

## INTRODUCTION TO EMULATE3D – EMULATION, SIMULATION, AND DEMONSTRATION

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### ABSTRACT

The Emulate3D product range is designed to fulfil the requirements of industrial engineers working with a wide range of partly or fully automated projects including warehousing, distribution, production and baggage handling. Emulate3D products are used for many purposes by different departments at various times throughout the project lifecycle, and an efficient workflow is made possible by employing the same core model throughout. Increasing time and resource constraints imposed upon project managers mean that the broad brush academic approach offered by classic simulation products is no longer appropriate within industry, and that the tools of tomorrow will be more task-specific, and quicker to put into useful operation. Emulate3D products are matched to the skill sets of their target users, and aim to reduce the learning curve and increase first-look familiarity.

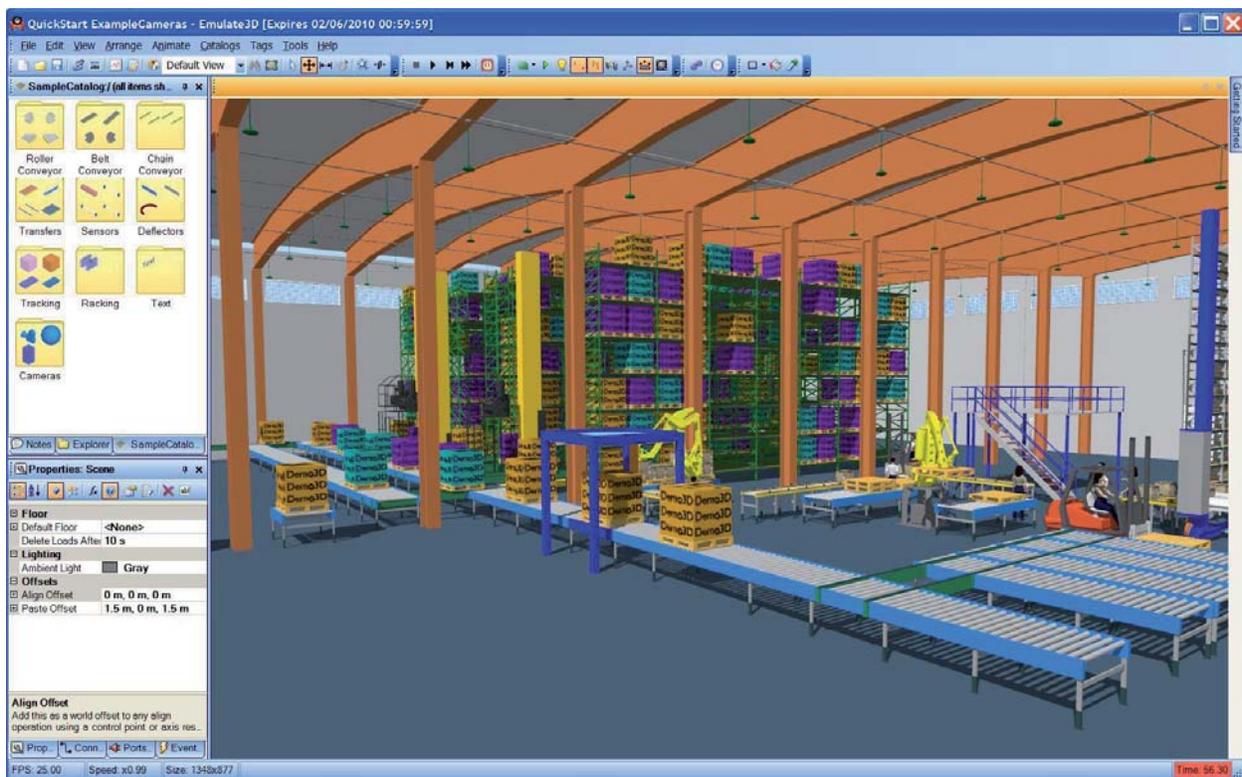


Figure 1: The Demo3D user interface.

