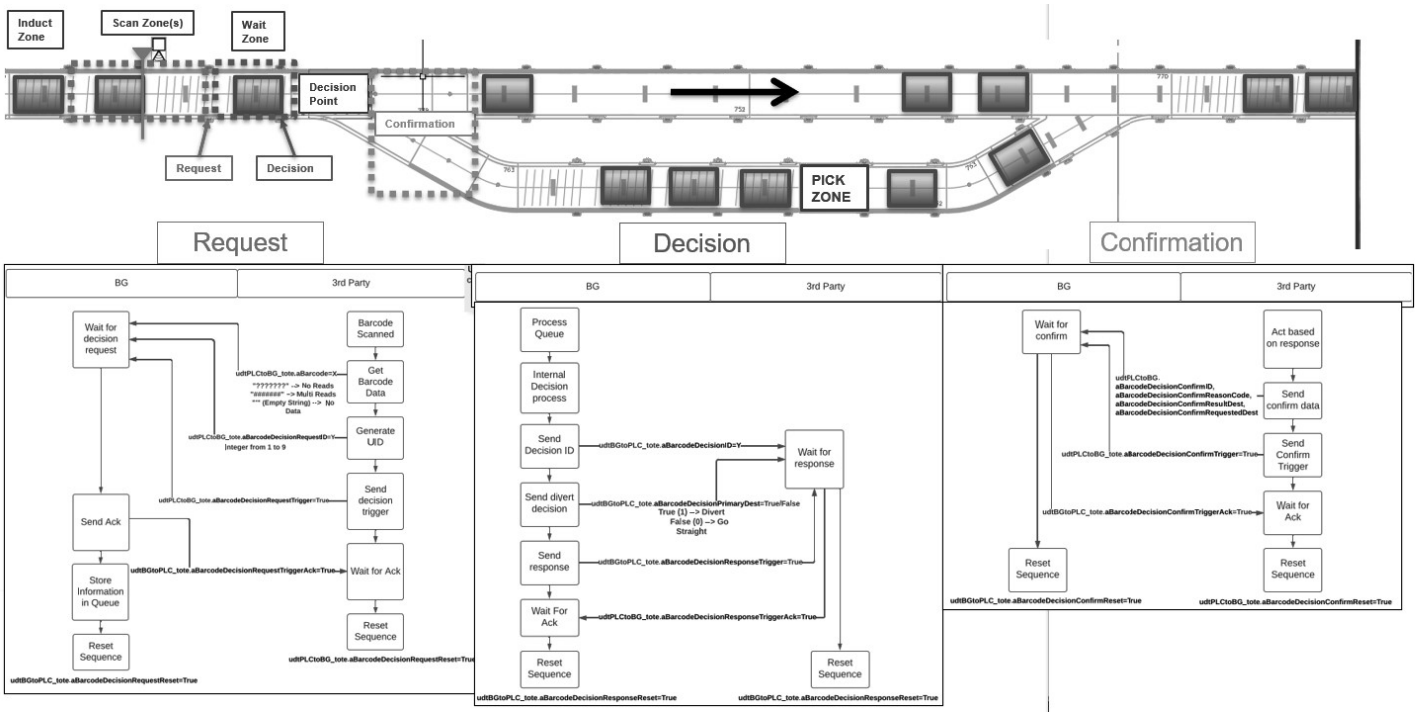


Figure 68 Barcode Decision Process Overview

- Barcode Decision Request:
    a) Tote/Carton enters the Scan Zone where Daifuku takes in scanned barcode from the scanner and expects to send:
        - (aBarcode) the barcode data,
        - (aBarcodeDecisionRequestID[1-9]) barcode ID request
        - (aBarcodeDecisionRequestTrigger = 1)
        - The decision trigger is expected before at the end of the Scan Zone photo-eye.
    b) BG responds:
        - (aBarcodeDecisionRequestTriggerAck = 1) response trigger.
    c) Reset Sequence:
        - BG initiates: (aBarcodeDecisionRequestReset = 1).
        - Daifuku acknowledges: (aBarcodeDecisionRequestReset = 1).
        - BG turn off Reset: (aBarcodeDecisionRequestReset = 0).
        - Daifuku turns off Reset: (aBarcodeDecisionRequestReset = 0).
- Barcode Decision Response:
    a) The tote/carton continues on to the Wait Zone while BG does their internal decision process for destination of the tote. BG sends:

