DAIFUKU
WYNRIGHT CORPORATION

Berkshire Grey, Inc.

Bloomfield, CT
Job #133535

July 29, 2022

Revision History

REV	DATE	BY	DESCRIPTION
0.0	07-08-2022	HZ	General Specification, First Draft
1.0	08-05-2022	HZ	Customer comments updates, Customer Approved

Contents

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

Box Collar – collar put on top of boxes to funnel product and keep flaps down

Closed Carton – box that is separated from the tray and collar, has been closed out

Empty Carton – tray, box, and collar that has not yet been filled with desired product

Full Carton – tray, box, and collar that has been filled with desired product

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

4-Span – wings of conveyor controlled by Berkshire Grey where cartons are filled with desired product

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 Full Carton Outbound (Box Merge)

Full cartons from 4-Span conveyor kick out when it is communicated that there is an empty space on the receiving conveyor. The two lines from either side of 4-Span conveyor then merge at a 2 to 1 merge point. Then the full cartons transport through the system to the pack out area. The full cartons divert between three lanes in round robin.

The three divert lanes have a lifter, then each lane splits into two lanes. This is where the six pack out workstations are located. Each description for the Lifter and Pack Out Stations apply congruently to each lane.

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

<u>Lifter</u>

The full cartons run up to an external box-lifter mechanism. This 3-section conveyor interlocks with Wynright conveyor to allow cartons in and out. This mechanism automatically separates the box from the tray and the tray transports in front of the box from this point. The tray and carton just separated are required to travel together (i.e., divert the same direction) to the pack out station.

<u>Pack Out Stations</u>

The pack out area is where operators close out cartons and set up the new empty cartons. The infeed and outfeed of these workstations is controlled by a worker pressing an illuminated pushbutton (provided by Berkshire Grey, controlled by Wynright). The process at this station is: operator pushes button to allow tray in, grabs new box to place on tray (see Section 1.2.4), grabs collar from hanger, places collar on empty box, sends it out, brings in box, removes collar and hangs it up, closes the box, sends it out.

6 to 1 Merge

After the pack out workstations, the new empty cartons and closed cartons queue up prior to the 6 to 1 merge. The cartons merge onto belted conveyor, after which empty cartons will be routed to empty carton inbound (see Section 1.2.2) and closed cartons will be routed to shipping (see Section 1.2.3).

1.2.2 Empty Carton Inbound

Refer to Section 4.1.2 for detailed descriptions for the Empty Carton Inbound area.

Divert

Cartons coming from the merge belt arrive at a divert point where all closed cartons route toward shipping. The empty cartons route toward the inbound 4-Span alternating between the two divert lanes. The divert directing cartons north then has another divert where empty cartons travel straight, and closed cartons divert to travel to shipping (see Section 1.2.3).

Information about how the determination between “closed” and “empty” cartons is made is detailed in Section 4.1.2.

Inbound Right-Angle Transfers

From the previously described divert points, empty cartons travel to enter the 4-Span conveyor. The empty cartons stage just before each pair of transfers, waiting for the signal received from Berkshire Grey that a new empty carton is needed on 4-Span. Then when the carton enters 4-Span, new empty cartons queue up in the vacated space.

1.2.3 Shipping

Full cartons arrive to the previously mentioned divert point from Section 1.2.2 and are determined to be “closed” or “empty” cartons based on height (see Section 4.1.2). Carton and tote descriptions are in Section 1.3.1. There are two divert points to route to shipping, if at both divert points the carton is the “closed” height that carton will be sent toward shipping. At the end of the shipping lane, Wynright conveyor interlocks with external conveyor to release the closed cartons.

Refer to Section 4.1.3 for detailed descriptions for the Shipping area.

1.2.4 Empty Carton Replenishment

This small section is where the operators at the pack out stations (see Section 1.2.1) get the new empty boxes. It has three lanes where each lane runs in between the pack out station conveyor. Upstream from this is an automatic box folder with a section of conveyor (not controlled by Wynright) where an interlock wake-up signal is sent to Wynright conveyor per box. Boxes are then diverted using right angle transfers to the three lanes in round robin. This section of conveyor is kept full provided the supply of boxes constructed is sufficient.

Refer to Section 4.1.4 for detailed descriptions for the Empty Carton Replenishment area.

1.2.5 Tote Loop

The tote loop consists of an outer loop, scan points, and “highway loops” where the operator picks product.

Refer to Section 4.1.5 for detailed descriptions for the Tote Loop and its corresponding areas outlined in this section.

Scan Points

There are scanners at every divert point on the tote loop. Eight before each highway loop divert, two to divert to the tote bypass loop (see Section 1.2.6), and one to divert to external conveyor. Every scan point in the system sends the barcode to Berkshire Grey and Berkshire Grey responds with the instruction of where to send the tote. Refer to Section 4.1.7 for scanner locations.

Highway Loops

The instructions at each scan point determine whether to divert totes into the highway loops. The totes that divert to the loop, queue and index into the pick zone when allowed. The pick zone is a one zone scale which is outlined in the next section. After product is picked and the tote indexes out of the scale section, the tote then merges back into the tote loop.

Scale Section

The scale section, the highway loop pick zone, is controlled by an Interroll Card, rather than the normal Wynright ERSC card. This section is provided by Berkshire Grey and controlled by Wynright. In this section, Berkshire Grey gives the signals to move into the pick zone and to exit once the allotted product has been taken.

Tote Outbound

This section of conveyor comes just after a scan point on the tote loop where Berkshire Grey gives the instruction to divert toward the external conveyor, if necessary. This section will then interlock with the external conveyor similar to the shipping transition. The totes will be released from Wynright conveyor based on the signals from the external conveyor.

To Tote Bypass

There are two scan points where a tote can divert from the tote loop to the tote bypass. One point is on the eastern side of the system and the other on the western side. Several zones before either scan point, the tote bypass merges back into the tote loop. At the scan point, Berkshire Grey responds with the instruction to divert to the bypass or continue straight on the tote loop.

1.2.6 Tote Bypass

Refer to Section 4.1.6 for detailed descriptions for the Tote Bypass area.

Inbound Totes

A section from external conveyor feeds new totes onto the tote bypass. This infeed interlocks with the external conveyor and gets a tote-by-tote wake-up signal. The incoming totes merge with the existing totes running on the tote bypass.

Bypass

The tote bypass loop is where totes go when not directly needed for the highway loop pick sections. These determinations are given by Berkshire Grey at each scan point.

Jackpot

There is one scan point on the tote bypass before the divert to the jackpot. Totes divert here at direction from Berkshire Grey if the tote needs to be addressed manually for a problem. The jackpot transports the problem tote to the end and is addressed by the operator. Once the tote has been addressed, the tote is pulled to the ball table and pushed to the next conveyor to re-induct and merge back onto the tote bypass.

1.2.7 Scanners

A total of twelve scanners, one-sided, are required in the system, provided by SICK. At each scan point, Wynright communicates the barcode to Berkshire Grey, and they respond with the destination instruction. No routing decisions are made directly by Wynright. At the request of Berkshire Grey, barcode scanner model used is Lector 621.

Refer to Section 4.1.7 for 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 various types of containers used in the system.

Description	Length	Width	Height
Closed Carton	24”	20”	17.5”
Empty/Full Carton	27.5”	23.5”	22”
Tote	30”	24”	15”

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, Figure 2, and Figure 3 show the rates throughout the system, broken apart for clarity.

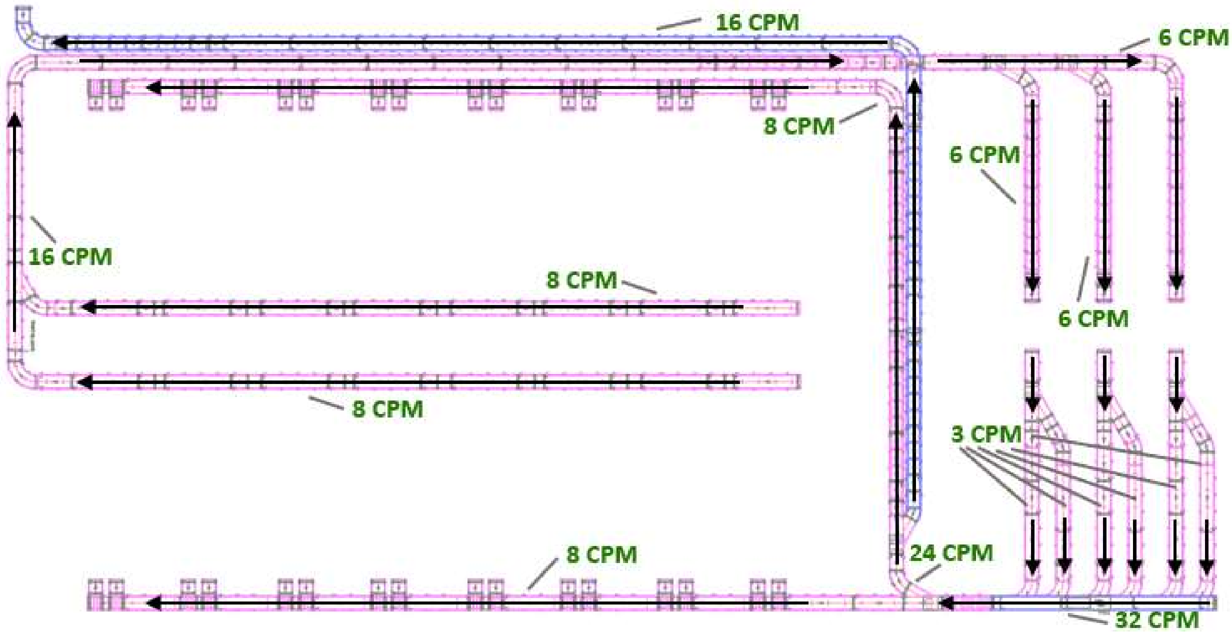

Figure 1 Rate for Carton Inbound/Outbound and Shipping.