## 1 INTRODUCTION

With ever-increasing global competition, companies of all kinds are under pressure to raise their game, whether they are in manufacturing, warehousing, logistics, or airport baggage handling. Part of this is the ability to produce high quality digital simulations of various types in a reduced timeframe, and at an acceptable cost. In consequence there is a growing demand for the virtual representation of proposed systems, as these can greatly enhance the viewer's ability to understand the complexities and operation of the systems before they exist. Today's technology allows models to become the focal point for all stakeholders; the models become the credible digital representations of the shared goal.

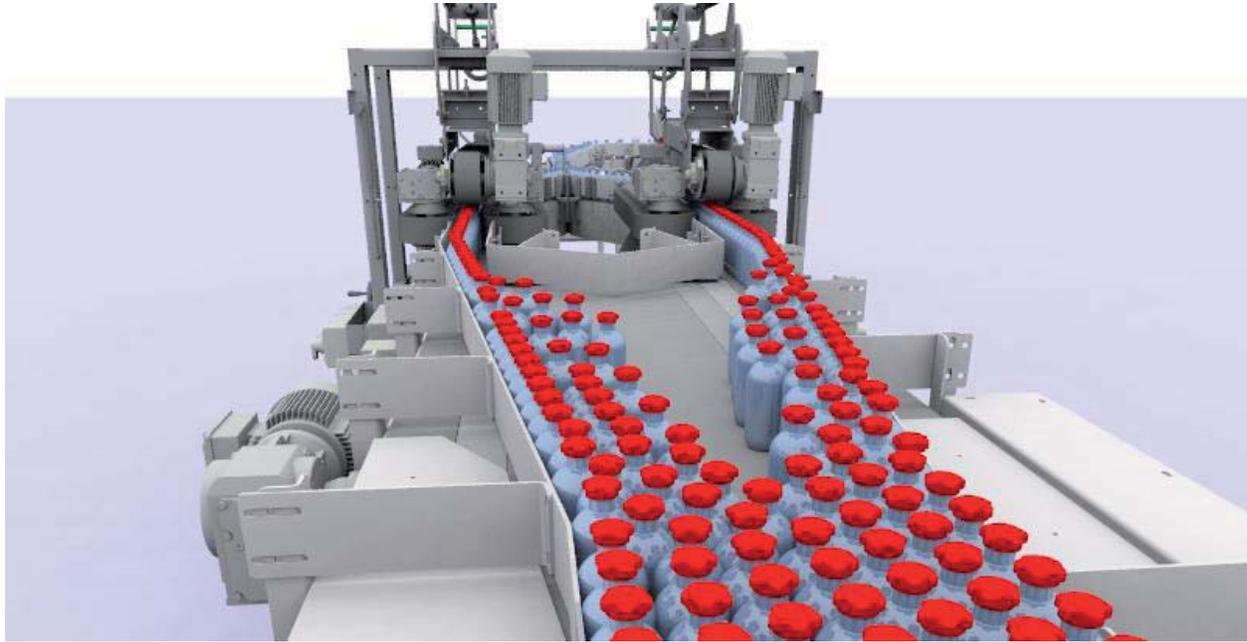


Figure 2: Emulate3D's unique environment allows bottling lines to be accurately modeled.

## 2 OVERVIEW OF EMULATE3D

All development projects pass through the broadly recognized stages of an initial research among many possibilities, then a distillation down to a few reasonable ones, and then the selection of a preferred solution, and finally its implementation. Passing from one stage to the next in this process requires different levels of model detail, and the Emulate3D range reflects these.

Emulate3D products are conceived to help with presenting initial solutions, simulating product throughput and system operation, and carrying out detailed controls testing.

- Demo3D – developing and presenting initial solutions
- Sim3D – throughput analysis, system operation and improvement
- Emulate3D – controls testing and virtual commissioning

Different versions of the products in each of these ranges reflect the various user types and their feature requirements, and this allows different versions to be offered at various price points.