- (aBarcodeDecisionID[1-9]) decision ID,
- (aBarcodeDecisionPrimaryDest[0 or 1]) primary destination
- (aBarcodeDecisionResponseTrigger = 1) response trigger.
- The BG decision is expected before the end of the Wait Zone photo-eye.

b) Daifuku responds (aBarcodeDecisionResponseTriggerAck = 1) response trigger.
c) Reset Sequence:
- BG initiates: (aBarcodeDecisionRequestReset = 1).
- Daifuku acknowledges: (aBarcodeDecisionRequestReset = 1).
- BG turn off Reset: (aBarcodeDecisionRequestReset = 0).
- Daifuku turns off Reset: (aBarcodeDecisionRequestReset = 0).

- Barcode Decision Confirmation:
  a) Daifuku instructs the tote to follow the destination received from BG.
  b) After the tote completes BG Decision Path Daifuku sends:
     - (aBarcodeDecisionConfirmID[1-9]) confirmation ID.
     - (aBarcodeDecisionConfirmReasonCode[1-99]) confirmation reason code.
     - (aBarcodeDecisionConfirmResultDest[0 or 1]) destination confirmation.
     - (aBarcodeDecisionConfirmRequestedDest [0 or 1]) confirm BG requested destination.
     - (aBarcodeDecisionConfirmTrigger = 1) confirm of destination success.
  c) BG responds with (aBarcodeDecisionConfirmTriggerAck = 1) confirmation of the destination.
  d) Reset Sequence:
     - BG initiates: (aBarcodeDecisionRequestReset = 1).
     - Daifuku acknowledges: (aBarcodeDecisionRequestReset = 1).
     - BG turn off Reset: (aBarcodeDecisionRequestReset = 0).
     - Daifuku turns off Reset: (aBarcodeDecisionRequestReset = 0).

The Research Scanner will follow the same process, but only complete the Barcode Decision Request process. Daifuku is only providing the barcode information to BG at these locations. The actual decision and action process is between BG and Existing System.