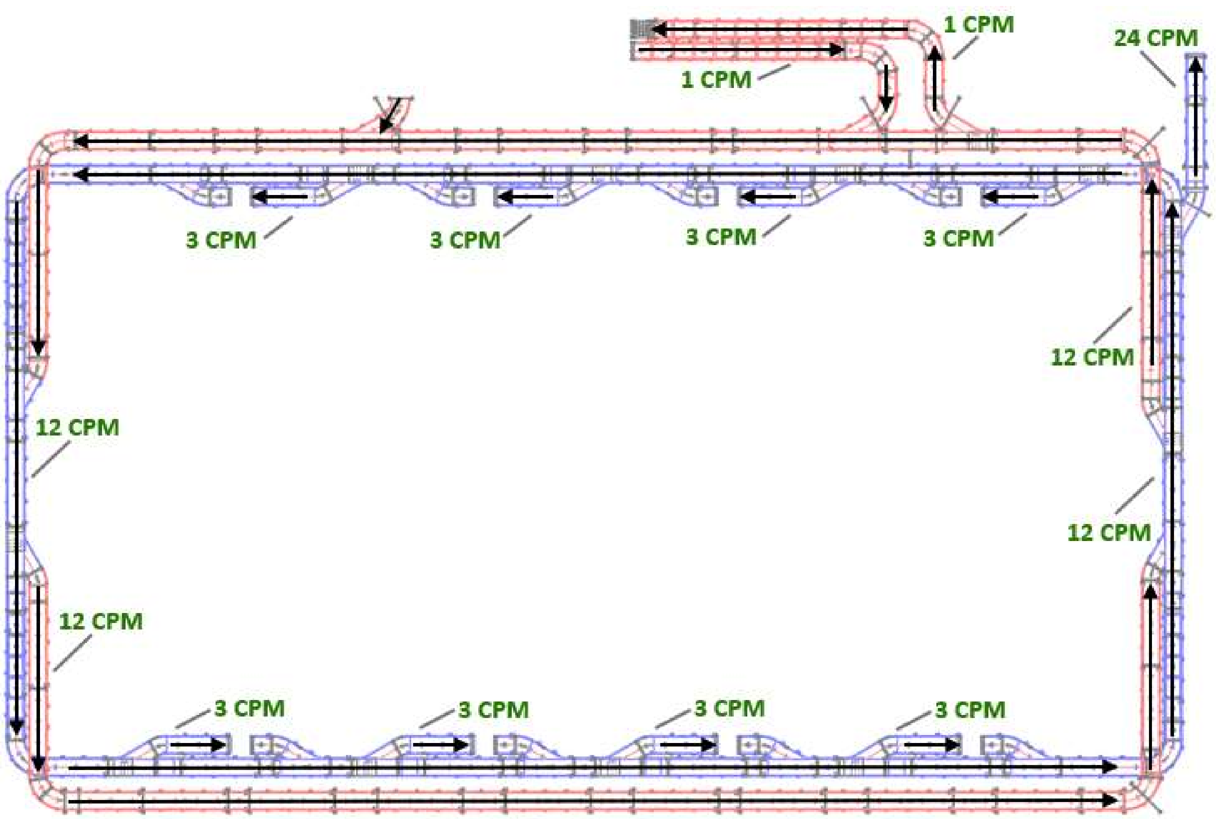

Figure 2 Rate for Inbound Tote Loop, Tote Bypass, and Jackpot.

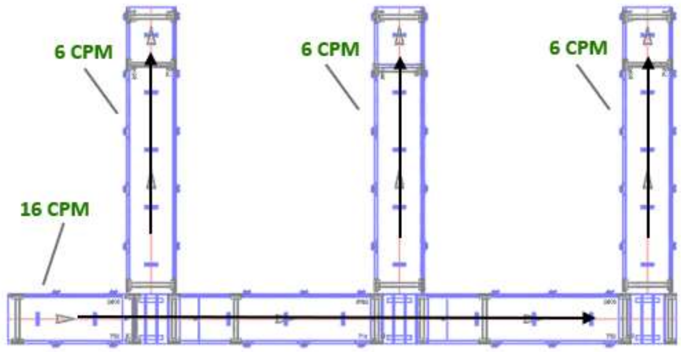

Figure 3 Rate for Empty Carton Replenishment.

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

1.3.3 Barcode Summary

There is only one type of barcode that will be used in the system. These are placed on the totes, on both the right and left faces. The barcode is 7-digit, Code 128, black lettering with white background.

Refer to Section 4.1.8 for the barcode specifics.

2.0 Control System Architecture

This section provides an overview of the control system architecture for the Wynright 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 Wynright system is divided into two primary layers of control:

- Physical equipment control – Wynright 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 Wynright 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. 480V AC, 350A power run, provided by the Customer, is necessary to power the power distribution panel (PDP). Power feed and routing information for PDP are located on the electrical layout drawings beginning from PDP-A-01.

2.2.2 Single-Phase 120V AC Power

120V devices in this system are the scanners. The power for these devices is branched from Berkshire Grey outlets. These outlets are located on the highway loops and are extended from 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 Wynright 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. Figure 4 shows the location of the MCPs and the PDP.

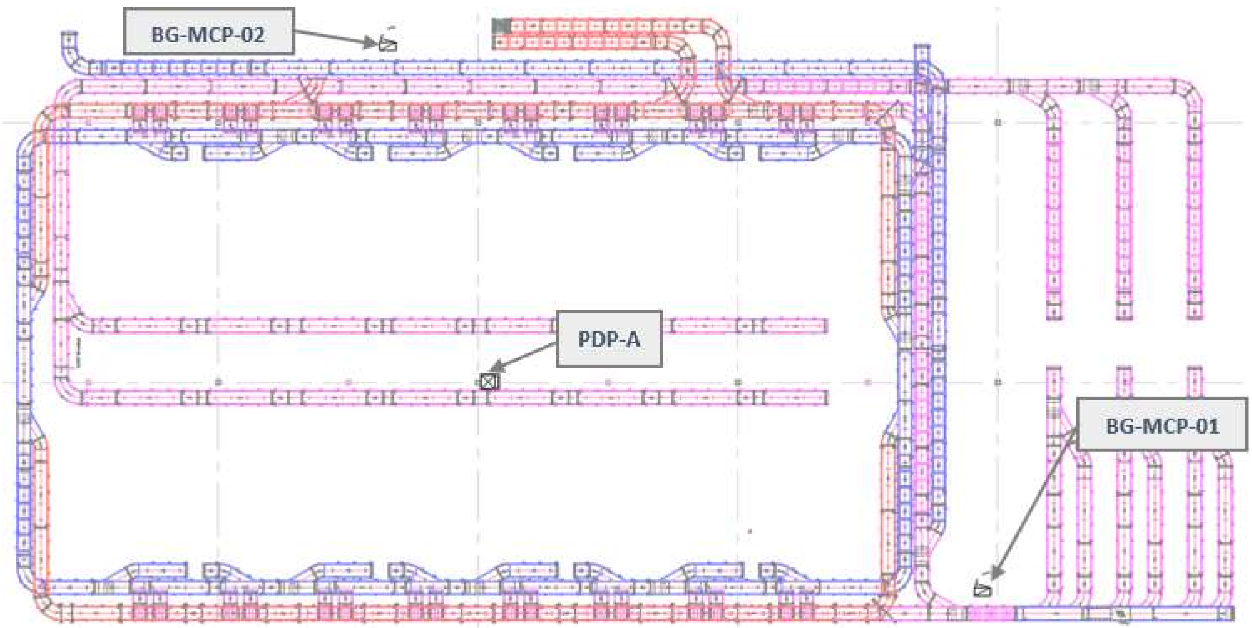

Figure 4 Locations of PDP and the two MCPs.

The following information in Table 2 outlines where the pages for the MCPs and PDP begin on the electrical layouts.

Table 2 Electrical Layout reference pages for PDP and MCPs

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

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, BG-MCP01 and BG-MCP02. Each panel has 2 drops, one for use and one for spare. This amount does not allow for remote PC connection for easier remote support access to the Wynright system.

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 5.

Figure 5 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 Wynright 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 Wynright system uses 1756-L72S GuardLogix controllers to control the system. These controllers also require the use of the 1756-L7SP GuardLogix Processor Safety Partner. Both devices are shown in Figure 6.

Figure 6 1756-L72S GuardLogix Processor (left) and 1756-L7SP Processor Safety Partner (right)

3.1.2 Safety Devices

ArmorBlock Guard I/O Modules (1732-ES, shown in Figure 7) 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 7 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. Wynright 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 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.

3.2.2 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 8 and described in Table 3.

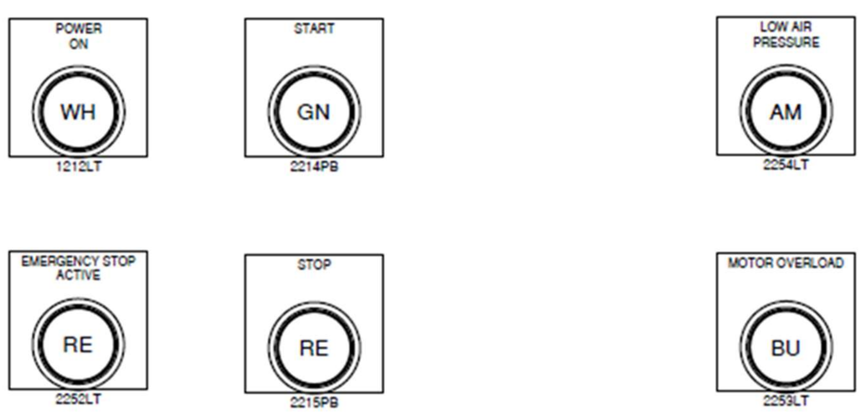

Figure 8 Motor Control Panel indicators and pushbutton controls, located on the front face of panel.

Table 3 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 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:	n/a	This indicator will be present on the panel but will <u>not</u> be used. There is no air used in the system.

*Refer to Section 3.2.1 for start/stop zoning.

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 9.

Figure 9 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 4

Table *4* Start/Stop Pushbutton Station details 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 4 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 3.2.1 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 10 for this station.

Figure 10 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 5. For devices that are customized for a particular area, see Section 4.0 *Area-Specific Operations and Product Flow.*

Table 5 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. **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.
Sorter Beacon Blue and Amber Beacons	Amber	**FLASHING (80ms ON / 100ms OFF (fast flash)):** when communications have been lost to the PLC. **FLASHING (.5s ON/OFF):** The sorter point has a jam

		FLASHING (250ms ON / 250ms OFF, 250 ms ON / 1250ms OFF (double flashes)): when there is an Induction Halt and no other faults exist. **SOLID:** A jam has been cleared and is waiting for a reset **OFF:** Scanner operating as expected, no faults.
	Blue	**ON:** Downstream conveyor full **OFF:** Downstream conveyor not full
Startup Horn		**PULSE (1s ON/OFF FOR 5s):** Equipment is starting up.

3.4 Equipment Types

There are several different 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.

The one VFD used in this system is located at the 6 to 1 merge, shown on EL01-37.

3.4.2 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 photoeyes 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).

3.4.3 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.

Photoeyes 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 EZ24-controls Motor-Driven Roller. For a product that isn't 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 234.0 *Area-Specific Operations* 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 Wynright'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 3.2.1 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. 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 photoeye 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.

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 Product Jam

A conveyor is considered to contain a product jam if a photoeye in a transition location is constantly blocked while the area is running. If no gap between products is detected by the photoeye 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 photoeye is cleared but will not restart until a reset button is pressed. Certain locations may be allowed to reset with the photoeye 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 photoeyes 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.

