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EMULATION: DEBUG IT IN THE LAB – NOT ON THE FLOOR

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ABSTRACT

Emulation is a very powerful tool for testing and debugging control code/logic in an office environment rather than on the plant floor. Through the use of emulation, the actual control logic is connected to a simulation model that imitates the actual machine/conveyance hardware. The emulation software also has the ability to mimic the operator stations. Logic problems can be found and corrected in the office with field time reduced to verifying physical, site specific, installation issues. Time, money, aggravation, lost production, employees (from burnout), and potentially marriages can be saved through the use of emulation.

1 INTRODUCTION

Emulation is the marriage of two distinct disciplines, simulation and controls designs, to effectively achieve "virtual world" system operations.

The first discipline, Simulation, is where a discrete event model of a real world system, such as a conveyance system, is recreated utilizing simulation software and a personal computer. The model can be built in great detail and include such things as location of conveyor field devices (e.g. limit switches, stop stations, transfers, and conveyor dogs). Jobs that travel on the conveyance system are then told how to move through the system utilizing simulation code written in the modeling program.

The second discipline is Controls, which in the real world of conveyors and/or other systems, is the means by which this equipment operates automatically. Typical machine/equipment controls utilize a Programmable Logic Controller (PLC) or PC with control software as the mainstay within an automated system. Common to both types of controls are Inputs which monitor the condition of sensors attached to the system and Outputs from the Controller which turn logical commands into real machine functions. Machine Inputs would include such items as limit switches, photoeyes, and pushbuttons, while Outputs control machine functions such as the movement of a pneumatic cylinder, release or hold a job at a workstation, turn on a light, etc..

Emulation combines these two worlds, the Simulation world and the Controls world, into one package as shown in Figure 1. Instead of controlling jobs moving on the conveyance systems with the simulation software, a real PLC or PC controller is interfaced with a simulation model. Now, the model can be run and analysis performed on an actual system (new or revised) to ensure that the system design is valid in both the mechanical and controls aspects. By monitoring the material flow through the system and analyzing the statistics generated by the simulation model the adequacy of the mechanical design can be determined. By ensuring that all jobs are routed to their intended destinations, the controls logic can be validated. Also, since Emulation is a duplication of the real world that can easily be changed, different scenarios for mechanical and controls systems can be tested, thus minimizing the installation cost to test the systems on the plant floor.

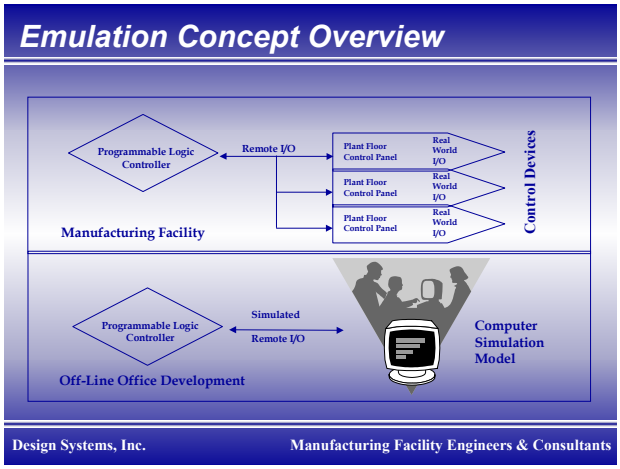

Figure 1: Emulation Concept Overview

After the Emulation is complete and verified, the system can be physically built and the controls logic installed into the actual field PLC or PC controller. This will achieve a complete, fully validated working system that will require minimal debug time on the plant floor.

2 IMPLEMENTATION METHODS

The typical emulation study consists of several elements.

- Simulation Model
  - Detail of physical mechanical system.
  - Detail of physical controls devices
  - Connections to I/O devices
- Operator Control Panels
  - On screen display of all panels with full functionality
- Hardware Electrical Components
  - Driven by Operator Control Panels
- Control Code/Logic (PLC or PC based)
  - Actual field controls used in the emulation
- I/O Networks
  - Connection between field devices and Control Code/Logic

These elements are combined into one unit to test the system through the use of emulation.

2.1 Simulation Model

The simulation model replaces the real world physical system and includes all of the mechanical and electrical physical elements that would exist on the plant floor. This will include such items as;

- Conveyor path
- Track switches
- Sensors
- Stops
- Motors

These devices will send and receive signals to/from the controller just as the actual devices would on the plant floor. The simulation model as it is coded for the emulation package cannot work without the aforementioned elements. To debug the simulation portion, it is first tested with typical simulation code to verify the model's functionality. That code is then replaced with appropriate I/O communication to be used in the emulation.

Figure 2 shows a sample display of the simulation portion of an emulation.

2.2 Operator Control Panels

The Operator Control Panels, as they would exist in the field, are displayed on the computer screen. Typical elements displayed include:

- Lights
- Selector Switches
- Push Buttons
- Horns
- Local Field Lights

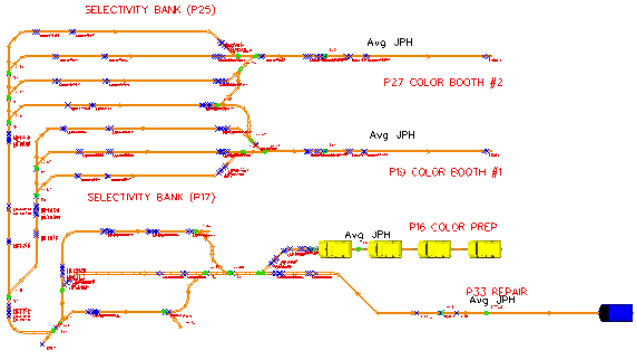

Figure 2: Simulation Portion of Emulation

The lights illuminate as they would on the real panel, being driven by the controller, and indicate the state of the system.