## 2.1 Emulate3D Approach

Simulation modeling consists of an initial model build phase, followed by verification and validation, to ensure that the model is not only accurate, but also fit for purpose. The resulting model may then be used for several applications, including demonstration, simulation analysis, and controls testing.

Clearly the main value of the model is extracted in the latter phase; the build and test phases represent costs. The use of tried and tested catalog items to build models presents users with two important methods to reduce these costs; firstly, the model build time is significantly reduced, and secondly, the amount of testing required is also minimized as the correct operation of the higher-level component parts is already known.

## 2.2 QuickStart – The Importance of Re-usable Catalogs

Emulate3D products are designed to allow users to progress past the model building phase as rapidly as possible, confident that their models are accurate and robust. At the core of Emulate3D technology is the notion of re-use, and so models are based on catalogs, or libraries of elements. The central catalog is based on a framework called QuickStart, and bears the same name.

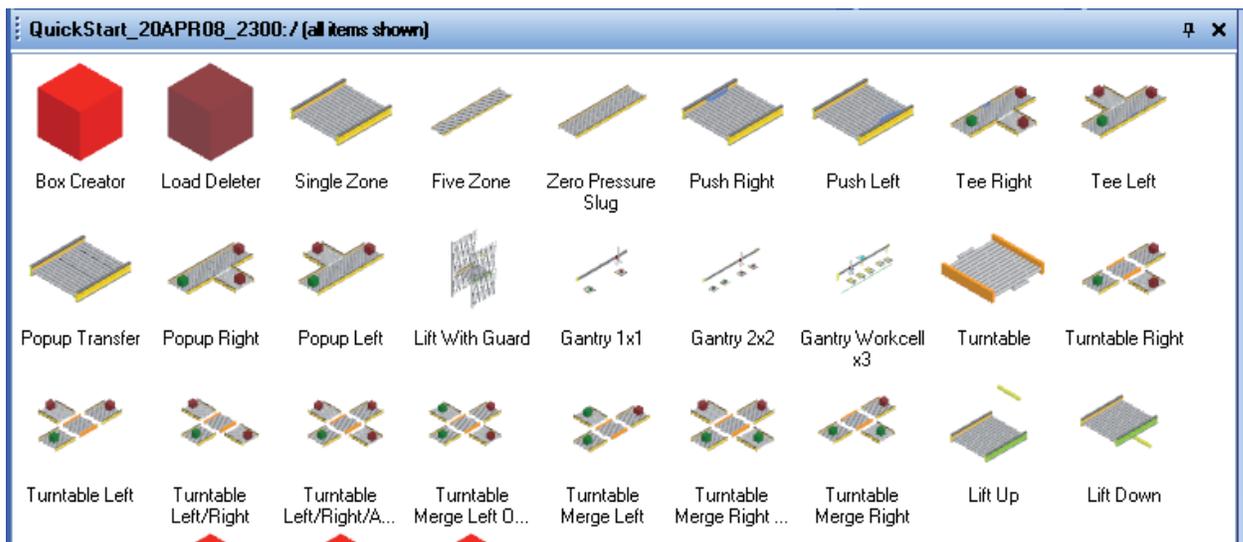


Figure 3: A glimpse of the QuickStart catalog.

Catalog elements can be anything users need them to be, but the elements supplied with the products are based on material handling equipment, and include:

- Conveyors (carton, pallet, baggage, roller, belt, chain, injector, merge, divert, lifts, luffers, specialist, etc)
- Path systems (fork lift trucks, operators, automatic guided vehicles, shuttles, RGVs, automobiles, etc)
- AS/RS (racks, cranes, single/multiple product carriages, deep storage shuttle/slaves, miniload, etc)
- Sorters (drop tray, cross-belt, sliding shoe, chain lift, roller lift, turntable, pusher, etc)
- Robots (general purpose, palletizing, scara, gantry, delta, etc)
- Buildings (mezzanine, stairs, handrails, step overs, walls, etc)
- General equipment (pallet stacker/destacker, pallet wrapper, profile checker, slip sheet dispenser, etc)

- Controllers (vehicle manager, palletizer, depalletizer, TargetSelector, BasicProcess, Games Controller, Keyboard Controller, etc)
- Data Collection (Throughput, TimeInSystem, Counter, TimeInState, StateTracker, etc)
- Cameras (Camera points, cameras)
- Control Panels (test, panel, push button, text panel, switch before merge, etc)
- ...

