



# Logix Echo

Version 1.0 & 2.0

expanding **human possibility**<sup>®</sup>



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# Digital Engineering Use Cases



## Machine Prototyping

Easily design and build the next generation of machines with confidence



## Virtual Commissioning

Design, test, validate, & commission machines before they go into service



## Throughput Analysis

Optimize throughput with real-time 3D simulation of dynamic processes

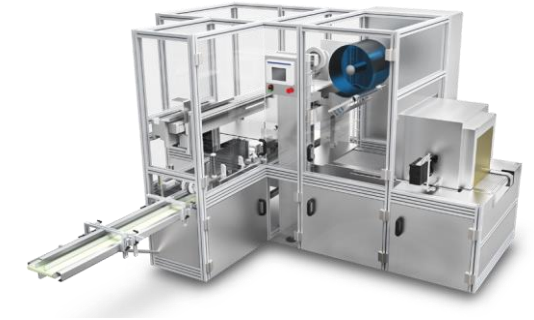


## Operator Training Simulators

Reduce risk by training your workforce in a safe, virtual environment

# Digital Twin Workflow

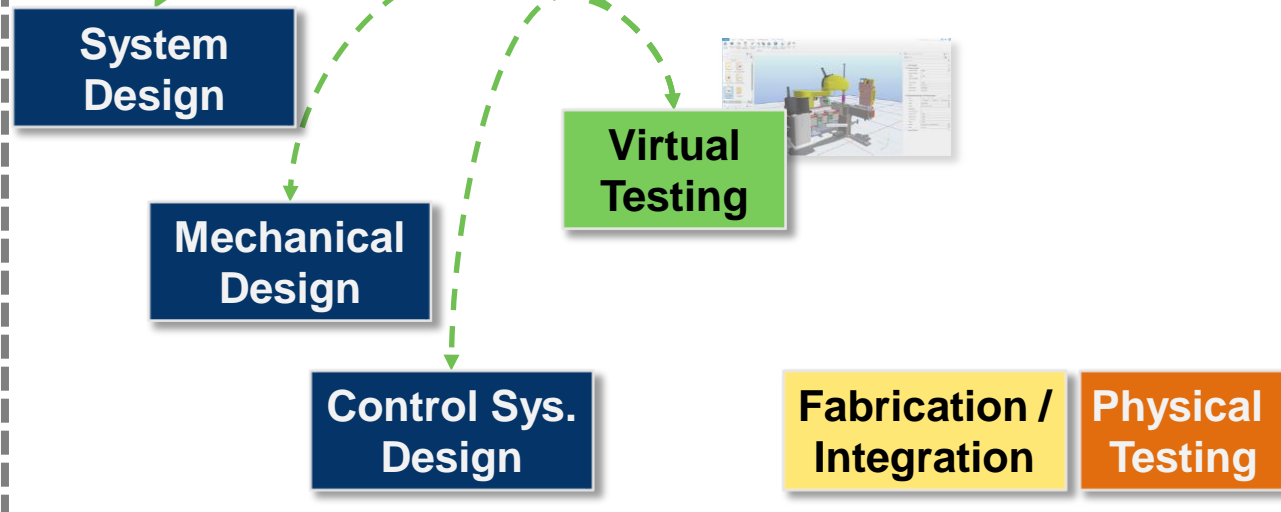
Mitigates risks and adds flexibility in your projects



## TRADITIONAL SCHEDULE



## DIGITAL TWIN SCHEDULE



← SAVINGS →

**Improve** project delivery timeline

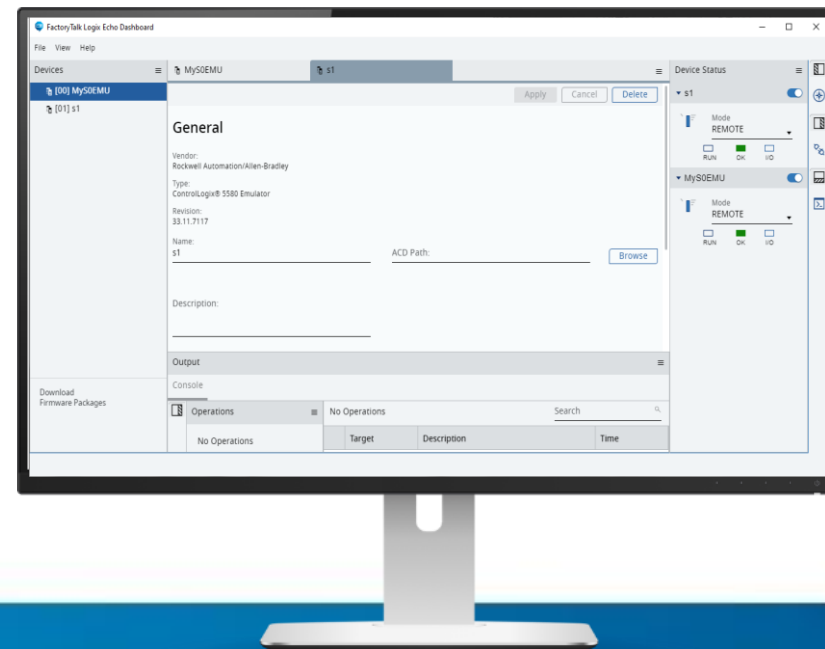
**Improve** quality of design

**Reduce** hardware dependencies

**Reduce** commissioning risks

# FT Logix Echo

V1.0



## Emulate ControlLogix® 5580 Controllers

- Fully test your control code in a safe, virtual environment
- The emulated chassis supports up to 17 controllers
- Execute controller project as designed without modifications

## Ethernet Connectivity

- Front port of controller emulated
- Produce/Consume and MSGs between emulated controllers
- Connect to HMI or other software with Class 3 MSGs

## SDK (Public Interface)

- Interface with high fidelity process simulators and Operator Training Simulators (OTS)
- High-speed data exchange
- Virtual time-scaling
- Snapshots



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Access is Similar to a Physical Controller

## Configuring an emulated controller is fast

- Get the corresponding emulator firmware kit from the PCDC
- Create emulated controller instance with appropriate firmware revision and IP address
- Configured controllers appear in FactoryTalk® Linx software
- Create up to 17 emulated controllers in one emulated chassis

The image displays two screenshots of the FactoryTalk Logix Echo software interface. The top screenshot is a dialog box titled "Add Controller" with the following fields: Type (ControlLogix 5580 Emu...), Name (MyS3Emu), Revision (33.11.00), Description, and IP Address (192.168.1.3). The bottom screenshot shows the "FactoryTalk Logix Echo Dashboard" with a "Devices" list containing [00] PlantPax\_R5\_00\_Demo, [01] MyS1Emu, and [02] MyS2Emu. A "General" tab is selected for the [00] PlantPax\_R5\_00\_Demo device, showing Vendor: Rockwell Automation/Allen-Bradley and Type: . A "FactoryTalk Linx Browser" window is overlaid, showing a tree view of the network structure under "GC63303", including "Ethernet, EmulateEthernet" with sub-items for IP addresses 192.168.1.1, 192.168.1.2, and 192.168.1.22.

Apply Same Project to Physical or Emulated Controller

## Same Project File

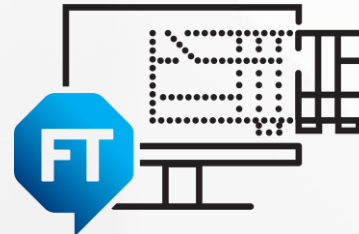
No changes to the project file required. The same project file developed for the physical controller will download to the emulator. The I/O tree will be maintained, all languages and instructions supported.



## Supported Controllers

### ControlLogix® 5580 Controllers

All -E, -XT, -NSE and -P controllers



**Logix Echo**

Firmware version 33 or later

### Catalogs

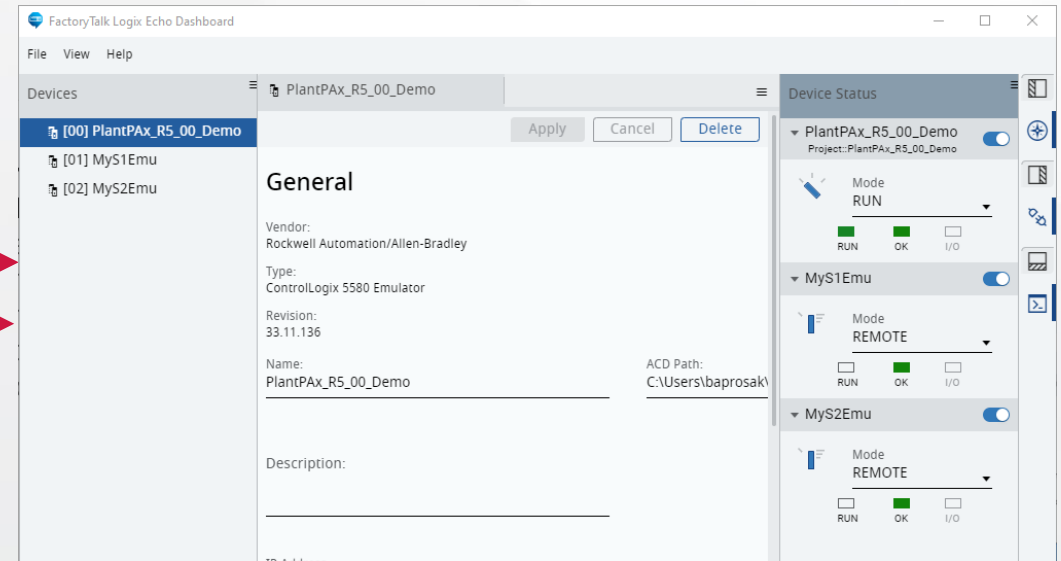
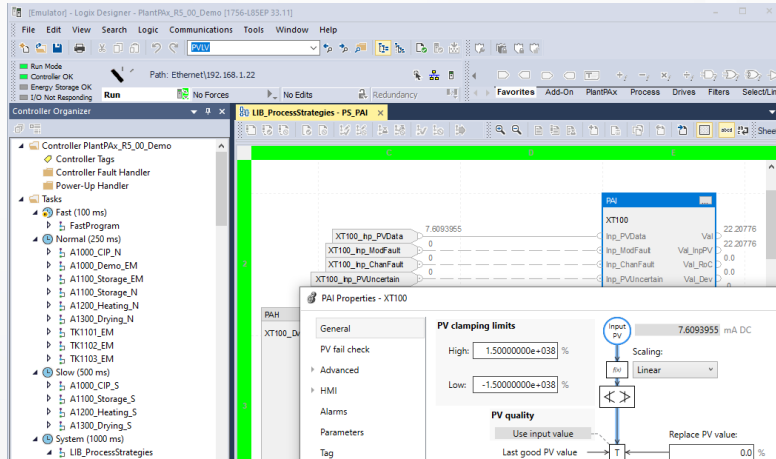
1756-L81E	1756-L82E	1756-L83E	1756-L84E	1756-L85E
1756-L81EK	1756-L82EK	1756-L83EK	1756-L84EK	1756-L85EK
1756-L81E-NSE	1756-L82E-NSE	1756-L83E-NSE	1756-L84E-NSE	1756-L85E-NSE
1756-L81EXT	1756-L82EXT	1756-L83EXT	1756-L84EXT	1756-L85EXT
1756-L81EP		1756-L83EP		1756-L85EP

**Future Releases:** GuardLogix® 5580, CompactLogix™ 5380 and Compact GuardLogix® 5380 Controllers

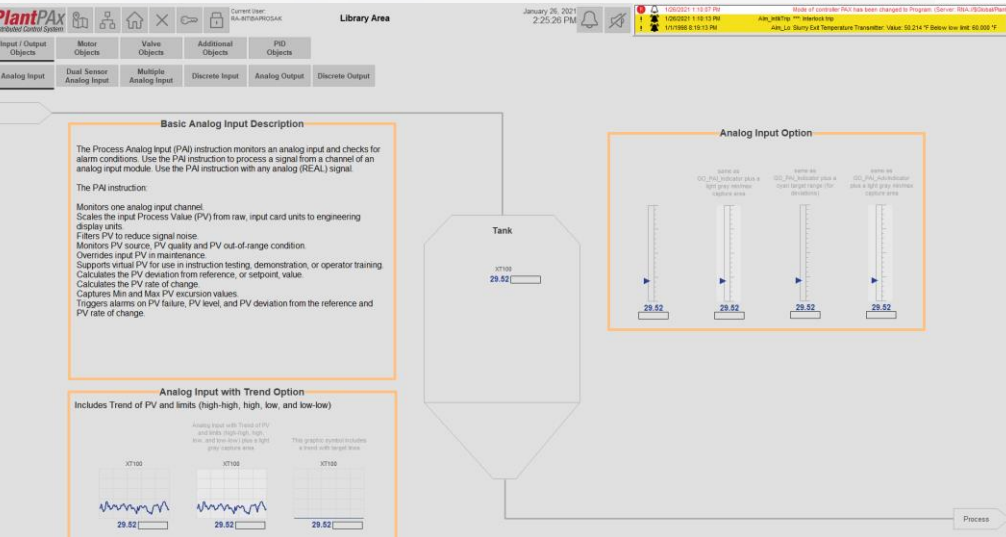


Simulate Control Code and HMI Interaction All from a Single Workstation or Distributed