3.5.4 Merges

The typical two-to-one merge is fed by two inbound conveyors, each of which is equipped with either an air brake or short belt conveyor at the end. The braking device is used to quickly start and stop the movement of product as necessary, based on the release priority of each lane. Each line generally has a photoeye 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 photoeye, so long as the opposite lane is not already releasing product. If a carton blocks a brake photoeye 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 photoeye senses that no product is present, and release is shifted to the other lane.

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 6.

Table 6 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

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 subdivided 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 Full Carton Outbound (Box Merge)

Full carton outbound, or Box Merge is two lines that receive the full cartons from the 4-Span conveyor. The two lines merge and then cartons run on transport conveyor to three divert lanes. This path is shown in Figure 11 and is expanded upon further in this section.

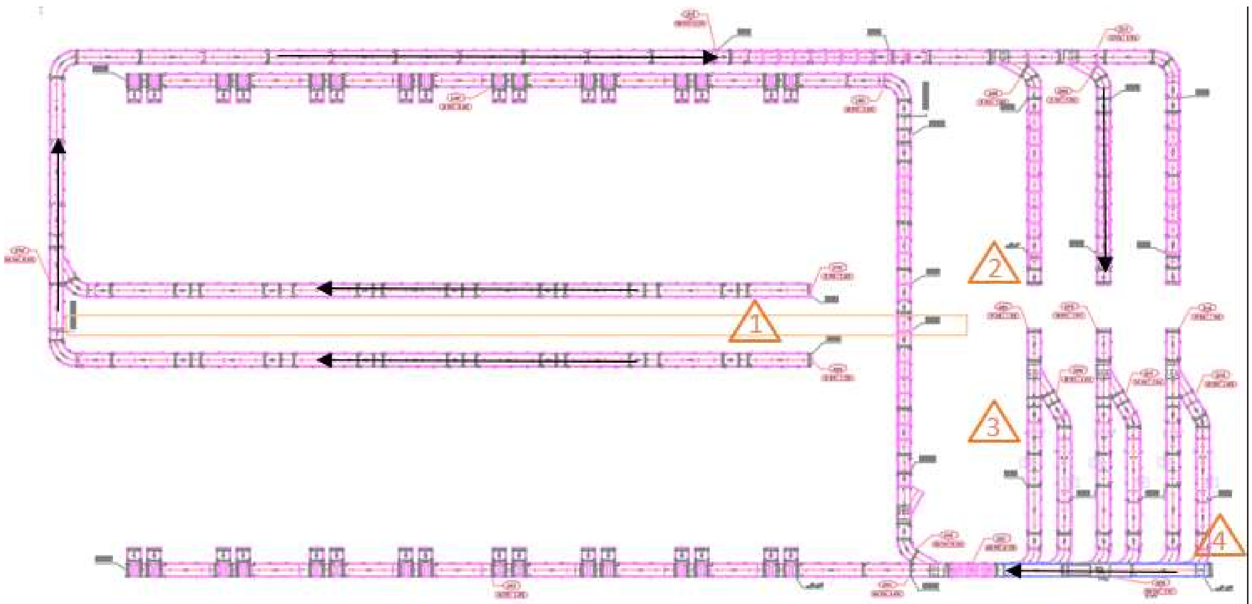

Figure 11 Flow of cartons through Full Carton Outbound area: "1" - Box Merge, "2" - Lifters, "3" - Pack out area, "4" - 6 to 1 Merge

High level messaging process is as follows: Berkshire Grey sends “Box Waiting”, then Wynright has logic to determine if the merge should occur. Once true, Wynright locks discharge zone and sends “Zone Ready”. Berkshire Grey sends discharge complete when box is successfully discharged from 4-Span system and Wynright sends discharge complete once the merge to conveyor has happened successfully. This process applies to each release point on both lines.

Once the full cartons have released to Wynright conveyor, labelled “1” in Figure 11, the cartons travel downstream 2 to 1 merge point. Refer to the standard 2 to 1 merge description in Section 3.5.4.

After the cartons merge, they travel on the transport section to the divert point with three lanes. There is no prioritization here, the cartons will route to a lane in round robin.

<u>Lifter</u>

Downstream from the previous divert point, each of the three lanes has a lifter, “2” in Figure 11, and detail drawing in Figure 12.

Refer to Appendix 5.1.1 for detail documents related to the lifter.

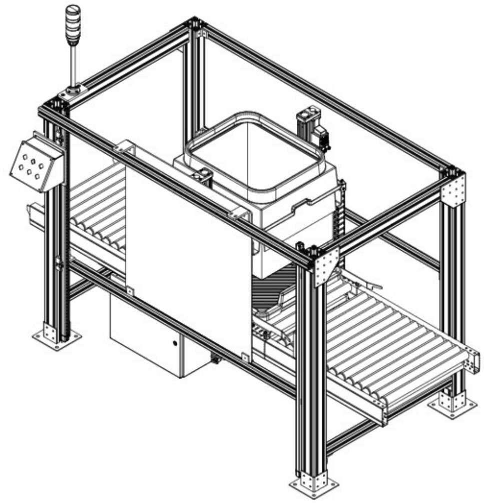

Figure 12 Box lifter assembly for separating tray from box and collar.

At this lifter section the box and collar are separated from the tray. Both Berkshire Grey and Wynright have interlocks here, shown in Table 7.

Table 7 List of interlocks from both Berkshire Grey and Wynright at the lifter section.

From Berkshire Grey	From Wynright
Lifter OK	Sending to Lifter
Lifter Ready to Receive	Can Receive from Lifter
Lifter is Sending	n/a
Lifter is Sending Tray	n/a
Lifter is Sending Box	n/a

The interlocks are wired to a relay provided by Berkshire Grey, and the details are included in the supporting documents (Appendix 5.1.1).

From this point, the tray travels in front of the box. This tray and box just separated, must travel together. There are two zones between the lifter and the divert point. To have the tray and box travel together, Wynright waits until the lifter is once again giving the Ready to Receive signal. Indicating that the lifter has transported both the tray and box out of its area and no faults occurred. Then, once Wynright is getting the Ready to Receive and both zones just before the divert are occupied, the tray and box are allowed to move. The option of which lane the two items travel toward alternates. Unless one of the pack out stations are disabled downstream. Then, the available lane is prioritized. After the divert point are the pack out stations described in the next section.

Pack Out Stations

At the pack out stations, the tray and box stage before the work zone. These staging zones are shown in Figure 13 outlined in green. The work zone is outlined in red. When the operator presses the pushbutton to bring in the tray, the carton will stay in the zone it is staged in. This is so the box does not run into the collar that is hanging.

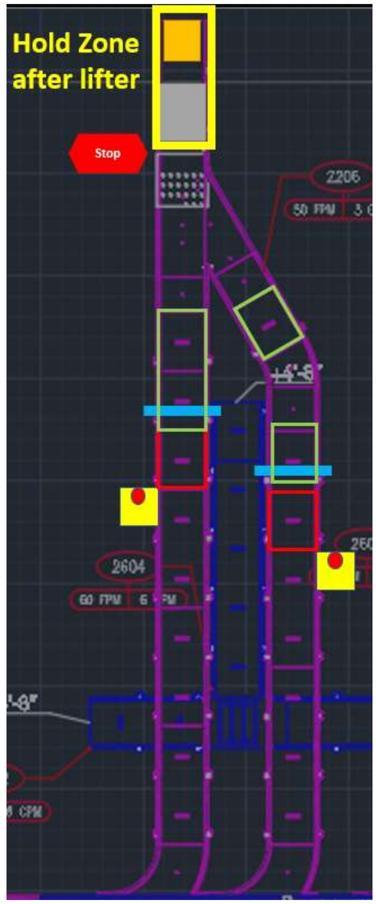

Figure 13 Staging zones of tray and box at packout lines

At the pack out stations, operators are manipulating the box and trays. The locations of the stations are shown as “3” in Figure 11.

There is Wynright controlled pushbutton with light, labeled “1” in Figure 14, see supporting document “EZ-LIGHT Touch_133535” (Appendix 5.1.1) for details on the pushbutton used here. To allow the tray into the work zone (“2”), the operator presses the button. The tray is transported into the work zone where the operator places an empty box onto the tray. This empty box comes from the “Empty Carton Replenishment” conveyor (see Section 4.1.4). The collar is then placed on the empty box to keep the flaps down. The empty carton assembly is now complete (tray, box, and collar) and the operator presses the pushbutton to send the carton out.

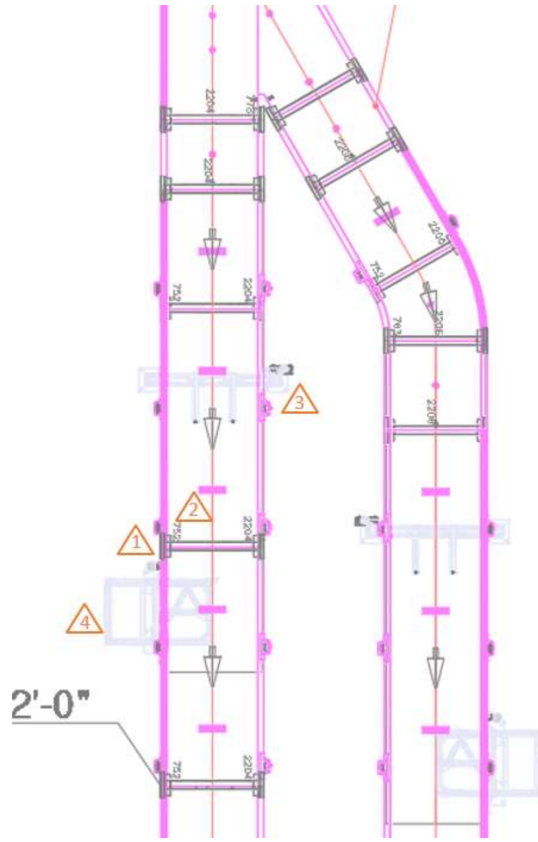

Figure 14 Pack out station location for one lane, with labels of its different parts.

The empty carton has now left the work zone and the operator presses the pushbutton to allow the box and collar to enter. The operator removes the collar and hangs it on a hanger (“3”). They close out the carton, adding the shipping label (“4”). Both full and empty cartons travel to the merge detailed in the next section about the 6 to 1 merge.

6 to 1 Merge

After the pack out stations, there are a mix of both empty cartons and closed cartons that merge at a peak rate of 32 CPM. This merge is shown in Figure 11, labelled as “4”. This merge is similar to the functionality of the 2-to 1 merges (Section 3.5.4), only with six infeed lanes. The belted section will also have an encoder to help track positions through the merging process. Coming off of the belted conveyor the cartons are sorted by “closed” or “empty”, detailed in Section 4.1.2.

4.1.2 Empty Carton Inbound

Divert

From the 6 to 1 merge, both closed cartons and new empty cartons are being sorted. The first divert, labelled “1” in Figure 15 has two photoeyes mounted on top of each other at specific heights, described later in this section.