Collections of static elements are also provided with the products, some of which are from third party 3D content providers such as Baumgarten™, FF-Digital™, Max-Realms™, and Cinema4D™. Users can also tap into the wealth of free 3D objects to be found in the Google Warehouse™.

### 2.3 QuickStart Framework

The QuickStart framework allows catalog objects to be snapped together intelligently to create viable systems consisting of elements which recognize each other and react accordingly. For example; fork lift trucks can be connected to pallet conveyor which feeds into a shuttle system and then on to an AS/RS. Pallets from the AS/RS can be output to depalletizing robots which send loads to accumulation lanes from where they are built into orders by palletizing robots. Each of these pieces of equipment behaves, by default, just as you would expect it to, facilitating the rapid model build necessary to justify the broad use of a 3D modeling tool for sales presentations.

In order to match the model behavior to the client's requirements, each catalog element has a range of user-accessible properties which can be changed to modify its dimensions, appearance, and operation. More important than this, however, is the fact that all QuickStart elements are open, so trained users can fundamentally modify their behavior, or even create their own unique catalog items or material handling equipment systems.

### 2.4 QuickStart Build Approach

#### 2.4.1 Layout

Catalog elements are dragged into the build environment and will snap together, if it is appropriate for them to do so. Users often import a 2D DXF file of the layout to use as a basic template, and then QuickStart catalog elements are stretched and altered to fit the template. Parameters such as speeds or heights may be altered on single or multiple objects at a time, and where necessary, users can connect shuttles or fork lift trucks to input and output conveyor sections by dragging visual connectors.

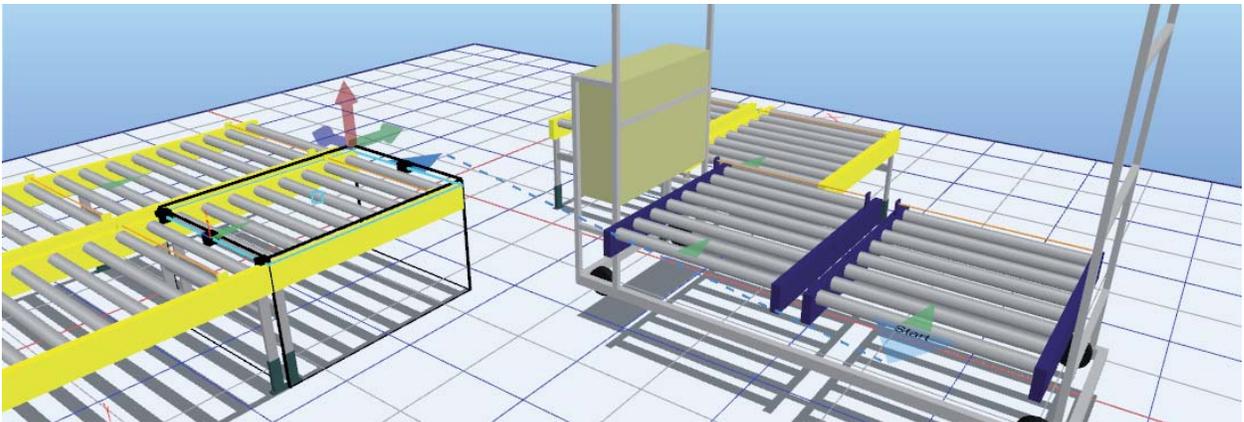


Figure 4: Visual Connections highlight the logical flow.