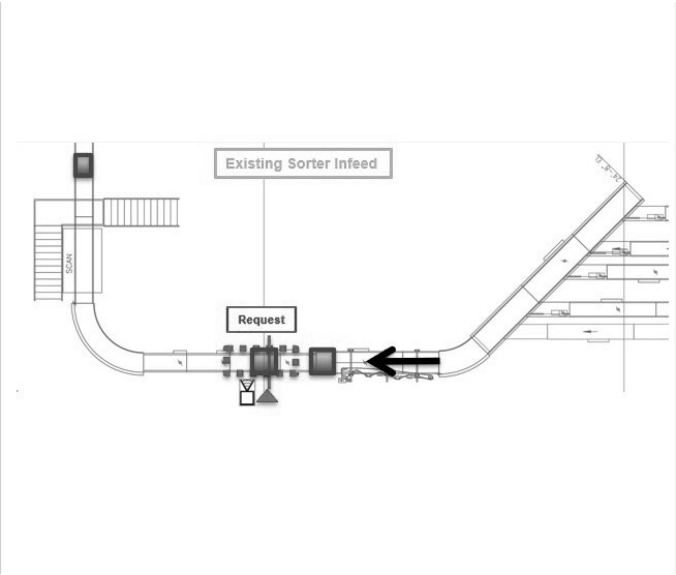


Figure 69 Research Scanner installed on Existing System Sorter Infeed

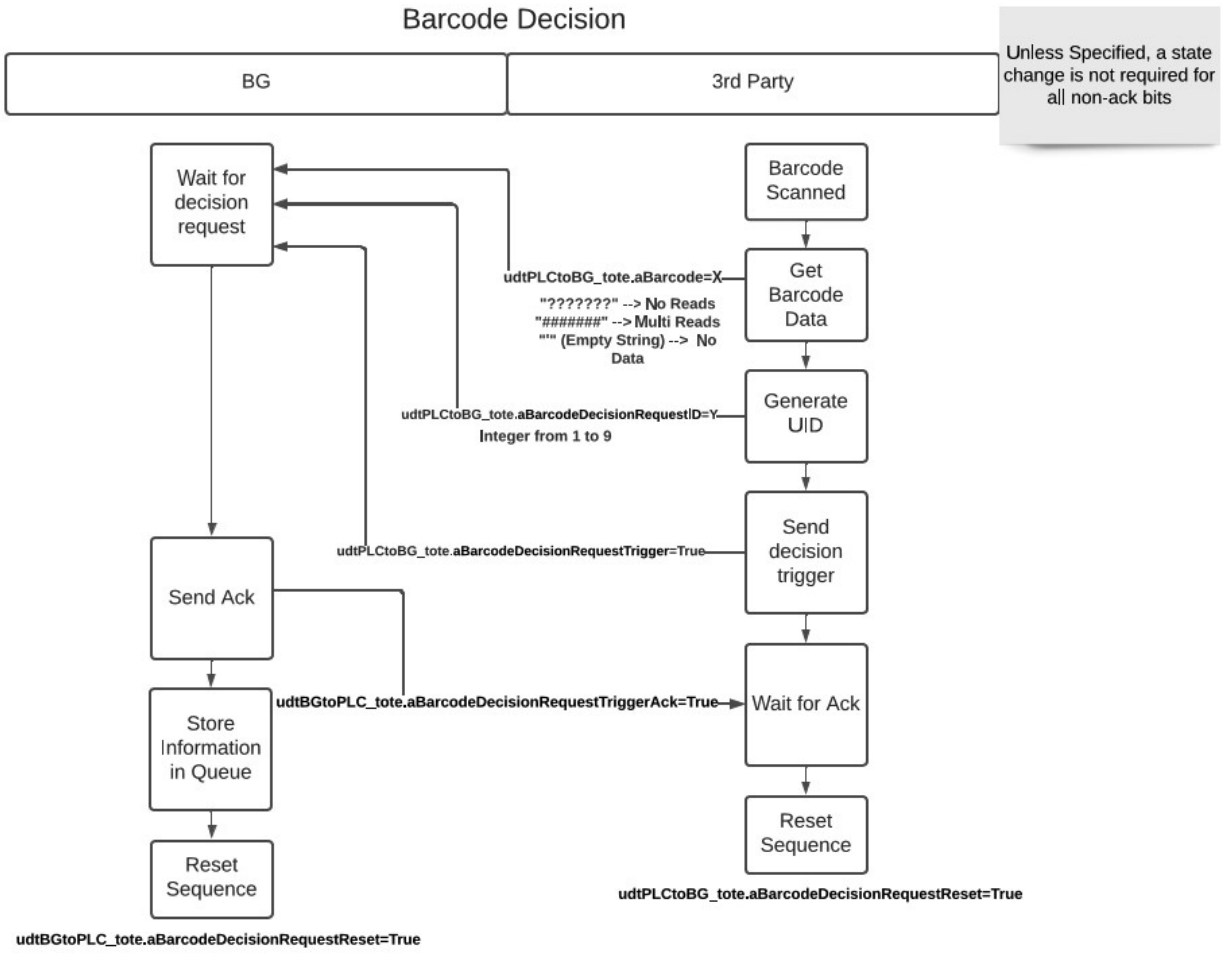