Figure 15 Flow of cartons through Empty Carton Inbound area: "1" - Divert 1, "2" - Divert 2, "3" - Inbound Transfers

The closed cartons all divert at this location. Then, any cartons at the “empty carton” height alternate between travelling straight and diverting, allowing 50% to be routed toward each of the empty carton inbound lanes, “3”. At divert “2”, the same determination of “closed” or “empty” carton is made with the photo eye configuration in Figure 16. The photoeyes are mounted on the same vertical, one at 17 inches and the other at 21.5 inches. The same configuration is present at both divert 1 and 2.

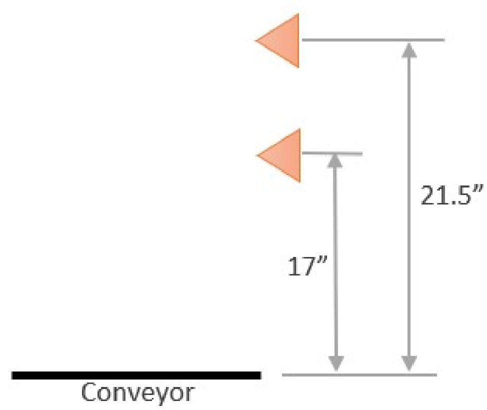

Figure 16 Photo eye configuration for the decision to route packages to shipping or empty carton inbound.

If closed, the carton diverts at divert “2” and travels down the shipping lane. If empty, it travels straight to the northern empty carton inbound lane.

Inbound Right-Angle Transfers

After the empty and closed cartons are separated, there are half of the empty cartons on their way to each of the empty carton inbound lanes labelled “3” in Figure 15. These lines are where the empty cartons stage to then be inducted to Berkshire Grey 4-Span when needed. The staging positions are shown in Figure 17. The cartons do not sit in the transfer, rather they are staged before the transfers. So long as the supply of cartons being sent here is sufficient, the positions shown are always full. As cartons transfer to the 4-Span, the staged cartons fill in the new empty space. These positions are the same for both lines of the empty carton inbound.

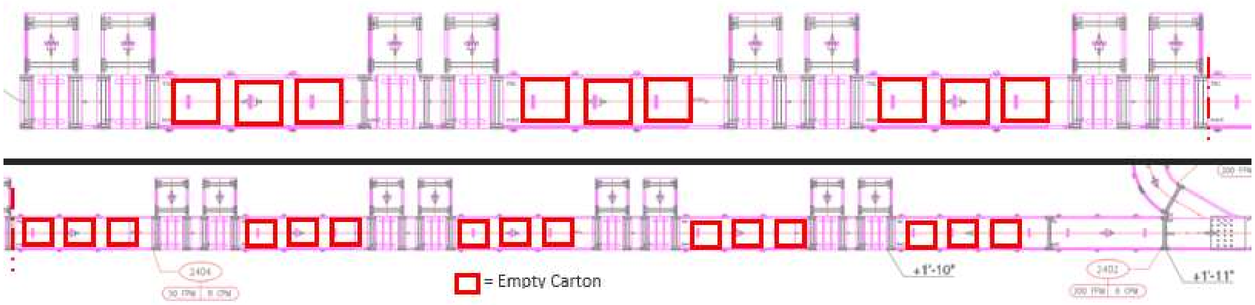

Figure 17 Staging positions of empty cartons on the empty carton inbound lines.

High level messaging here will take place like this: Berkshire Grey sends “Box Needed” and Wynright requests a “Start Induct”. Berkshire Grey locks the 4 -Span section and sends “Induct Ready”. Once induct ready is indicated, Wynright transfers the box through the RAT and stages on the MDR section after. Wynright sends “Ready” and Berkshire Grey starts the 4-Span induct, also sending “Ready”. Wynright transfers the box and sends a “Complete” once the section is clear. Once Berkshire Grey has successfully accepted the box, they send a “Complete”

4.1.3 Shipping

Closed cartons from the previous section (4.1.2) have now diverted at both diverts and travel down the shipping lane. This lane is shown in Figure 18.

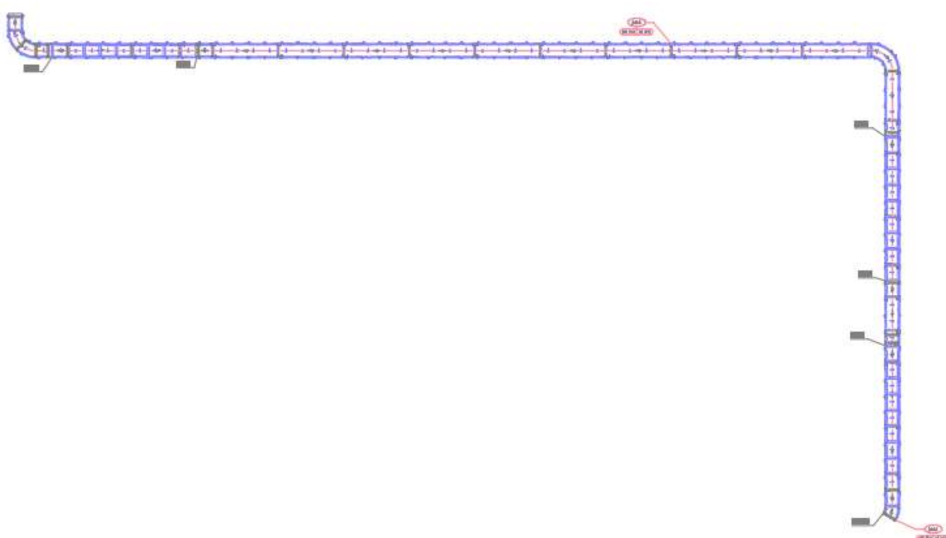

Figure 18 Shipping Lane

At the end of the shipping lane, Wynright interlocks with the external conveyor leading to the rest of the building.

4.1.4 Empty Carton Replenishment

This section has a trunk line that feeds three short lines which are located in between the pack out station conveyors (see Figure 19).

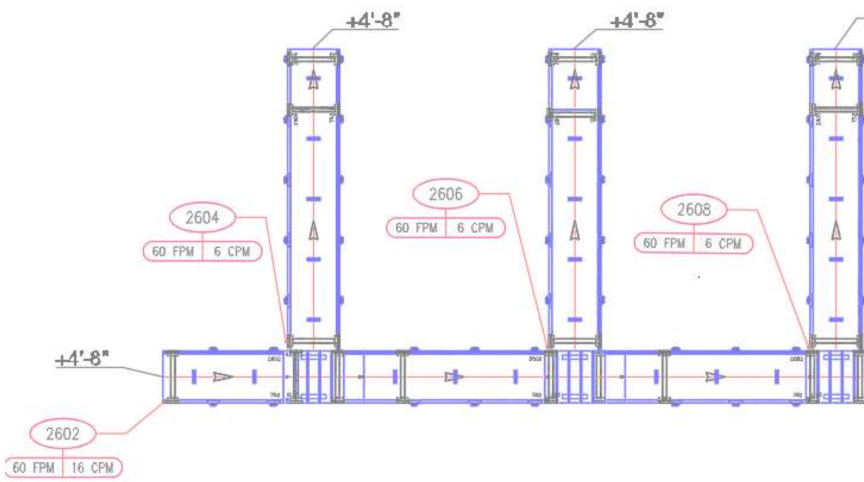

Figure 19 Empty Carton Replenishment

It is fed by an automatic box folder with a short section of conveyor. The Wynright conveyor is woken up by receiving a wake-up signal two zones upstream from the first zone of Wynright conveyor. The boxes are diverted in round robin fashion, and the section is kept full so long as the supply of boxes being made is sufficient.

4.1.5 Tote Loop

The tote loop, shown in Figure 20, consists of an outer loop, scan points, and highway loops. For details on the scanners, see Section 4.1.7.

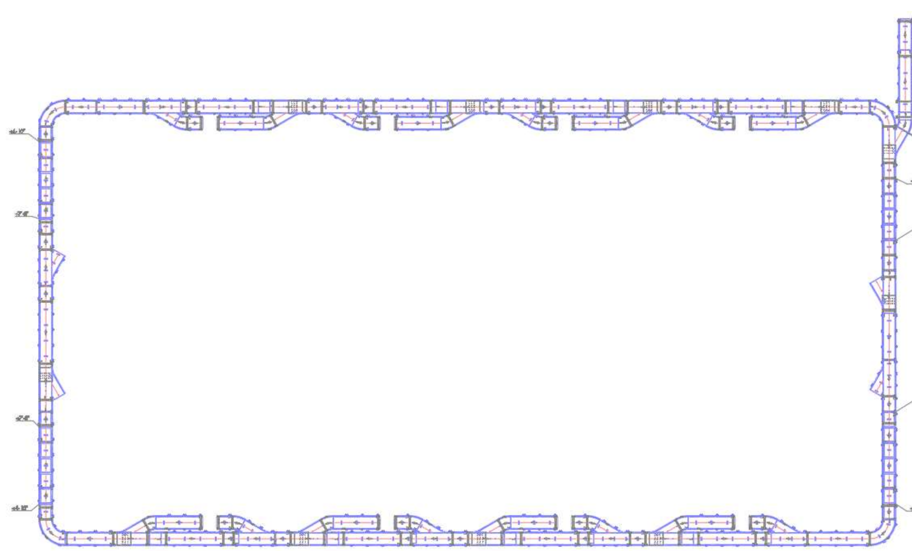

Figure 20 Tote Loop

<u>Highway Loops</u>

The highway loops are where the operator picks product. There is a scanner prior to each divert to a highway loop (see Section 4.1.7). When a tote enters the highway loop, there are a few zones of staging before the pick zone, shown in Figure 21.

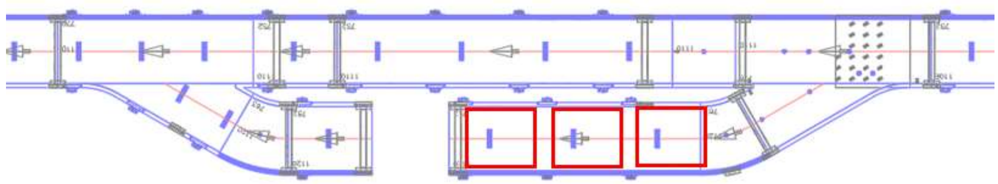

Figure 21 Highway loop tote staging example.

The pick zone is a scale, and the functionality is detailed in the next section. Once the allotted product is picked the tote exits the zone and merges when there is a window gap in product on the tote loop.

Scale Section

The pick zone on each highway loop is where an operator stands to pick product from a tote. The pick zone is a scale and is highlighted in Figure 22. Power for the scale module comes from Berkshire Grey, the card and rollers are powered by Wynright.