## 2.4.2 Logic

In many cases the default operation of the various pieces of QuickStart equipment is all that is needed; in the cases where it is not, two options are available to the user. The first is to use the supplied Control Blocks, created as a means of extending the QuickStart framework functionality in a user-friendly way, without resorting to scripting. Control Blocks are connected to the relevant pieces of QuickStart equipment using Visual Connectors, making it easy for the user to see where they have modified the default behavior, and greatly accelerating the model debugging process.

An example of a Control Block is a Target Selector, which can be used to separate a type of product from the others. Users can add filters into the Target Selector, so products of a certain type are sent one way, while all others go a different way. The Target may be many merges and diverts (or even systems) away from the initial “ListeningTo” conveyor section, but the underlying QuickStart takes care of the equipment-level decisions and allows the user to focus on defining product flows.

The second option available to trained users is to open the QuickStart object and edit the operational script to create the exact behavior required.

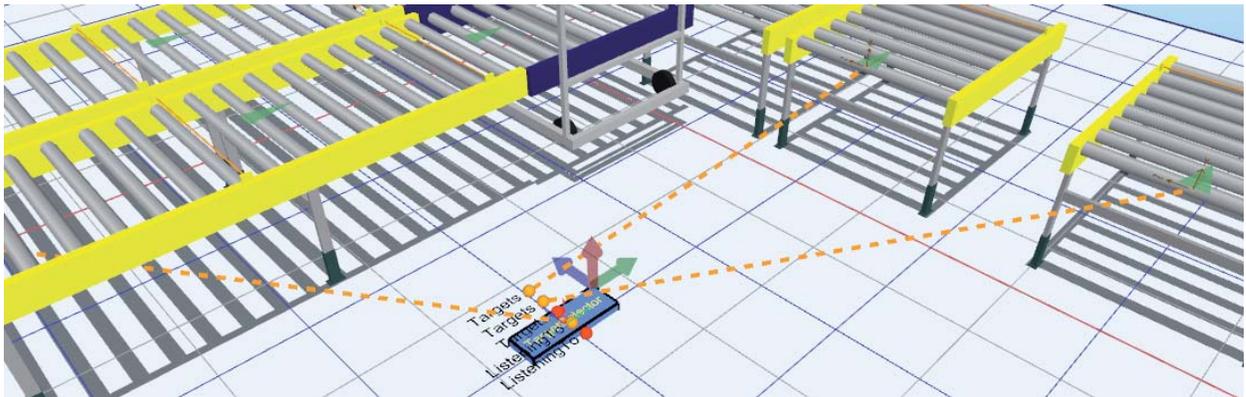


Figure 5: Target Selector control block, showing Visual Connectors.

## 2.4.3 Presentation or Analysis

Once the model has been constructed and the logical flow of parts through it has been created and verified, it is ready to be used for presentation or analysis purposes. In the case of a presentation model, users can create camera paths and views in order to generate fly-through videos which take viewers through the system in an enlightening and memorable way. Still images of various formats can also be created easily, for inclusion in reports or for use as banners at trade shows, for example.

Models built for simulation are often data-driven, with external spreadsheets providing the data to populate the model and inform its operation.

## 2.5 Three Different Ranges – One Approach

The three different ranges of Emulate3D products reflect the different application areas the technology is applied to.

### 2.5.1 Demo3D

Demo3D is the range of products designed for presenting solutions to project stakeholders, and for prototyping new systems. Models can be based on QuickStart catalog elements or not, according to the requirements of the project. Demo3D models exhibit realistic load movement based on friction constraints and the notion of gravity. Loads may bump into each other or even fall from conveyors or other handling equipment, and their resulting movement is emergent, as opposed to deterministic. Models not built with QuickStart are constructed with Demo3D primitives and all behavioral logic must be created by the user. Users may also be trained to create custom-made QuickStart catalog elements of specific or non-standard equipment which conform to the QuickStart framework.