**Step 1:** create Logix application and run in Studio 5000®  
Logix Emulate™



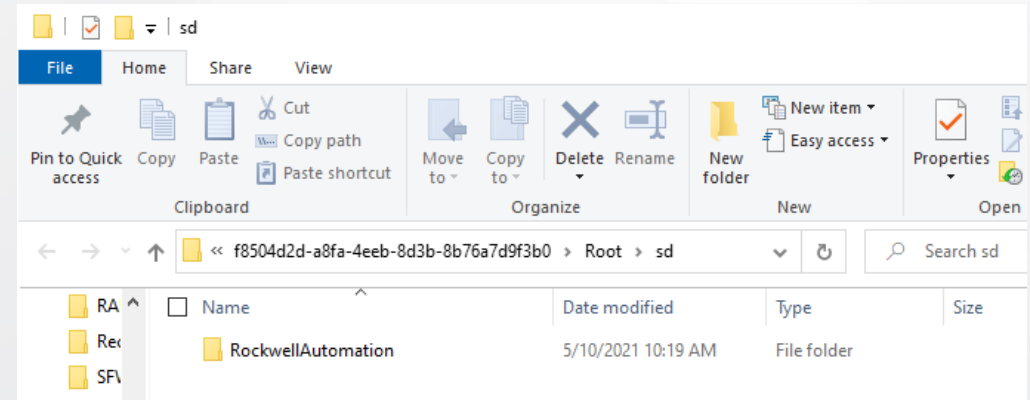
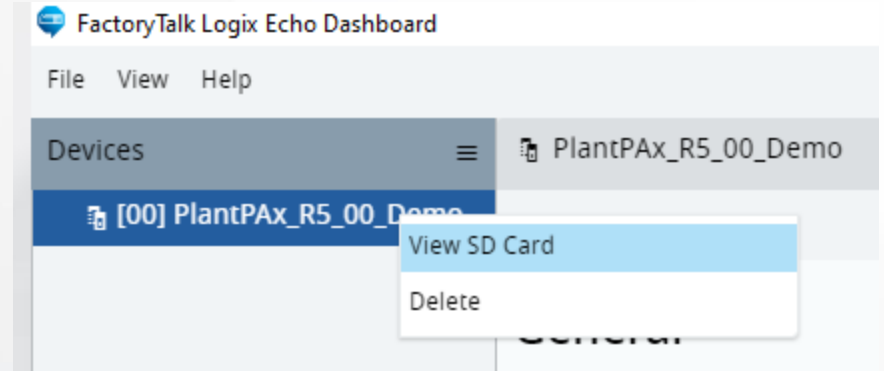
**Step 2:** Existing HMI shortcut(s) will work provided the emulated controller is at same IP as physical controller





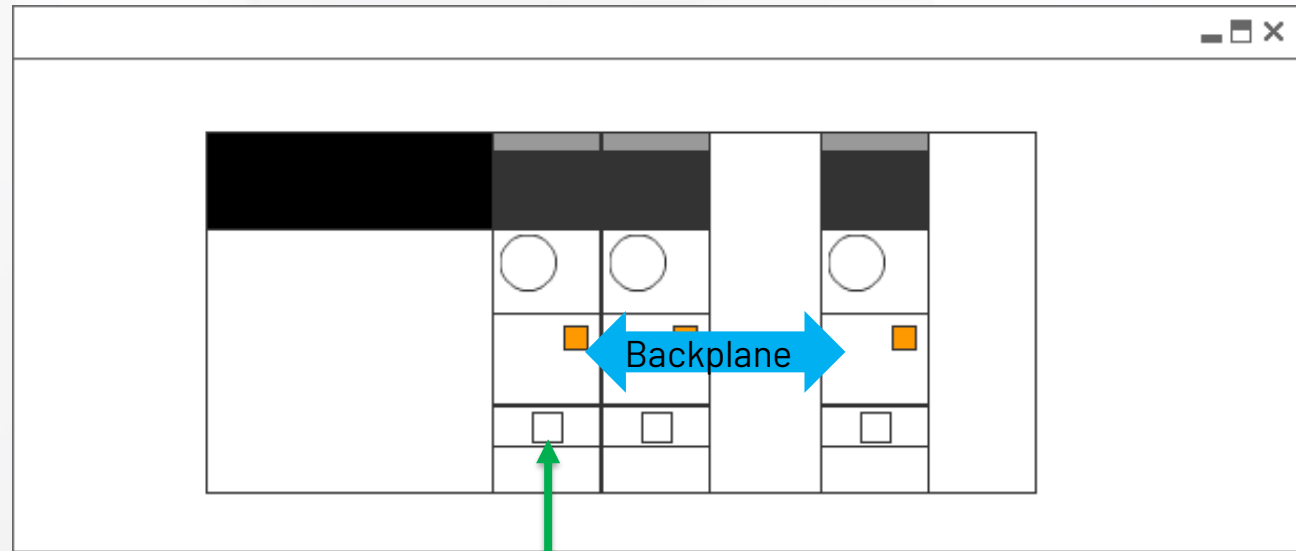
### Support for SD Cards

- By default, a virtual SD card is attached to a controller (as a folder on your Windows directory)
- You can backup/restore projects, read/write data from the controller applications, log, just as you would with a physical SD card in the controller.
- Unlike the physical controller:
  - Firmware is not stored to the virtual SD
  - The content is stored unencrypted



## Studio 5000 Logix Designer® to Emulator Instance

Studio 5000 Logix Designer® can download over Ethernet. It can also bridge through one emulator instance connected over Ethernet to another emulator instance through the emulated backplane.

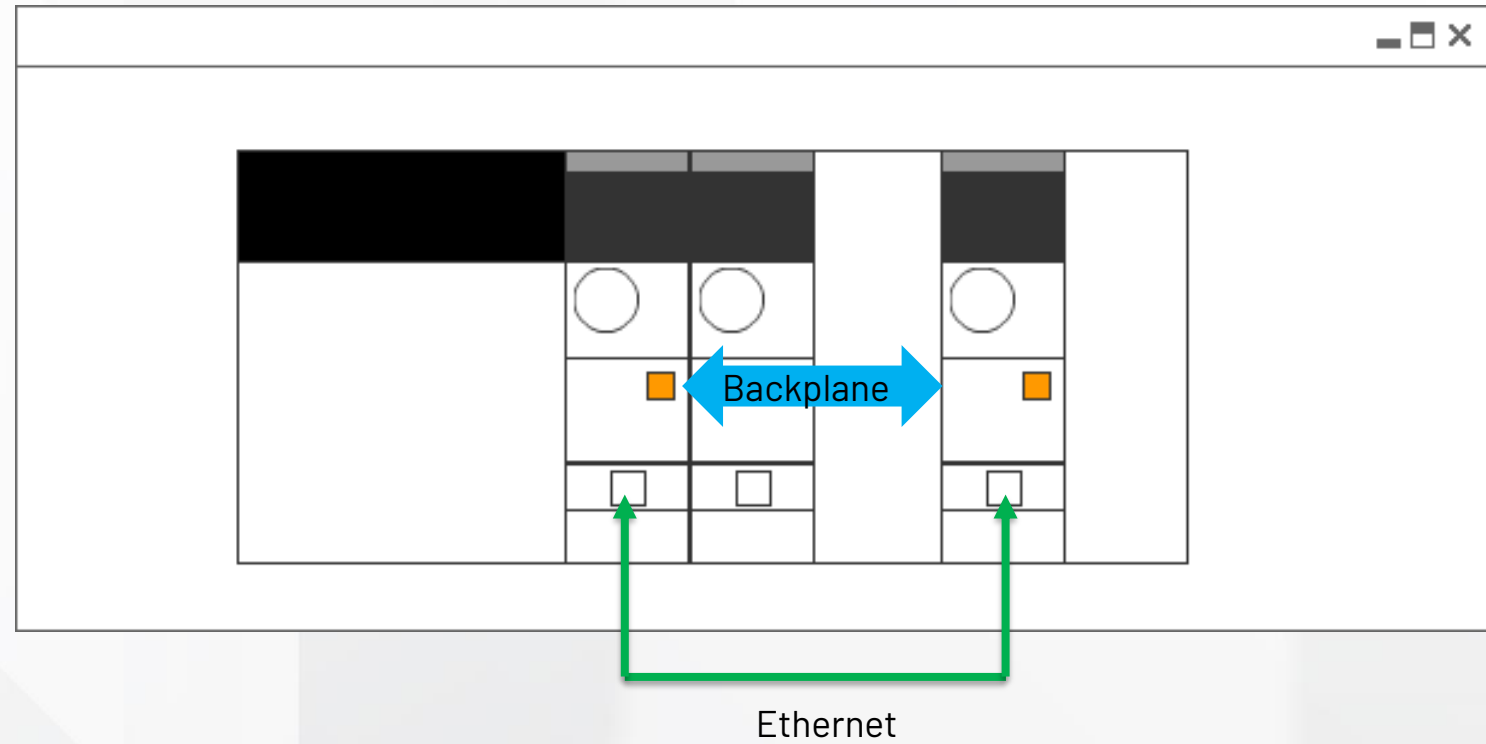


Ethernet

## Emulator-2-Emulator Communications

Class 1 (Produce/Consume) or Class 3 (Messages) communication between emulator instances can be established across:

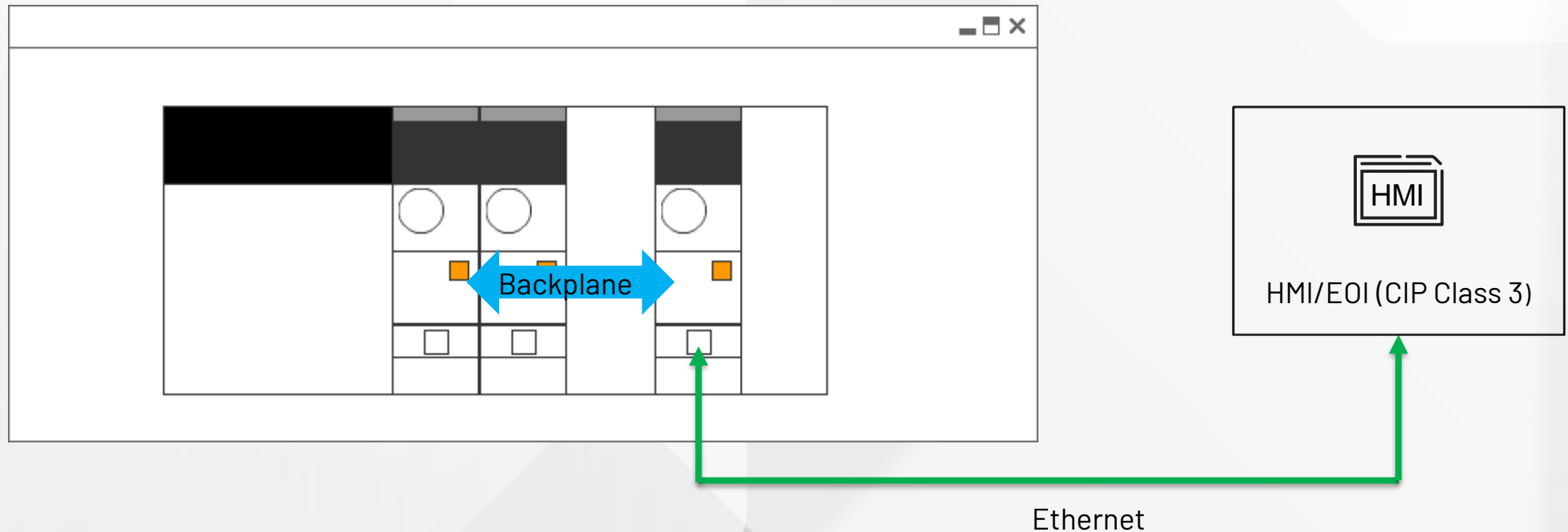
- the emulated backplane
- Ethernet using the EtherNet/IP protocol.



