



MULTIBELT

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Conception created by Tommaso Focchi – Snr. GOTC – EMEA

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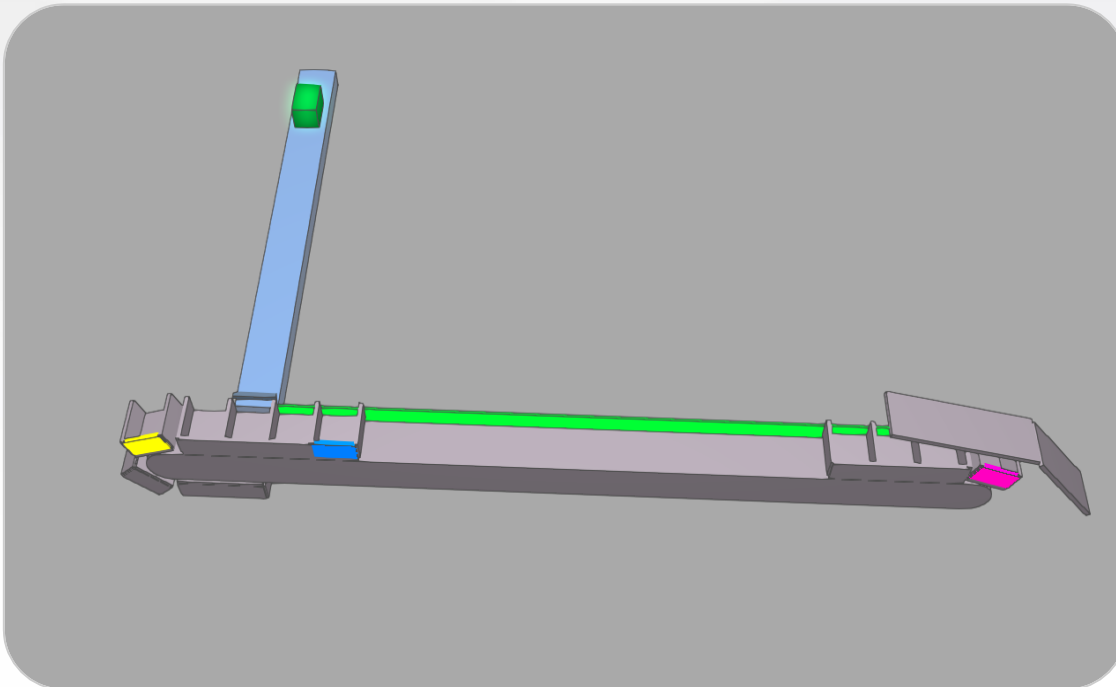
PUBLIC

MultiBelt

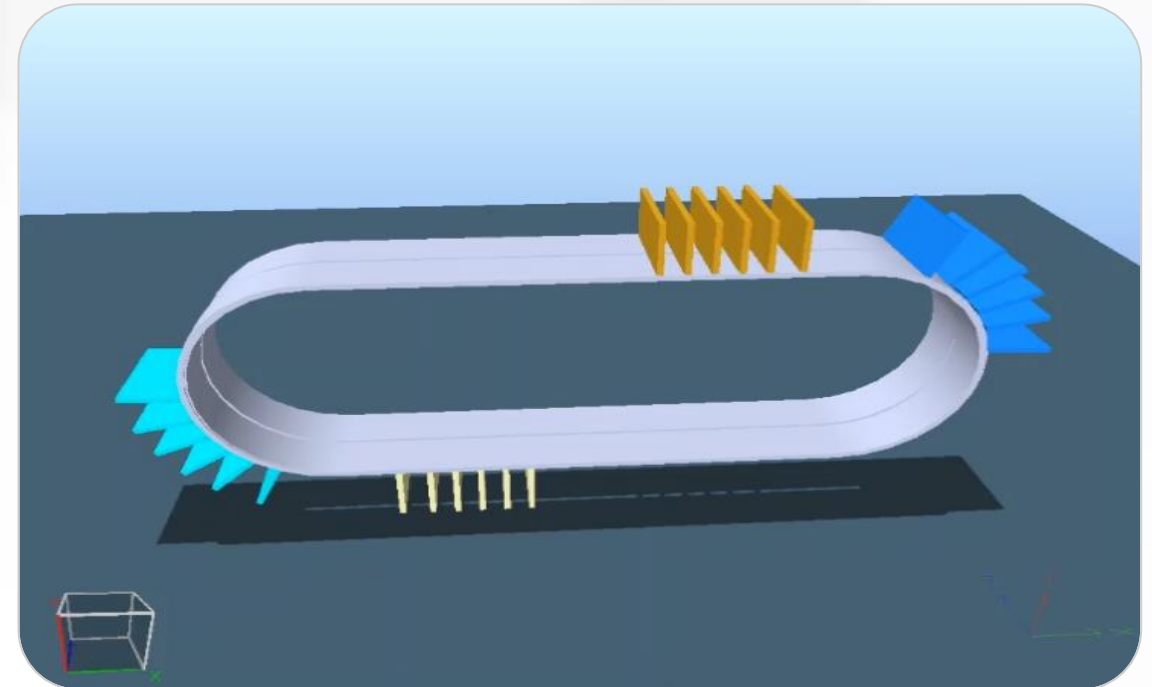
What is this document about?

- This document explain in short steps how we can setup a simple MultiBelt system using specials **Add-On Instructions**, using tree wagons/trains of two applications:
- Multibelt – 3 Wagons
- Multibelt – 2 Collators

Multibelt 3 wagons



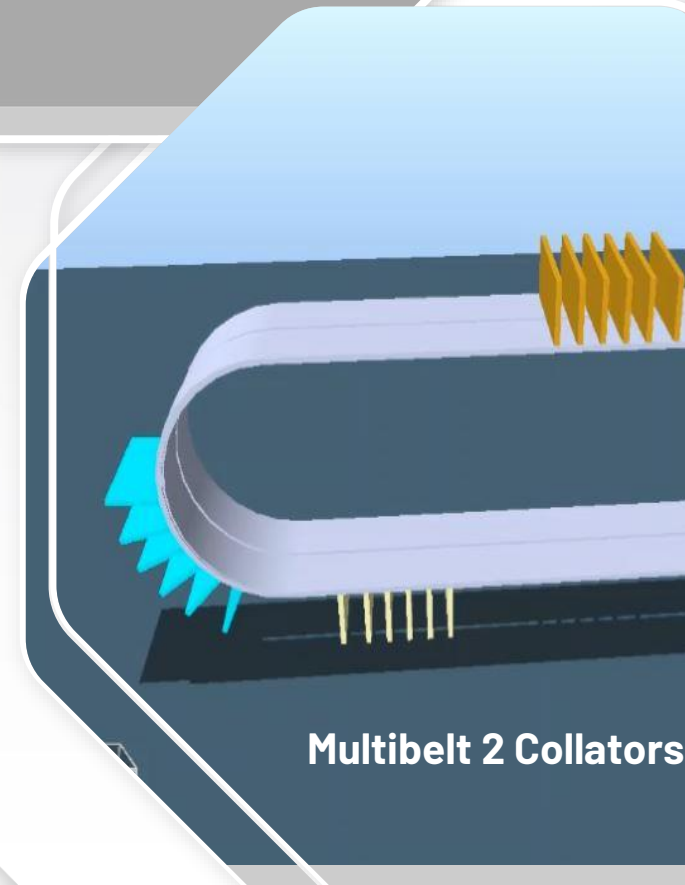
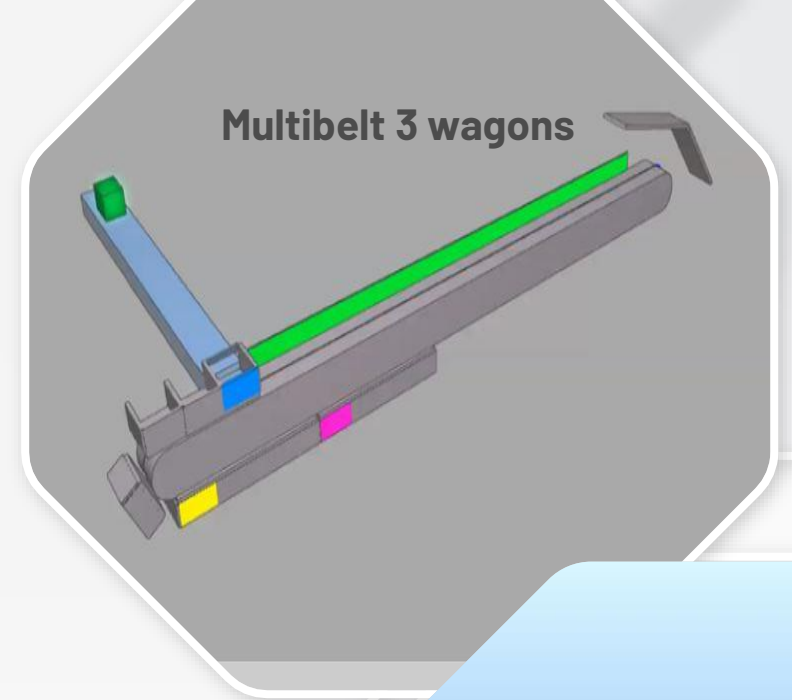
Multibelt 2 Collators



MultiBelt

What is this document about?

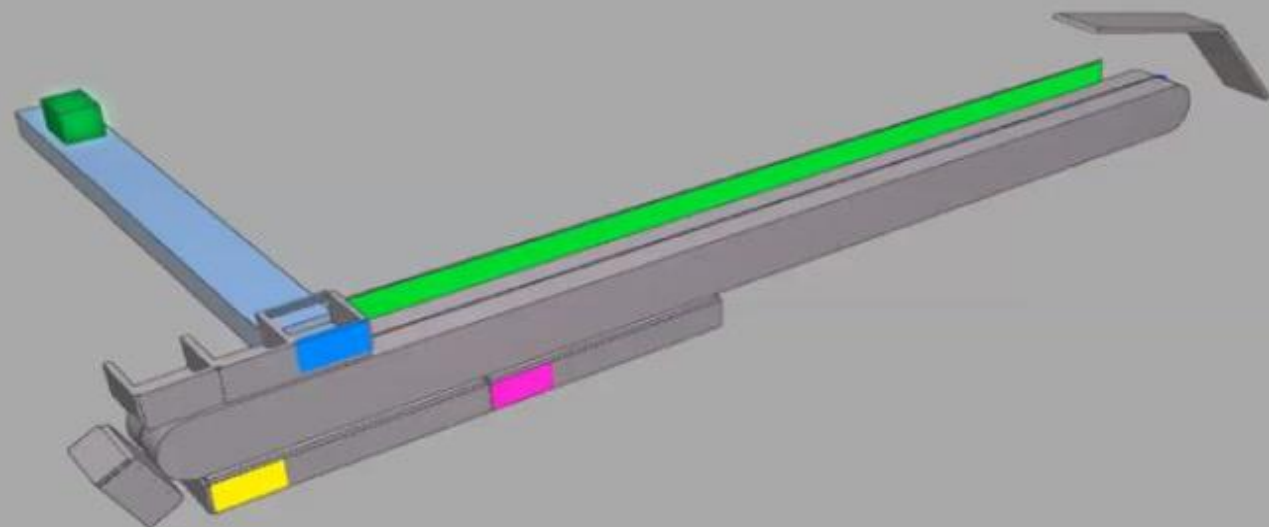
- This document explain in short steps how we can setup and configure a simple MultiBelt system using Add-On Instructions, applied of two applications:
- Multibelt – 3 (tree) wagons/train
- Multibelt – 2 (two) collators



Multibelt

General concepts, configuration, setup.

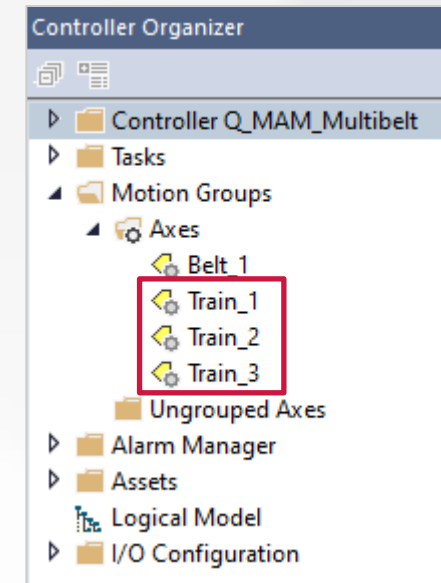
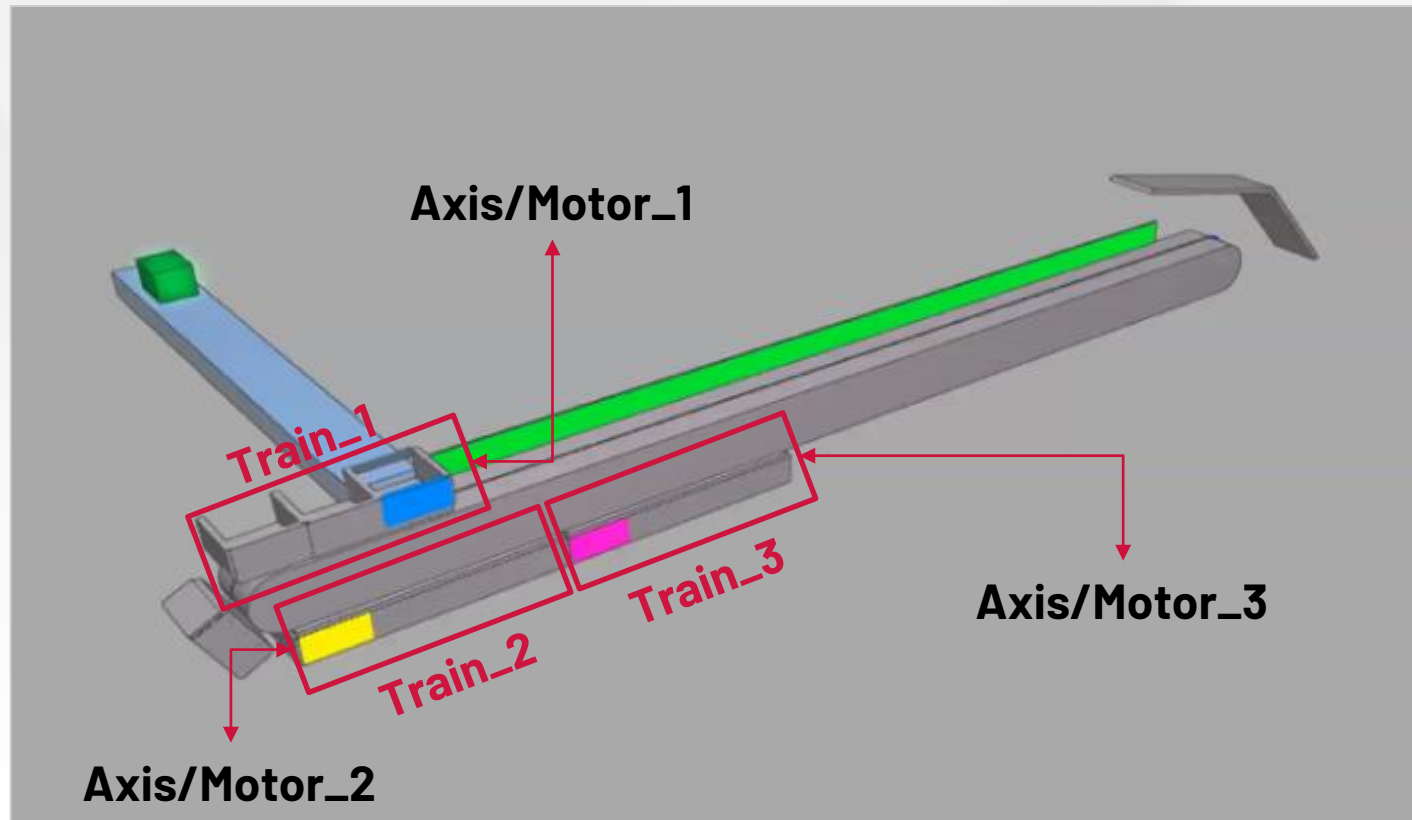
Multibelt - 3 wagons/train



MultiBelt

General concepts

- Each wagon/train must be linked with your axis/motor



Create Axis for each Train

This document does not included specific motor paramateres, tunning, etc..

MultiBelt

Add-On Instructions

- Import/use the Add-On Instructions/Defined → **Q_MAM_P** and **MultiBelt_AOI**

Queued MAM Positive

Q_MAM_P	Q_MAM_Train_2	Out_PPI	0.0
Q_MAM_P	0	Sts_Command_Position	67.019
xxxxxxxxxxxxxxxxxxxx_AXES_xxxxxxxxxxxxxxxxxxxxx	Train_2		
Axis	Train_1		
Axis_Preceding	0		
xxxxxxxx_MOTION_DATA_xxxxxxxxxxxxxxxxxxxxx	Train_2_CommandPosition		
CmdPosition	277.0		
CmdVel	Q_MAM_CmdVelocity		
	2000.0		
CmdAcc	Q_MAM_CmdAcc		
	12500.0		
CmdDec	Q_MAM_CmdDec		
	10000.0		
CmdAccJerk_PercentageOfTime	Q_MAM_AccJerk		
	33.0		
CmdDecJerk_PercentageOfTime	Q_MAM_DecJerk		
	33.0		
xxxxxxxxxxxxxxxxxxxx_DATA_xxxxxxxxxxxxxxxxxxxxx	Train_Unwind		
Unwind	4000.0		
Axis_Min_Distance	Train_Min_Distance		
	410.0		
MotionCoarseUpdateRate_msec	CUR		
	2		
xxxxxxxxxxxxxxxx_LINKED_PARAMETERS_xxxxxxxxxxxxxxxxx	Q_MAM_Train_1.Mover_ip1_Follower		
Mover_ip1_Follower	0		
In_PropagatedPositionIncrement	Q_MAM_Train_1.In_PropagatedPositionIncrement		
	0.0		
xxxxxxxxxxxxxxxx_OPTIONS_xxxxxxxxxxxxxxxxx	in_PositionFF		
In_PositionFeedForward	1		

THIS AOI Handles a simple Multibelt program in conjunction with Q_MAM set of instructions

MultiBelt_AOI	Train_2_AOI	TrainCommandPosition	Train_2_CommandPosition
MultiBelt_AOI	0	277.0	
_TRAINS_xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx	Train_2		
ThisTrain	0		
_TRAIN_DATA_xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx	WagonSize		
WagonSize	100.0		
NumberOfWagons	Train_NoWagons		
	4		
LoadingStationPosition	LoadingStationPosition		
	277.0		
IntermediateStationPosition	IntermediateStationPosition		
	1200.0		
UnloadingStationPosition	UnLoadingStationPosition		
	1580.0		
_INPUT_SIGNALS_xxxxxxxxxxxxxxxxxxxxxxxxxxxxx	Cycle_Run		
Cycle_Run	StartCycle		
	0		
NextWagon_TriggerInput	Trigger_Product_IN		
	0		
UnloadingStation_Busy	Unloading_Station_Busy		
	0		
UnloadingComplete	UnloadingComplete		
	0		
Q_MAM_Completed	Q_MAM_Train_2.PC		
	0		