Figure 6: Demo3D's friction-based world creates emergent load movement.

### 2.5.2 Sim3D

Sim3D models may also be built from QuickStart components, but the primary aim is to generate outcomes as fast as possible in order to simulate, analyze, and improve systems. QuickStart components are designed to operate realistically in both Demo3D and Sim3D modes, but whereas loads and other parts of Demo3D models display emergent behavior, Sim3D models are deterministic and consequently can run considerably faster. Sim3D features an Experiment and Analysis Manager which allows users to define parameter sets for different model runs to identify robust solutions.

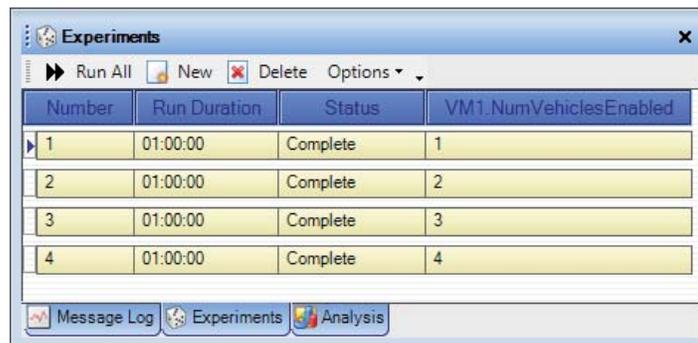


Figure 7: The Experiment and Analysis utility in Sim3D

### 2.5.3 Emulate3D Controls Testing

Emulate3D Controls Testing is used to reduce the time and costs associated with control system development and testing by taking much of the task off the project's critical path. Without virtual commissioning control systems can only be tested properly once the real equipment they control is in place, with products on it. As this is inevitably at the end of the project time line, any accumulated lateness presses heavily on the demanding task of verifying the control system. By using a model to replace the real equipment, the controls can be developed and tested in parallel with other parts of the project, and carried out in an office environment rather than in a factory or a warehouse. The result is a more thoroughly tested control system, delivered on time, and at a lower cost.

As controls testing models replace the actual material handling equipment with their virtual equivalents, models are equipment-centric and load behavior is again emergent, as it is with Demo3D models. Load movement results from the friction caused between the conveyor belt material and the load material, for example. Emulate3D virtual commissioning models are connected to external control systems, usually residing on programmable logic controllers or PLCs. Models may also be connected to any kind of control or data acquisition system using a wide range of methods including SOAP, TCP/IP, UDP, and sockets.

## 3 WORKING WITHIN THE EMULATE3D FRAMEWORK

Emulate3D products are open and easily extended, and many users are trained in how this is accomplished. Companies wishing to add their equipment to a catalog can import their 3D CAD via a wide range of industry standard formats and use it to skin existing elements, or may create more complex behaviors by adding their own custom operational logic.

Catalogs are separable from the main product and may be used by others who can simply read them into their Demo3D license. Catalogs can also be locked so they may contain elements which can be included in models but not opened, so their internal operation remains protected. A further safeguard is available in the form of a time-limited operation for catalog elements – once past this date, any model containing a time bombed element will no longer work.

### 3.1 Flexible Modeling Framework + Multiple Control Languages = More Happy Users

Emulate3D technology is unique among industrial modeling systems in offering a choice of control methods to suit the different requirements of its broad range of users. An overriding development goal is to continue to suit the products to the skill sets of the users, and this is reflected in the fact that users can choose between several control languages and scripts.



Figure 8: Not keen on Microsoft Jscript? Try QuickLogic instead.

### 3.1.1 Emulate3D Control Methods

Control methods fall into two categories – those which are integrated within the products, and which are therefore operational at the model clock speeds, and those which are external to the products, run in real time, and communicate with the models using OPC, sockets, Modbus, or other product-specific communications.

- Microsoft Jscript (internal to the product)
- QuickLogic drag and drop (internal to the product)
- Ladder Logic (internal or external to the product)
- Instruction List (internal to the product)
- Sequential Function Charts (Grafcet – external to the product)
- Programmable Logic Controllers (external to the product)
- ...