## Emulator-2-HMI/Other CIP-based software

Class 3 (Messages) communication between emulator instance and HMI/other CIP-based software:

- Over EtherNet/IP
- Bridged over backplane to EtherNet/IP

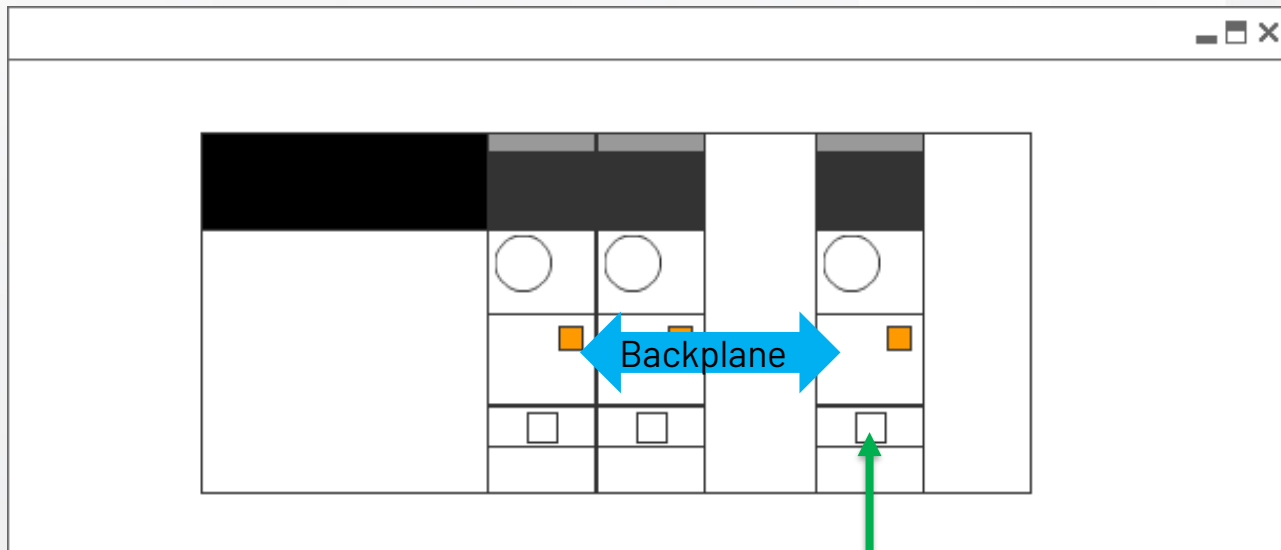


## Remote connections to Emulators

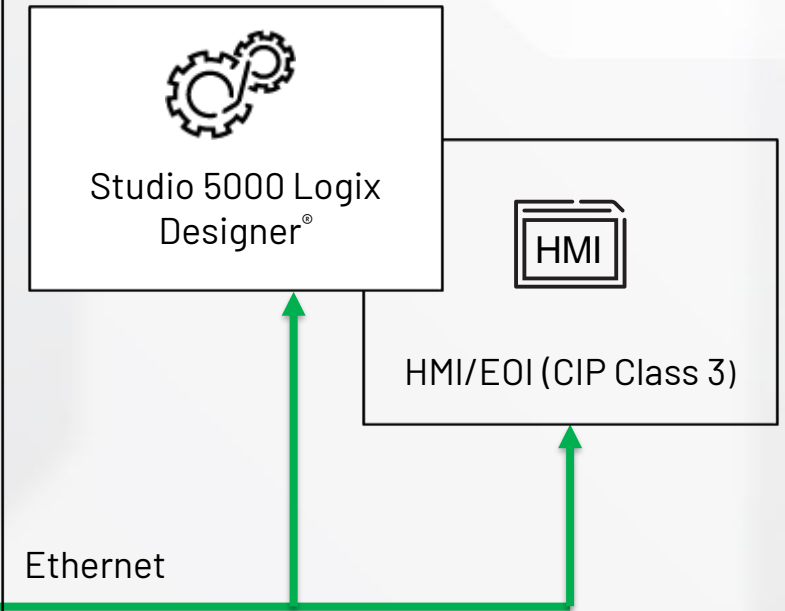
Remote instances of Studio 5000® Logix Emulate™ and HMI software can communicate with the emulator instances over Ethernet.

- When Studio 5000 Logix Designer® is not installed on the same OS as FactoryTalk® Logix Echo certain workflows are disabled that depend on Logix Designer application services (that is Creating an emulator from ACD, program Download through FactoryTalk® Logix Echo dashboard or API)

Workstation or Virtual Machine #1



Workstation or Virtual Machine #2



## IP address Considerations

- Only one controller needs an IP address assigned (the rest of the controllers can be bridged to through the Ethernet connected controller, over the backplane)
- The dashboard will only present IP addresses that are configured on the workstation including the loopback address, reserved in Windows for testing, 127.0.0.1.
- After assigning 127.0.0.1 to an emulator, you can reassign the IP address to any loopback address (127.x.x.x) on the general properties pane of the controller.
- Alternatively, if you have administrative privileges, additional IP addresses can be assigned to your network adapters to support additional controllers on Ethernet.

## Important

- Studio 5000 Logix Designer® will not allow you to use loopback addresses for the controller in the I/O tree, helping help prevent you from using loopback addresses for Produce/Consume messages between emulators over Ethernet.



## Maximum Achievable Specifications

- Class 1 Produced/Consumed messages between emulators: 20,000 pps
- Class 1 chassis total: 160,000 pps
- Class 3: 700 messages/second
- Class 3 chassis total: 3,700 messages/second
- Minimum RPI: 15ms

## Important

- As the software runs as a normal user program, it can and will be interrupted by other Windows services and processes adversely impacting performance
- Despite 99.9% of messages getting successfully transmitted/received, CIP connections will occasionally time out due to interrupts from other Windows services

## Performance – Installation Hardware Requirements

### CPU – 2.2 GHz Intel Core i3 or faster processor:

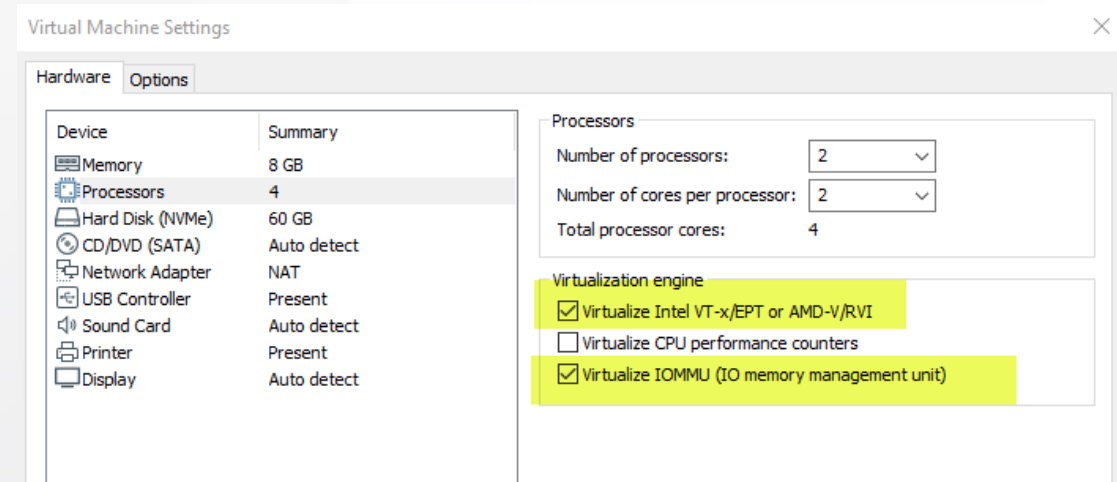
- At least one logical core for the OS
- At least two logical cores for the core FactoryTalk® Logix Echo application
- At least one logical core per emulated controller instance
- Additional logical cores dependent on additional software installed on workstation

### Memory – at least 8GB:

- 2GB for the base FactoryTalk® Logix Echo application
- 256MB per emulated controller instance (4.52GB for full 17 controller emulated chassis)
- Additional memory for OS and other software applications

### Virtual Machine Consideration

- Use Intel Virtualization Technology



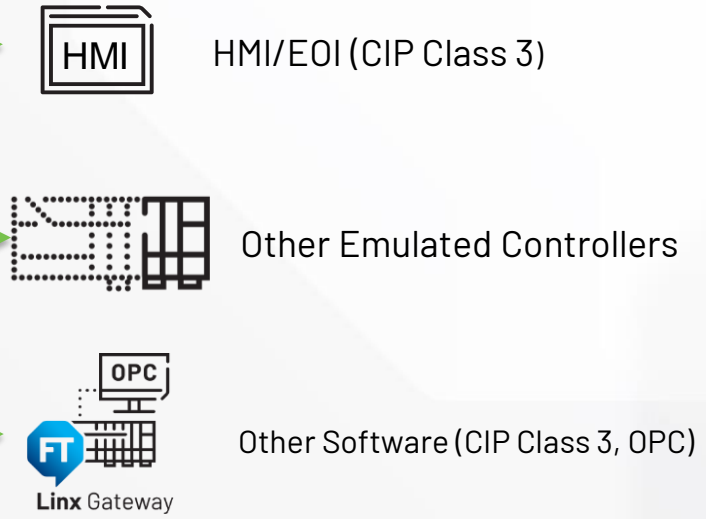
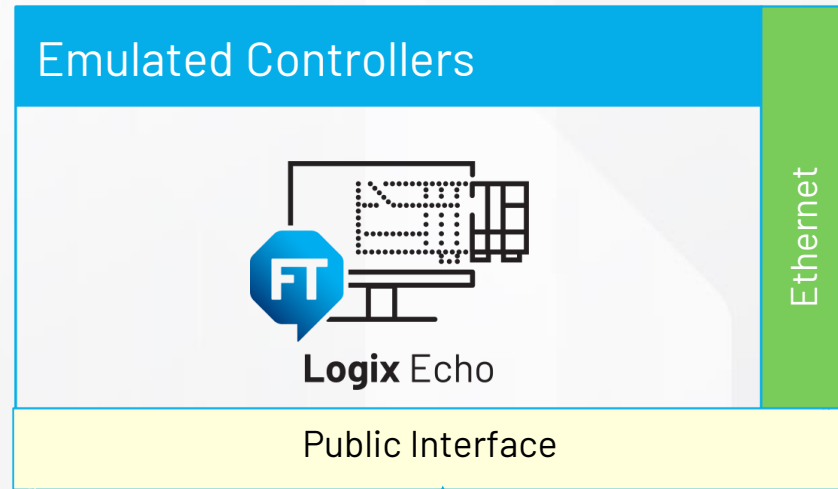


## Note on Building the Project

- Studio 5000 Logix Designer® will build for the physical controller by default

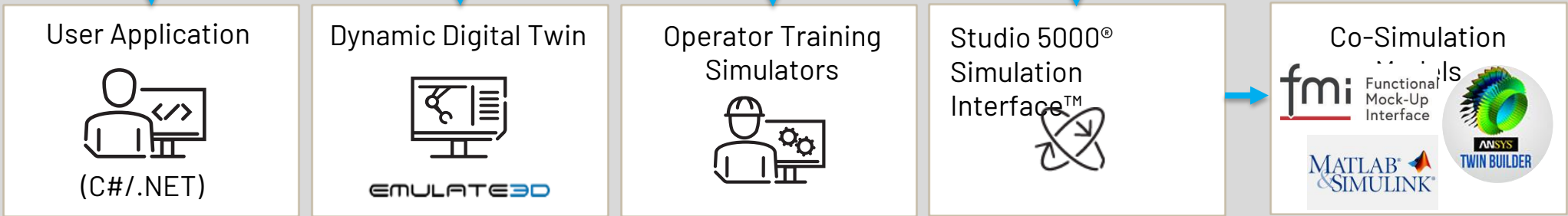
## First Download

- If you build before connecting to the emulator, the build process will be repeated when connecting to the emulated controller for the first time
- Subsequent downloads are typically 2x faster than on physical controllers



**External Simulations:**

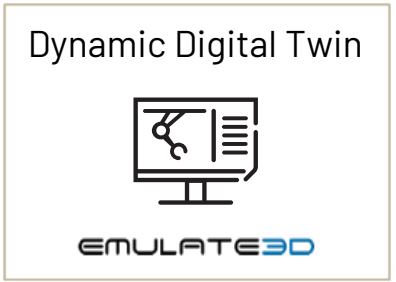
- Device
- Machine
- Process
- Plant





# Emulate3D™ Integration

Introduction: A note about Free-Running vs. Co-Simulation Modes



## Free-Running mode:

- By default the virtual timing model of the emulated controller tracks real-time (windows system time) as closely as possible (to within a few milliseconds), we refer to this as 'Free-Running mode'.
- In the event there are not enough computing resources to track the system time, the model will begin skipping Continuous Task scans (and will set a fault once too many scan skips are necessary to keep up)

## FMI for Co-Simulation

- Through the API, the emulator can be switched into Co-Simulation mode using the FMI for Co-Simulation Interface. This is an open standard interface for coupling simulation models in a co-simulation environment. The data exchange between models (for example the controller model and the plant/machine model in Emulate3D™) is restricted to discrete communication points. In the time between, the models are solved independently from each other. A time master application (in our case Emulate3D™) controls the data exchange between the models and the time synchronization.