101 010 Add-On Instructions

- ▶ 101 010 Axes_Fcn_St
- ▶ 101 010 MNG_SimUpdater
- ▶ 101 010 MNG_TcpClient
- ▶ 101 010 MRP2
- ▶ 101 010 MultiBelt_AOI
- ▶ 101 010 Q_MAM_P

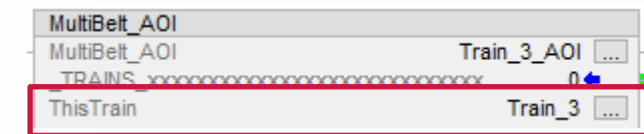
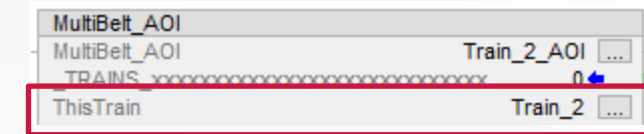
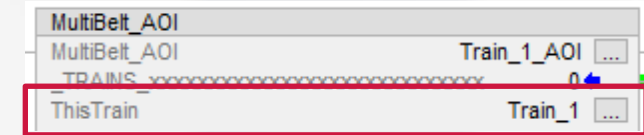
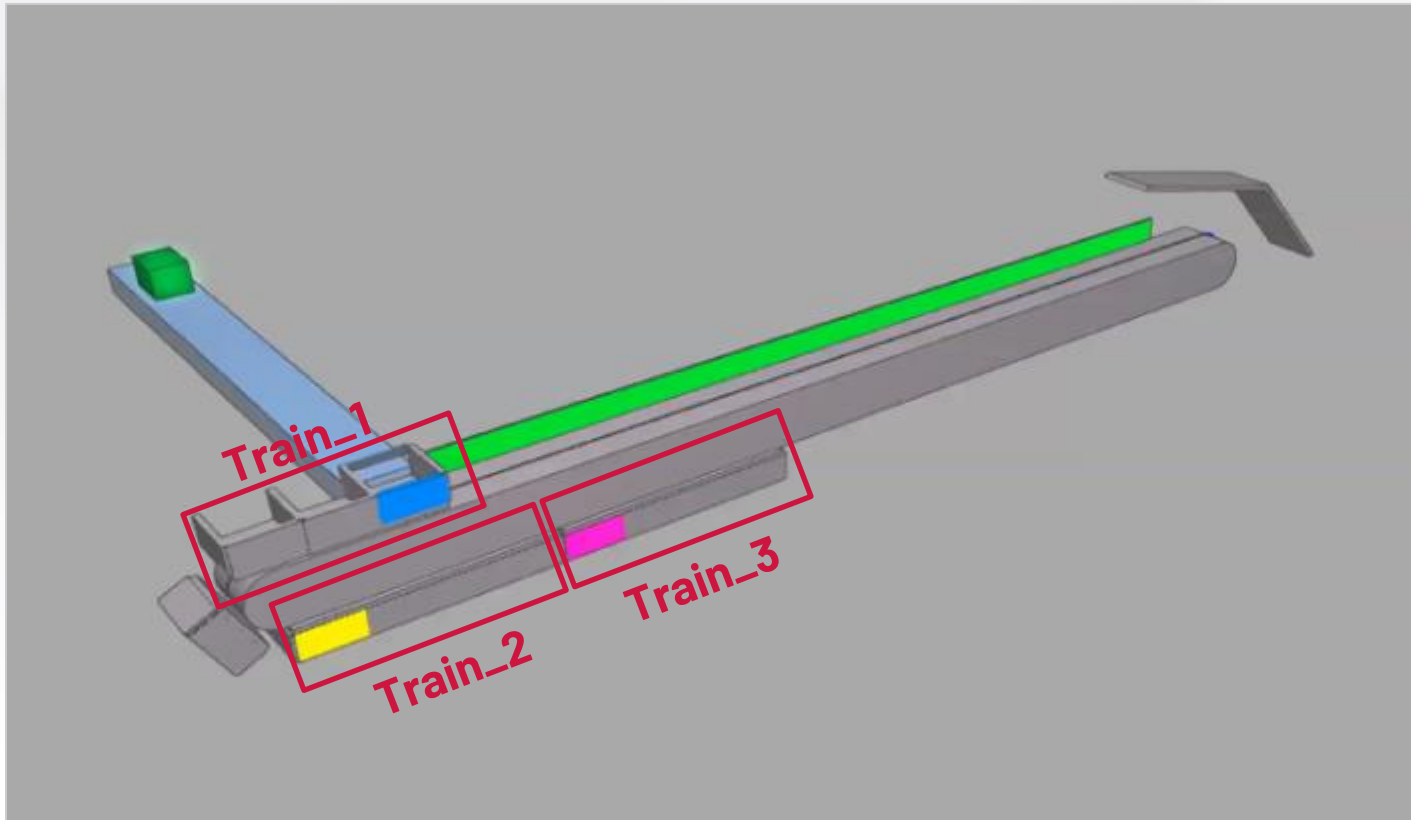
101 010 Data Types

- ▶ 101 010 User-Defined
- ▶ 101 010 Strings
- ▶ 101 010 Add-On-Defined
- ▶ 101 010 Axes_Fcn_St
- ▶ 101 010 MNG_SimUpdater
- ▶ 101 010 MNG_TcpClient
- ▶ 101 010 MRP2
- ▶ 101 010 MultiBelt_AOI
- ▶ 101 010 Q_MAM_P

MultiBelt

General configuration

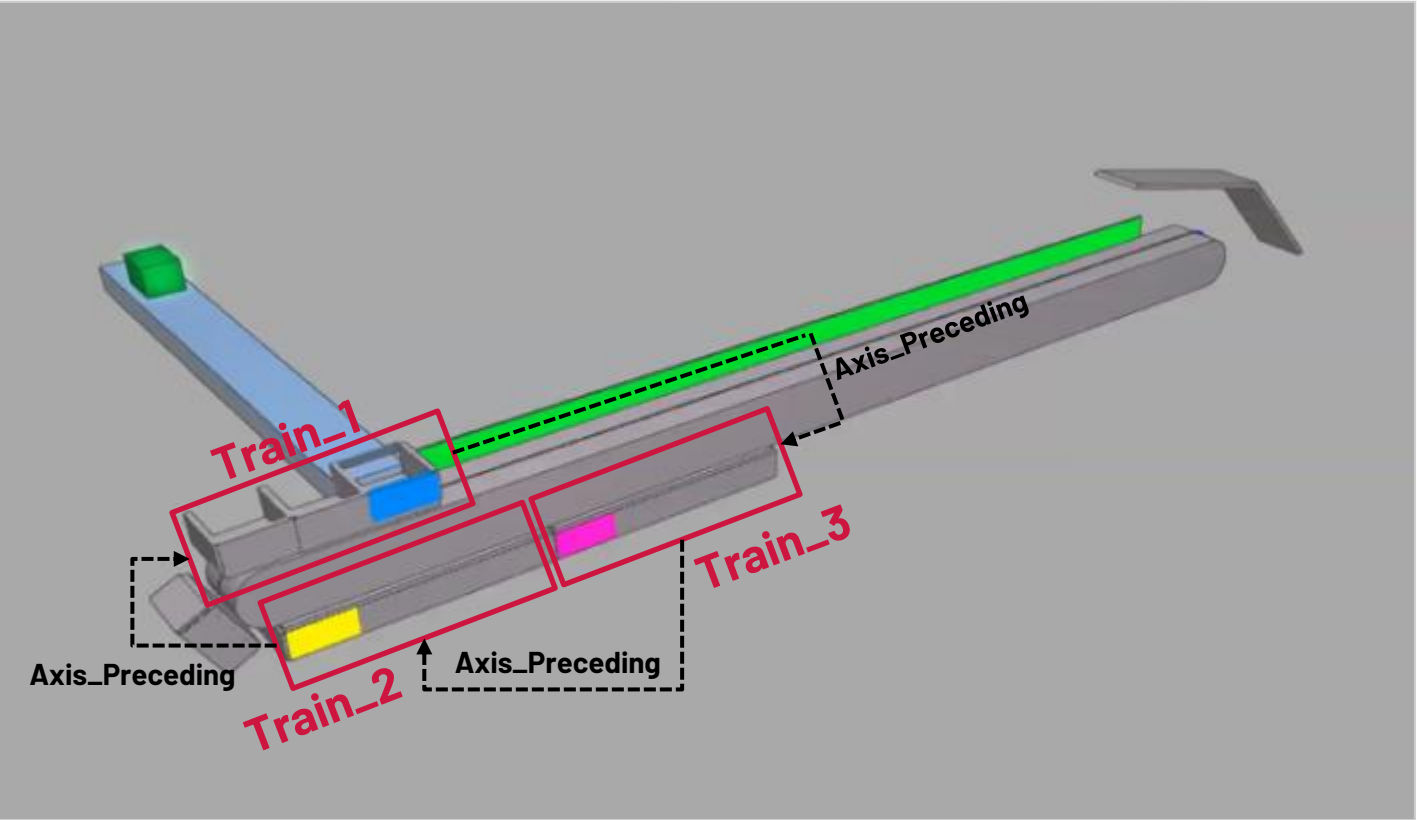
- Each Train (Axis) must be configured and linked with your respective **Multibelt_AOI**



MultiBelt

General configuration

- Each Train (Axis) must be configured and linked with your respective **Q_MAM_P**



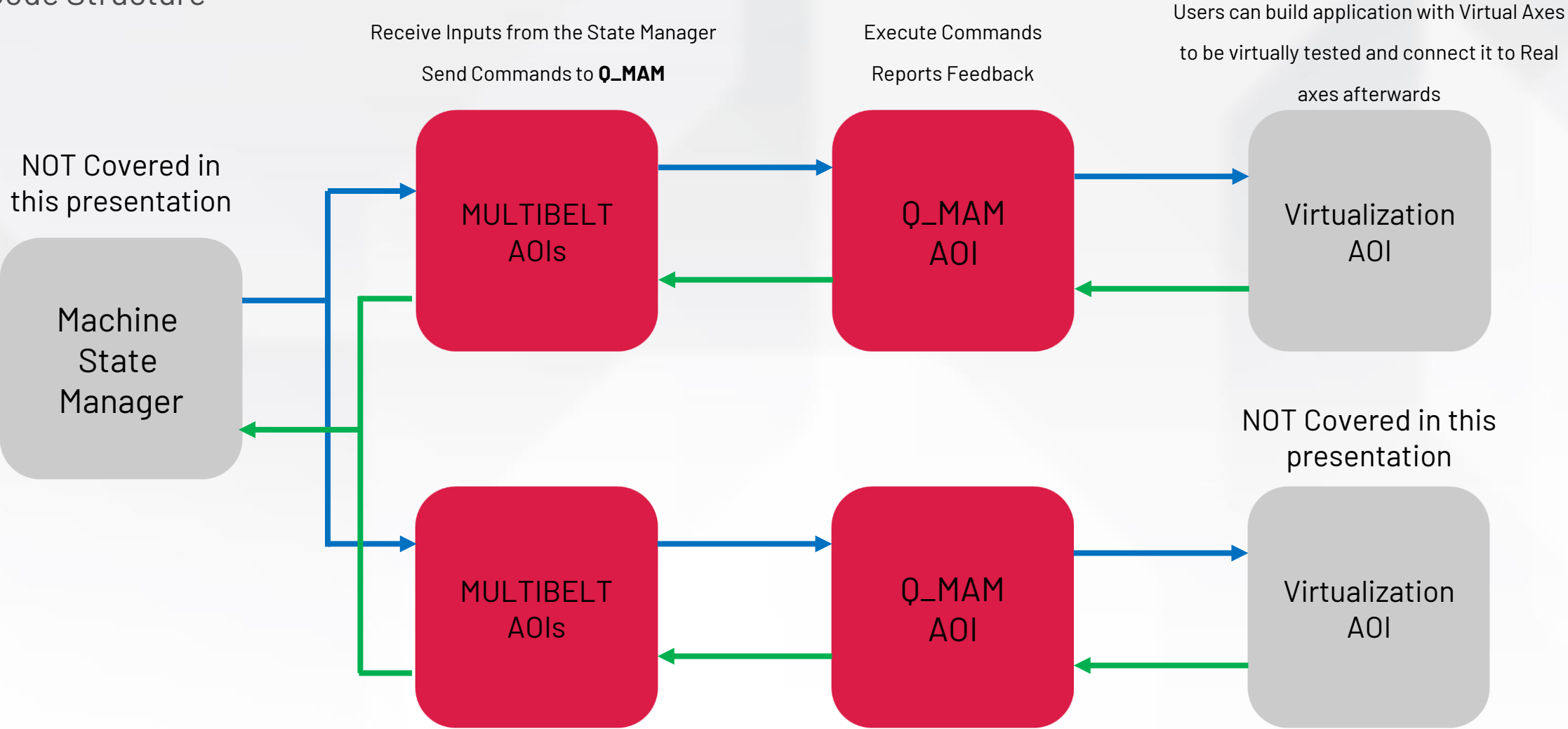
Queued MAM Positive		
Q_MAM_P		
Q_MAM_P	Q_MAM_Train_1	...
xxxxxxxxxxxxxxxxxx AXES xxxxxxxxxxxxxxxxxxxxx	0	...
Axis	Train_1	...
Axis_Preceding	Train_3	...

Queued MAM Positive		
Q_MAM_P		
Q_MAM_P	Q_MAM_Train_2	...
xxxxxxxxxxxxxxxxxx AXES xxxxxxxxxxxxxxxxxxxxx	0	...
Axis	Train_2	...
Axis_Preceding	Train_1	...

Queued MAM Positive		
Q_MAM_P		
Q_MAM_P	Q_MAM_Train_3	...
xxxxxxxxxxxxxxxxxx AXES xxxxxxxxxxxxxxxxxxxxx	0	...
Axis	Train_3	...
Axis_Preceding	Train_2	...

Multi-Belt

Code Structure

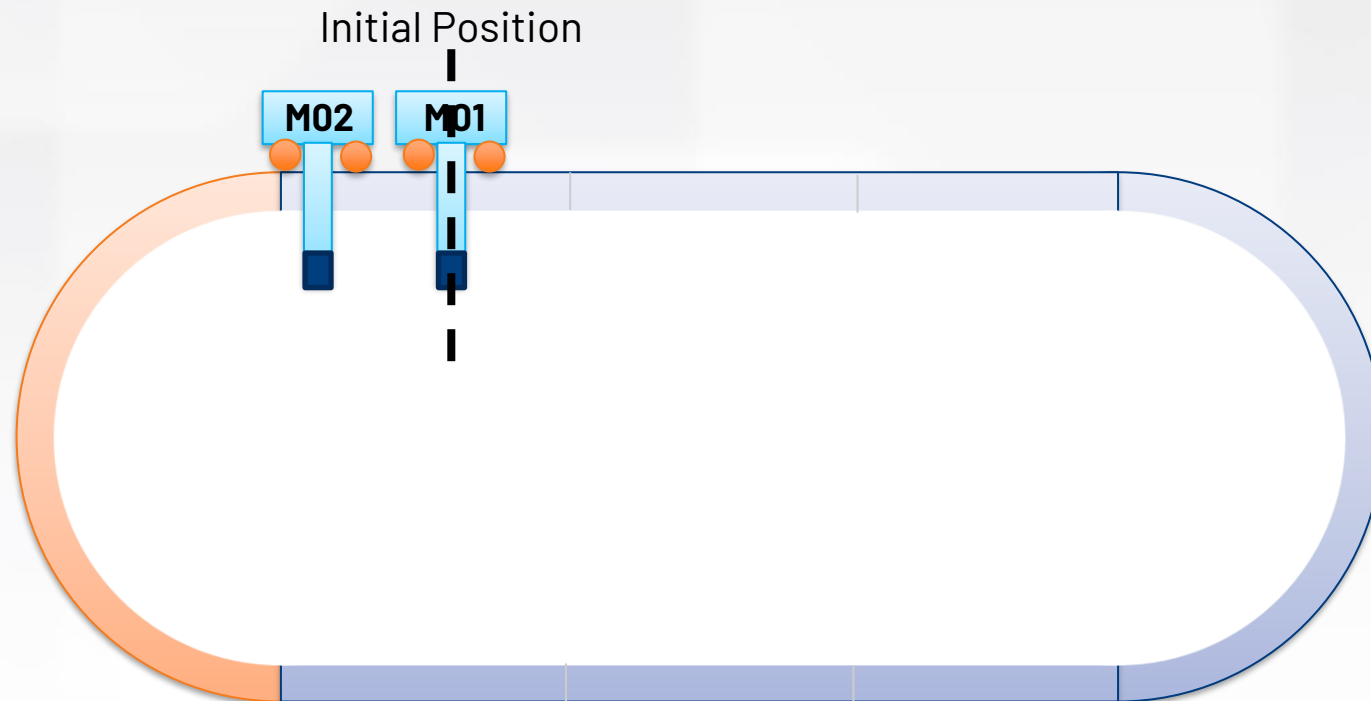


MultiBelt

How it works - Concepts

Define the initial Position (0.0mm zero point), options:

- Create your home position sequence using sensor homming
- Define manually position moving the axis for position as you want and set this position to **initial position** (0.0mm)

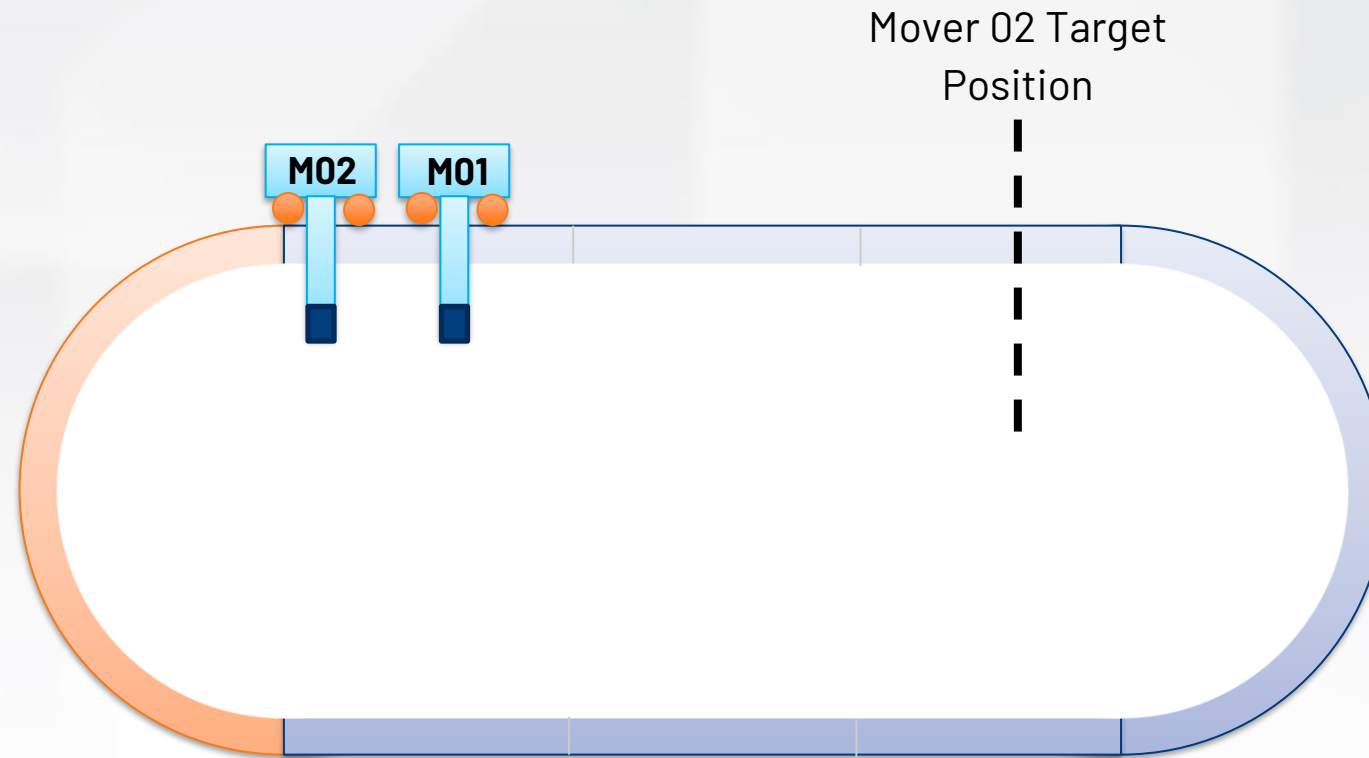


MultiBelt

How it works - Concepts

1 – Assign a **Q_MAM_P** command to M02:

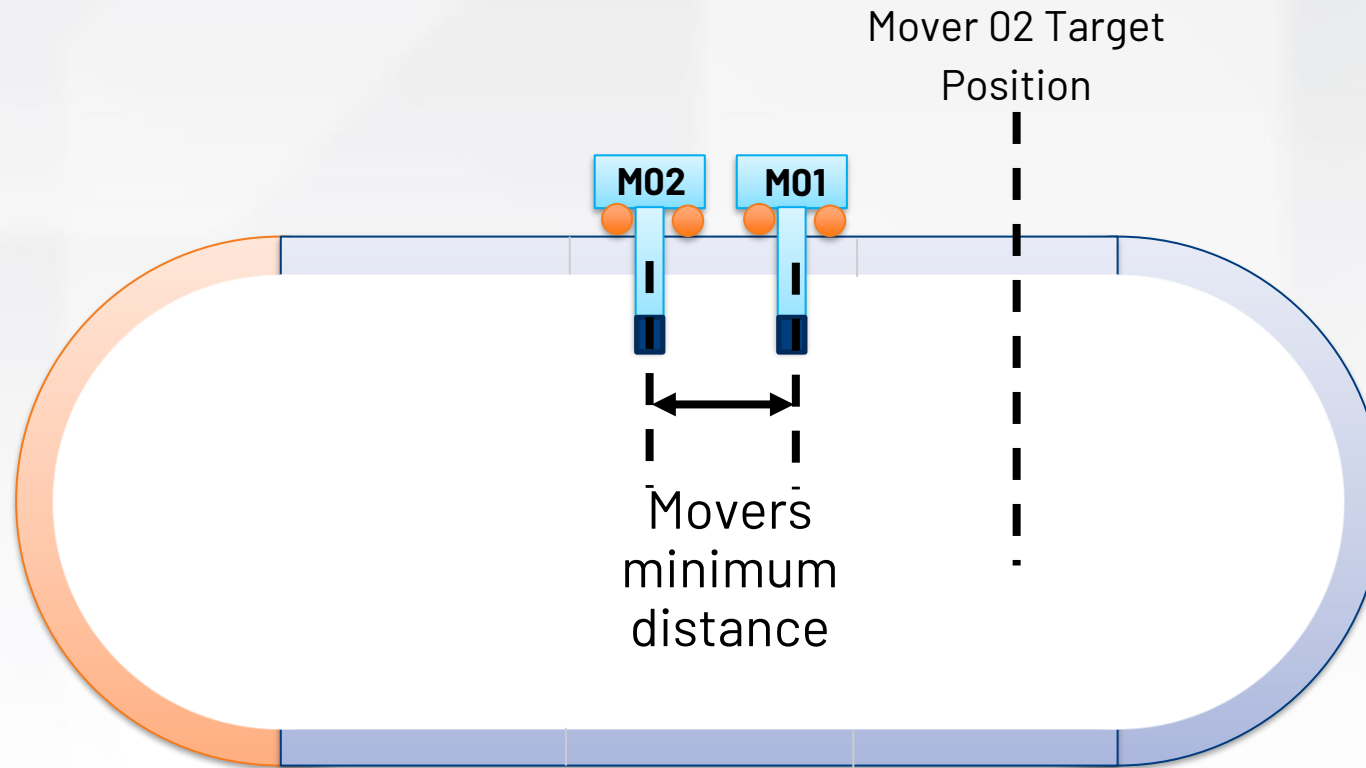
if Mover 01 does not move forward the Mover 02 will stand still



MultiBelt

How it works - Concepts

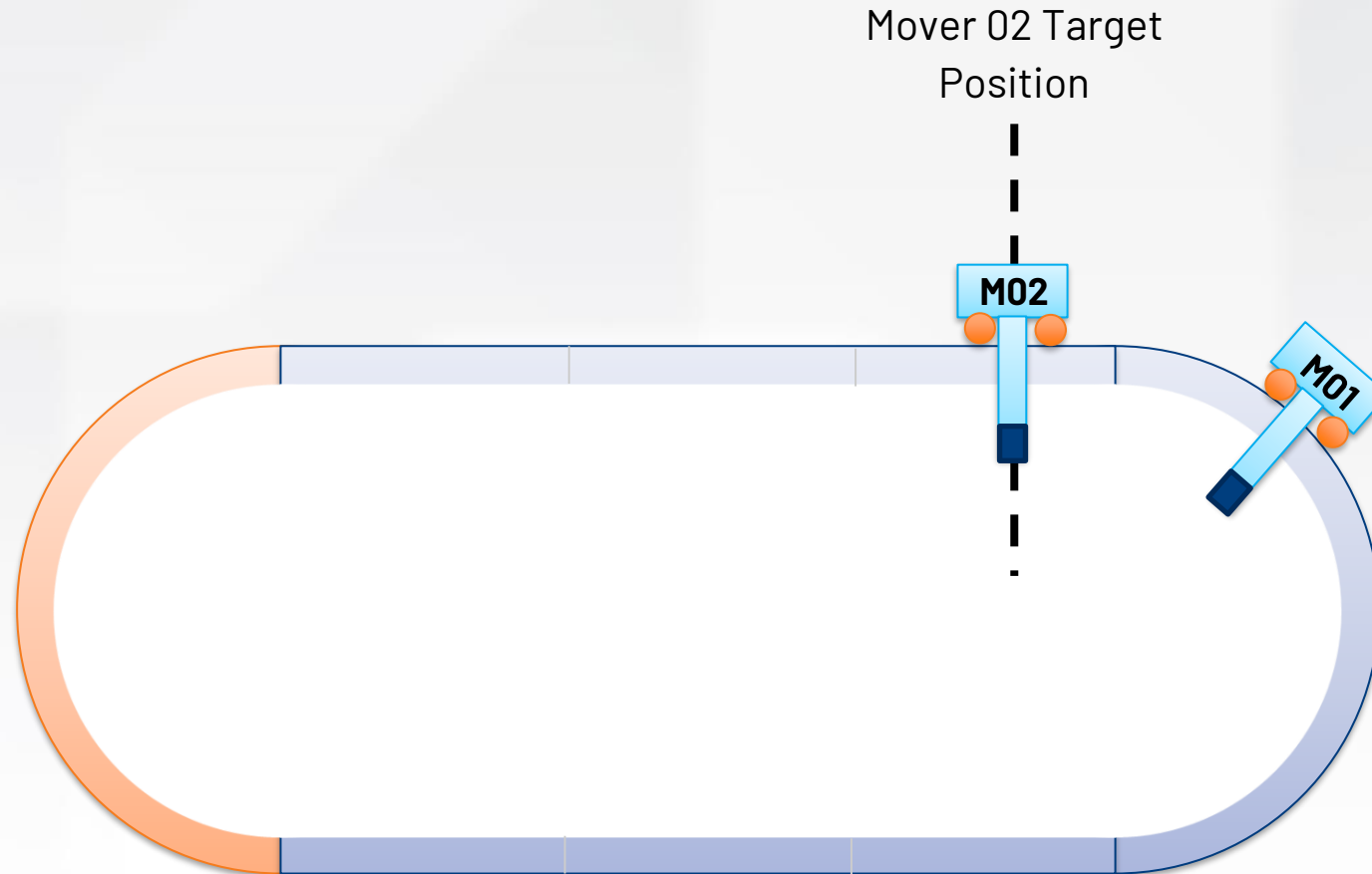
2 – If Mover 01 frees up some space, Mover 02 will proceed towards the Target Position. Mover 02 will respect the commanded Distance from preceding Mover



MultiBelt

How it works - Concepts

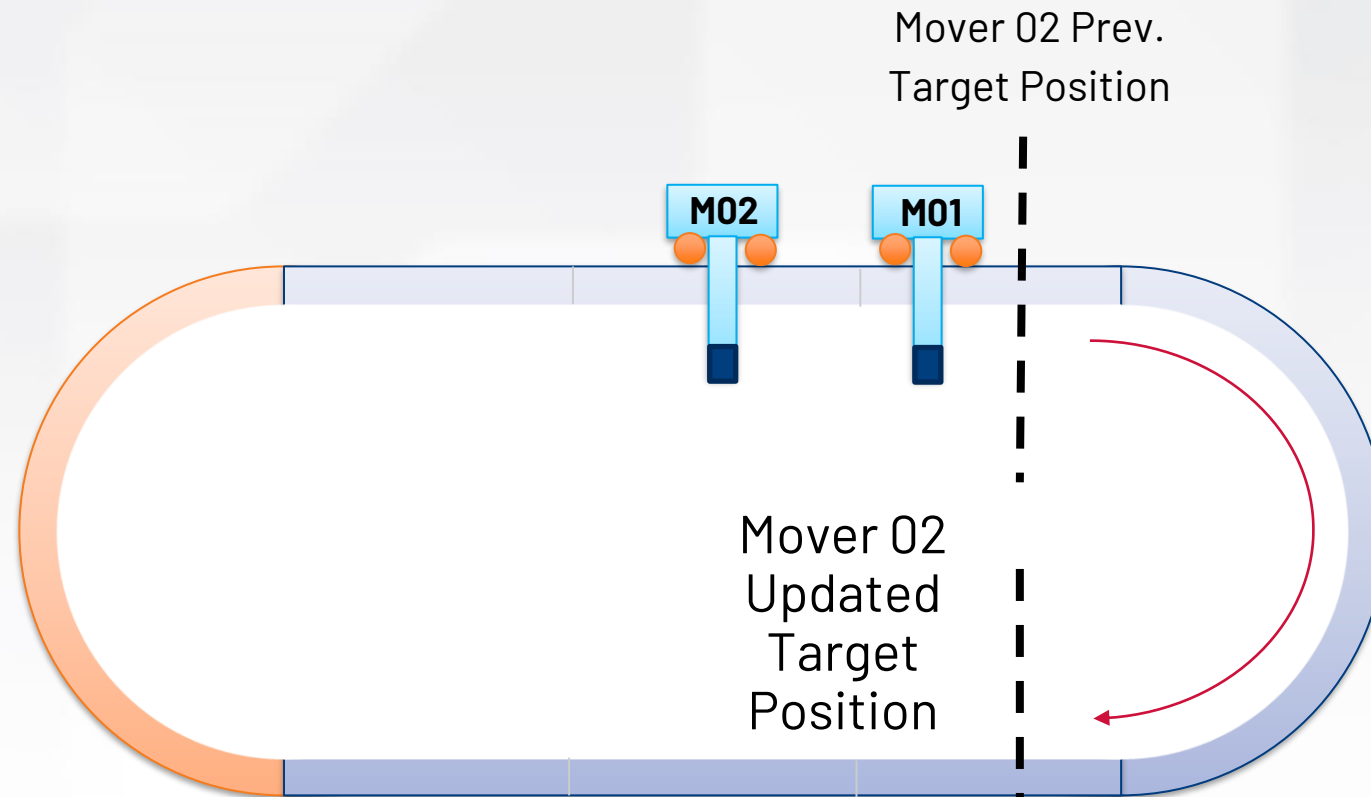
3 – If Mover 01 moves beyond Mover 02 target position Mover 02 will stop at its target



MultiBelt

How it works - Concepts

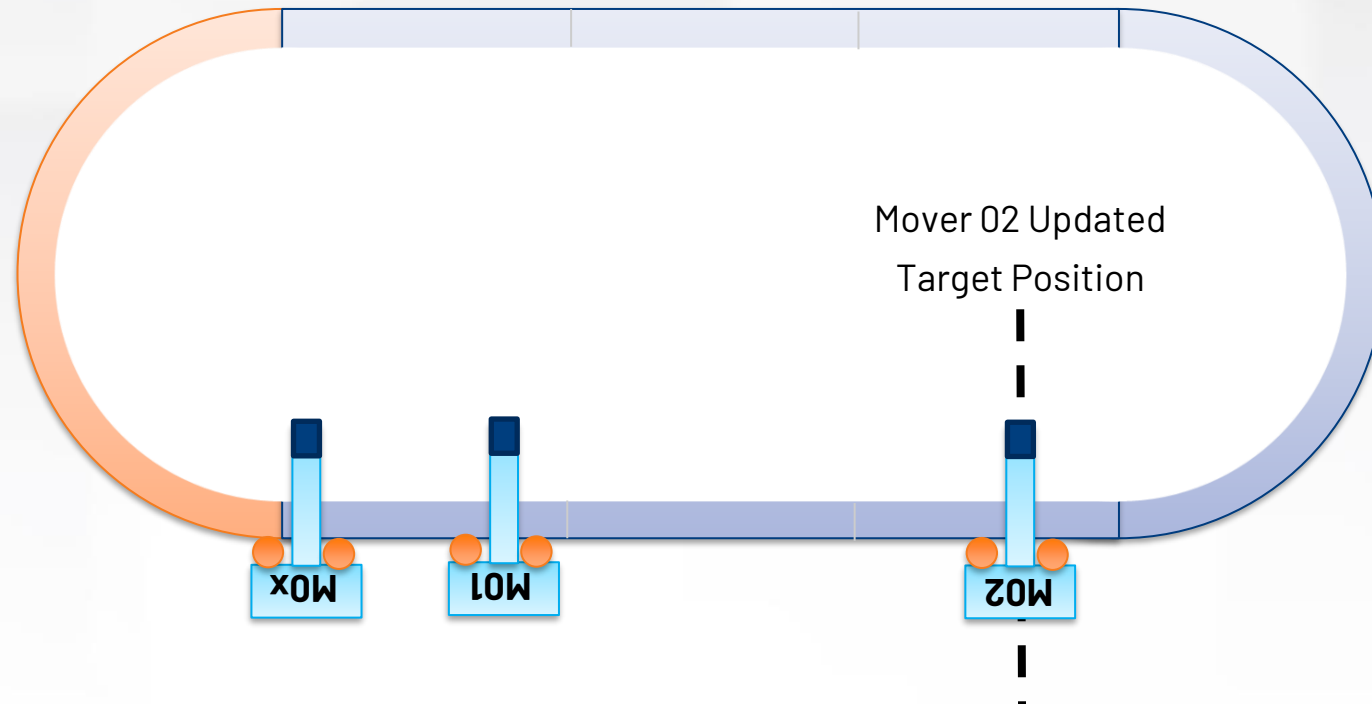
4 – If I change Mover 02 target position during execution the instruction updates the target position



MultiBelt

How it works - Concepts

5 – When Mover 02 reaches the target position it stops. Mover 01 is free to continue moving unless it is limited by another mover



MultiBelt

AddOn - Q_MAM_P

- **Queued**: If the way to the target is not free the mover queues until the way is free or the instruction is disabled
- **Positive**: Only one direction possible
- **Note that:**
 - The target Position for the Mover is entered as ABSOLUTE on the Trak.
 - Subsequently the distance to be covered is turned into an incremental movement inside the instruction. This allow others Motion Commands to be superimposed



MultiBelt

Q_MAM_P: INPUT_DATA

INPUT DATA	Type	Description
Axis_i	AXIS_VIRTUAL	Actual Mover
Axis_ip1	AXIS_VIRTUAL	Preceding mover
Mover_ip1_Follower	BOOL	Is the Preceding Mover a Follower?
Cmd_Position	REAL	Target Position [mm]. This Position must be entered as an absolute value. Than the instruction turn it into a incremental position.
CmdVel	REAL	Command Velocity [mm/sec]
CmdAcc	REAL	Command Acceleration [mm/sec^2]
CmdDec	REAL	Command Deceleration [mm/sec^2]
Unwind	REAL	Trak Lenght [mm]
Axis_Min_Distance	REAL	Axis Minimum Distance [mm]
In_PropagatedPositionIncrement	REAL	Propagated Position Increment from Preceding Mover [mm]
MotionCoarseUpdateRate	DINT	Motion Coarse Update Rate to Compensate [msec]
In_PositionFeedForward	BOOL	Enable Delay Compensation

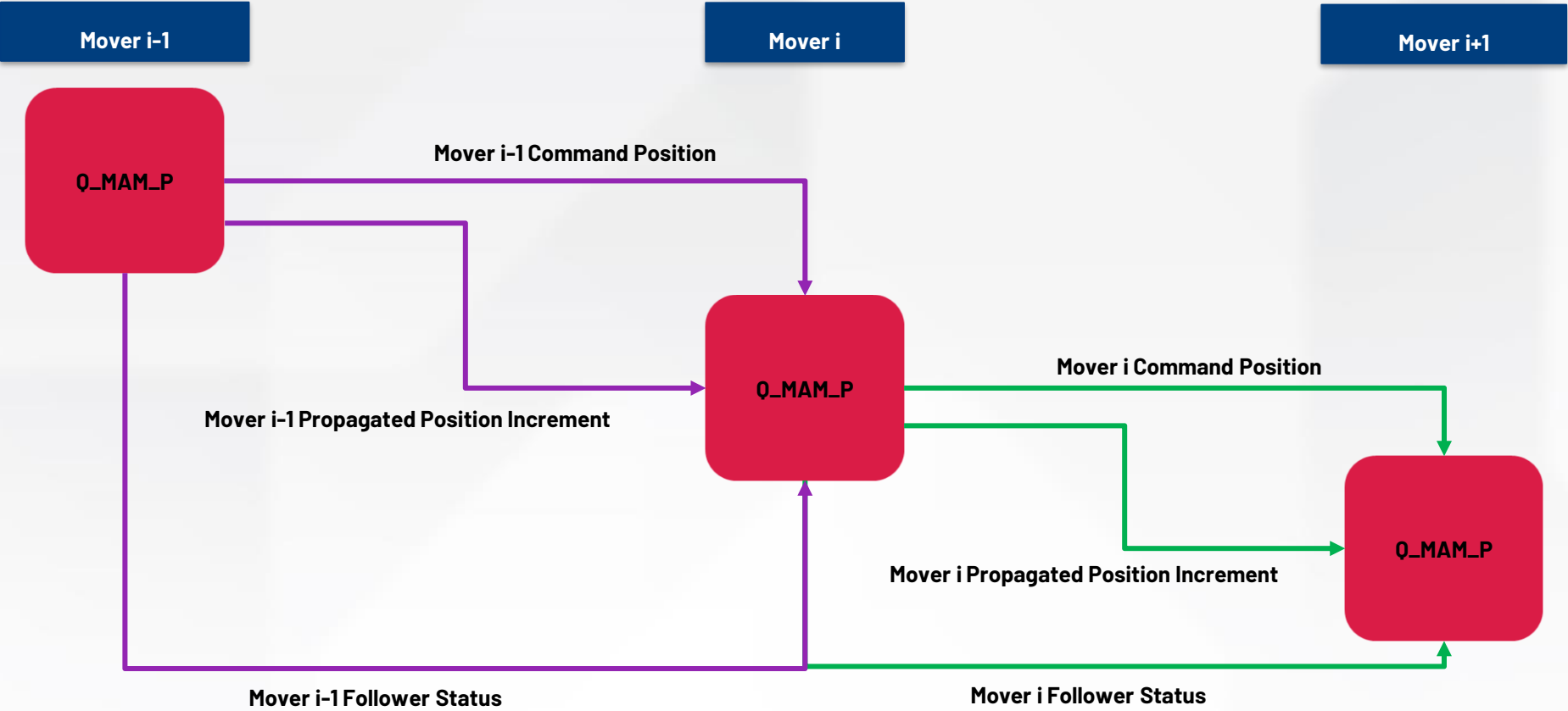
MultiBelt

Q_MAM_P: OUTPUT_DATA

OUTPUT DATA	Type	Description
EN	BOOL	Rung Conditions
IP	BOOL	Instruction in Progress
ER	BOOL	Instruction error
PC	BOOL	Target Position reached
Out_Follower	BOOL	This mover is a Follower. Another mover is in between this mover and the target position
Move Status	BOOL	The Instruction is in process and the mover is commanded with an incremental movement
Out_PPI	REAL	Propagated Position Increment. Each instruction look at the preceding mover to mitigate command Position Update