### 3.1.2 Event Based Behavior

Occasional users are generally most comfortable and productive using the default behaviors of the QuickStart elements, modified using Control Blocks. Specific behaviors or prototype systems can often be conveniently controlled using the drag and drop QuickLogic elements, which allow logic to be expressed without entering into the bureaucracy of a full programming language. QuickLogic encourages a focus on logical operation, as opposed to language structure. Catalog element builders, and those who are most comfortable with a full scripting language can use Microsoft Jscript, a robust industry standard. Trained users can create QuickStart-compatible catalogs of their proprietary equipment, task-specific Control Blocks, or complete systems of their own.

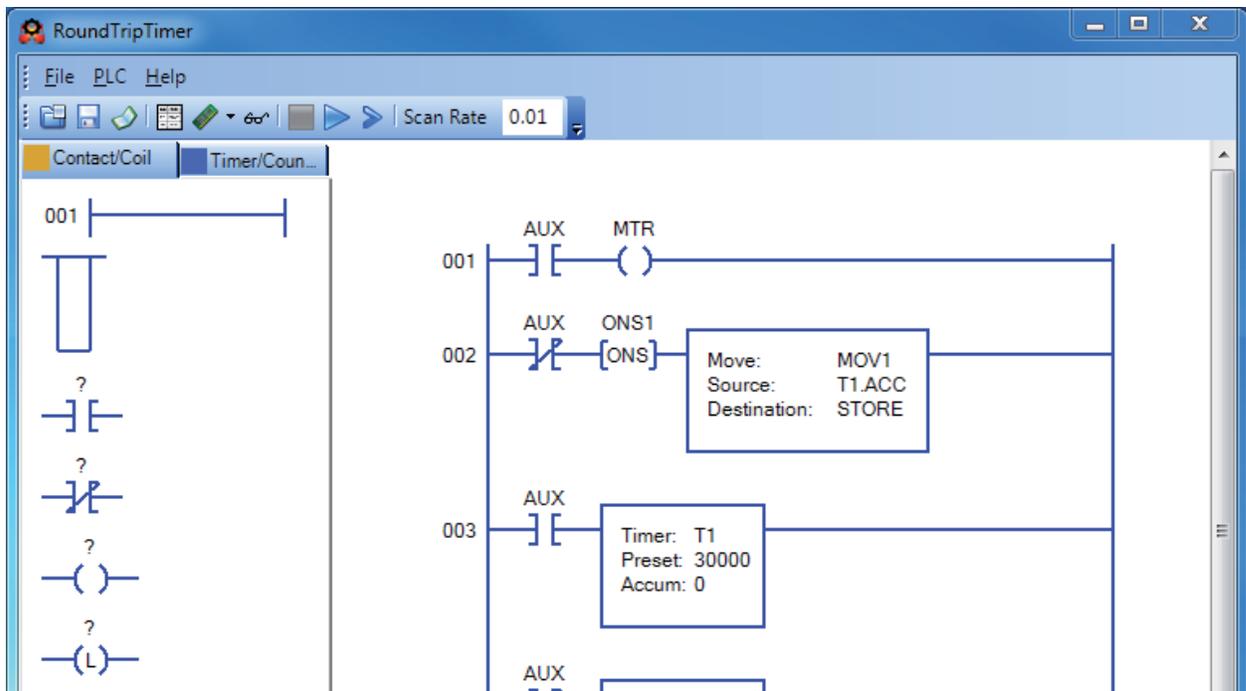


Figure 9: State-based ladder logic is an internal control option.

### 3.1.3 State Based Behavior

Emulate3D Controls Testing users are not often familiar with creating control in event-based languages like QuickLogic or Microsoft Jscript, and for them the Emulate3D environment offers several state-based control options, including an internal soft PLC which can be operated with Relay Ladder Logic or Instruction Lists. In addition to these two, we also added Sequential Function Charts (SFC – a standardization of Grafcet) as an external stand alone application connected via the Emulate3D Controls Testing tag browser. These represent three of the five programmable controller programming languages defined by the IEC 1131 standard.