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# Functional Mockup Interface for Co-Simulation

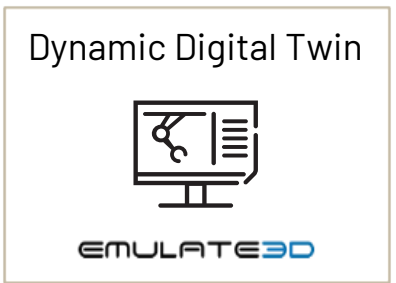
Available in Emulate3D™ 2020 minor release at launch of FactoryTalk® Logix Echo

## Integration using Co-Simulation and Data Exchange API

- Enables E3D model and controller model to be synchronized
- Supports time-scaling (Change between Free-running mode and Co-Simulation mode)
- Modifying Continuous Task Fidelity (skip task scans)

## Integration over Class 1 or Class 3

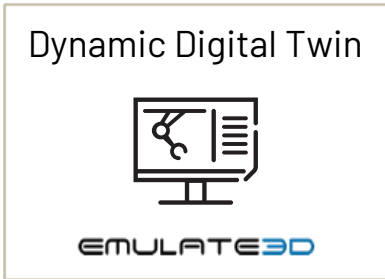
- E3D can communicate over EtherNet/IP just like physical controllers



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# Emulate3D™ Integration

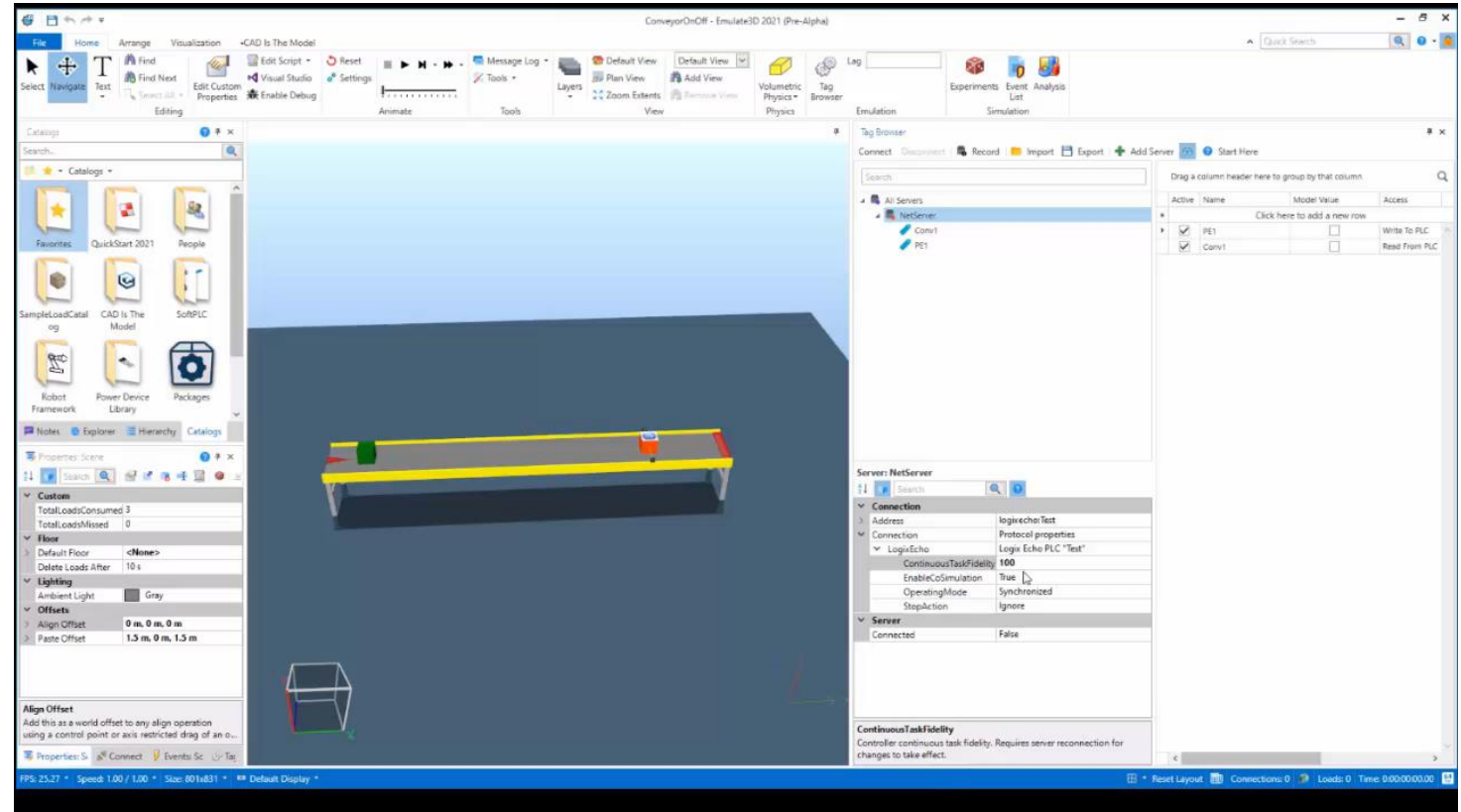
Available in Emulate3D™ 2020 minor release at launch of FactoryTalk® Logix Echo



V1.0

## Example 1:

- E3D runs as fast as possible with Controller in **Co-Simulation** mode
- Emulate3D™ reports the controller can be scaled to ~3x



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# Emulate3D™ Integration

Available in Emulate3D™ 2020 minor release at launch of FactoryTalk® Logix Echo

Dynamic Digital Twin

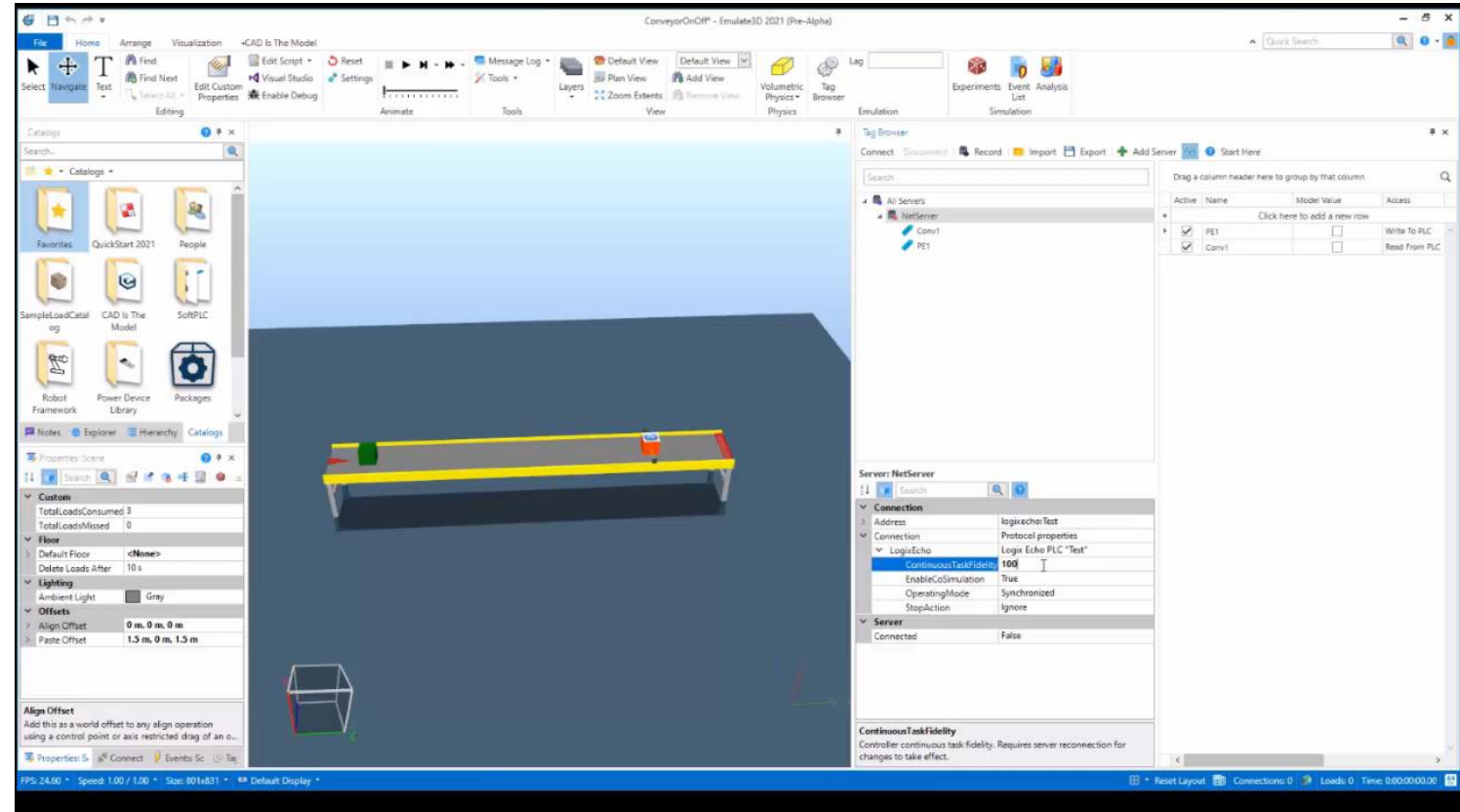


EMULATE3D

V1.0

## Example 2:

- Emulate3D™ runs as fast as possible with Controller in **Co-Simulation** mode
- User reduces the **Continuous Task Fidelity to 10%**
- Emulate3D™ reports the controller can be scaled to ~11x-12x



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# Operator Training Simulators

High-Speed Data Exchange and Co-Simulation Interface for Integration with OTS



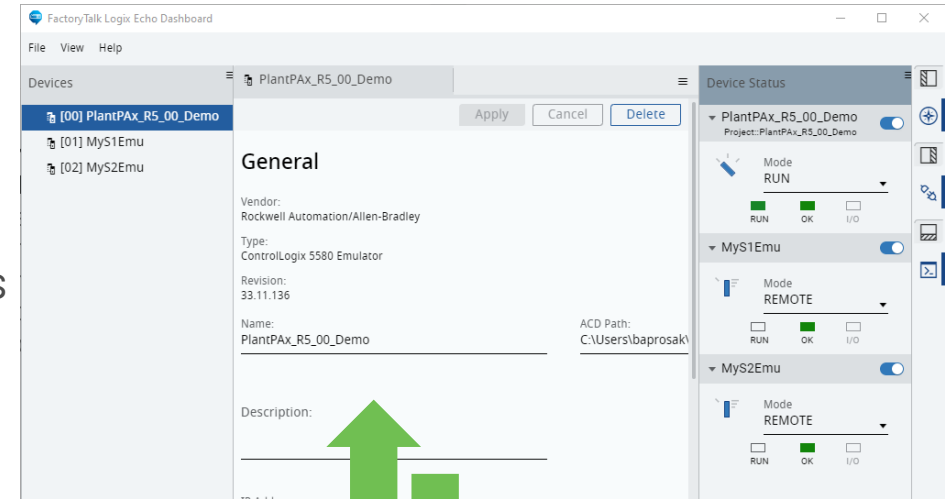
## Overview

- Use your own or third-party party simulation tools to interact with emulated controllers to create and simulate the plant responses

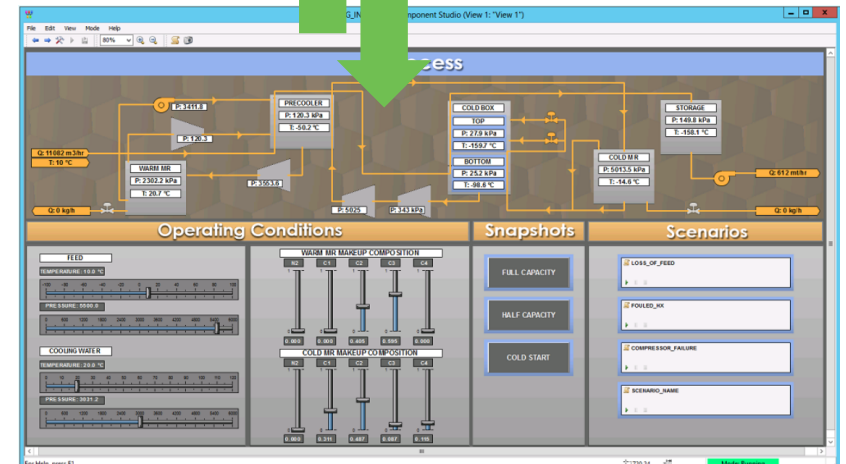
## Benefits

- Provides dynamic, real-time responses like the actual plant
- Train operators in specific scenarios in a safe, fully functioning virtual system using the actual displays from operations
- Develop and test new control strategies or plant optimizations in a lab environment