Figure 70 Barcode Decision Request process, with labelled tag names

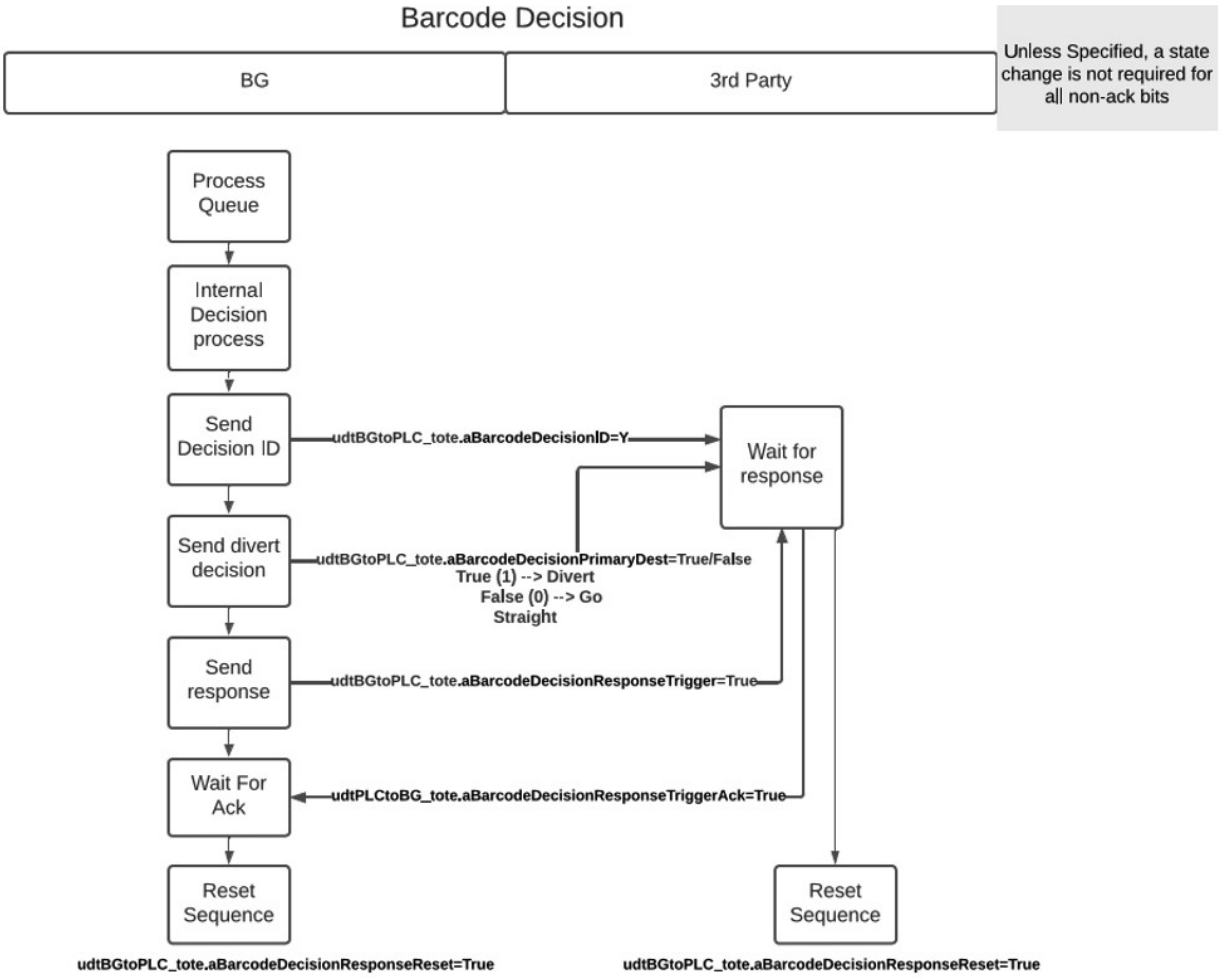


Figure 71 Barcode Decision