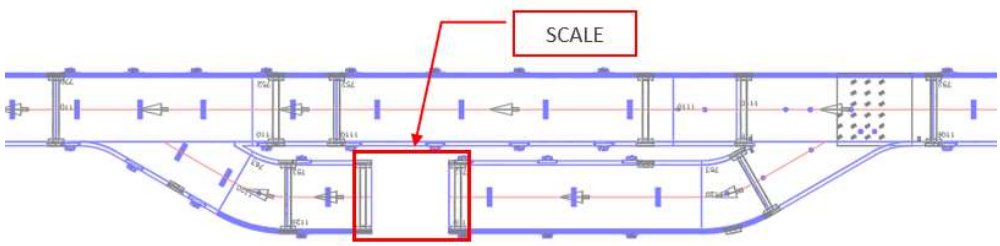

Figure 22 Pick Zone scale section callout.

High level functionality of this scale section is: Wynright sends tote present, Berkshire Grey sends an index start, and then Wynright begins the tote index. Wynright unlocks the pick zone and allows the tote to enter until it blocks the photoeye, then the zone is locked. Wynright sends a transfer complete and waits for Berkshire Grey complete. Berkshire Grey handles the decision of when the tote is completed. Once Wynright gets the complete, the tote is moved out and the process restarts for the next tote.

Tote Outbound

The tote outbound is how totes exit the system when needed, shown in Figure 23. There is a scanner where the decision is made to divert or travel straight.

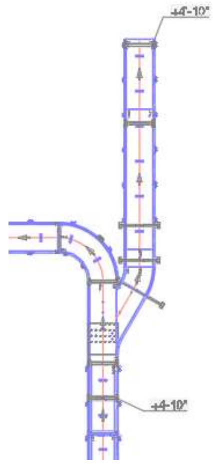

Figure 23 Tote Outbound, located on northeast corner of tote loop.

The decision to divert comes from Berkshire Grey, Wynright sends the barcode and Berkshire responds with the destination. This outbound conveyor section interlocks with the external conveyor.

<u>To Tote Bypass</u>

There are two points where totes can be diverted to the tote bypass loop (see Figure 24). The tote bypass and tote loop merge together. Then, the totes are routed to tote loop or tote bypass at the scanner. For more detail on scanners and messaging see Section 4.1.7.

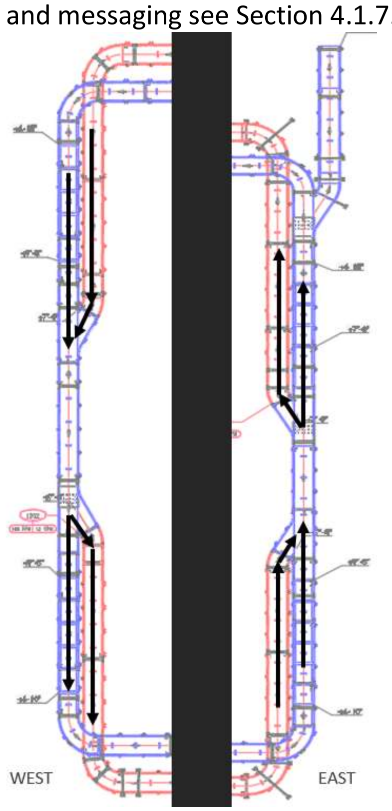

Figure 24 East and West diverts to the tote bypass lanes.

4.1.6 Tote Bypass

The tote bypass is shown below in Figure 25. The labelled sections are as follows, “1” is the infeed for totes and “2” is the jackpot.

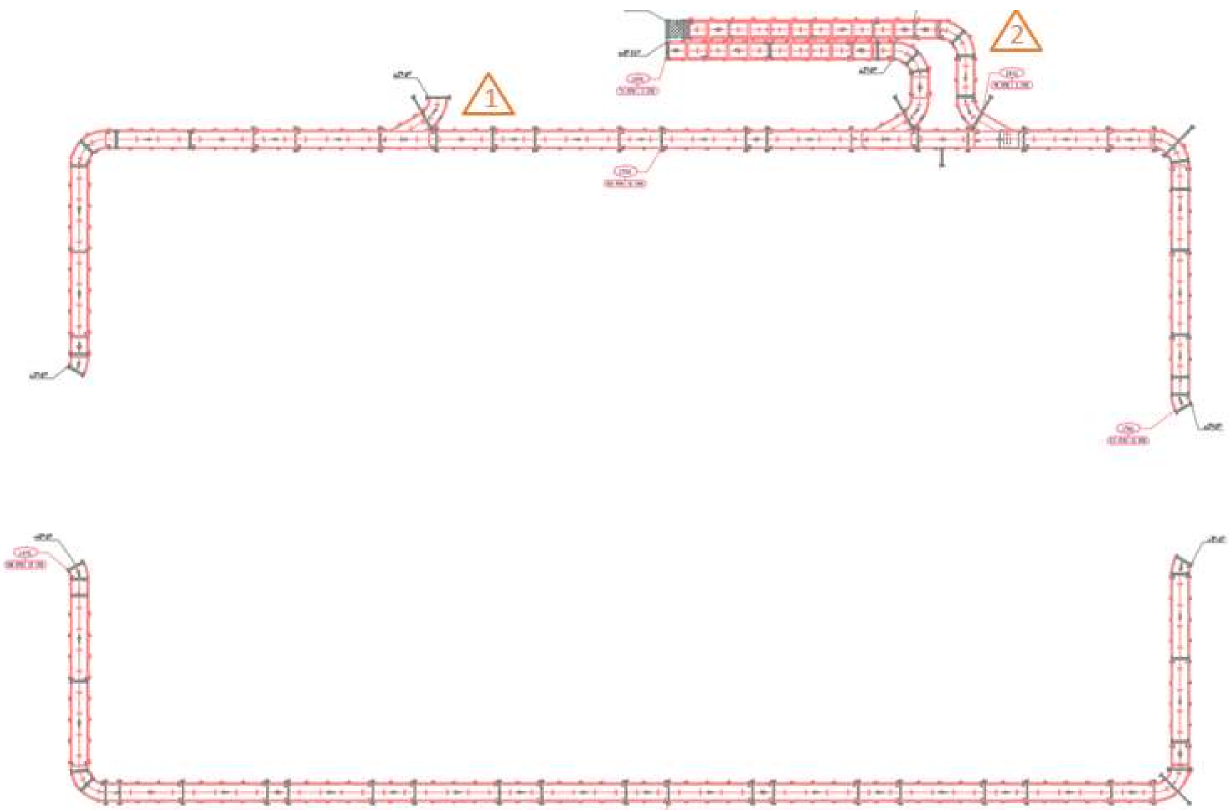

Figure 25 Tote Bypass, "1" - Tote Infeed, "2" - Jackpot

<u>Inbound Totes</u>

The Wynright conveyor inbound tote section receives a wake-up interlock signal from the external conveyor and then merges onto the tote bypass. See Section 3.5.4 for the standard 2 to 1 merge logic.

<u>Bypass</u>

When totes are not directly needed to route to the highway loops, the instruction is given to divert to the tote bypass. This instruction comes at the scanner and the decision is made by Berkshire Grey, more details on scanners in Section 4.1.7. Refer to Section 3.5.4 for the standard 2 to 1 merge logic.

<u>Jackpot</u>

The final scan point is on the tote bypass line just before the divert to the jackpot. Totes are diverted here, “2” in Figure 25, if the tote needs to be addressed manually. After diverting, the tote runs to the bottom of the decline for the operator to address. Then, they move the tote from the conveyor to the ball table and push the tote to the next conveyor. The tote re-inducts to the tote bypass by merging with the existing totes. The tote from the jackpot waits for a window, or gap, in product on the tote bypass.

4.1.7 Scanner Details

Scanners for this project are designed and provided by SICK. Each scanner is 1-sided, scanner positioned on the left-hand side of the conveyor. Each scanner communicates the barcode to the Wynright PLC through ethernet connection. The barcode information is communicated to Berkshire Grey, and they give the destination instruction. Destinations based on barcode are not decided by Wynright. The scanners are powered by 120V outlets provided from Berkshire Grey. The scanners are connected to Wynright local network, not Berkshire Grey corporate network.

Locations

Figure 26**Error! Reference source not found.**, Figure 27, Figure 28, and Figure 29 shown below illuminate the locations of the scanners in the system.

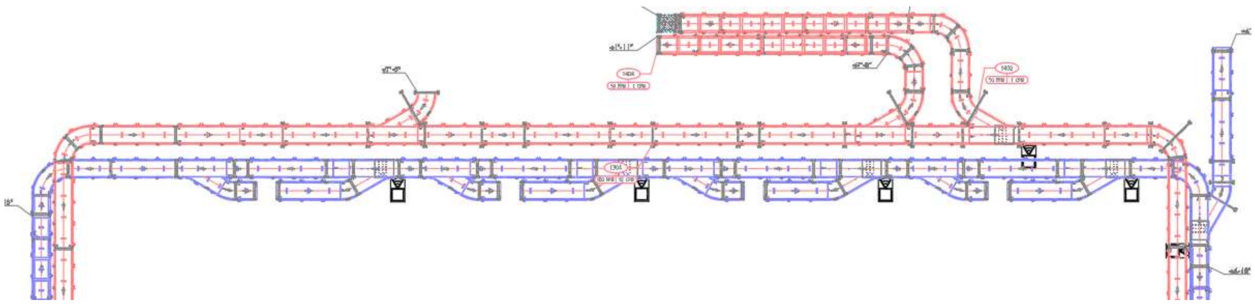

Figure 26 North Tote Loop scanner, Tote Outbound scanner, and Jackpot scanner location

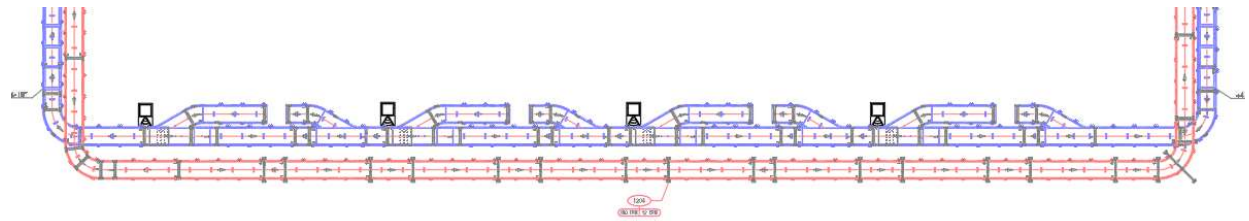

Figure 27 South Tote Loop scanner locations

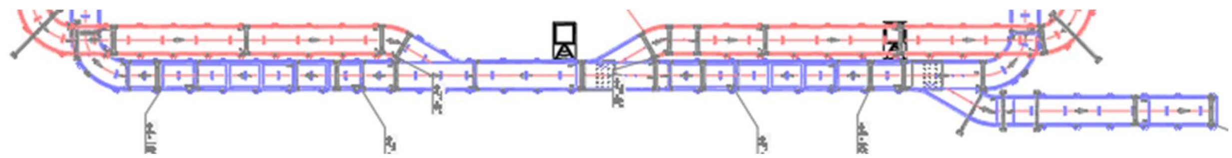

Figure 28 East Tote Bypass divert scanner location

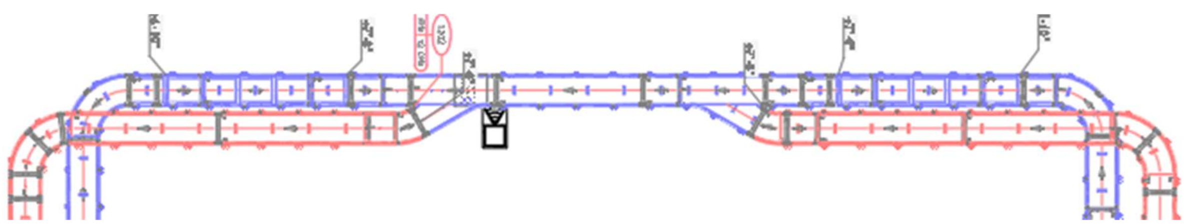

Figure 29 West Tote Bypass divert scanner location

4.1.8 Barcode Specifications

Please see the separate document "Tote Barcode Specification_133535" (Appendix 5.1.1) for more details on the barcodes being scanned in this system. This section is a summary of the barcodes that are used in the system.