Emulated controllers



Operator Training Simulator







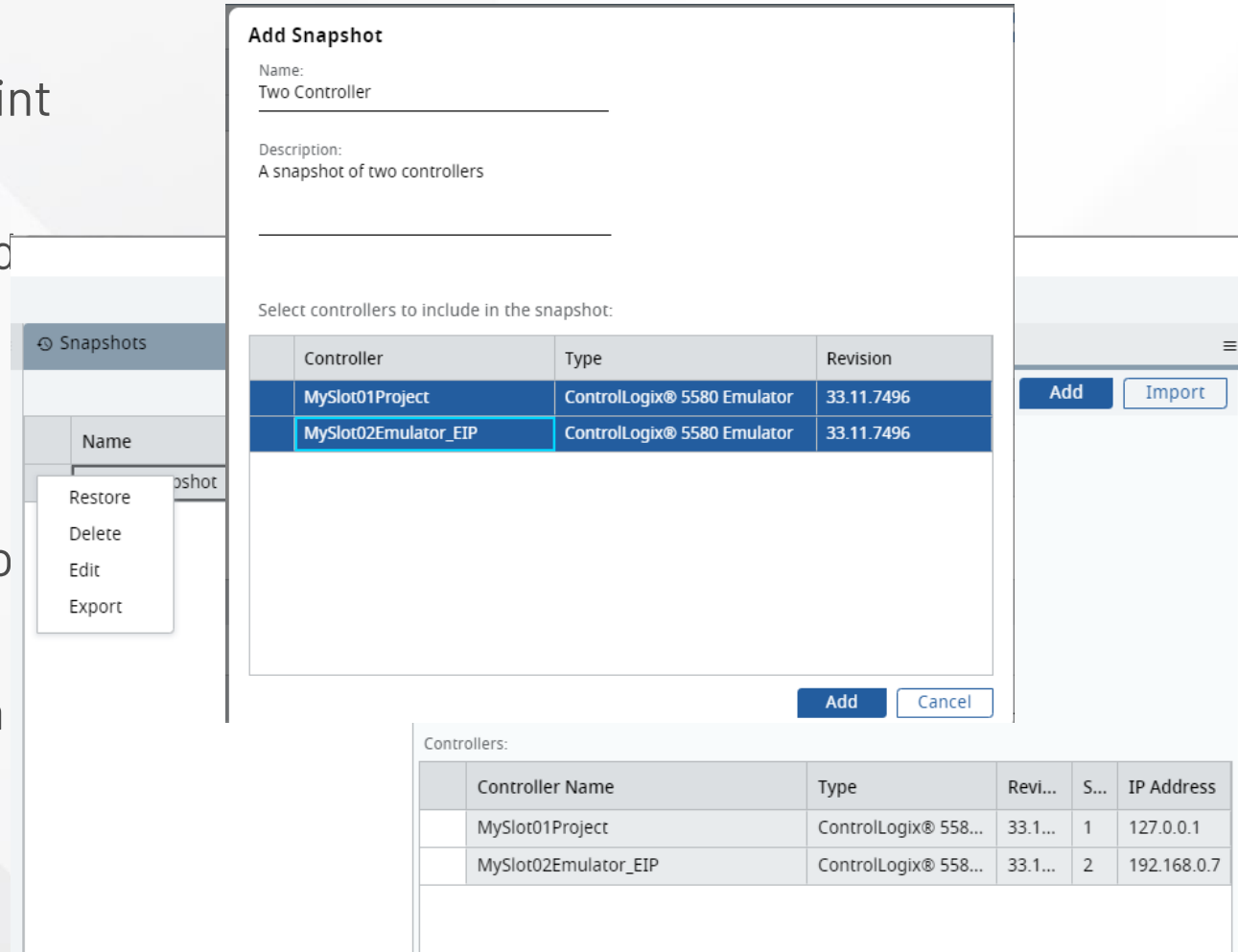
## Snapshot Concept

Save one or more controller's state at a specific point in time that can latter be restored

- Includes controller time, application tag data and execution context

## Use Cases

- Operator Training Simulators: Restore training scenarios that are difficult or time-consuming to recreate
- Automated Testing: Continuously recall a known scenario for testing



**Add Snapshot**

Name:  
Two Controller

Description:  
A snapshot of two controllers

Select controllers to include in the snapshot:

Controller	Type	Revision
MySlot01Project	ControlLogix® 5580 Emulator	33.11.7496
MySlot02Emulator_EIP	ControlLogix® 5580 Emulator	33.11.7496

Buttons: Add, Cancel

Context Menu (over Snapshots table):

- Restore
- Delete
- Edit
- Export

Controllers:

Controller Name	Type	Revi...	S...	IP Address
MySlot01Project	ControlLogix® 558...	33.1...	1	127.0.0.1
MySlot02Emulator_EIP	ControlLogix® 558...	33.1...	2	192.168.0.7

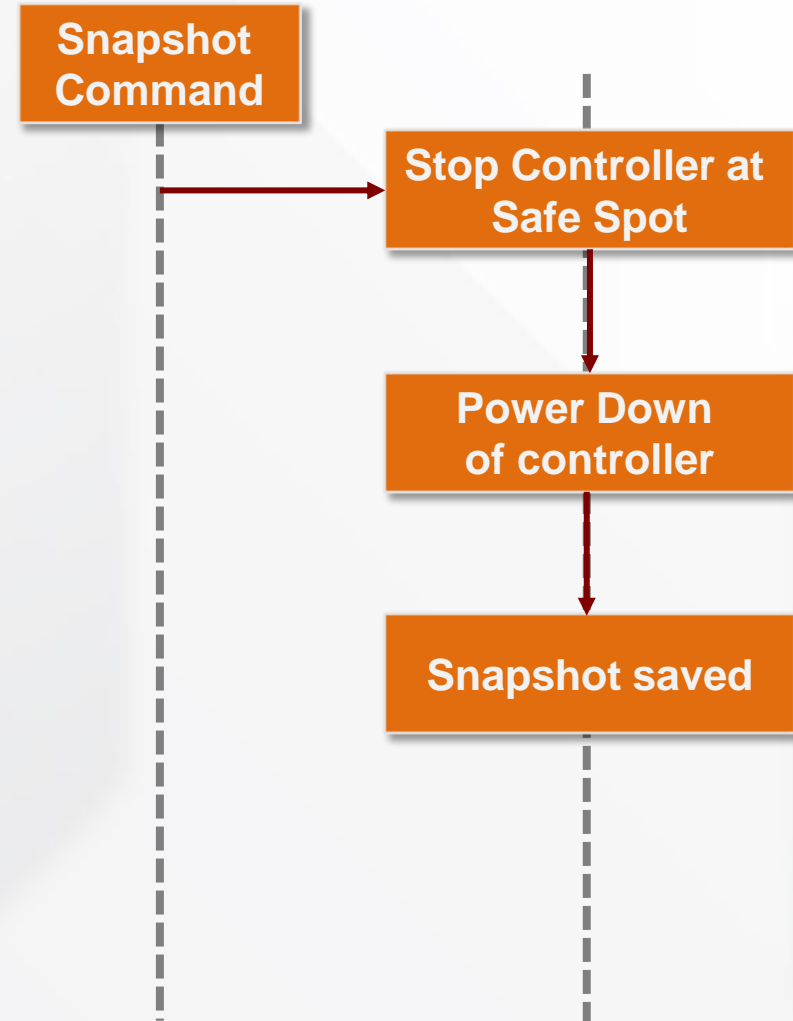
## Saving a Snapshot

A “Power Cycle Persistence Snapshot”: We take an entire capture of the controller (static and dynamic data, like what happens during a power down of a physical controller)

## Sequence of Events

- Snapshot Command: To help prevent data integrity issues that the controller is paused at the end of task scanning (beginning or end of continuous task (or idle if no continuous task))
- The controller powers down to save dynamic and static data
- Power up of the controller (first scan and pre-scan skipped)

The full state is captured as a snapshot

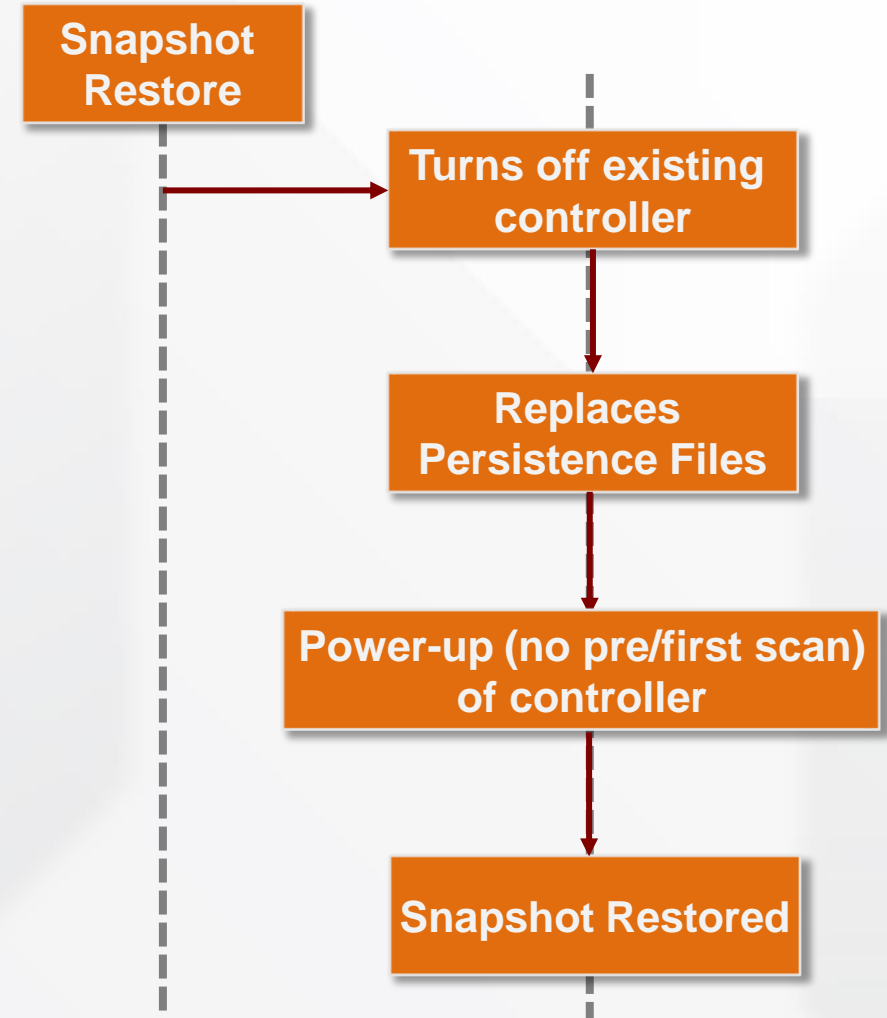


## Restoring a Snapshot

Replaces over existing controllers

### Sequence of Events

- Snapshot Restore: Turns off existing controllers. Controllers must be present in target slots of the snapshot restore. Inconsistencies presented to the user.
- The persistence files are replaced with the files from the snapshot
- On power-up the controller restores and resumes user execution, skipping first scan or pre-scan operations
- While the IP address from the snapshot will be applied to the controller, it will not bind to the IP address unless that IP is present on the workstation



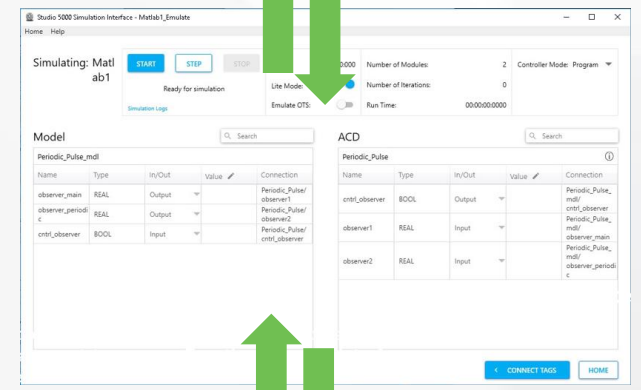
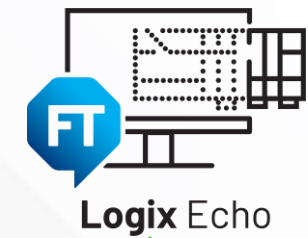
Integration with Studio 5000® Simulation Interface™

## Connect

Leverage Studio 5000® Simulation Interface™ to map tags in your emulated controller to variables in your mathematical model for precise simulation scenarios

## Supported Interfaces

- Functional Mockup Interface: Open standard for model data exchange. Import FMI 2.0 co-simulation compliant models in Studio 5000® Simulation Interface™
- MATLAB with Simulink. Exchange data with Simulink models.
- New: Import and reduced order model digital twins