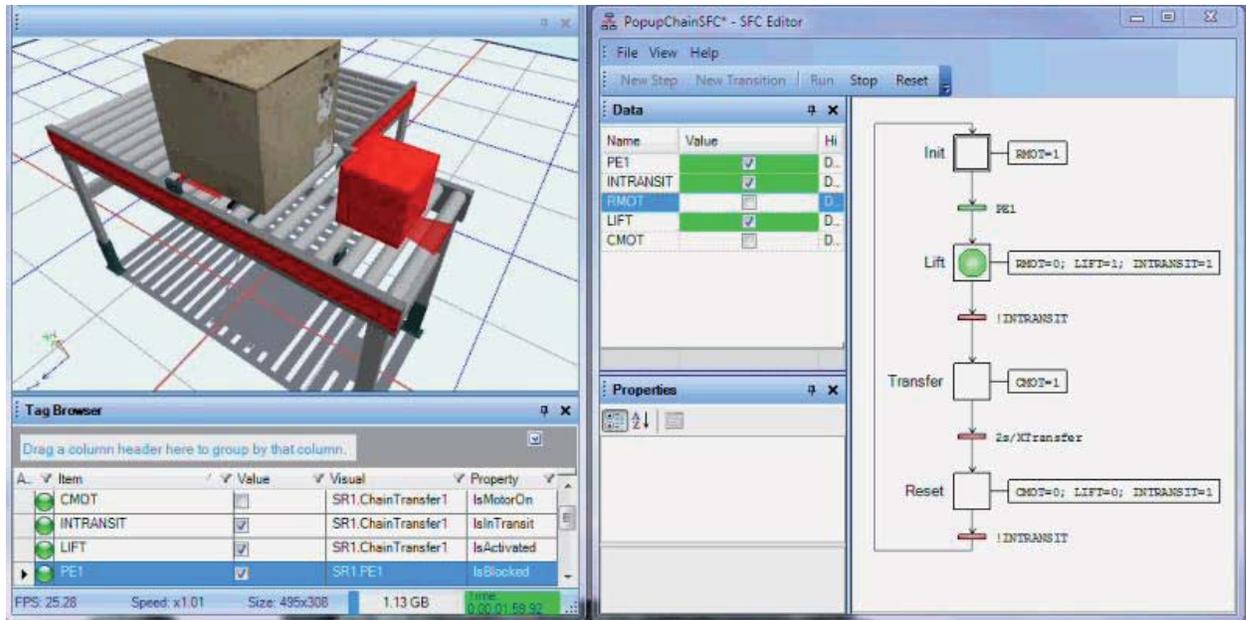


Figure 10: Sequential Function Blocks are an external control option.

## 4 SUMMARY

Emulate3D represents a significant change in the world view of dynamic industrial modeling, and has raised the bar for controls testing. The classic simulation product world view was inadequate for the “zero abstraction” level required for building useful emulation elements and models.

Emulate3D allows the creation of friction-based equipment models which are closely analogous to the real thing, and which behave credibly and usefully.

Demo3D successfully employs this realistic environment within the QuickStart framework to build operational demonstration models in a fraction of the time it would take to create them in a CAD package, and results in captivating videos and credible models.

Sim3D uses the rapidity of the QuickStart model build and creates friction-free analytical models to help understand the complex operation of modeled systems, and make informed choices resulting in robust systems.

Emulate3D Ltd develops cost-effective industrial modeling solutions which provide support to engineers working in a wide range of automation industries.

## **REFERENCES**

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- Svensson, P. Å., *IEC 60848 Ed. 2 Specification language GRAFCET for sequential function charts*, IEC Committee Draft.

## **AUTHOR BIOGRAPHY**

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