Selector Switches and Push Buttons are operational and are used for Manual Controls of Devices and directional control.

Horns and local field lights are also shown on the Operator Control Panels and are typically stand alone devices located overhead. These elements are shown on the operator control panels in the emulation package to indicate the area configuration.

Figure 3 shows an example of how the operator stations are displayed in the Emulation Master.

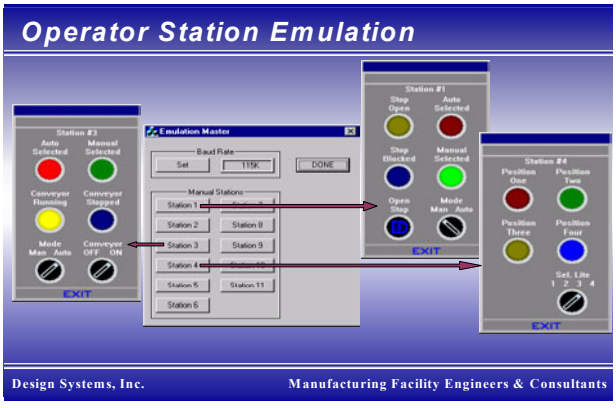

Figure 3: Operator Control Panels

2.3 Hardware Electrical Components

Hardware Electrical Design is mimicked through the Operator Control Panels. The hardware electrical components are driven from the selector switches and push buttons on the operator control panels.

Figure 4 shows a sample hardware electrical drawing that is mimicked in the emulation through operator control panels.

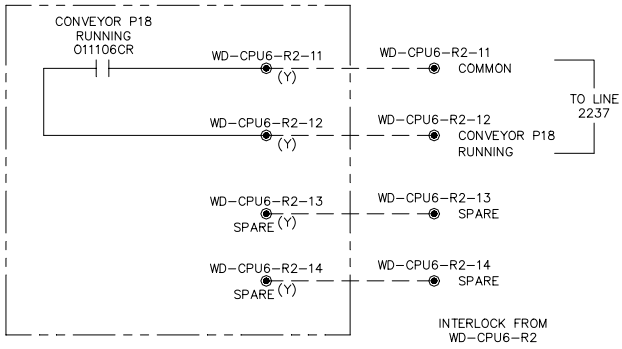

Figure 4: Hardware Electrical Drawing

2.4 Control Code/Logic

The actual Control code/logic that will be installed in the field is used in the emulation. This logic is either PLC or PC based. No modifications are made to the logic to have it drive the emulation.

Figure 5 shows a sample section of PLC logic that is used in emulation.

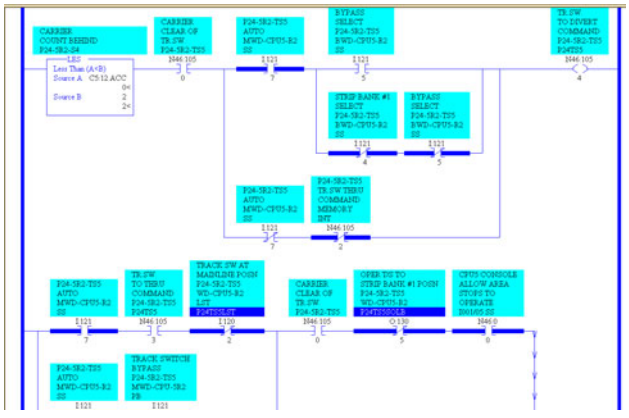

Figure 5: Sample Control Code/Logic

2.5 I/O Networks

The I/O Network is the hardware connection between the field devices and the controller. A variety of I/O network configurations are available (i.e. Profibus, Allen-Bradley, DeviceNet, etc.)

3 BENEFITS

There are numerous benefits from doing an emulation of a system. Some of these are

- Provides integration testing/debugging in a lab environment.
- Facilitates logic check-out prior to the testing on the Plant Floor
- Reduce the amount of time people spend in the field. This reduces employee burn out and reduces start up cost.
- Cost savings from a reduction in debug time spent on the plant floor.
- Reduce startup time. Time to market can be substantially decreased.
- Ability to test scenarios that won't actually exist in the field until a future date. This allows the end user to hold the contractor to all of their obligations and not be surprised by system malfunction when full production requirements of product variability and throughput are experienced.
- Reduces debug time. Test scenarios may be setup and tested far quicker through emulation than on the plant floor.
- Allows great visibility of the control system prior to installation
- Allows testing of complex product blends and complex scenarios
- Assure schedule reliability
- Provides an effective tool for training

4 SUMMARY

In summary, the use of emulation saves time, money, and headaches. The minimal cost of an emulation can be recouped many times over by reducing startup time and cost (including travel costs and overtime)and meeting full production rate on or ahead of schedule, and reducing field employee burnout.

AUTHOR BIOGRAPHY

CINDY SCHIESS is the Simulation Assistant Group Manager at Design Systems, Inc., a Manufacturing Engineering Consulting Company based in Farmington Hills, Michigan. She has been involved in the field of simulation for 18 years and has been with Design Systems for 13 of those years. She has a B.S. in Industrial Engineering from the University of Wisconsin – Platteville. She is involved in the Michigan Simulation User Group (MSUG) and has been on the Steering Committee for the last 6 years. Current Simulation activities at Design Systems include traditional material handling simulations as well as Emulation (AutoMod & PLC/PC Controller) and Ergonomic (AutoMod & EAI Jack) simulation. Her email and web addresses are <cschiess@dsi-solutions.com> and <www.dsi-solutions.com and www.dsi-simulation.com>.