Studio 5000®  
Simulation  
Interface™



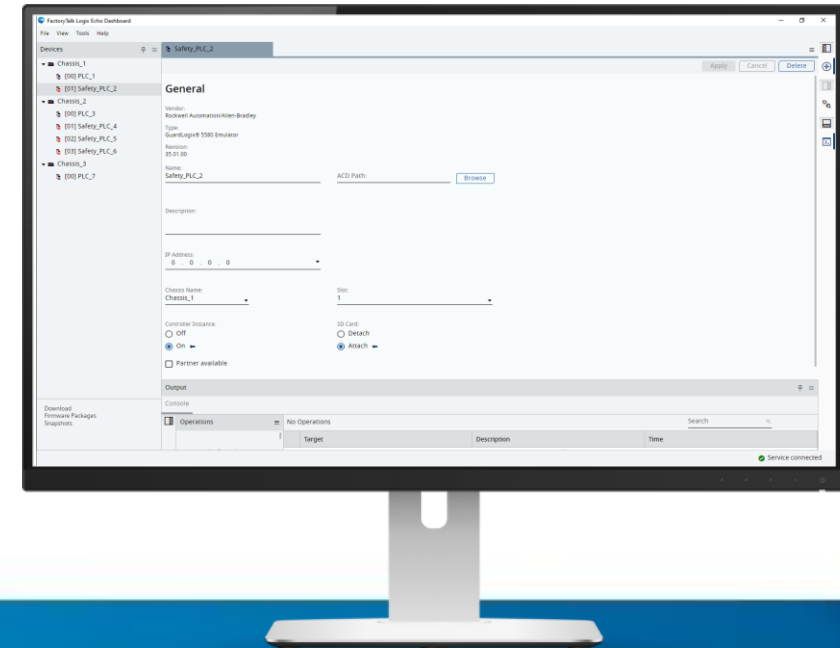


**Logix Echo**  
V2



# Logix Echo

V2



## Emulate GuardLogix® 5580 Controllers

- Fully test your standard and safety control code in an isolated, virtual environment
- Execute controller project configured as SIL2/PId and SIL3/PLe as designed without modifications

## Architecture & interfacing enhancements

- Multiple chasses instances in one node
- Produce/Consume and MSGs between emulated controllers in another chassis
- Echo API enhancements

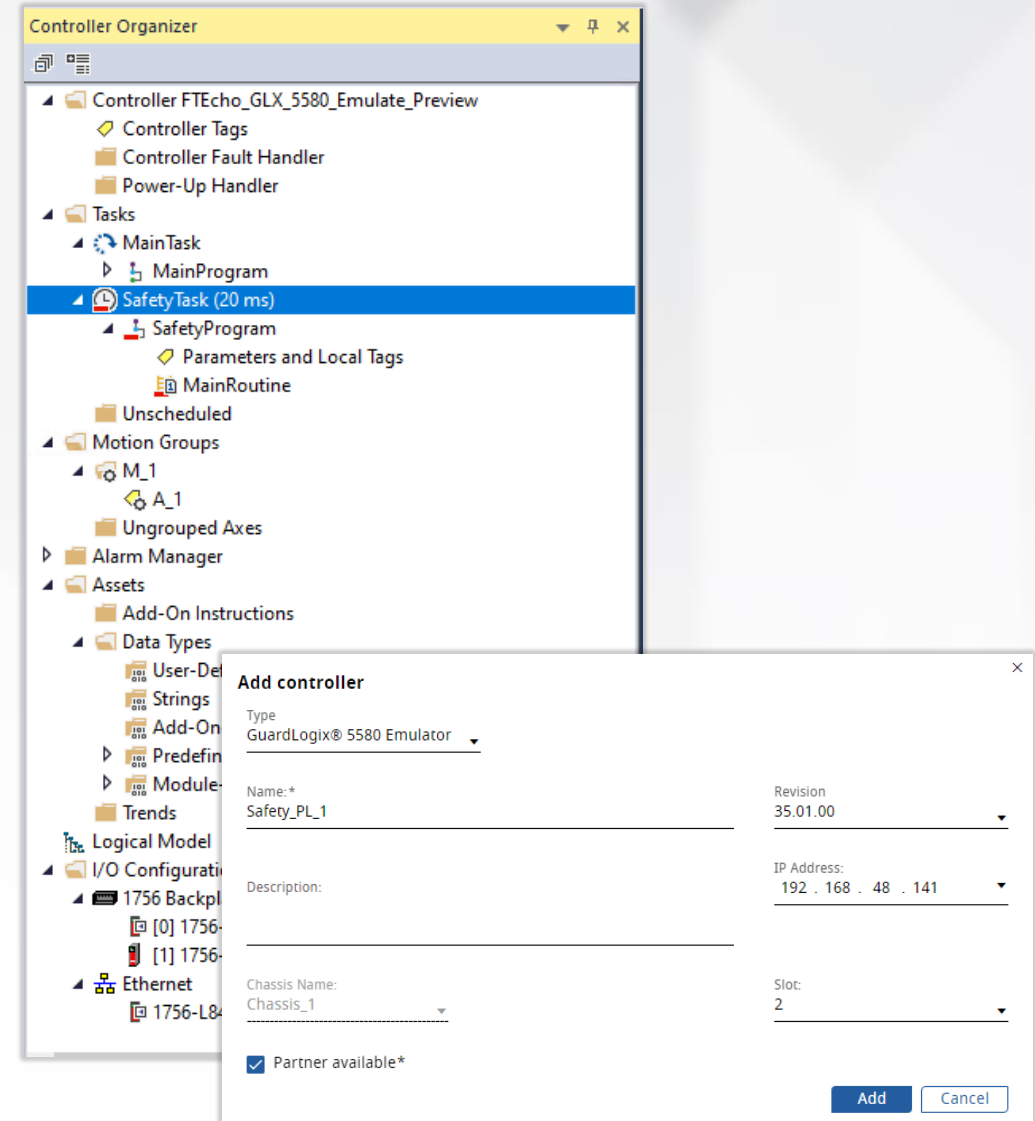
## Axis Test Mode

- 5580 ControlLogix® & GuardLogix® Standard task motion logic and CIP Motion drive connection emulation
- Low Fidelity CIP Motion axis/drive simulation model for tlwec, PowerFlex® CIP Motion drives and 5730 iTRAK®

Emulated GuardLogix® 5580

## GuardLogix® 5580 Controller Emulation

- Fully test your safety control code in a safe, virtual environment
- Execute controller project as designed without modifications. The I/O tree will be maintained, all languages, instructions and task types supported
- All functionalities introduced in FactoryTalk® Logix Echo V1 apply to GuardLogix® Emulator
  - Virtual SD Card
  - Emulator 2 Emulator Ethernet and Backplane communication (Class 0/1 & 3)
  - Snapshot - controller state save
  - Service and Controller API



Emulated GuardLogix® 5580

## GuardLogix® 5580 Safety Controllers

All -ES -ESK controllers and safety partners



**Logix Echo**

Firmware version 35 or later

### Catalogs

1756-L81ES	1756-L82ES	1756-L83ES	1756-L84ES	1756-L8SP
1756-L81ESK	1756-L82ESK	1756-L83ESK	1756-L84ESK	1756-L8SPK

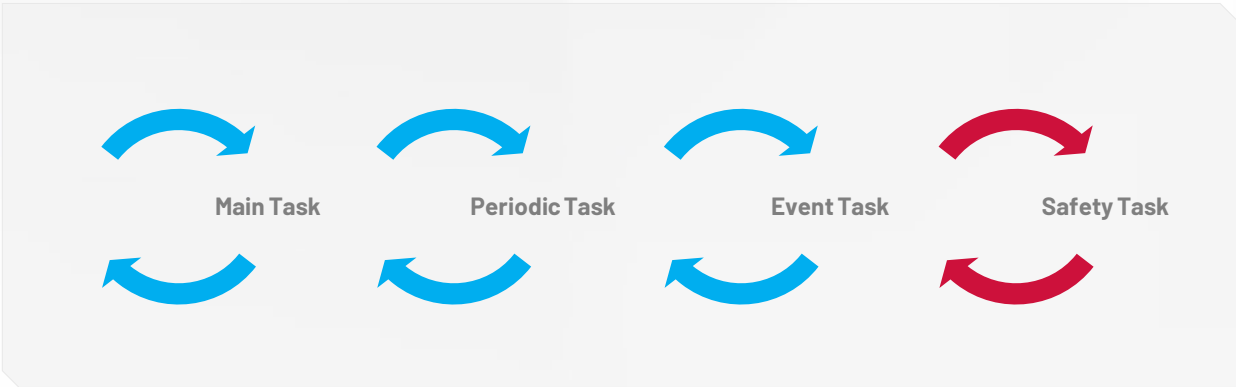
**Future Releases:** CompactLogix™ 5380 and Compact GuardLogix® 5380 Controllers



Emulated GuardLogix® 5580

## Safety task

- Emulation of both **standard** and **safety tasks**
- Safety instructions set execution within the safety task
- Safety Add-On instructions support



The screenshot shows the 'Controller Organizer' window with the 'SafetyTask (20 ms)' selected. The 'Task Properties - SafetyTask' dialog box is open, showing the following configuration:

- General tab selected
- Type: Periodic
- Period: 20 ms
- Priority: 10 (Lower number yields higher priority)
- Watchdog: 20,000 ms

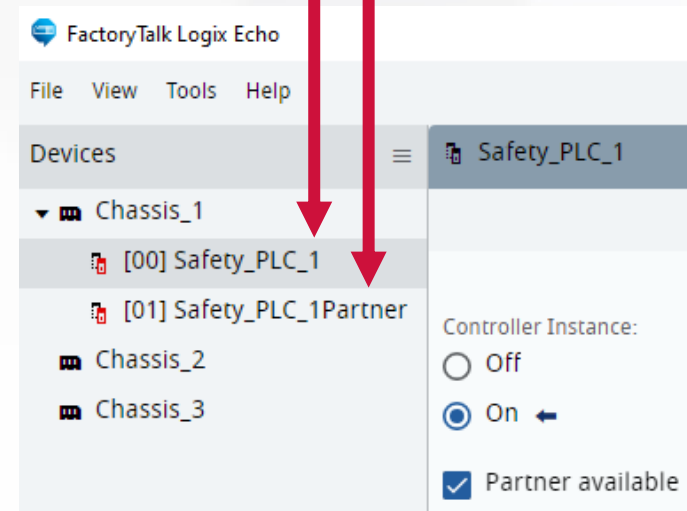
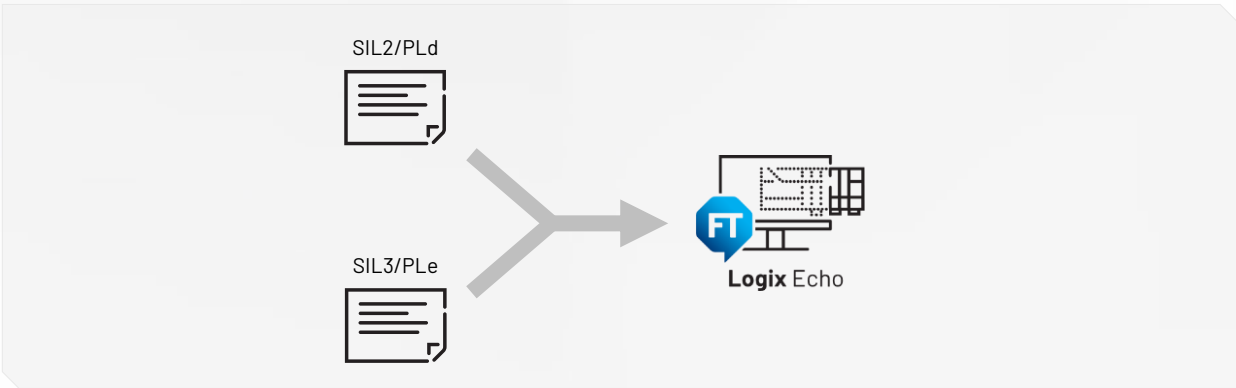
The 'Controller Organizer' tree structure includes:

- Controller FTEcho\_GLX\_5580\_Emulate\_Preview
  - Controller Tags
  - Controller Fault Handler
  - Power-Up Handler
  - Tasks
    - MainTask
      - MainProgram
    - SafetyTask (20 ms)
      - SafetyProgram
        - Parameters and Local Tags
        - MainRoutine
      - Unscheduled
  - Motion Groups
    - M\_1
      - A\_1
    - Ungrouped Axes
  - Alarm Manager
  - Assets
    - Add-On Instructions
    - Data Types
      - User-Defined
      - Strings
      - Add-On-Defined
      - Predefined
      - Module-Defined
      - Trends
    - Logical Model
    - I/O Configuration
      - 1756 Backplane, 1756-A
        - [0] 1756-L84ES FTEc
        - [1] 1756-L8SP FTEch
      - Ethernet
        - 1756-L84ES FTEcho