Response process, with labelled tag names

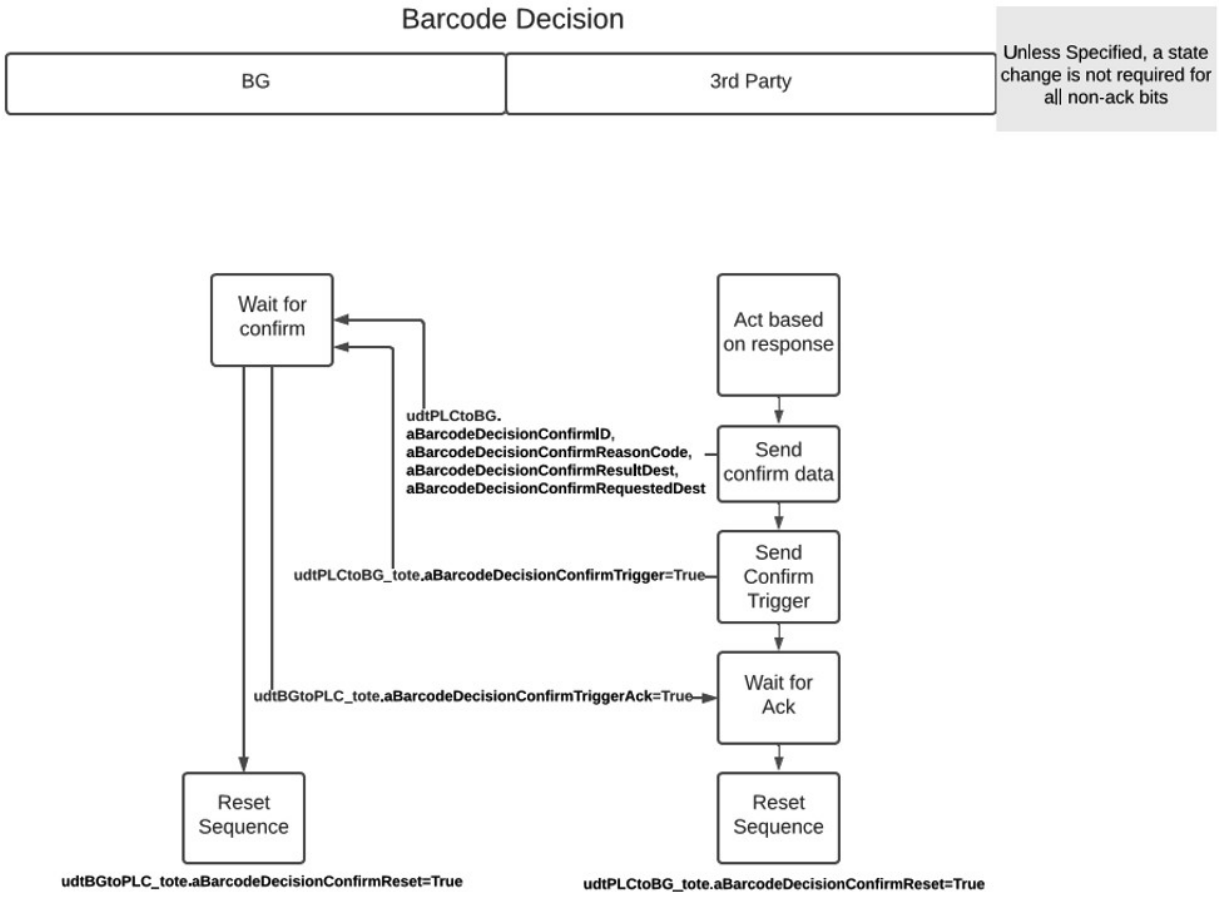


Figure 72 Barcode Decision Confirm process, with labelled tag names.