Barcode Information

Figure 30 below shows an example of the tote barcode used. This is the only barcode use in the system and is only placed on totes.

Figure 30 Tote barcode example with dimensions (format of characters is updated and different than this figure)

Attributes:

- Gloss white TT Polyester w/ Permanent Acrylic Adhesive
- Matte laminated polyester labels (3M 7868), black print
- 2.5”x1.0” rectangle, .125 C Radius, 2 mm thickness
- Code 128, 19.74 mil barcode size
- 7 digits, pattern: “R:12345” or “D:12345”

Placement:

Each barcode is placed on totes within the allowable window shown in Figure 31. The labels are also placed on both the right and left faces of the tote, see Figure 32.

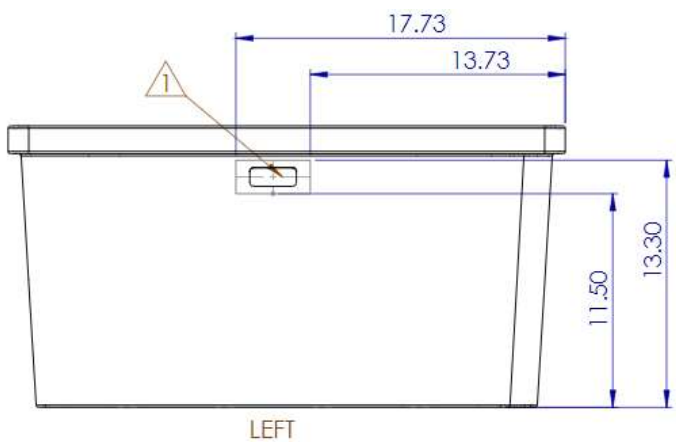

Figure 31 Allowable barcode placement (shown on left face), label "1" shows the outline of the barcode itself.

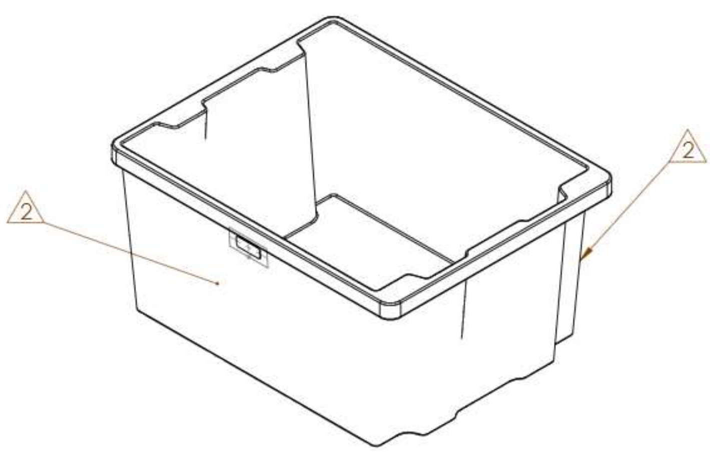

Figure 32 Label "2" shows which faces the barcode should be placed on, both left and right face.

5.0 Appendix

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

5.1.1 Supporting Documents

The SharePoint folder with the supporting documents mentioned throughout are linked – here.

5.1.2 E-Stop Zoning

Below, in Figure 33, is an outline of the E-Stop zones. Zone boundaries may overlap based on actual footprint of MDR circuits.

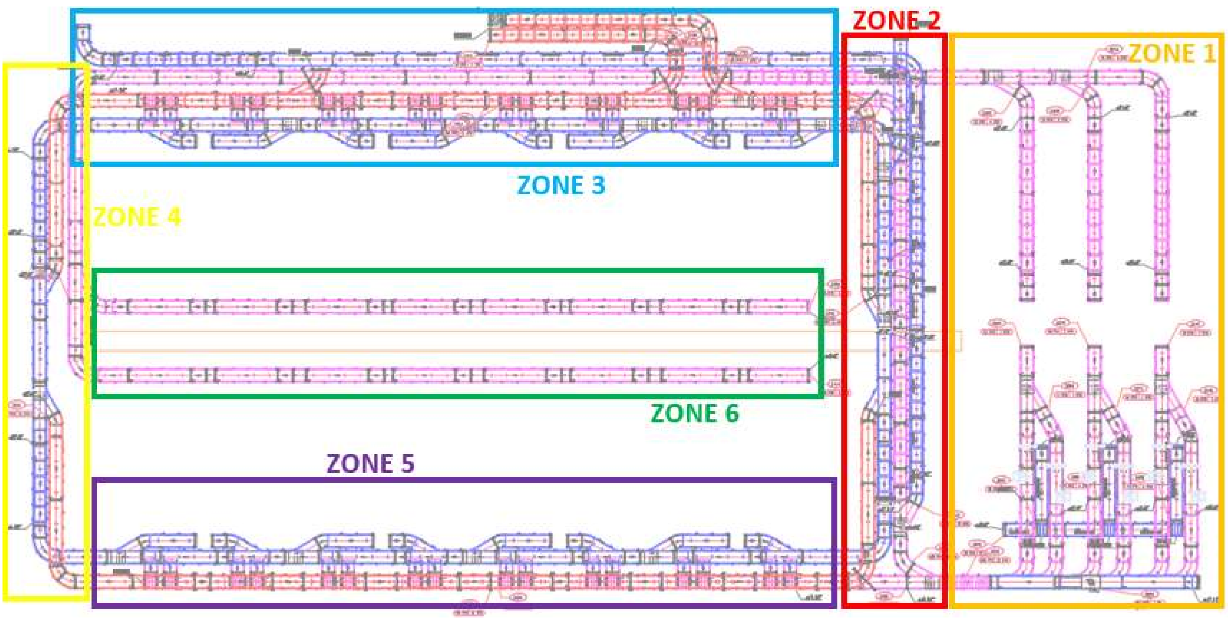

Figure 33 E-Stop Zone outline

5.1.3 HMI

The HMI is located as shown in Figure 34. It is located near the pack out workstations for operator access. The HMI will be mounted on a stationary stand.

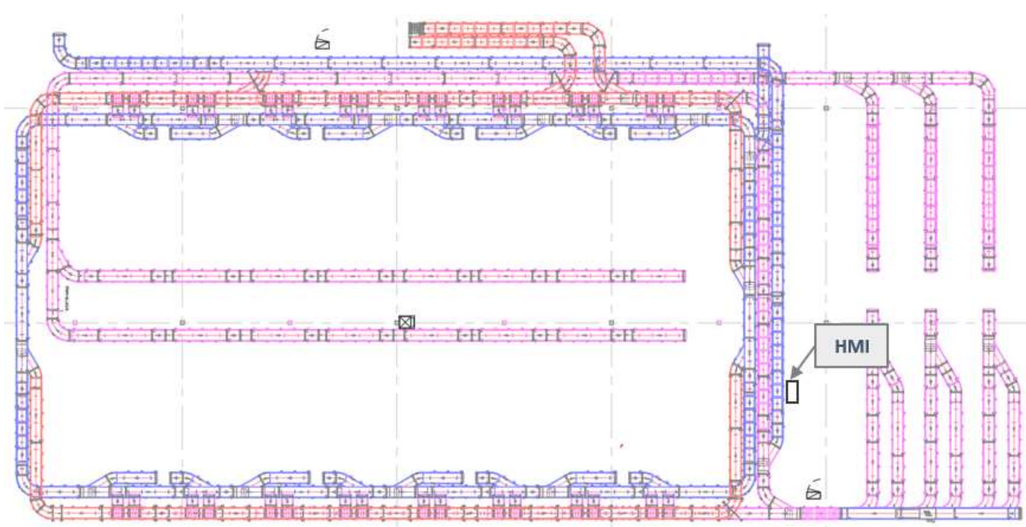

Figure 34 HMI location

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.

5.1.4 Functionality Details

Refer to "3rd Party Payload_133535" document (Appendix 5.1.1) for tag details referenced in this section.

Refer to "3rd Party Common Handshake Components_133535" 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

Customer discussion still needed for labelling of "RSPS" 4-Span, preliminarily shown in Figure 35. Each pair of shuttles is referred to as "RSPS X". See Figure 36 for the 4-Span section specific naming.

Figure 35 Preliminary naming of RSPS 4-Span cells, customer input still needed

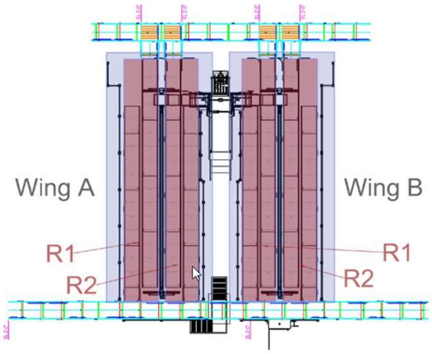

Figure 36 4-Span section labelling

System Status

Both Wynright and Berkshire Grey have a tag called "wSystemSts". 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.

Full Carton Outbound (Box Merge)

All tags used for this area are from "udtPLCtoBG_box" and "udtBGtoPLC_box" for Wynright 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 index 40-79.

The process is described next, and graphically represented in Figure 37.