Emulated GuardLogix® 5580

## Safety levels support

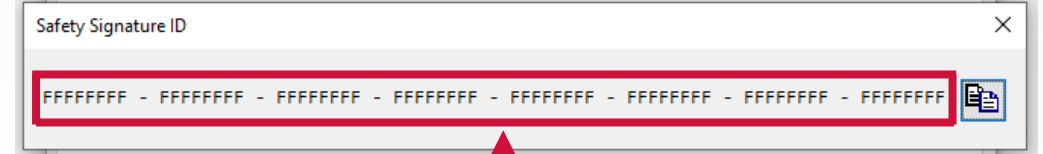
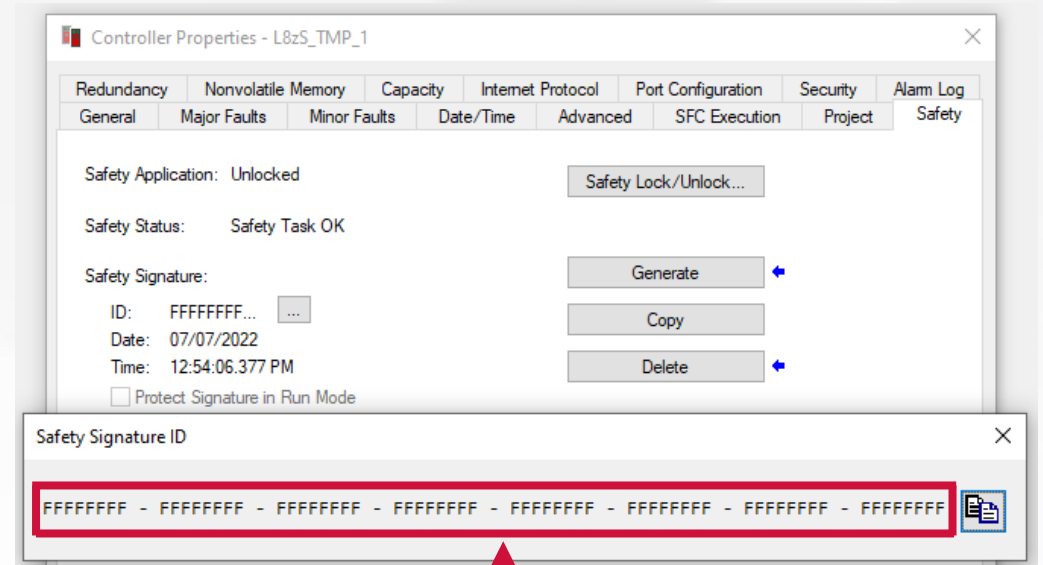
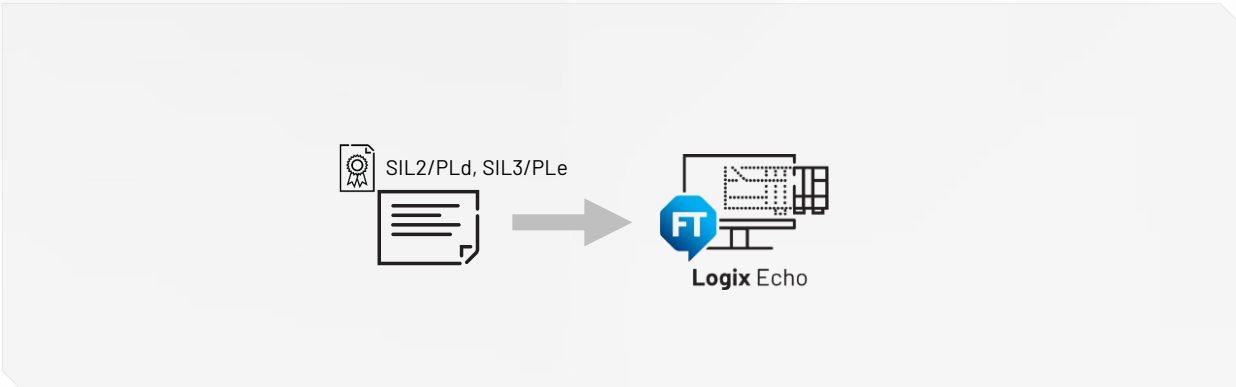
- Both **SIL2/PLd** and **SIL3/PLe** safety levels are supported
- Safety Partner mimicking in Echo Dashboard and API
  - Chassis slot reservation
  - Partner available configuration parameter
- No parallel emulation of Safety Partner module



Emulated GuardLogix® 5580

## Safety signature

- Project with a safety signature can be downloaded without any modification (signature remains unchanged)
- Generation of imitated signature for training purposes (valid only for Echo controller)

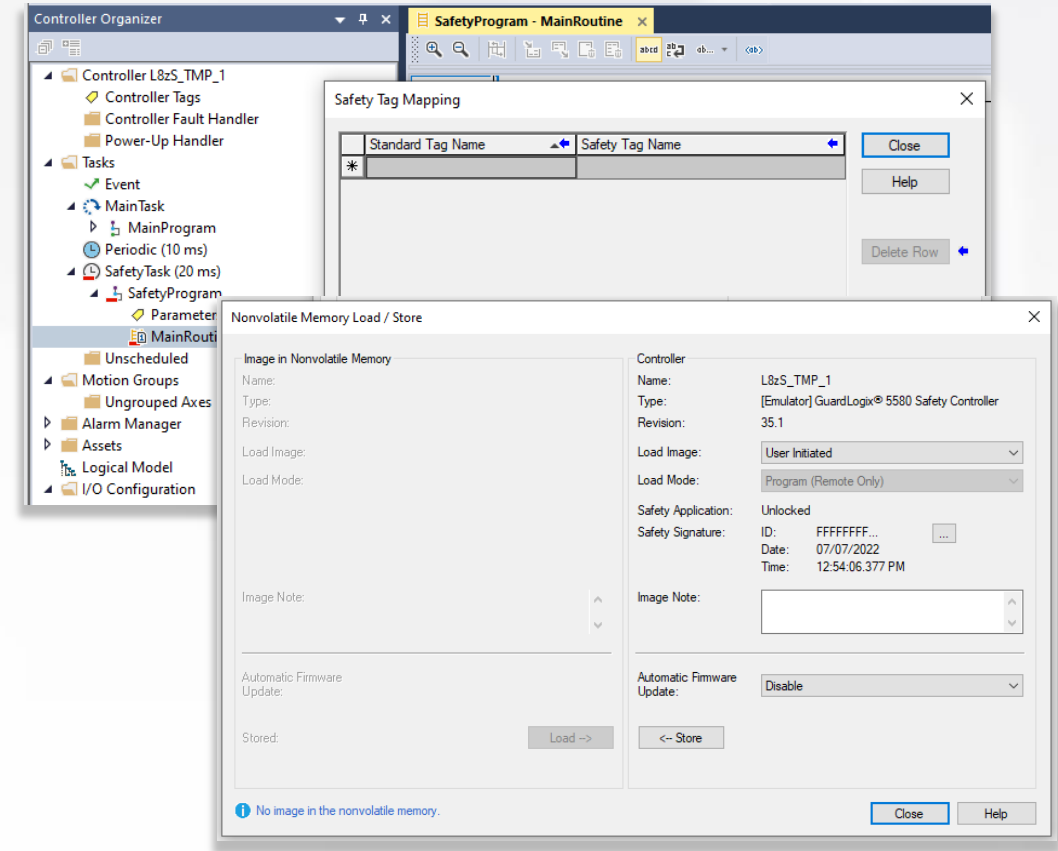


IMITATED  
SAFETY SIGNATURE

Emulated GuardLogix® 5580

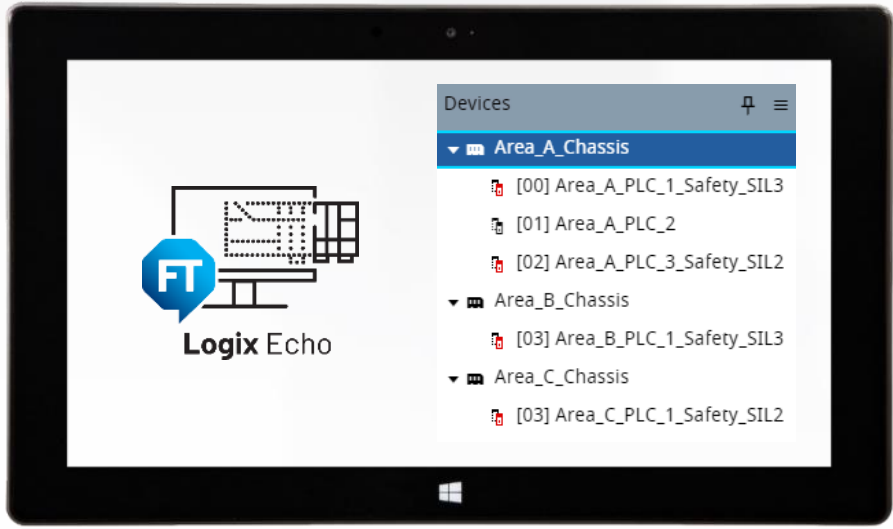
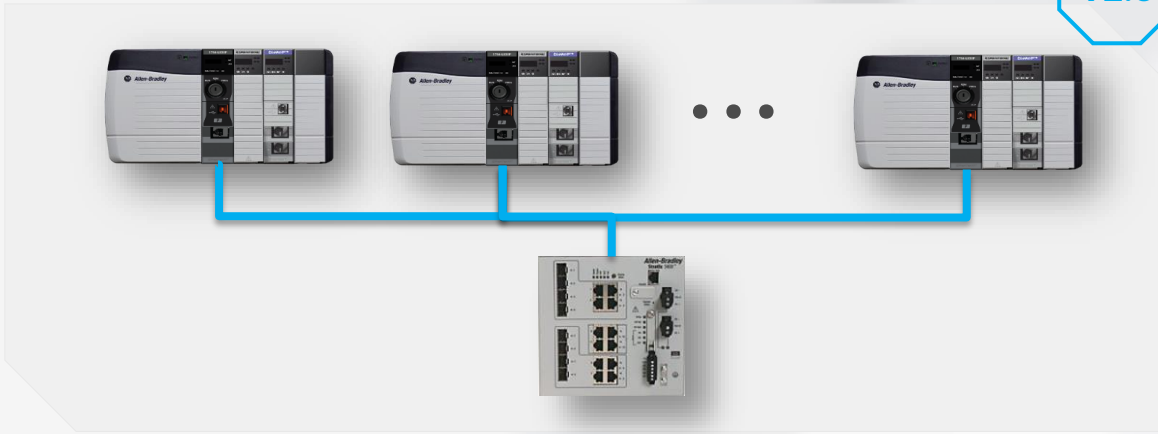
## Other safety feature supported

- Tags mapping between safety and standard tasks
- Project Online Editing
- Safety Produce/Consume communication between emulated GuardLogix® controller instances
- Safety Virtual SD Card handling
- Safety Lock/Unlock



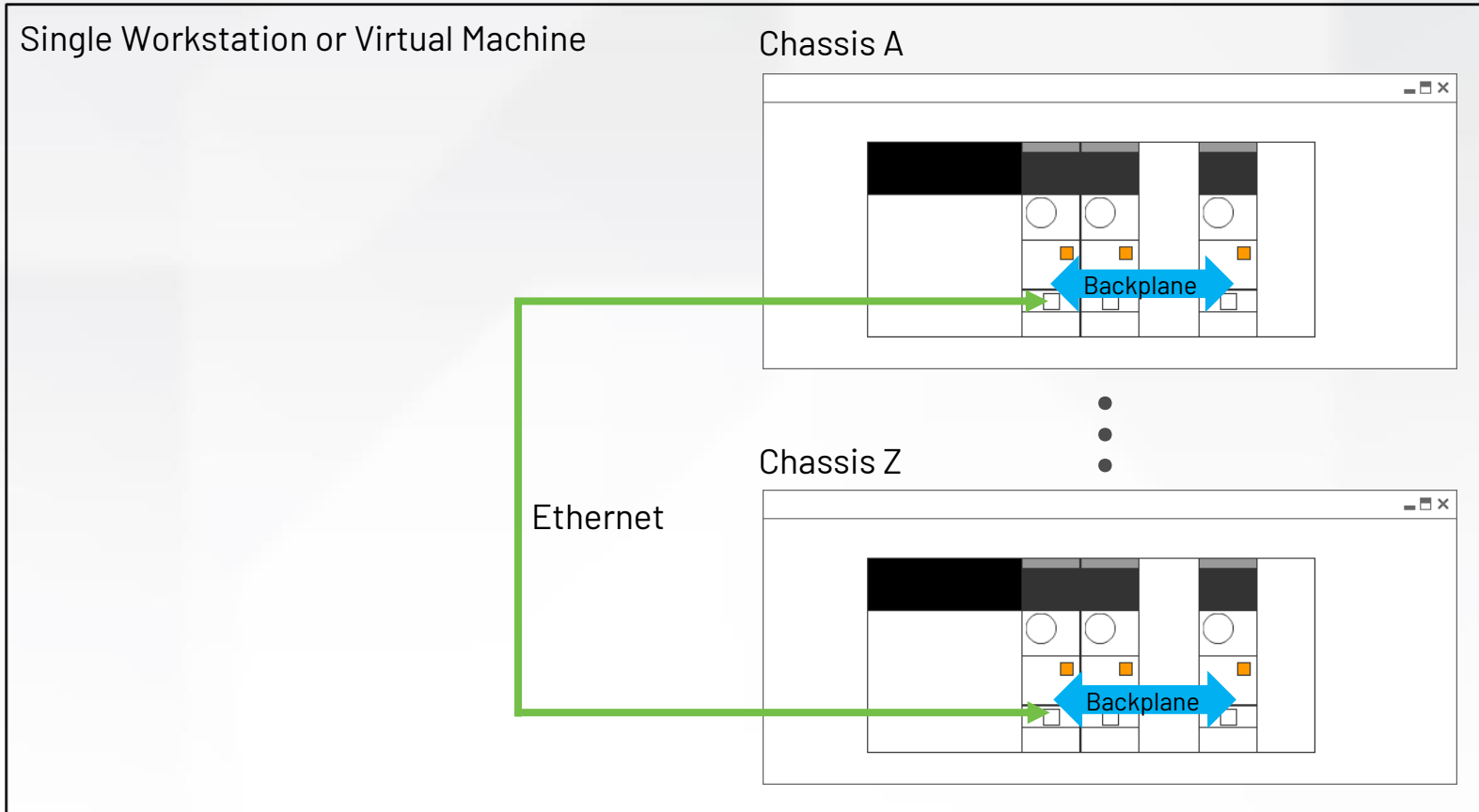
### Multi-Chassis in a Single Node (PC/VM)