MultiBelt

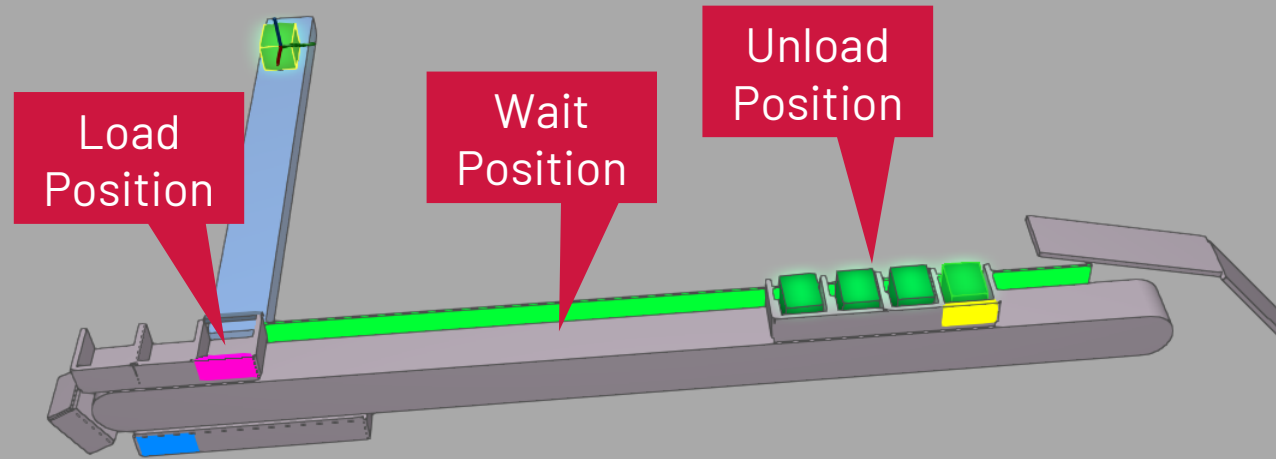
Q_MAM_P: Cascade Links



Each Instance of the **Q_MAM_P** instruction is linked to the previous Mover instruction to build a cascade chain of movers status. Out_PPI and FollowerStatus are needed to compensate delay propagation

MultiBelt

Define Stations Positions



MultiBelt

Define Station Position for Q_MAM

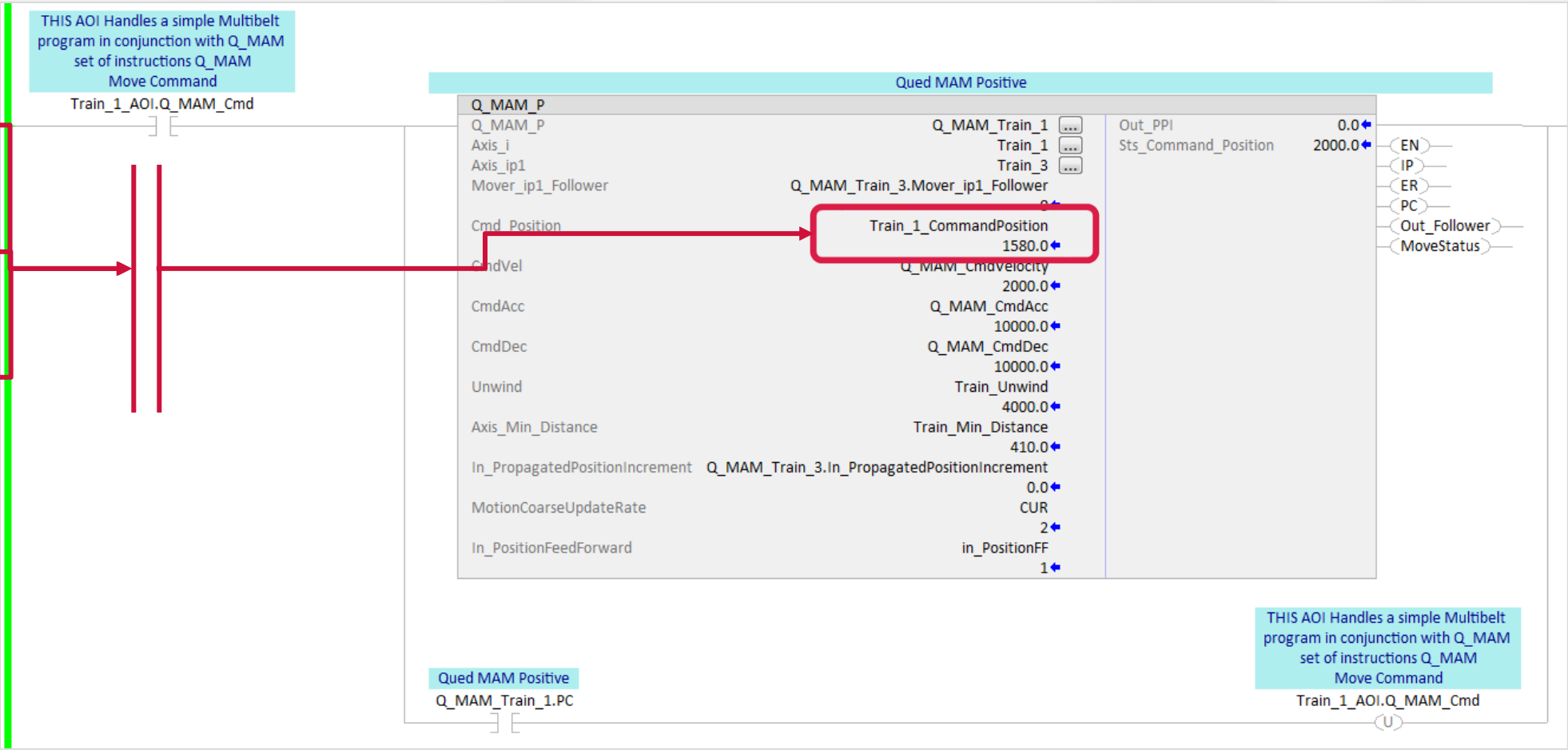
Loading
Position

Waiting
Position

UnLoading
Position



These Position Targets
will be loaded into **Q_MAM**
Instruction according to
the application current
state



MultiBelt

Populate Q_MAM chained parameters

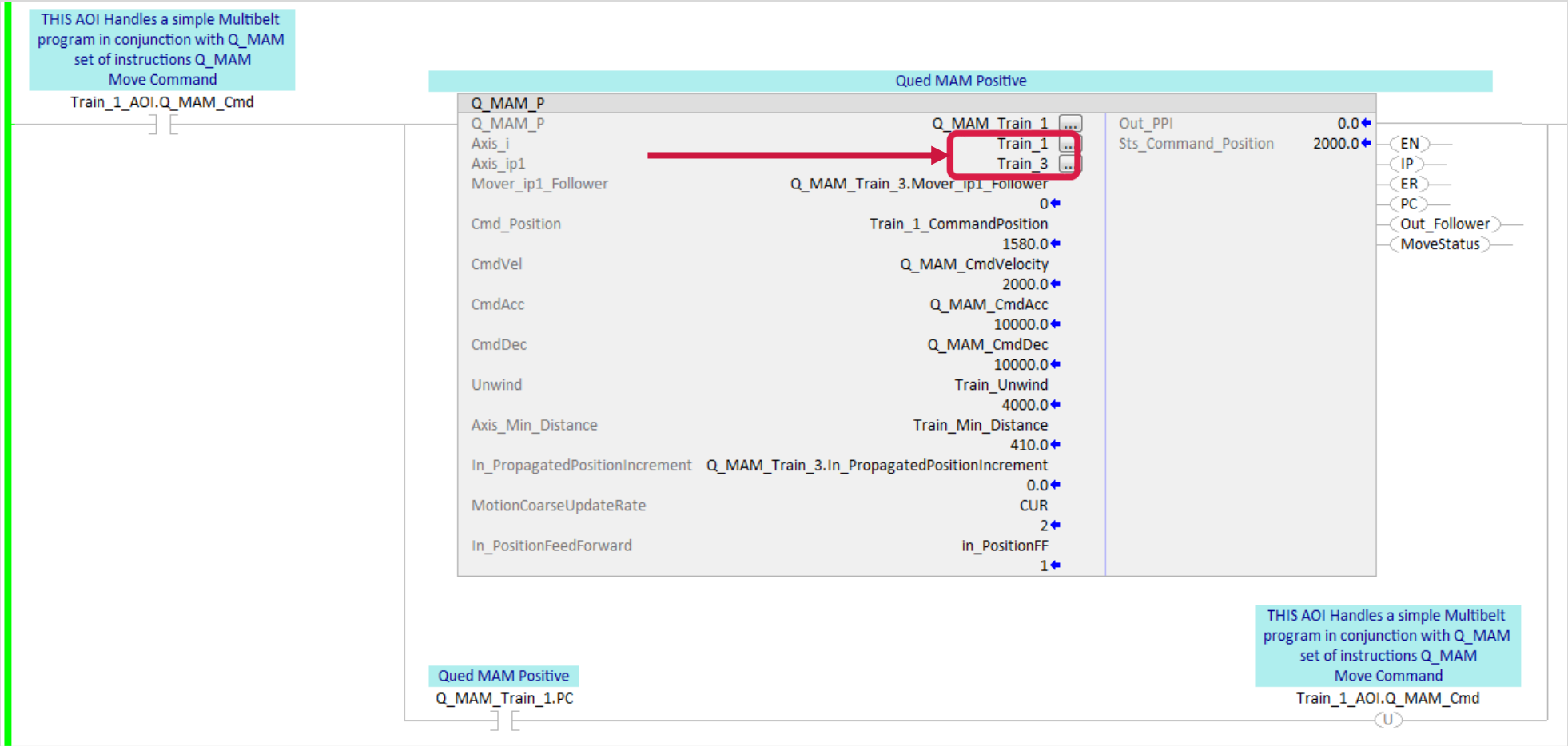
- Q_MAM AOIs need to be chained together. Every AOI needs input data from the preceding train and passes data to the following AOI



MultiBelt

Populate Q_MAM chained parameters 2

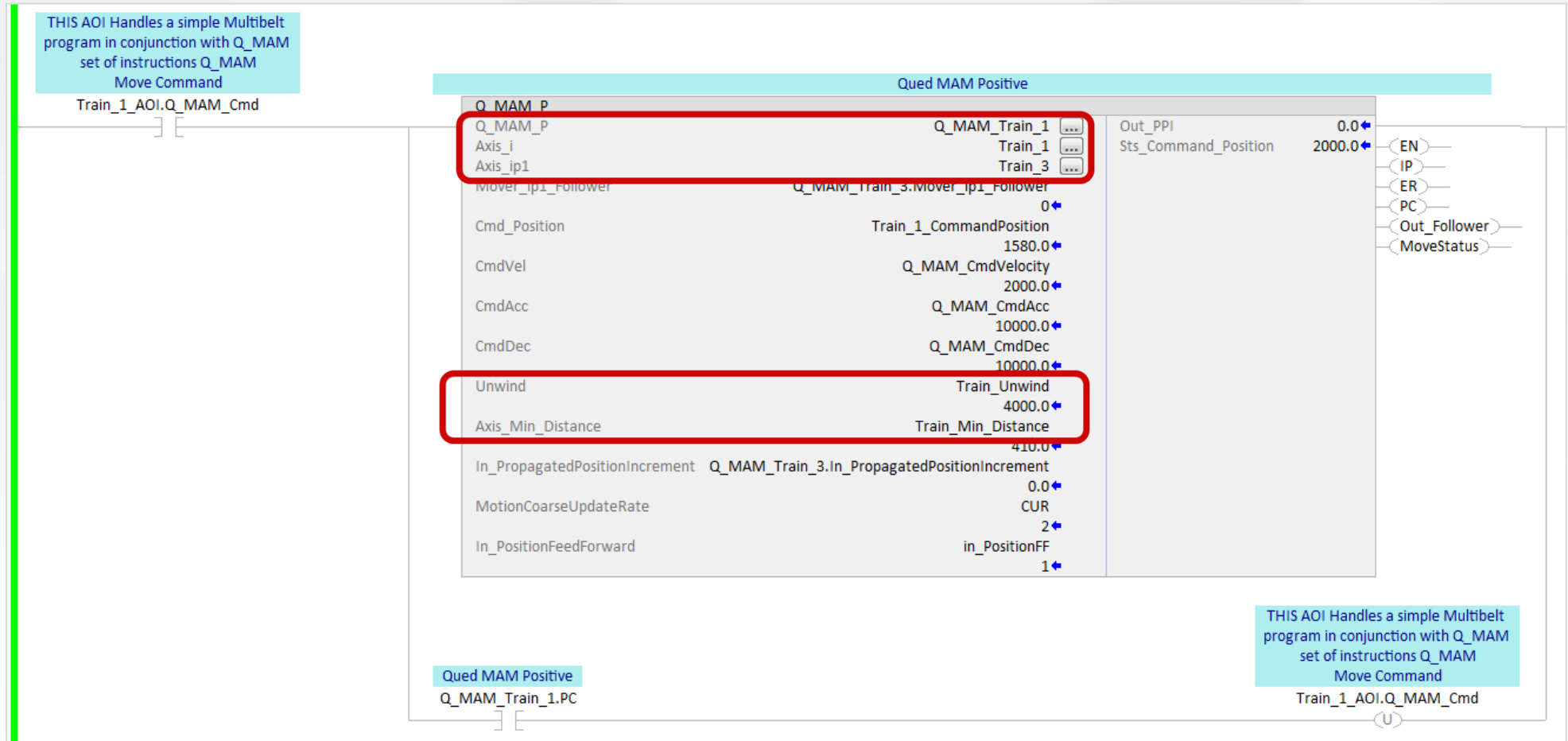
- Populate Axes Fields according to the number of Trains in the Application