BG sends (aDischargeAvailable) to indicate that a full carton is ready to discharge, Wynright stops the zone upstream of the merge zone if a carton arrives anytime during the merge. Wynright ensures the merge zone photoeye is not blocked and the zone is stopped, when that is true sends (aHandshakeReady) indicating that the merge zone is ready. Once the discharging carton leaves the BG zone, BG sends (aHandshakeComplete) indicating that the merge is complete from the BG side. Wynright responds with (aHandshakeCompleteAck) which is just for analytics related to timing between the Wynright PLC and BG. Wynright accepts the carton and waits x seconds to move the merge zone until the photoeye is blocked. Then, the carton and any other cartons waiting upstream can move and resume normal behavior. When the carton reaches the merge photoeye, Wynright sends (aHandshakeComplete) indicating that the merge was successful. Then, both BG and Wynright 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.

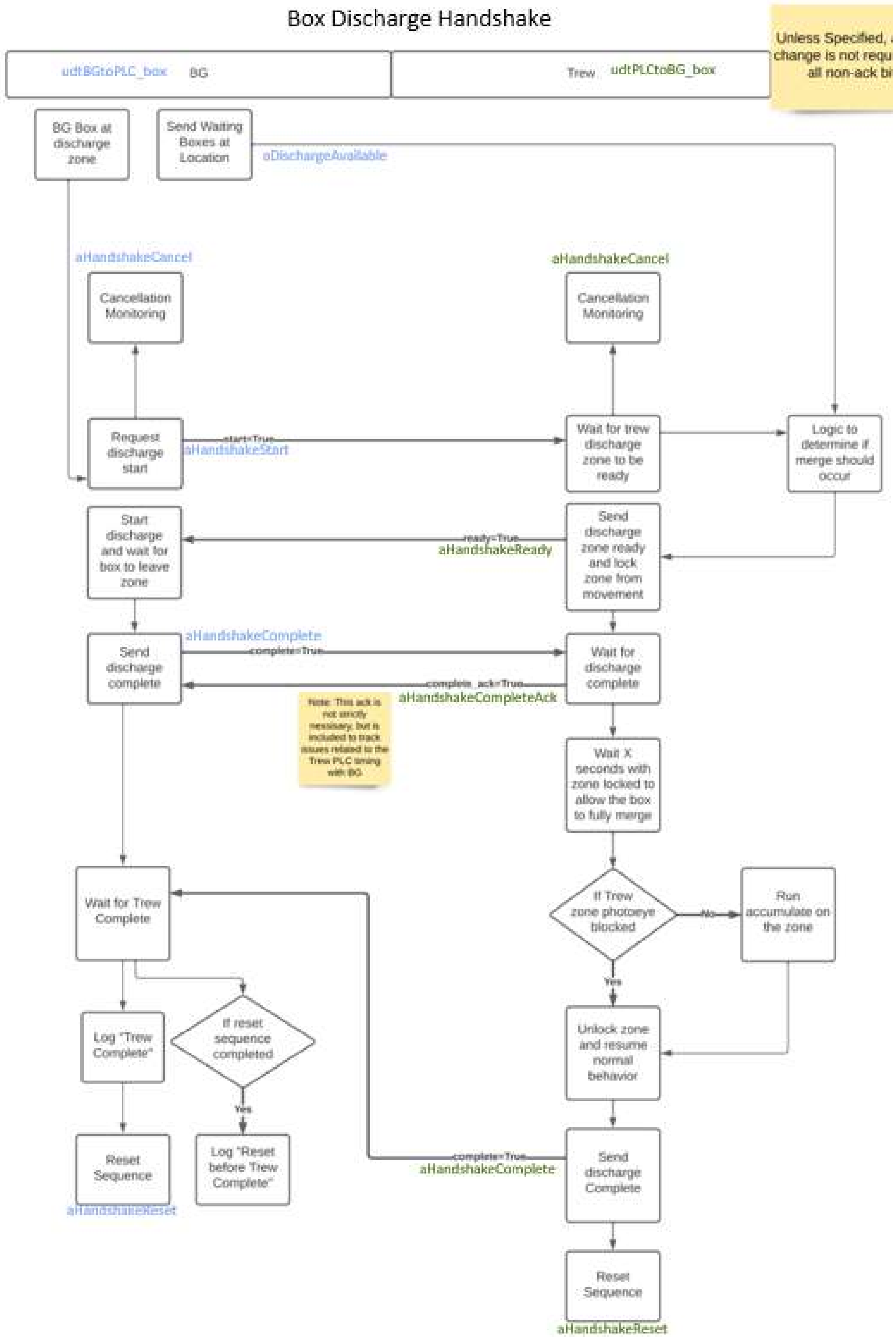

Figure 37 Box Discharge Handshake outline, labelled with tag names

Empty Carton Inbound

All tags used for this area are from “udtPLCtoBG_box” and “udtBGtoPLC_box” for Wynright 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 index 0-39 are utilized for the induct.

The process is described next, and graphically represented in Figure 38.

BG sends a number of available slots (aInductSlotsAvailable) in the 4-Span and (aInductAvailable) indicating that the 4-Span induct zone is ready to receive. Wynright sends (aHandshakeStart) to start the induction and waits for BG to respond with (aHandshakeReady) to signal to start the transfer. When Wynright senses the empty carton at the RAT (aHandshakeReady) is sent and BG responds with (aHandshakeReadyAck) as they start the induction of the carton. This last message is used to track errors in the BG process. Once the carton leaves Wynright conveyor, (aHandshakeComplete) is sent and Wynright waits for (aHandshakeComplete) from BG once the 4-Span induct is completed. 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.

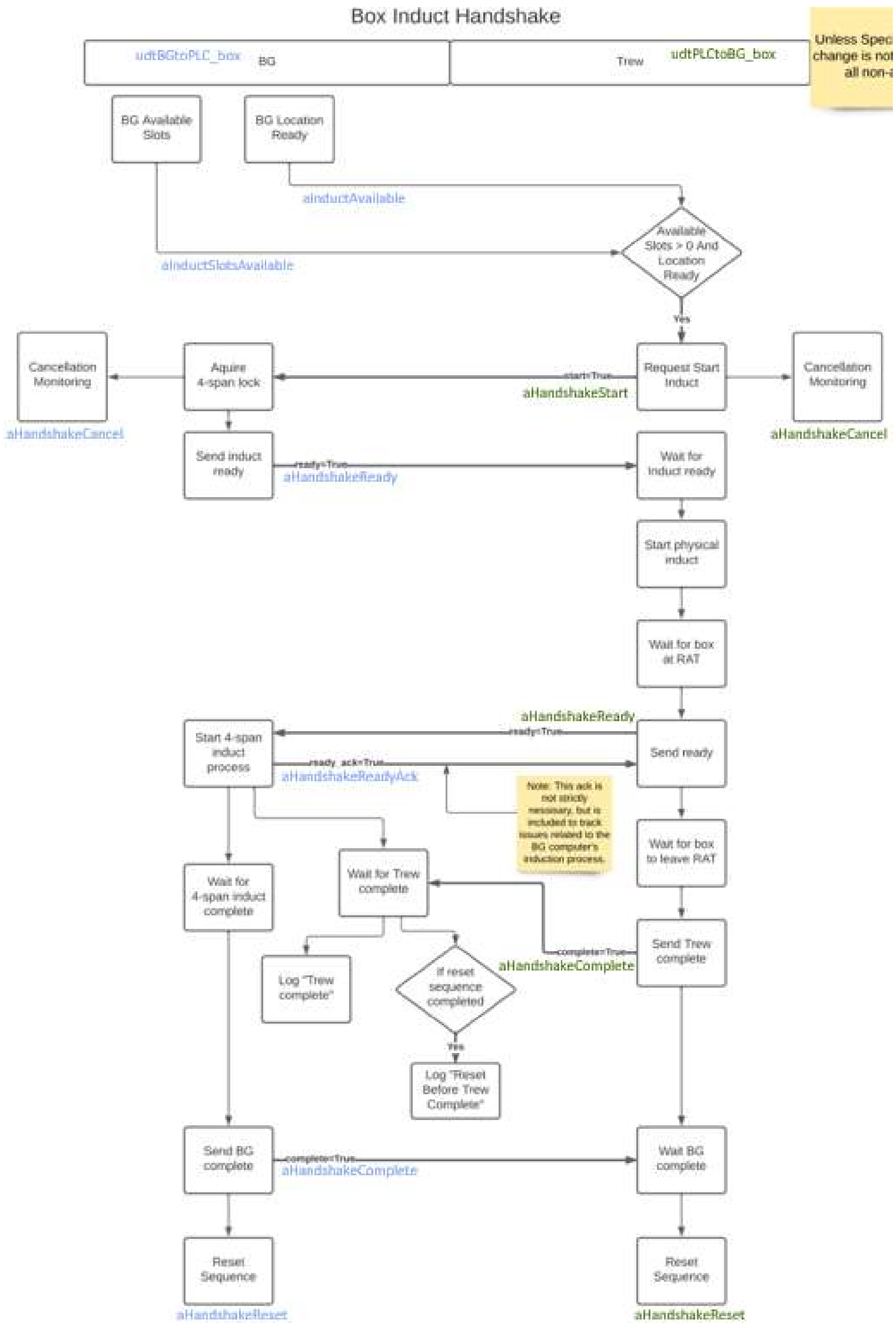

Figure 38 Box Induct Handshake, with labelled tag names

Packout

The only information handled by Wynright and sent to Berkshire Grey is when the EZ-LIGHT pushbutton is pressed. Berkshire Grey uses this for data collection on their side. Wynright will change the state of "aBCSZoneOccupied" when the pack out button is pressed. This tag is an array of 32 booleans, where index 0-5 are utilized one for each station.

Tote Loop (Tote Index)

All tags used for this area are from "udtPLCtoBG_tote" and "udtBGtoPLC_tote" for Wynright 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, and graphically represented in Figure 39.

Wynright sends the status of the pick zone photoeye, indicating that there is a tote present. Throughout the sequence, Wynright monitors the highway loop for jams and sends (aStationConvZonesJammed) with corresponding index for the highway loop if a jam is detected. Berkshire Grey sends (aHandshakeStart) to start the handshake. Wynright moves the tote out of the pick zone and allows a new tote in. When a new tote arrives, Wynright stops the pick zone and stops the totes upstream of the pick zone. Wynright reports the status of the zone directly upstream of the pick zone. Wynright sends (aHandshakeComplete) once the totes are stopped and waits for BG complete. Once BG complete (aHandshakeComplete) is received, both sides reset the sequence (aHandshakeReset). Note: through the entire sequence, there is cancellation monitoring (aHandshakeCancel) that each side is looking for throughout.