- Create Multiple chassis within one FactoryTalk® Logix Echo installation
- Emulate more complex distributed control systems
- Exceed the limit of 17 emulated controller instances
- Manage the emulated control system architecture via Echo Dashboard and Service API
- Create, restore and manage the complex control systems snapshots



## Cross-Chassis controller connectivity scenario

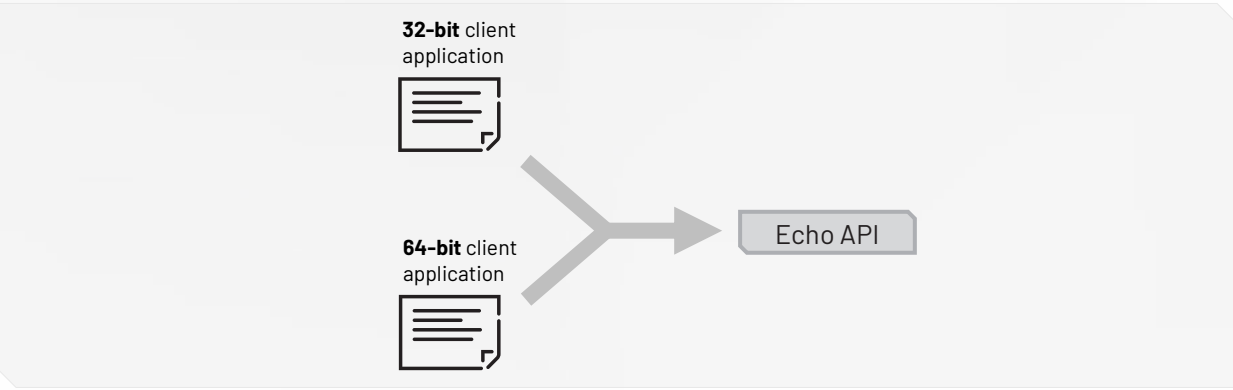
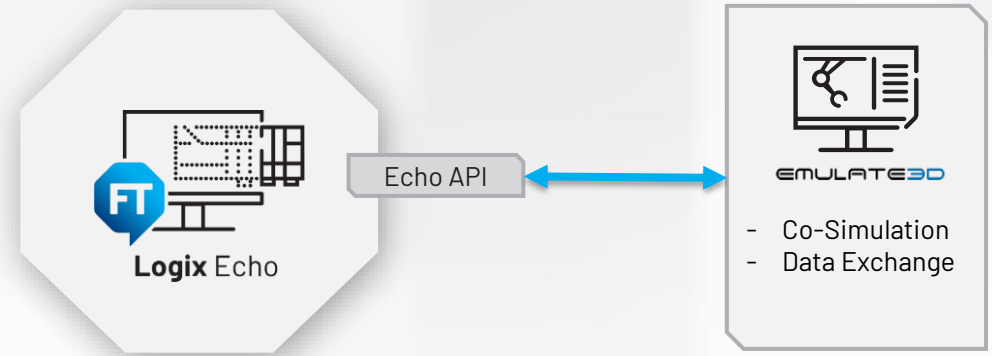
Class 1 (Produce/Consume) or Class 3 (Messages) communication between emulator instances in multiple, different chassis within the single Node



## Echo API enhancements

### 64-bit applications support

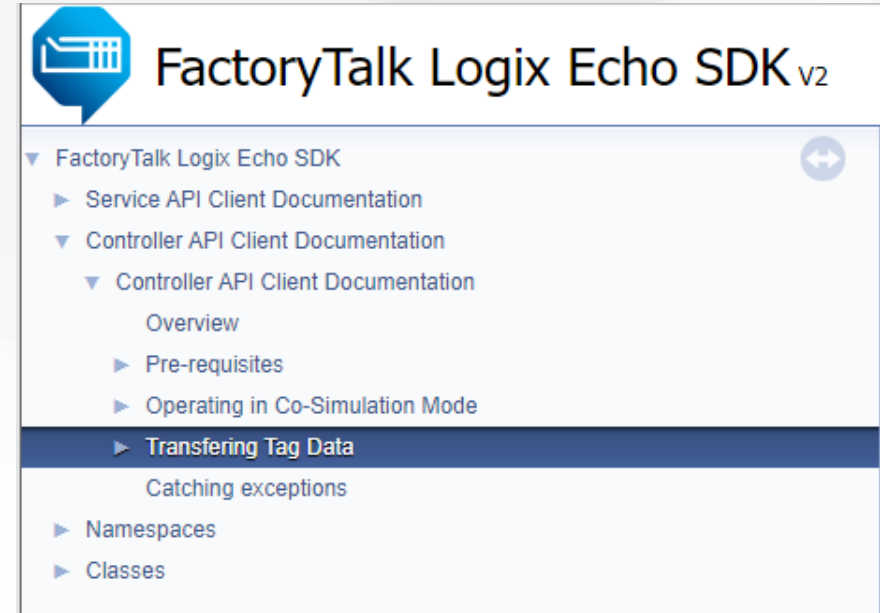
- The Client Library is modified to support the „Any CPU“ platform – both 32-bit and 64-bit applications
- Significant improvement for simulation packages users



Echo API enhancements

## Client Library update

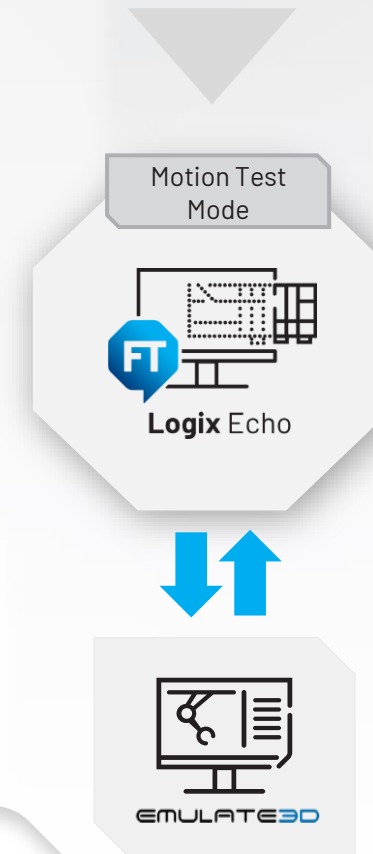
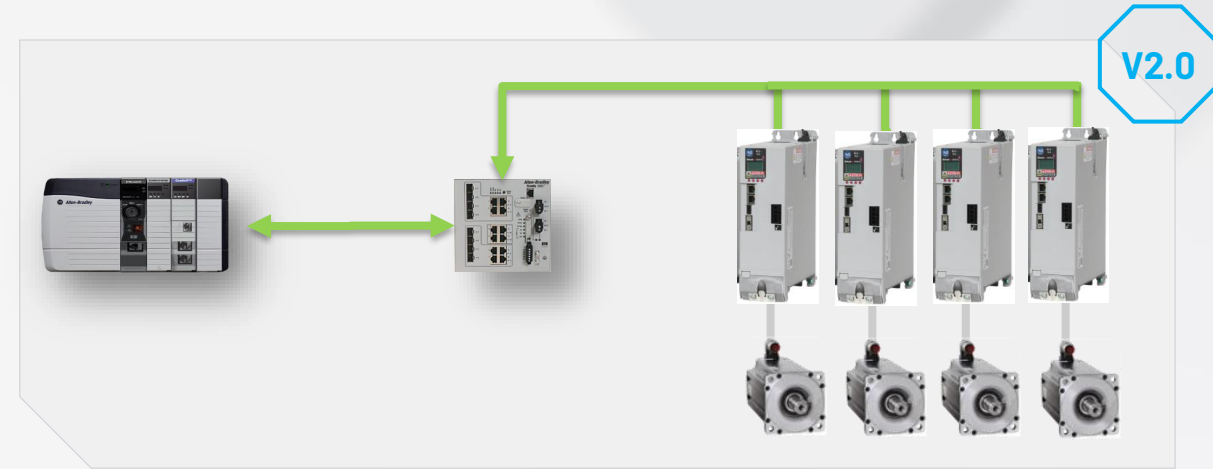
- New Client Library function for returning all user application tags (controller and program scope tags)
- Individual bits access for integer tags (SINT, SINT, INT,...)





### CIP Motion Axis simulation

- Build the digital twin of your assets by integrating an emulated control system with a model
- Validate and commission your motion application without connection to hardware
- Cross-controller platform feature, available for physical and emulated controllers (ControlLogix® and GuardLogix® 5580)
  - *Standard task motion logic, CIP Motion drive connection*
- Low Fidelity CIP Motion axis/drive simulation model
  - *Kinetix® & PowerFlex® CIP Motion drives, 5730 iTRAK®*
- *For the emulated controller, the Motion Test Mode is enabled by default*



The emulator is a virtual controller, used in the development, testing and simulation environments

### With an emulator, **you can:**

- Download and run logic written in any Logix language
- Be online with Logix Designer application, and all that entails
- Connect from an HMI [except for HMI Button Control (HMIBC)]
- Produce/Consume tags with other emulators
- Use MESSAGE instructions
- Use virtual axes or/and Motion Test Mode to validate and commission your motion applications without connection to hardware
- Download a project configured for redundancy, although it will always behave as a "Primary with no Partner" (simplex mode)

### With an emulator, **you cannot:**

- Connect to physical I/O devices
- Connect motion axes to real drives
- Produce/consume tags with other physical controllers
- Use licensed-based source protection (precompile & encrypt)
- Emulate a true redundancy primary/secondary pair (duplex mode)



## Differences between emulated controllers and physical controllers

Functionality	Emulated Controller Behavior
Communication to physical devices	The emulated controller is restricted from establishing connections to physical devices. However, the API can be used to simulate input and output values
License-based source protection	Not supported, must be removed before downloading the project
SD card encryption	Content on virtual SD card is not encrypted or digitally signed
Automatic Diagnostics	Only controller instance diagnostics are collected. No I/O device diagnostics supported.
Email	Email functionality is not supported
USB port	Not supported
Serial Number matching	Ignores serial number matching



Differences between emulated controllers and physical controllers – Con't.

Functionality	Emulated Controller Behavior
Module discovery	Not supported.
Motion support	Motion support is limited to low fidelity CIP axes simulation (Motion Test Mode) and virtual axes and consumed axes. Produce-consume virtual axes supported.
Connections between controllers	Produce/Consume messages work between emulated controllers. Other I/O modules in the I/O Tree will show as faulted.
Time-scaling	Supported through the API.
SNMP	Not supported
Redundancy	Operates only as a primary controller. High availability reports success, but the sync. with a second controller/support of sync modules is not available. Scan time does not reflect redundancy impacts.
Controller webpages	Not supported



Differences between emulated controllers and physical controllers – Con't.

Functionality	Emulated Controller Behavior
Fault dumps	Fault dumps are always stored in the virtual SD card directory, even if detached in emulated controller properties. Important: contents are not encrypted
HMIBC instructions	HMI Button Control (HMIBC) instructions do not function (no Class 1 connection to HMI)
GSV and SSV instructions	Supports Get System Value (GSV) and Set System Value (SSV) instructions for emulated controller instances only. When GSV and SSV instructions target external objects, the instructions return the result for an unconnected device.





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