MultiBelt

Populate Q_MAM chained parameters 3

- Populate Axes Fields according to the number of Trains in the Application

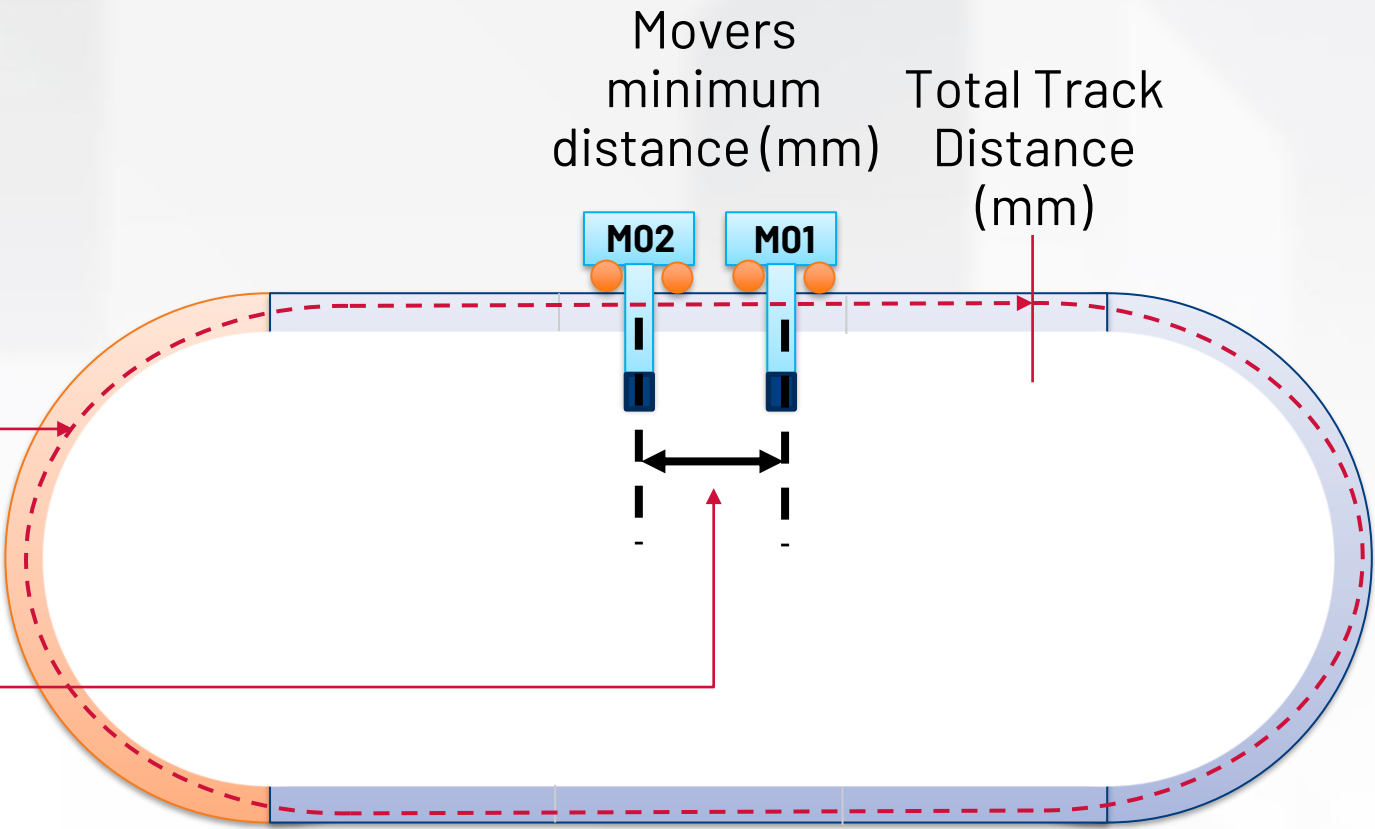


MultiBelt

Q_MAM Parameters

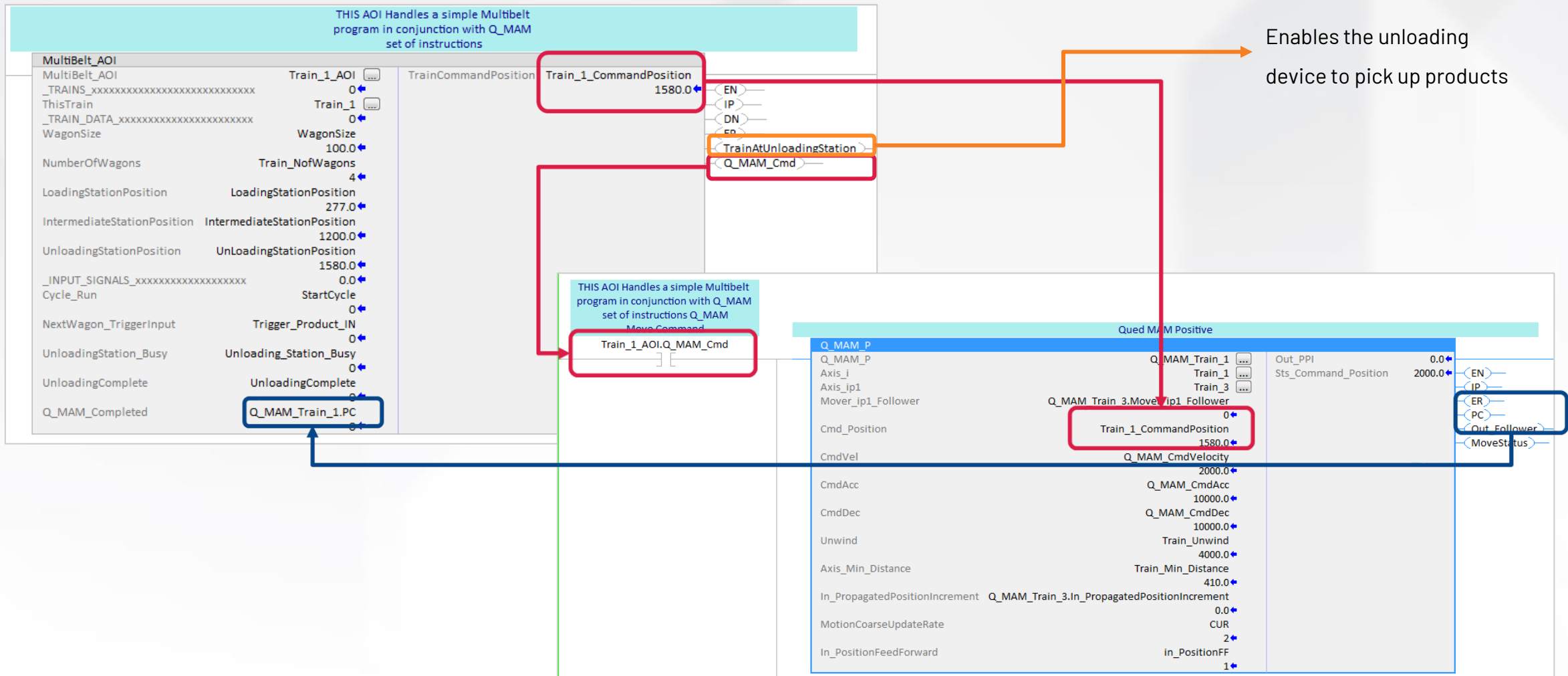
- Unwind, Axis_Min_Distance

Q_MAM_P	
Q_MAM_P	Q_MAM_Train_2
xxxxxxxxxxxxxxxxxxxx_AXESxxxxxxxxxxxxxxxxxxxx	0
Axis	Train_2
Axis_Preceding	Train_1
xxxxxxxx_MOTION_DATAxxxxxxxxxxxxxxxxxxxx	0
CmdPosition	Train_2_CommandPosition
	277.0
CmdVel	Q_MAM_CmdVelocity
	2000.0
CmdAcc	Q_MAM_CmdAcc
	12500.0
CmdDec	Q_MAM_CmdDec
	10000.0
CmdAccJerk_PercentageOfTime	Q_MAM_AccJerk
	33.0
CmdDecJerk_PercentageOfTime	Q_MAM_DecJerk
	33.0
xxxxxxxxxxxxxxxxxxxx_DATAxxxxxxxxxxxxxxxxxxxx	0
Unwind	Train_Unwind
	4000.0
Axis_Min_Distance	Train_Min_Distance
	410.0
MotionCoarseUpdateRate_msec	CUR
	2
xxxxxxxxxxxxxxxx_LINKED_PARAMETERSxxxxxxxxxxxxxxxx	0
Mover_ip1_Follower	Q_MAM_Train_1.Mover_ip1_Follower
	0
In_PropagatedPositionIncrement	Q_MAM_Train_1.In_PropagatedPositionIncrement
	0.0
xxxxxxxxxxxxxxxx_OPTIONSxxxxxxxxxxxxxxxx	0
In_PositionFeedForward	in_PositionFF
	1



MultiBelt

Multibelt_AOI Drive Q_MAM instruction

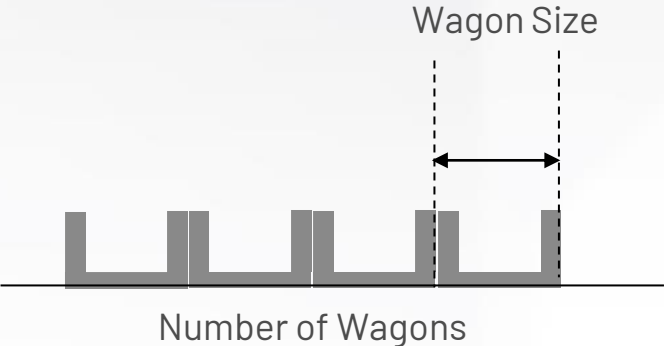


MultiBelt

Multibelt_AOI Add-On - Application Data - Wagon General configuration

Train Data:

- Wagon Size
- Number of Wagons
- Loading Station Position
- Waiting Station Position
- Unloading Station Position



THIS AOI Handles a simple Multibelt program in conjunction with Q_MAM set of instructions

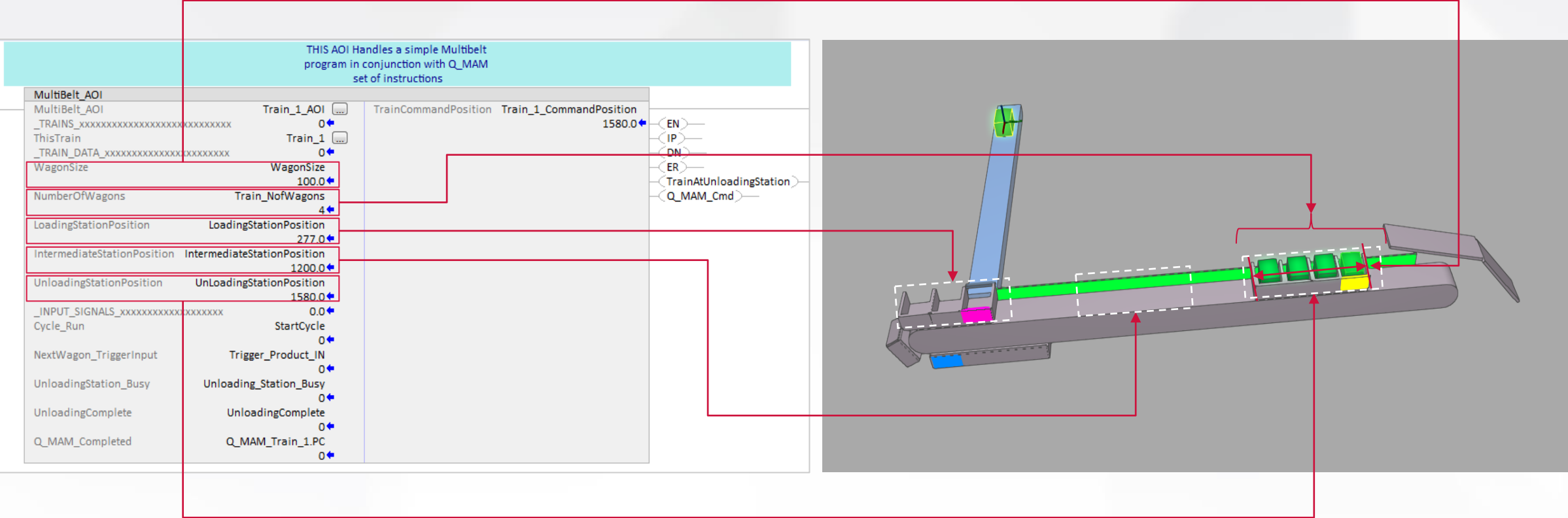
MultiBelt_AOI	
MultiBelt_AOI	Train_1_AOI
_TRAINS_XXXXXXXXXXXXXXXXXXXX	0
ThisTrain	Train_1
_TRAIN_DATA_XXXXXXXXXXXXXXXXXXXX	0
WagonSize	WagonSize
	100.0
NumberOfWagons	Train_NofWagons
	4
LoadingStationPosition	LoadingStationPosition
	277.0
IntermediateStationPosition	IntermediateStationPosition
	1200.0
UnloadingStationPosition	UnLoadingStationPosition
	1580.0
_INPUT_SIGNALS_XXXXXXXXXXXXXXXXXXXX	0.0
Cycle_Run	StartCycle
	0
NextWagon_TriggerInput	Trigger_Product_IN
	0
UnloadingStation_Busy	Unloading_Station_Busy
	0
UnloadingComplete	UnloadingComplete
	0
Q_MAM_Completed	Q_MAM_Train_1.PC
	0

TrainCommandPosition Train_1_CommandPosition 1580.0

EN
IP
DN
ER
TrainAtUnloadingStation
Q_MAM_Cmd

MultiBelt

Multibelt_AOI Add-On - Application Data - Train General configuration

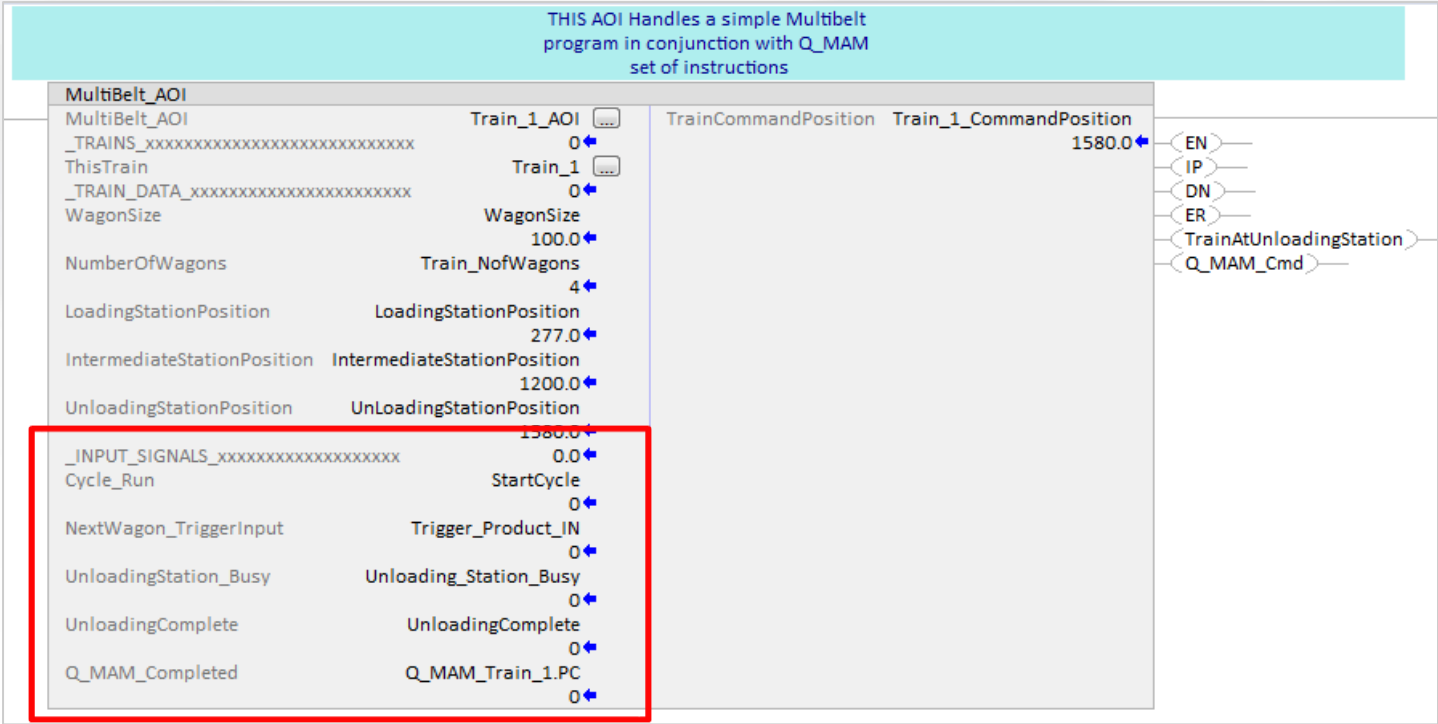


MultiBelt

MultiBelt_AOI: Input Signals

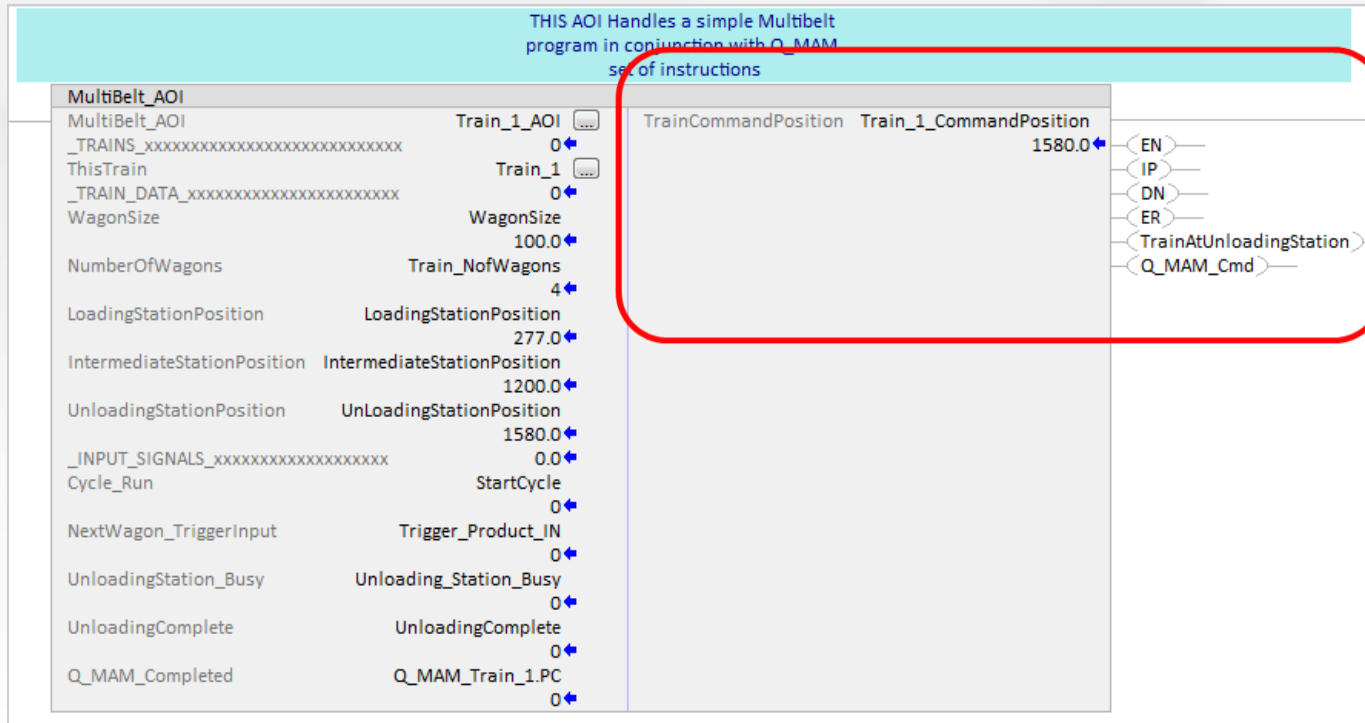
Input Data:

- Cycle Run**
Comes from Machine State handler. Enables the Multibelt Cycle. Transition from 0 to 1 Reset ER bit
- Next Wagon trigger Input**
On a transition from 0 to 1 triggers the movement of the train to the next position when loading products
- Unloading Station Busy**
Unloading Station is not accessible (i.e. Robot is in).
Train will stop at waiting station
- Unloading Complete**
Unloading is complete. Train can exit the Unloading Area
- Q_MAM_Completed**
Q_MAM instruction has completed its current task



Multibelt

MultiBelt_AOI: Output Signals

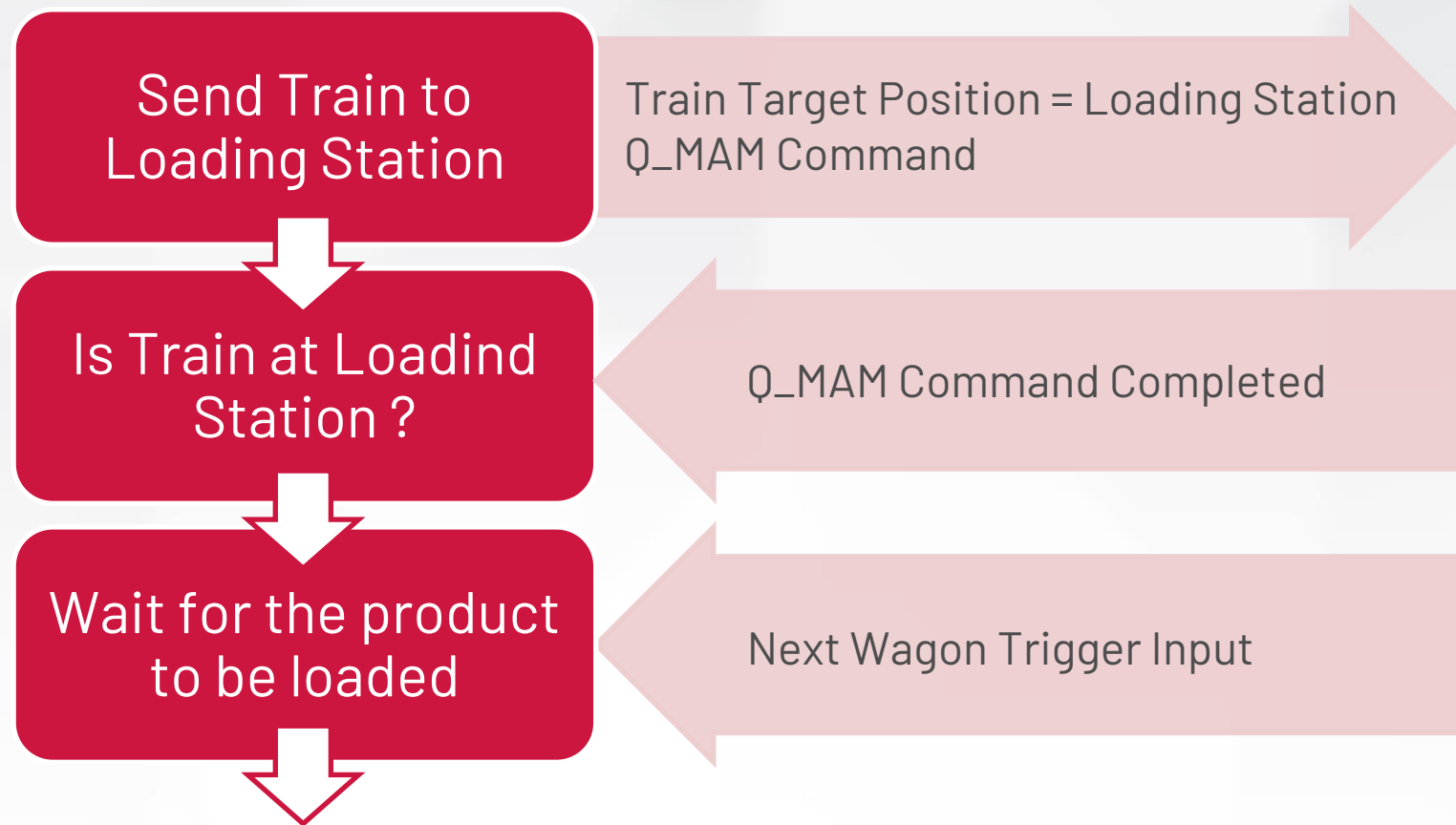


Output Data:

- **Train Command Position**
Send position target to the Q_MAM AOI
- **EN**
Instruction is enabled
- **IP**
Instruction is Active
- **DN**
Parameters are compatible with Instruction
- **ER**
Function Error. Error is cleared on a transition of Cycle_Run
Input from 0 to 1
- **TrainAtUnloadingStation**
Tells the Machine state manager the train is ready to be unloaded
- **Q_MAM_Cmd**
Send Motion Command to Q_MAM AOI

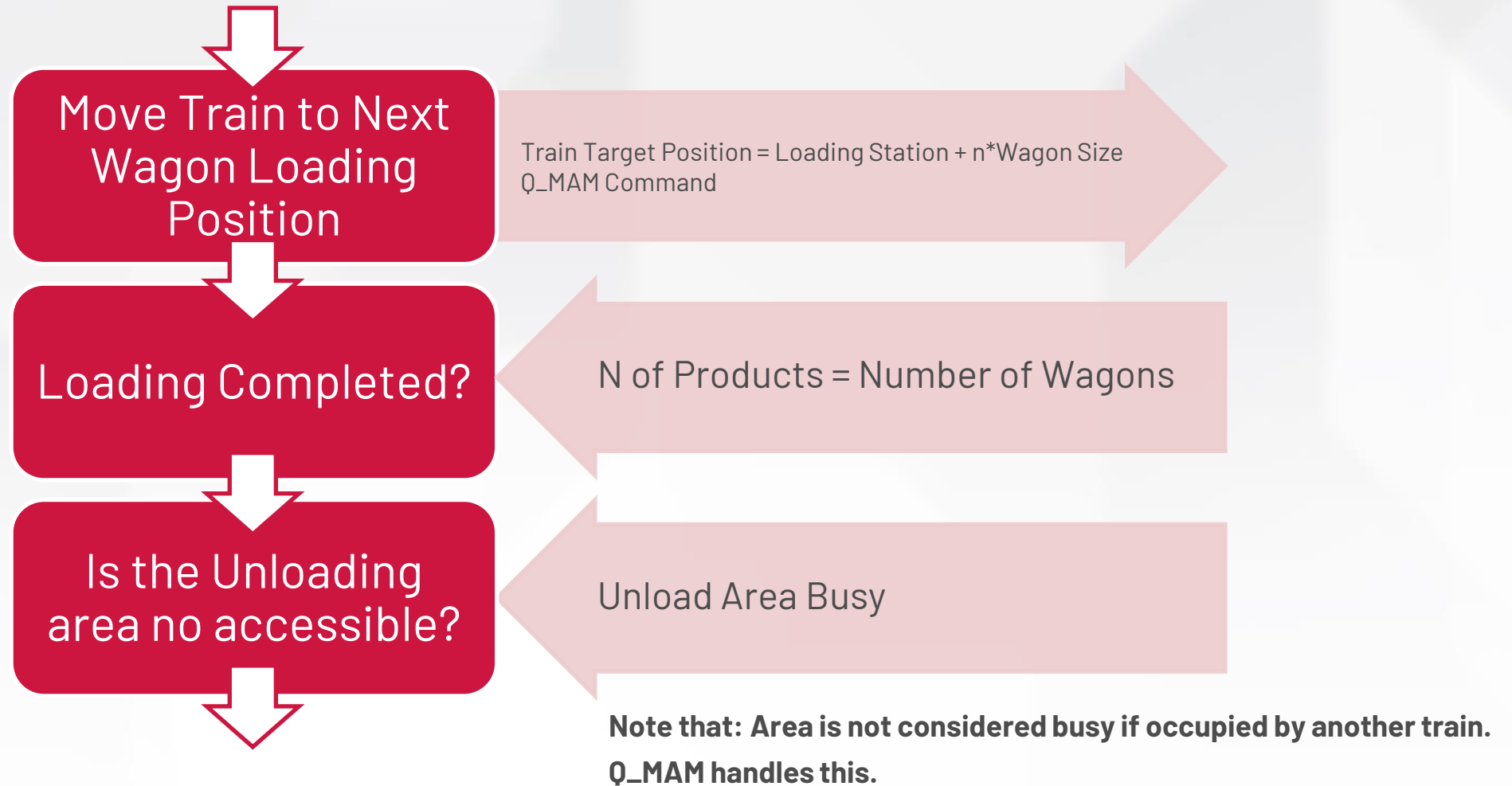
Multibelt

Multibelt_AOI State Machine



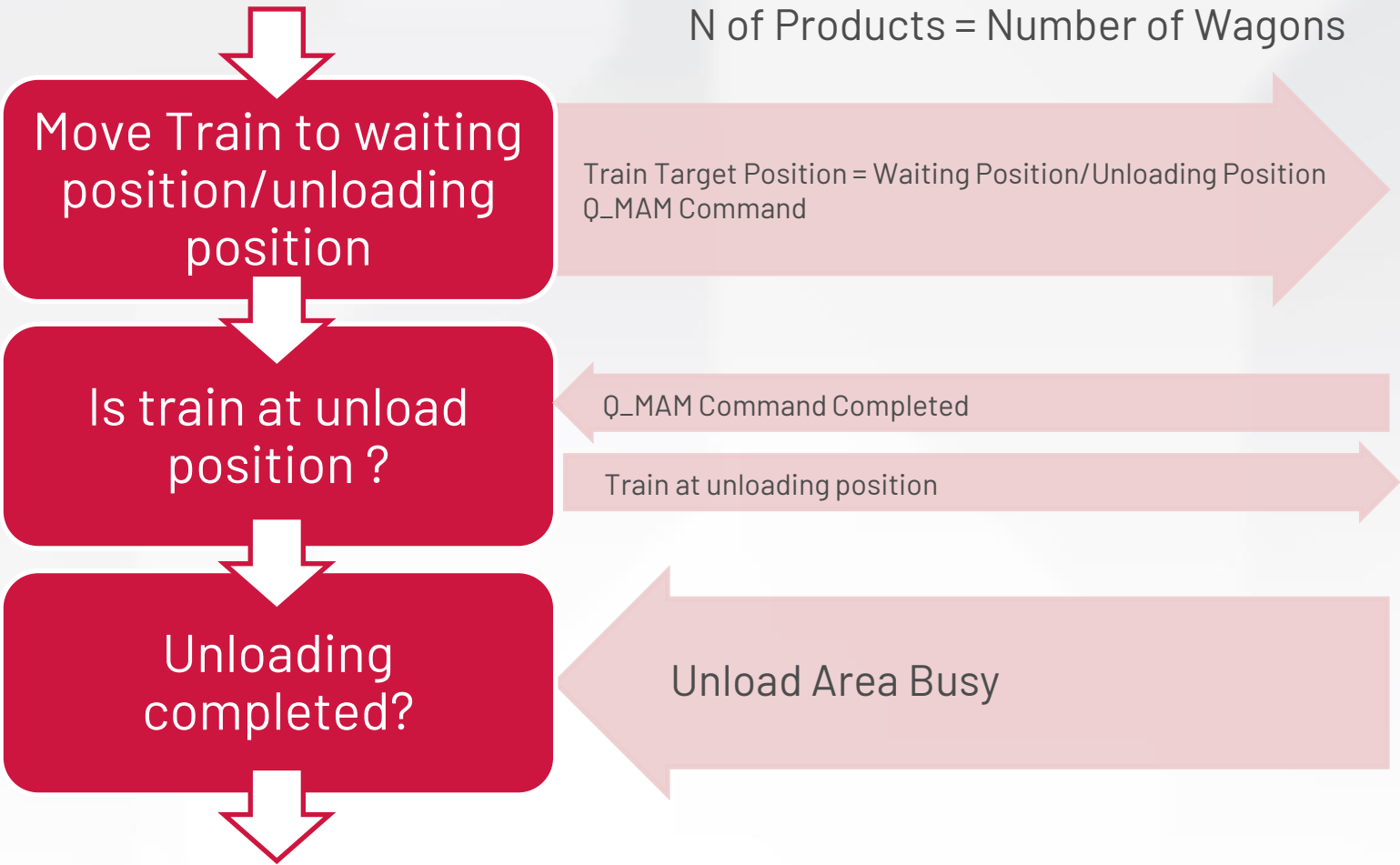
Multibelt

Multibelt_AOI State Machine



Multibelt

Multibelt_AOI State Machine



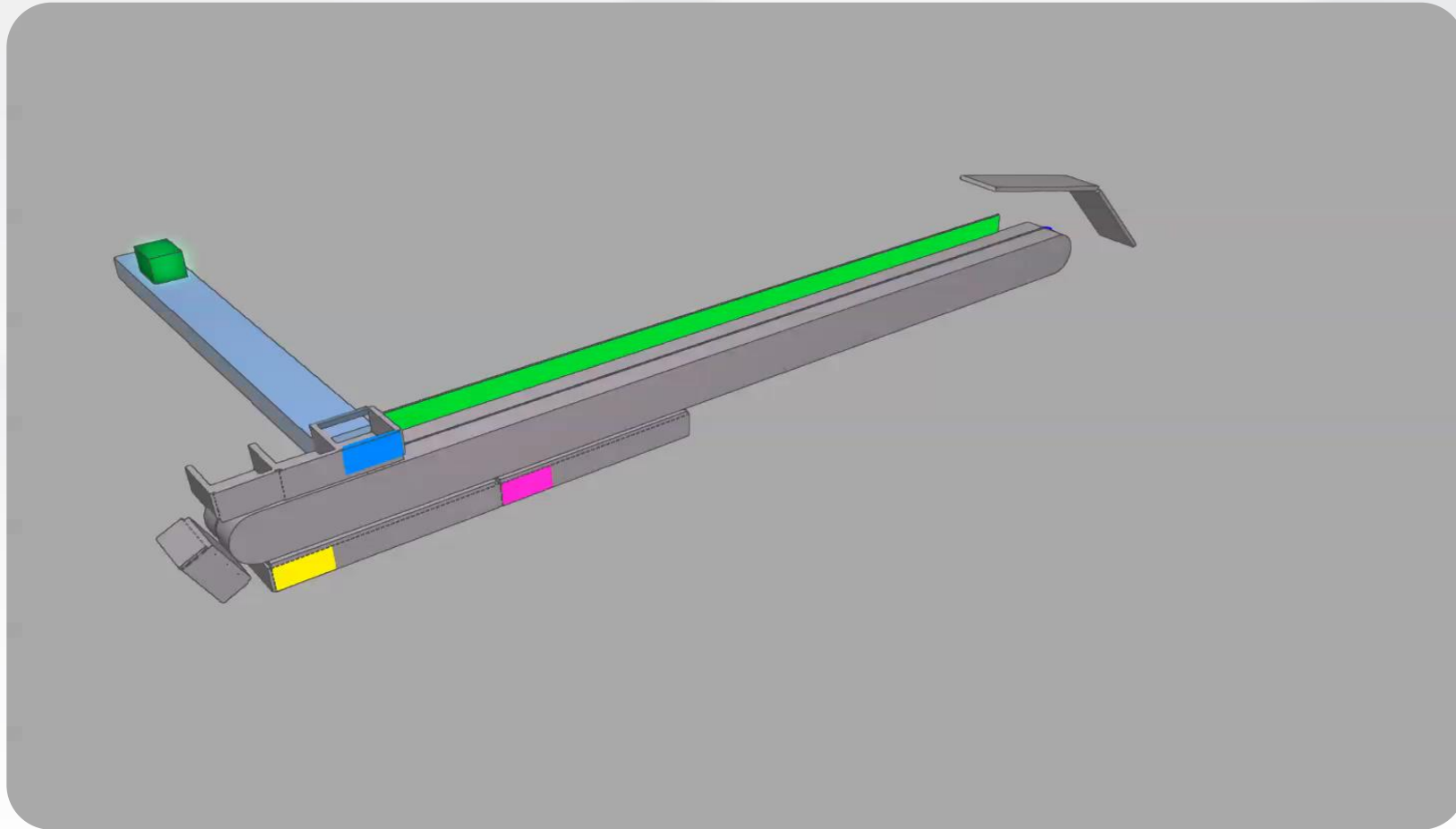
Multibelt

Multibelt_AOI State Machine



Multibelt

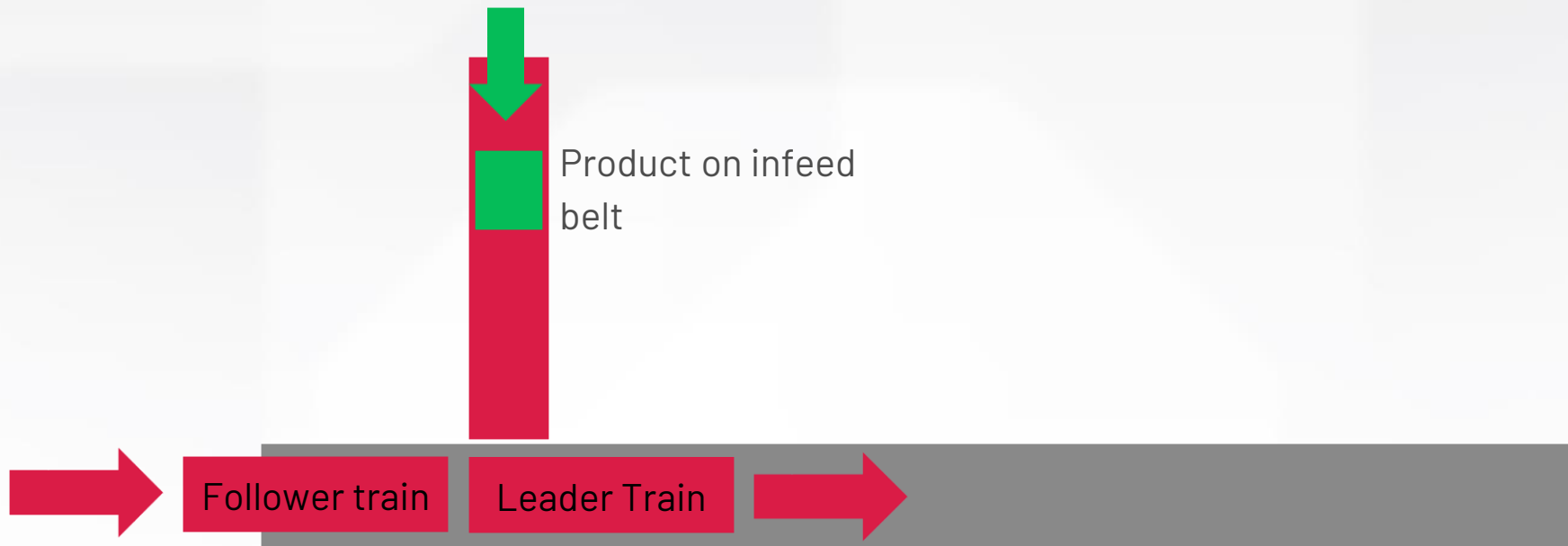
Simulation video example



Multibelt

Performances using Q_MAM

- Using Q_MAM to perform step moves introduces some delay when a follower is waiting for the leader to move out of interference. In particular we are interested in evaluate the time delay taken by the first wagon of the following train to replace the last wagon leaving the loading position



Multibelt

Some thoughts about it

Performances of a Multibelt using Q_MAM instead of a combination of Moves+Gear are slightly lower, in particular when replacing train at loading station

This can be an issue in very demanding application where a “traditional” programming may be preferred

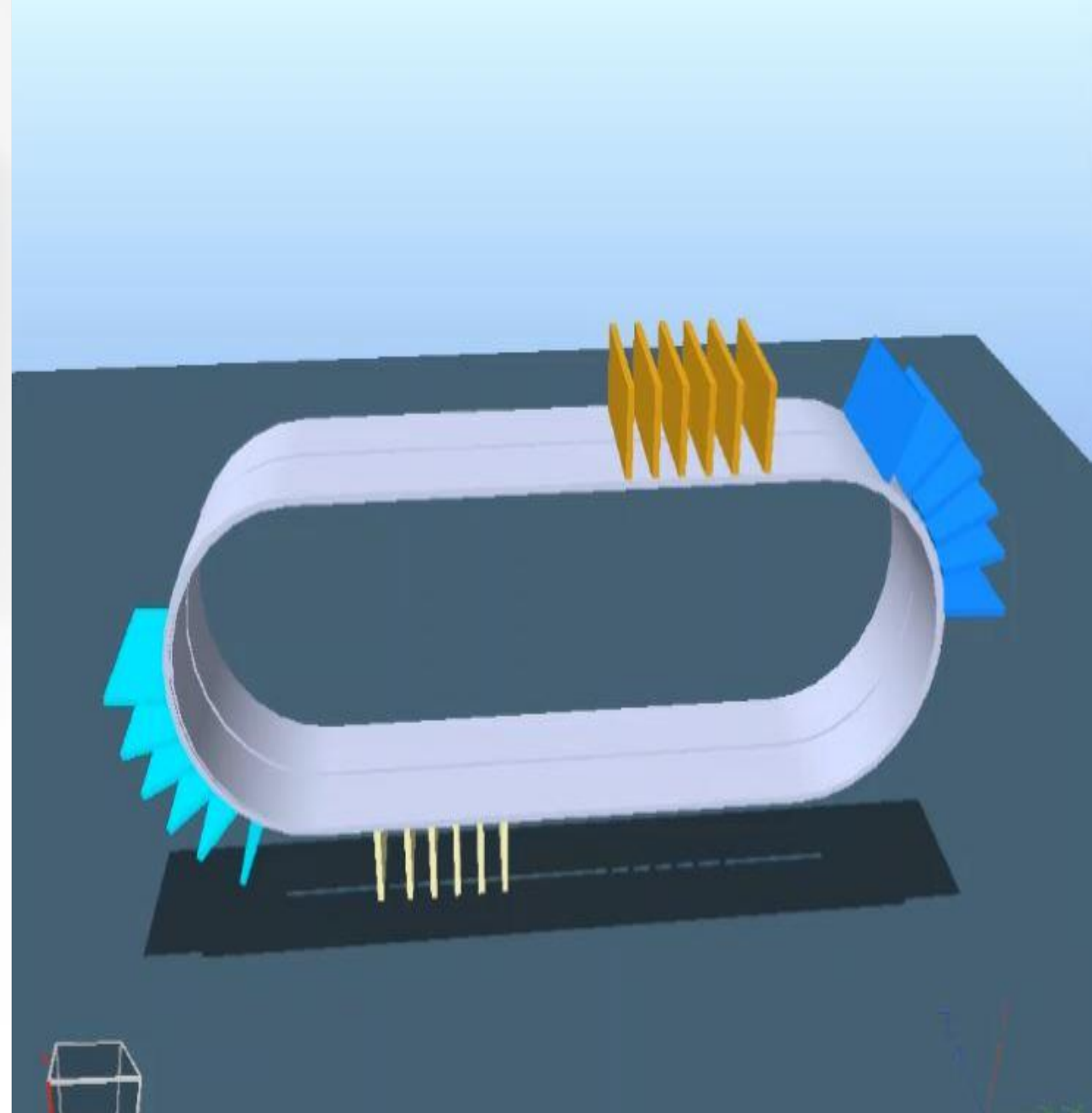
Using **Q_MAM** to program a Multibelt system dramatically lower complexity of code:

- Q_MAM instructions takes care of reaching target positions without collisions.
- No need to evaluate trains state or position to lock/unlock gear
- Restarting the cycle after an event is easy to program, as you just need to resend the Q_MAM command to the last position loaded
- Increasing or reducing the number of trains involves only modifying the chained parameters for the Q_MAM instructions

Multibelt

Application using multibelt with two collators

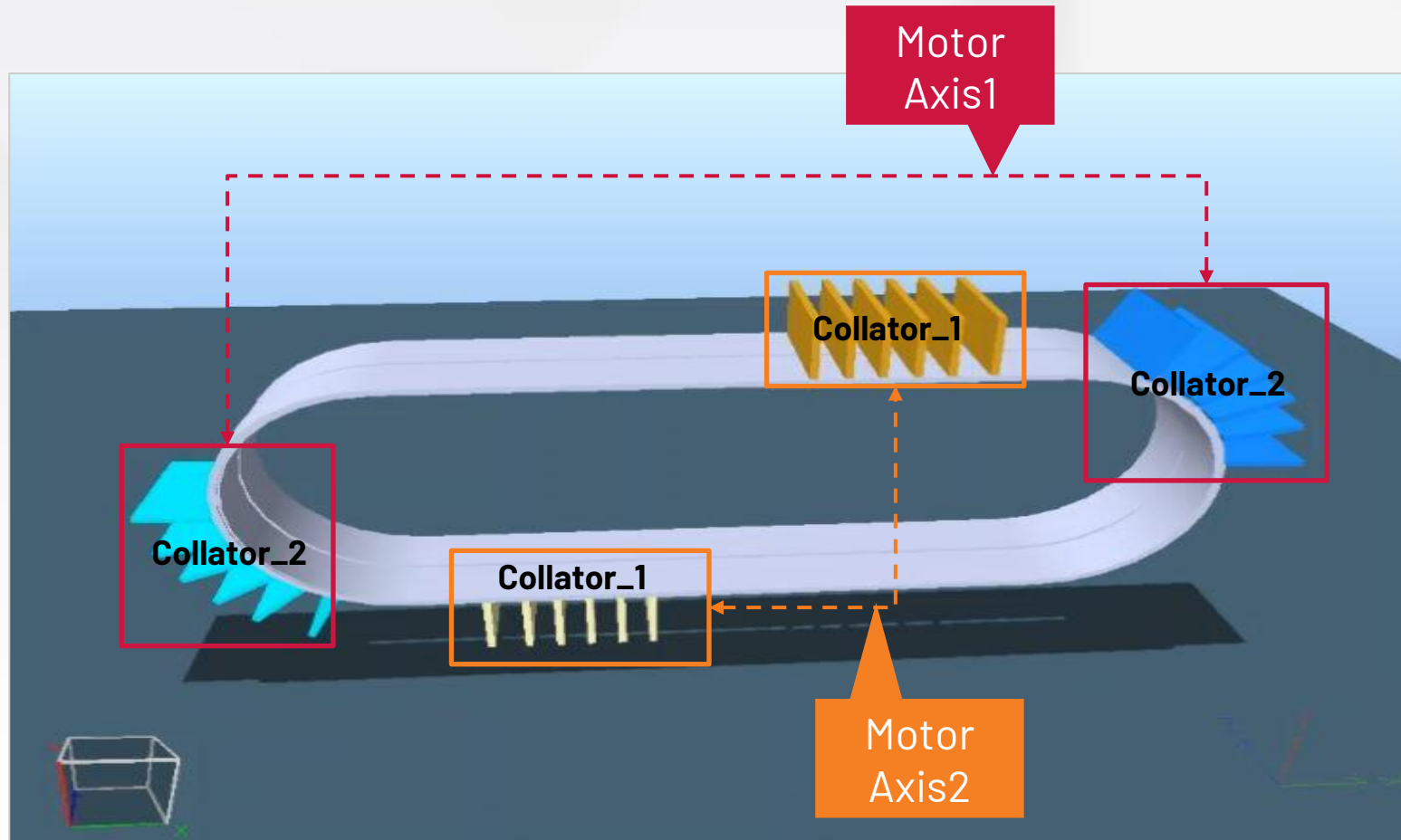
Multibelt - 2 collators



Multibelt

General mechanical concepts

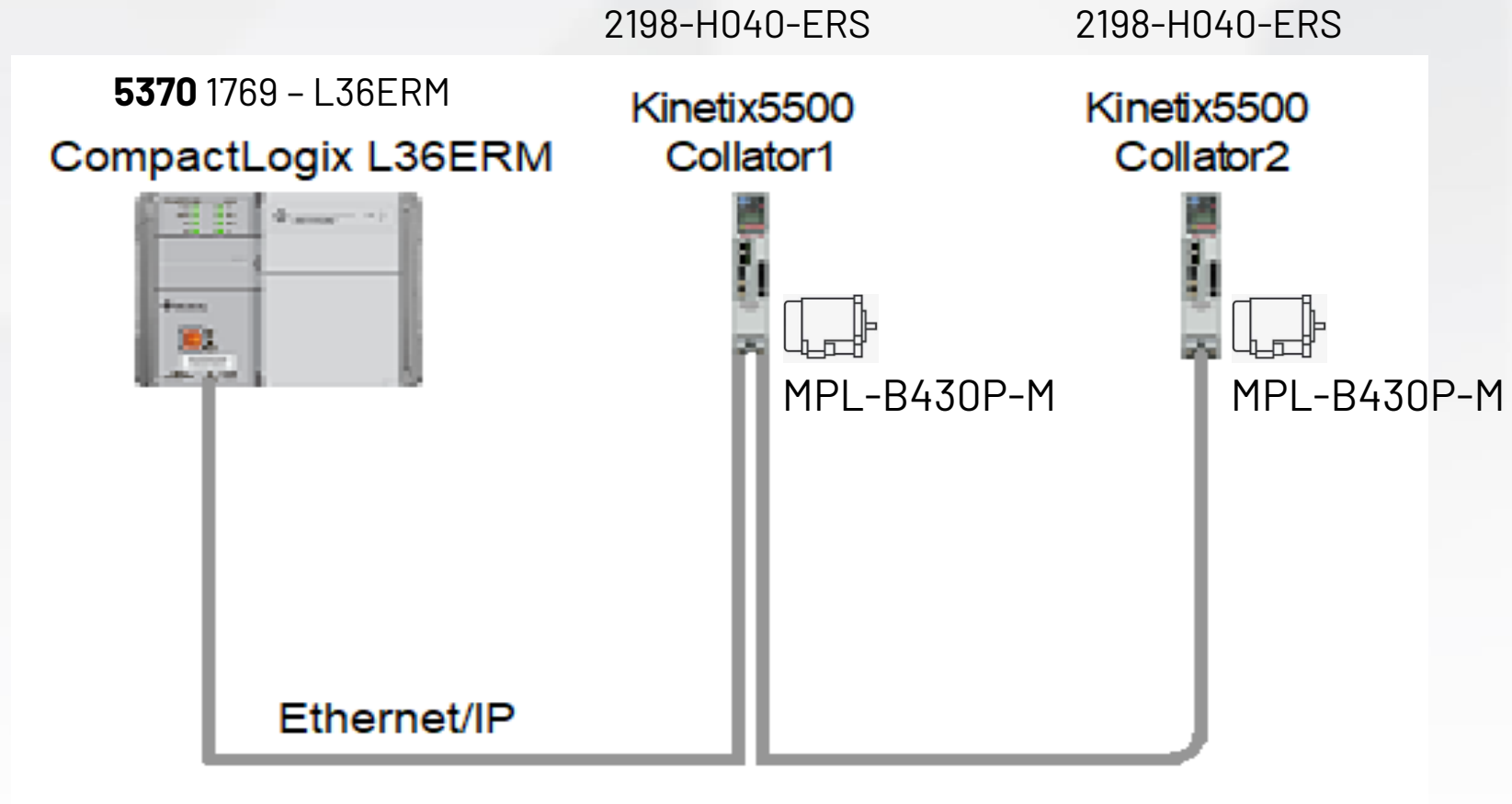
One axis controls 2 collators.



- Motor/Axis1 controls **Collators_1**
- Motor/Axis2 controls **Collators_2**

Multibelt

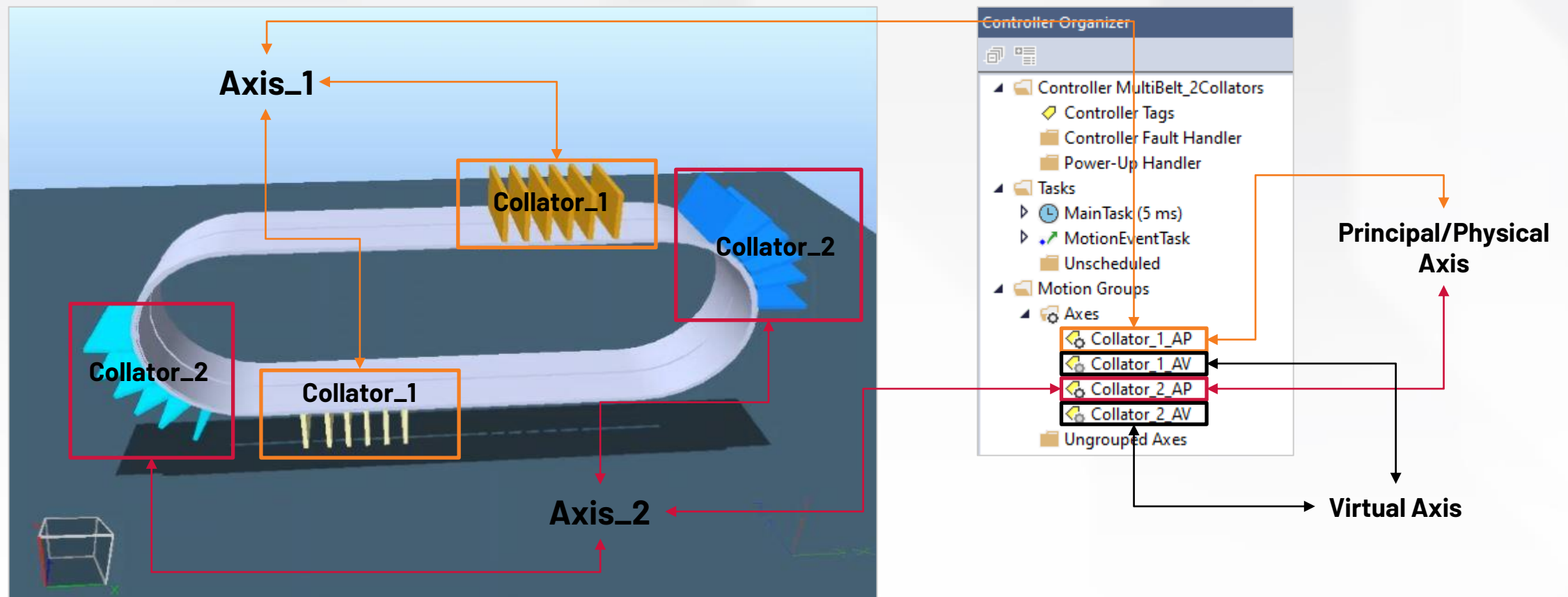
Hardware Architecture



Multibelt

General concepts

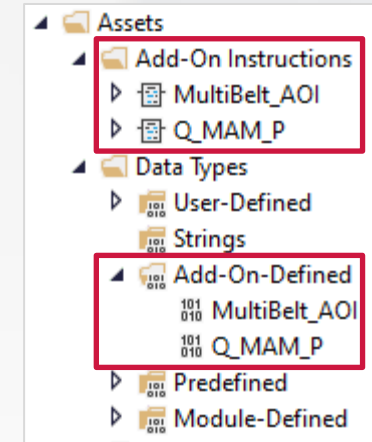
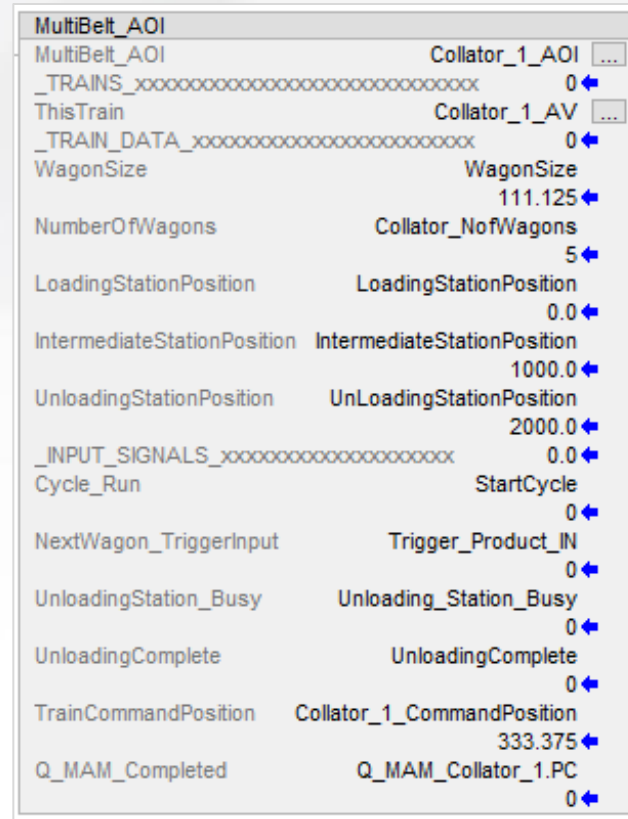
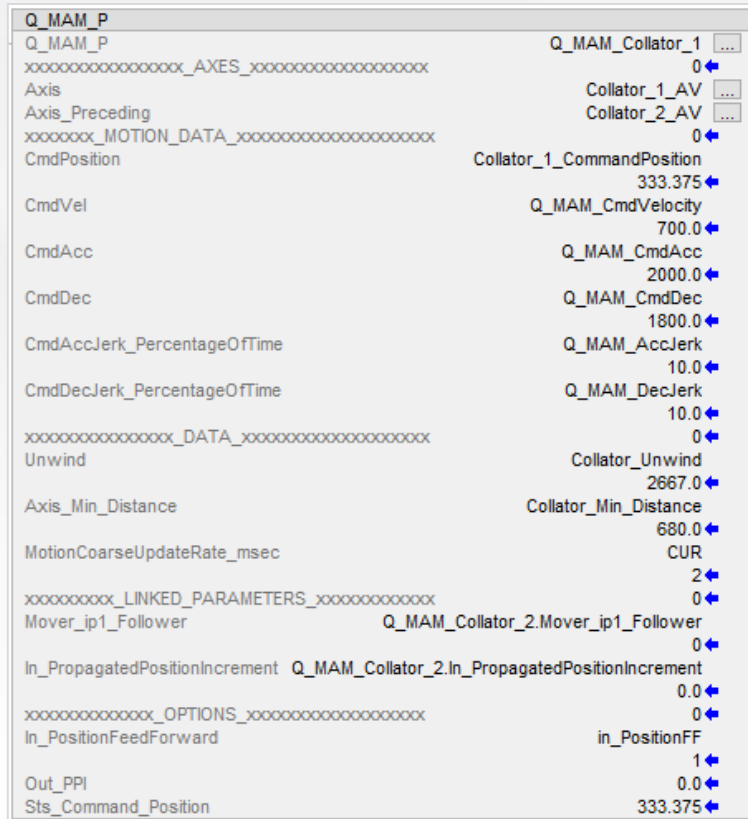
- Each Collator must be linked with your respective physical axis/motor. We used a virtual axis to facilitate testing and commissioning



Multibelt

Add-On Instructions

- Import/use the Add-On Instructions/Defined → **Q_MAM_P** and **MultiBelt_AOI**

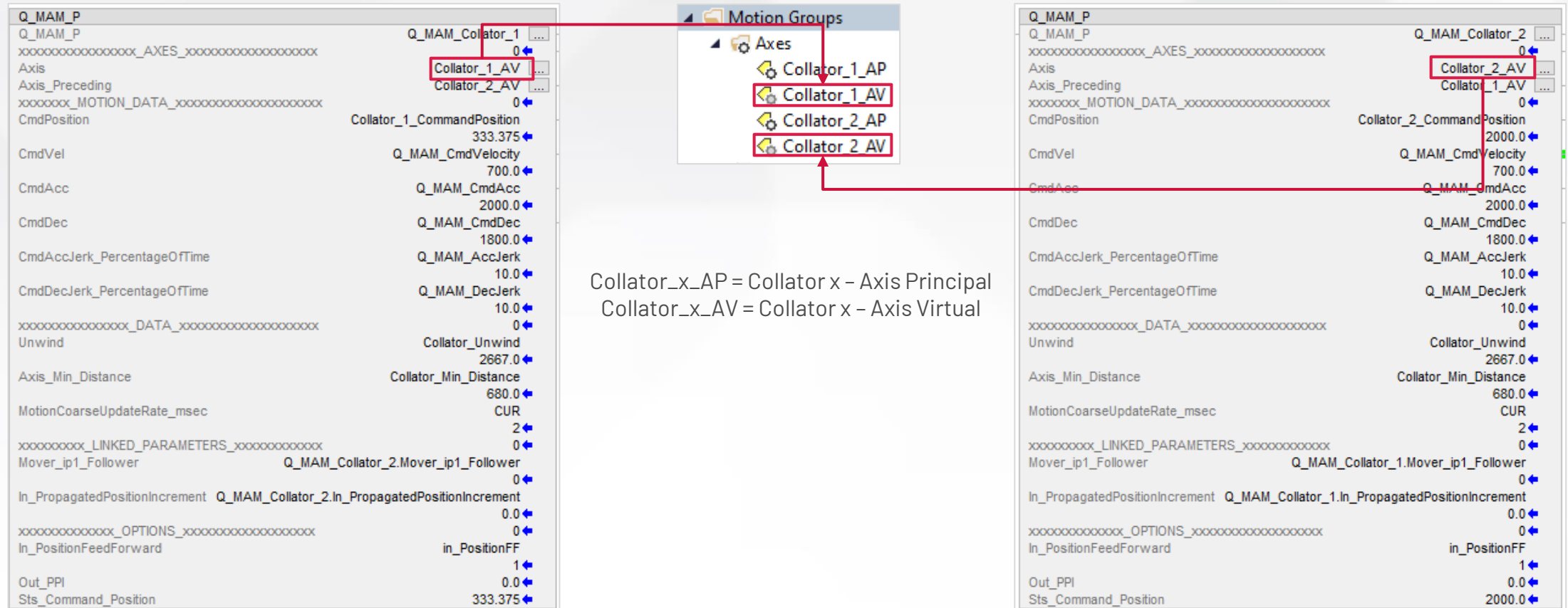


Configure the paramaters according your application data..