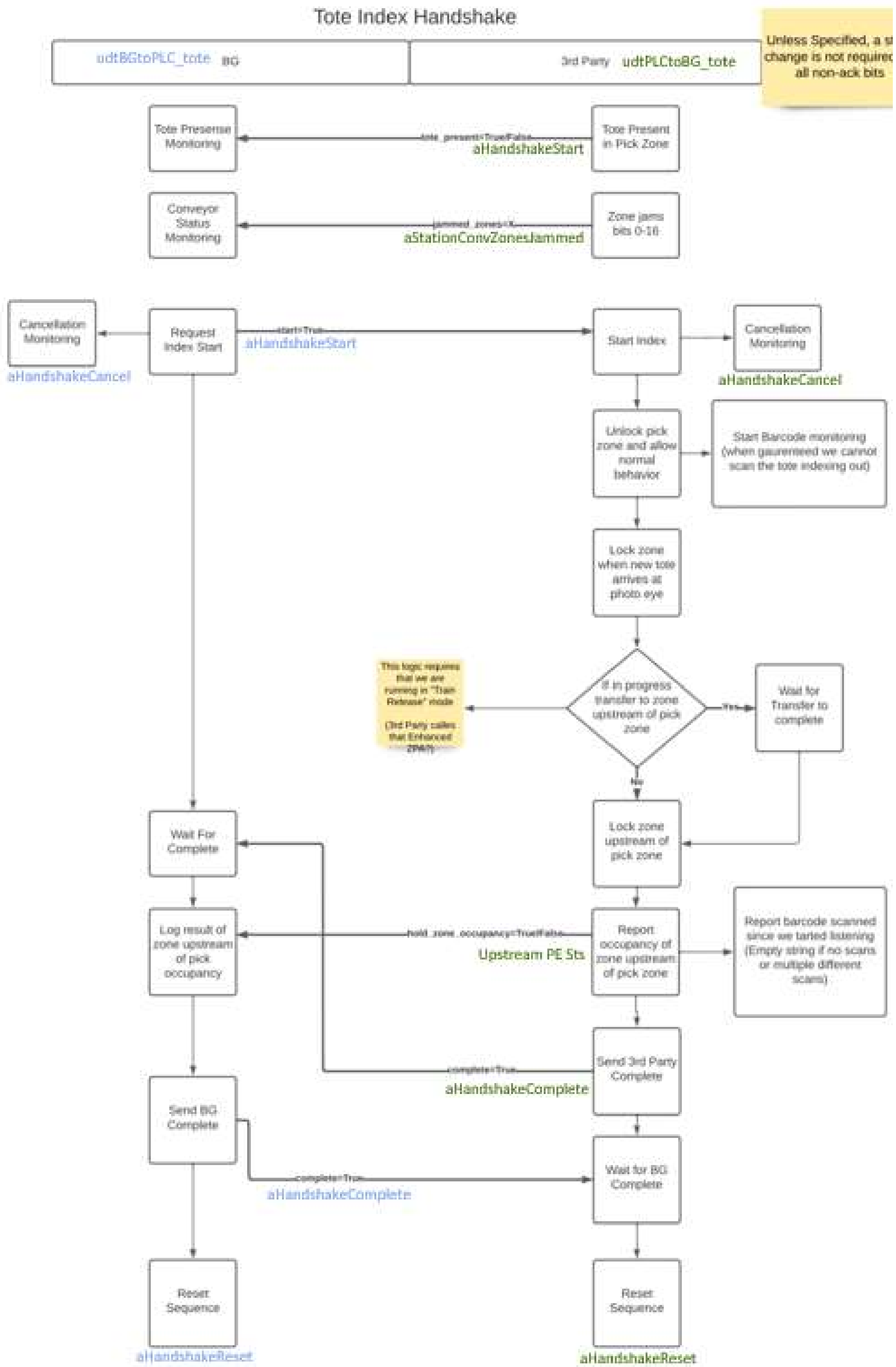

Figure 39 Tote Index Handshake, with labelled tag names

Scanner

All tags used for this area are from “udtPLCtoBG_tote” and “udtBGtoPLC_tote” for Wynright 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, Request (Figure 40), Response (Figure 41), and Confirm (Figure 42). Request is as follows: Wynright takes in scanned barcode and sends (aBarcode) the barcode data, (aBarcodeDecisionRequestID) barcode ID request, and (aBarcodeDecisionRequestTrigger) decision trigger. After getting those three items, BG sends (aBarcodeDecisionRequestTriggerAck). Then both parties reset the sequence. Response is as follows: BG does their internal decision process for destination of the tote. BG sends (aBarcodeDecisionID) decision ID, (aBarcodeDecisionPrimaryDest) primary destination, and (aBarcodeDecisionResponseTrigger) response trigger. Once these three items have been received, Wynright sends (aBarcodeDecisionResponseTriggerAck) response trigger. Both parties reset the process. Confirm is as follows: Wynright instructs the tote to follow the destination received from BG. Wynright sends (aBarcodeDecisionConfirmID) confirmation ID, (aBarcodeDecisionConfirmReasonCode) confirmation reason code, (aBarcodeDecisionConfirmResultDest) destination confirmation, and (aBarcodeDecisionConfirmRequestedDest) confirm requested destination. Wynright then also sends (aBarcodeDecisionConfirmTrigger) confirm of destination success. BG responds with (aBarcodeDecisionConfirmTriggerAck) confirmation of the destination. Both parties then reset the process.

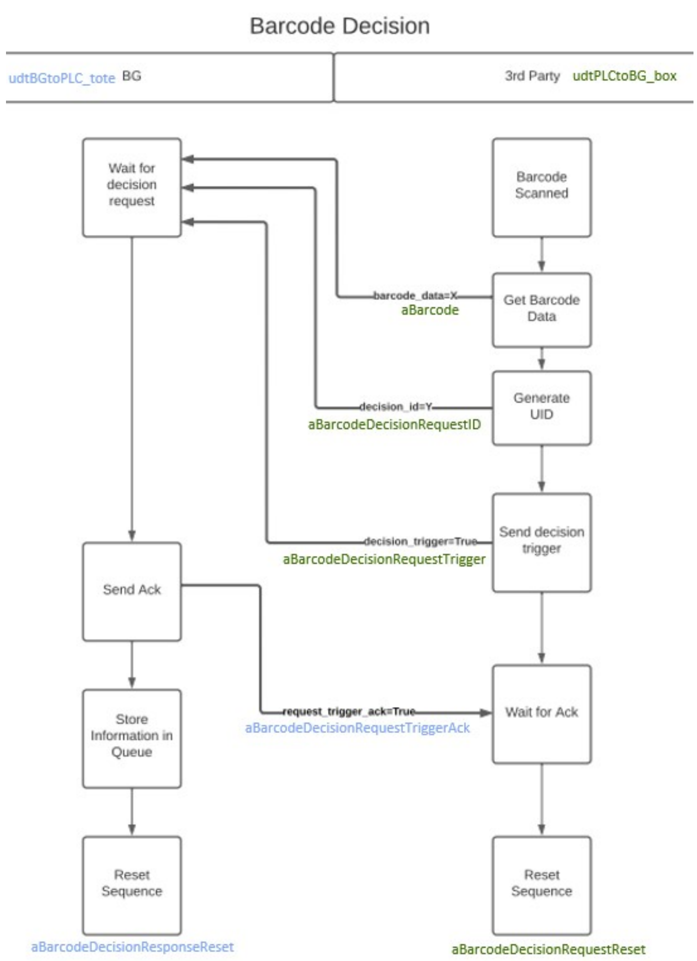

Figure 40 Barcode Decision Request process, with labelled tag names

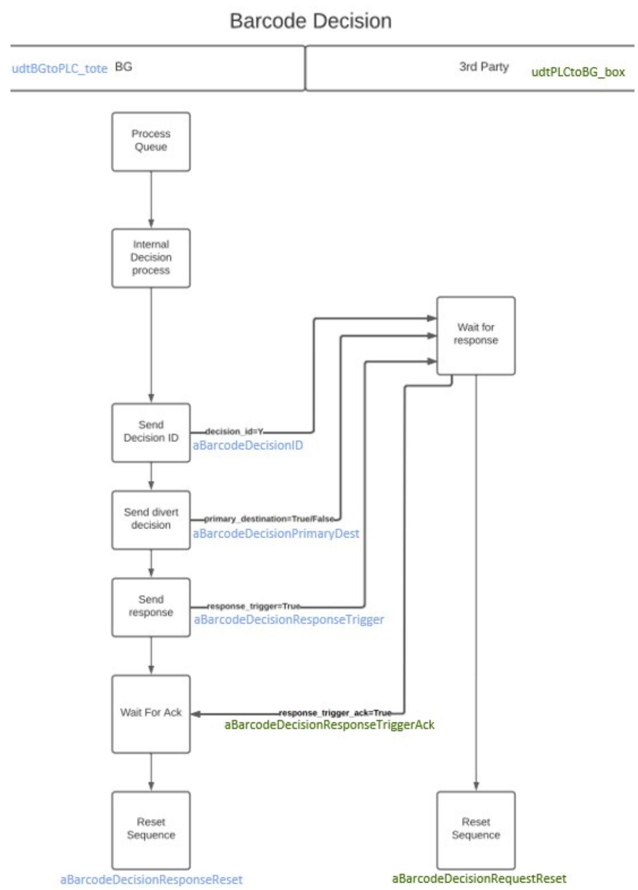

Figure 41 Barcode Decision Response process, with labelled tag names

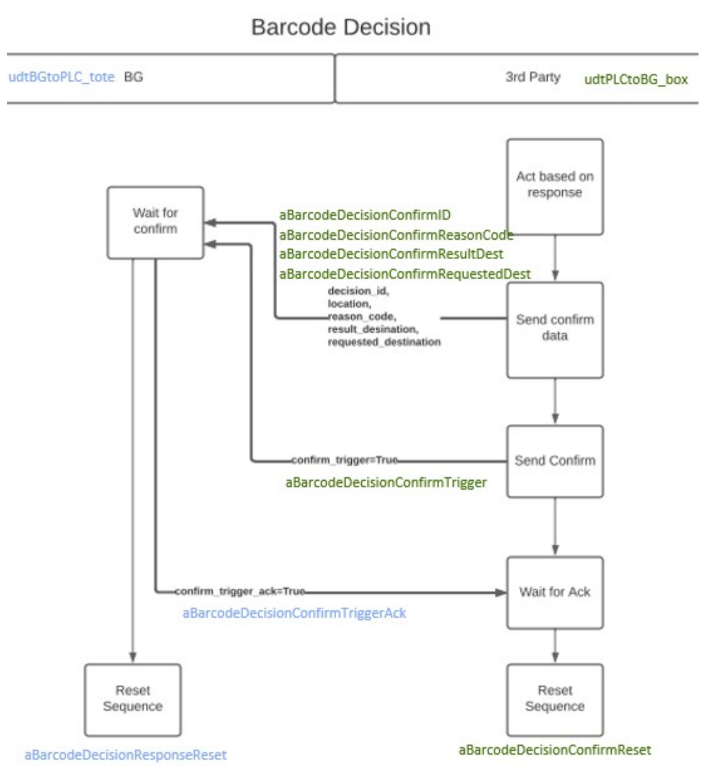

Figure 42 Barcode Decision Confirm process, with labelled tag names