Multibelt

Add-On Q_MAM_P

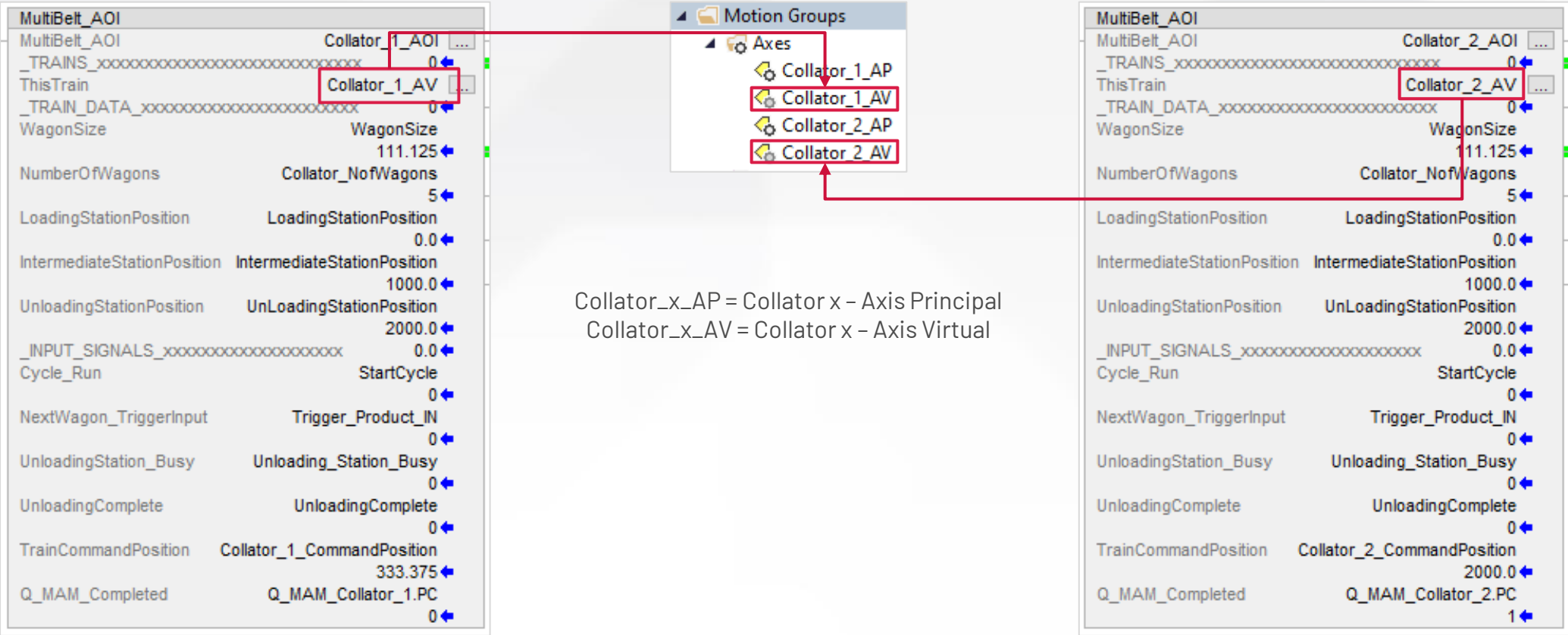
- Q_MAM_P blocks are linked with your respective virtual axis



Multibelt

Add-On Multibelt_AOI

- Multibelt_AOI blocks are linked with your respective virtual axis

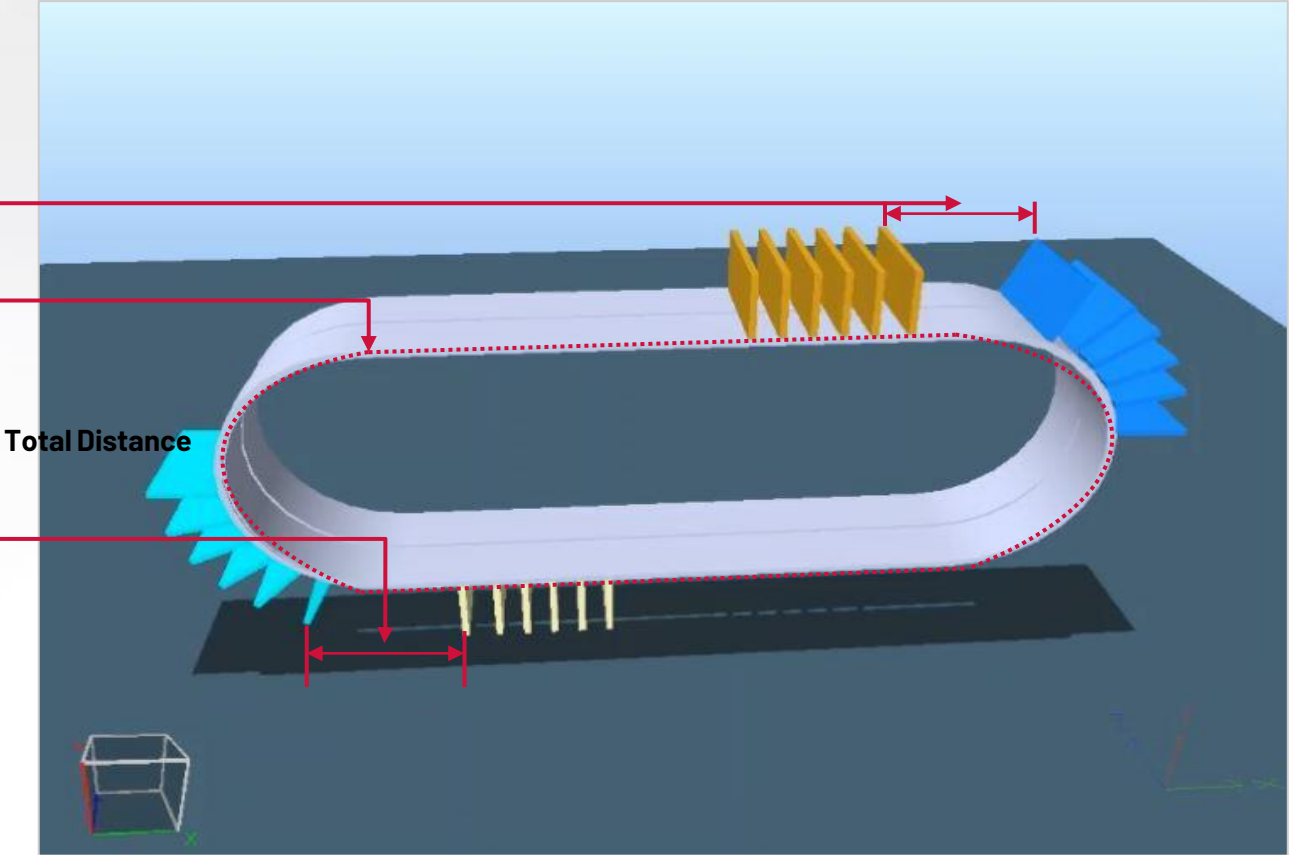


Multibelt

Q_MAM_P

- Data

Q_MAM_P	
Q_MAM_P	Q_MAM_Collator_1
xxxxxxxxxxxxxxxxxxxx_AXESxxxxxxxxxxxxxxxxxxxx	0
Axis	Collator_1_AV
Axis_Preceding	Collator_2_AV
xxxxxxxx_MOTION_DATAxxxxxxxxxxxxxxxxxxxx	0
CmdPosition	Collator_1_CommandPosition
	333.375
CmdVel	Q_MAM_CmdVelocity
	700.0
CmdAcc	Q_MAM_CmdAcc
	2000.0
CmdDec	Q_MAM_CmdDec
	1800.0
CmdAccJerk_PercentageOfTime	Q_MAM_AccJerk
	10.0
CmdDecJerk_PercentageOfTime	Q_MAM_DecJerk
	10.0
xxxxxxxxxxxxxxxxxxxx_DATAxxxxxxxxxxxxxxxxxxxx	0
Unwind	Collator_Unwind
	2667.0
Axis_Min_Distance	Collator_Min_Distance
	680.0
MotionCoarseUpdateRate_msec	CUR
	2
xxxxxxxxxxxxxxxxxxxx_LINKED_PARAMETERSxxxxxxxxxxxxxxxxxxxx	0
Mover_ip1_Follower	Q_MAM_Collator_2.Mover_ip1_Follower
	0
In_PropagatedPositionIncrement	Q_MAM_Collator_2.In_PropagatedPositionIncrement
	0.0
xxxxxxxxxxxxxxxxxxxx_OPTIONSxxxxxxxxxxxxxxxxxxxx	0
In_PositionFeedForward	in_PositionFF
	1
Out_PPI	0.0
Sts_Command_Position	333.375

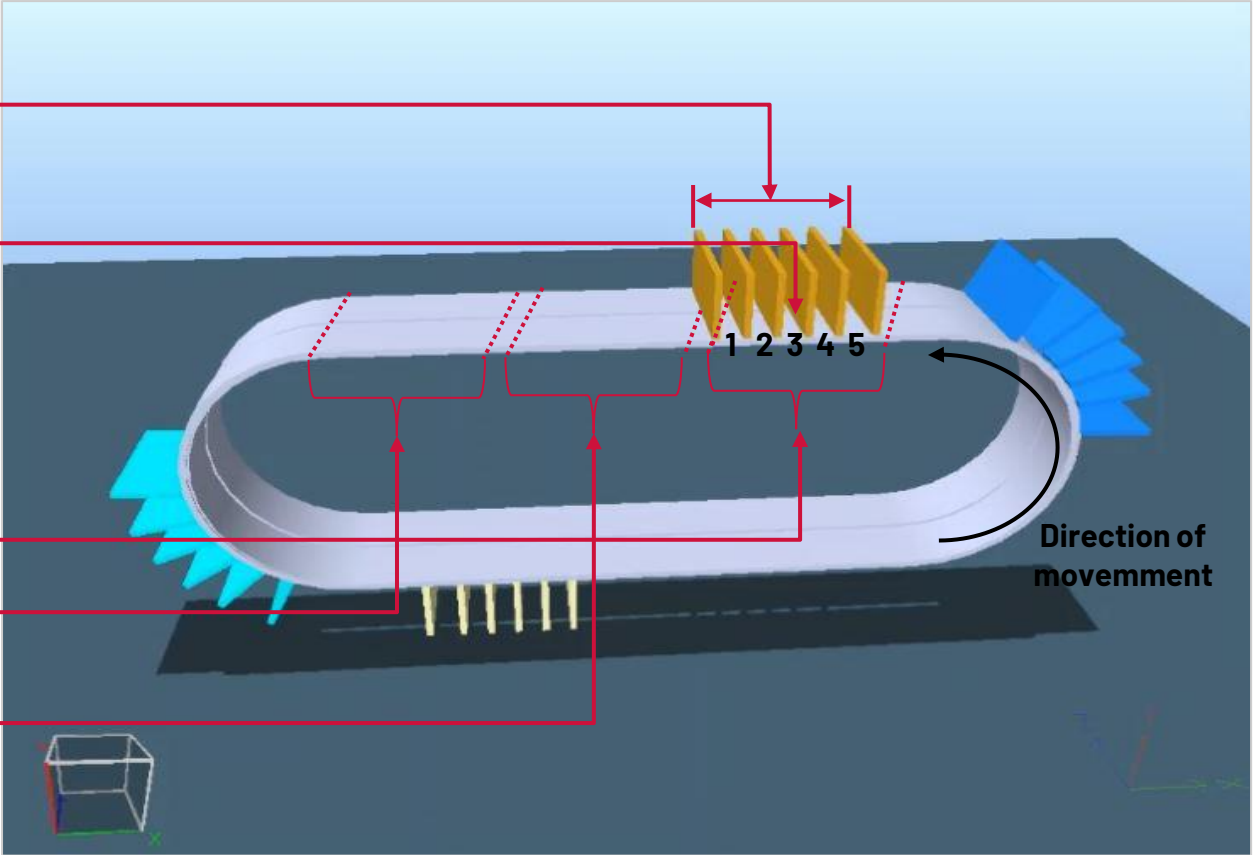


Multibelt

Multibelt_AOI

- Collector Data parameter

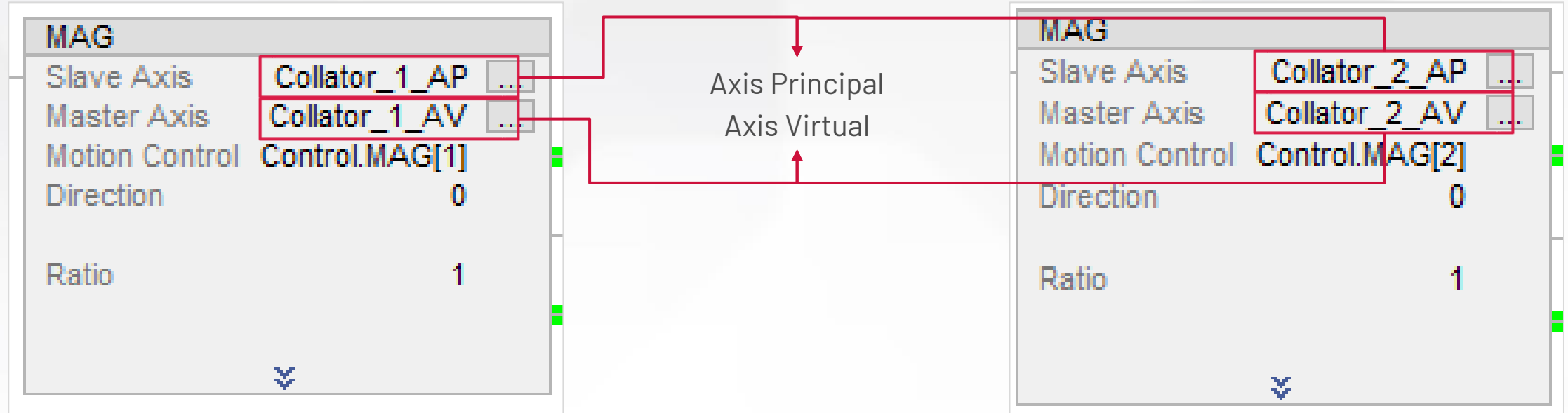
MultiBelt_AOI	
MultiBelt_AOI	Collator_2_AOI ...
_TRAINS_XXXXXXXXXXXXXXXXXXXXX	0
ThisTrain	Collator_2_AV ...
TRAIN_DATA XXXXXXXXXXXXXXXXXXXXX	0
WagonSize	WagonSize
	111.125
NumberOfWagons	Collator_NofWagons
	5
LoadingStationPosition	LoadingStationPosition
	0.0
IntermediateStationPosition	IntermediateStationPosition
	1000.0
UnloadingStationPosition	UnLoadingStationPosition
	2000.0
_INPUT_SIGNALS_XXXXXXXXXXXXX	0.0
Cycle_Run	StartCycle
	0
NextWagon_TriggerInput	Trigger_Product_IN
	0
UnloadingStation_Busy	Unloading_Station_Busy
	0
UnloadingComplete	UnloadingComplete
	0
TrainCommandPosition	Collator_2_CommandPosition
	2000.0
Q_MAM_Completed	Q_MAM_Collator_2.PC
	1



Multibelt

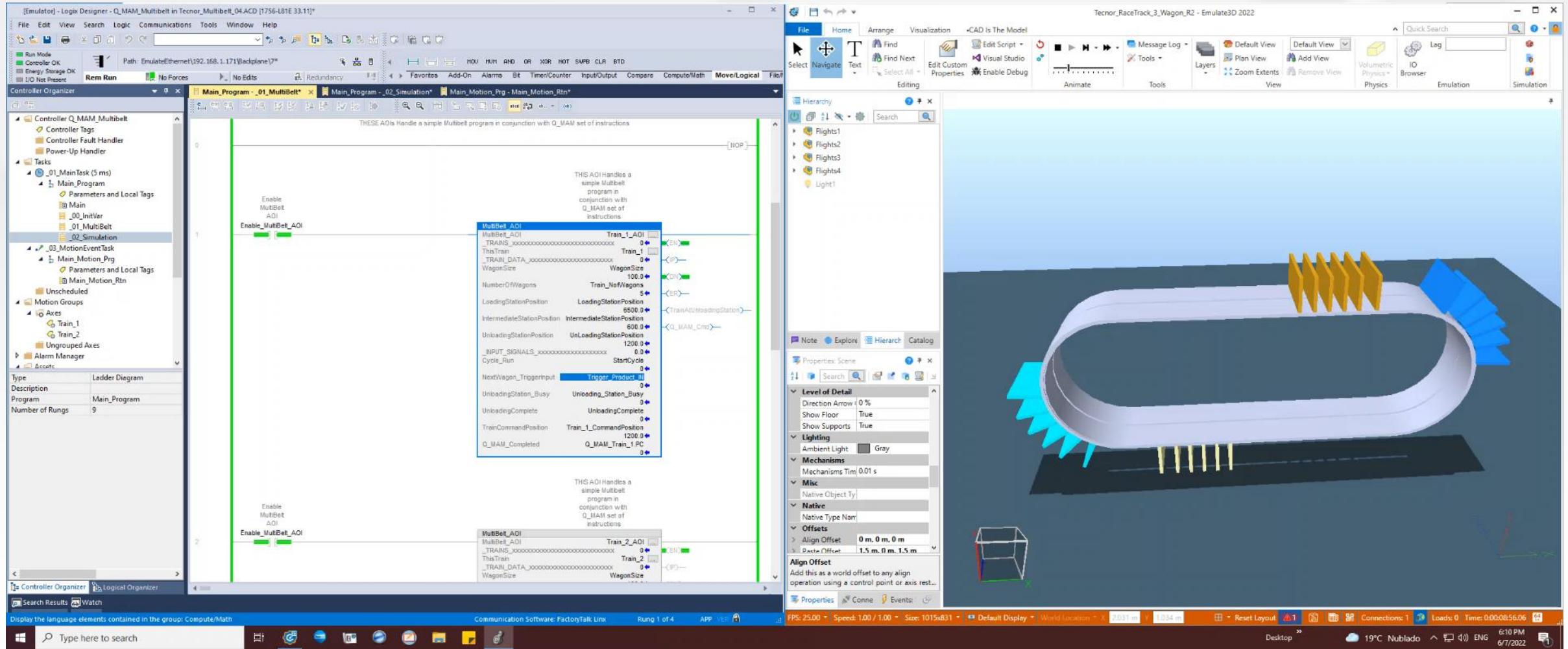
Gear Master/Slave Axis

- Don't forget to create the **Gear** sequence between Master and Slave axis in your program using **MAG-AOI** (Motion Axis Gear). The Axis need to be gearing before start control.



Multibelt

Simulation video example



Multibelt

General final notes

- The purpose of this document is to show in general steps how to implement and configure code using special Add-Ons (Q_MAM_P, Multibelt_AOI) to control multibelt systems. This document is not a manual to implement a multibelt systems.
- This document requires a previous Studio5000 motion knowledge and Kinetix configurations
- **Q_MAM_P** and **Multibelt_AOI** are Add-Ons created especially for multibelt controls and do not belong to any special library



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