CONTROL

WHITE PAPER

# Three ways dynamic simulation reduces lifecycle risk

Simulation can help to ensure efficient and accurate project execution, train competent operators and validate new control strategies, too

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The process industries are by nature a complex, risky business. And that risk can take many forms over a plant's lifecycle. First there's schedule risk. From the first moment a new facility gets green-lighted, corporate stakeholders want the plant up and running as quickly as possible so they can start to realize a return on the investment they've approved. Project delays can mean revenue lost forever, as in the case of a patented pharmaceutical. And in the energy industry, earlier "time to first oil" can mean millions of dollars in cash flow.

Second there are operational risks. Would an alternate control strategy make the process more efficient? Or would it give rise to instabilities or other unintended consequences? And does one ensure that any changes are made accurately upon first attempt?

Third, are operators prepared to handle process upsets and tasks that are not often performed, such as start-ups and shutdowns? Then again, what happens when your most seasoned operators walk out the door, never to return?

Among all the software tools at the process manufacturer's disposal, dynamic simulation is uniquely suited to help address these various sources of risk from the earliest stages of system design throughout a plant's operating life.

Dynamic simulation makes possible the early testing and troubleshooting of new control system code, when course corrections are easiest, fastest and least costly to make. It also makes possible the early hands-on training of process operators, which can be started even before the physical process is commissioned.

And, once a unit is up and running, dynamic simulation paired with an offline replica of the control system provides operators with experiential preparation for process upsets and procedures that are not often performed, such as start-ups and shutdowns—an impossible or impractical task when only the live production system is available. Dynamic simulation also is an effective tool for exploring the implications of potentially more optimal "what-if" scenarios—without putting actual production at risk.

**ALL SIMULATIONS ARE NOT CREATED EQUAL**

Since dynamic simulations can be used for a range of different purposes, they also possess a range of capabilities which, in turn, represent different levels of complexity and development effort (Figure 1). Early in the engineering of a control system, one might need only to simulate the behavior of analog and discrete inputs and outputs (I/O) or field instruments in order to do virtual commissioning or for a factory acceptance test (FAT). Simulation at this level can be created almost automatically out of the control system's project data, and represents what is referred to as a low-fidelity simulation.

If one is looking to do more advanced testing or training on sequences, interlocks or control scenarios, another layer of process simulation representing the dynamic, real-world interactions of the devices in the plant will be needed. Such medium-fidelity dynamic simulations rely on simplified process curves and equations and are adequate for basic training on the control system human-machine interface (HMI) and control logic.

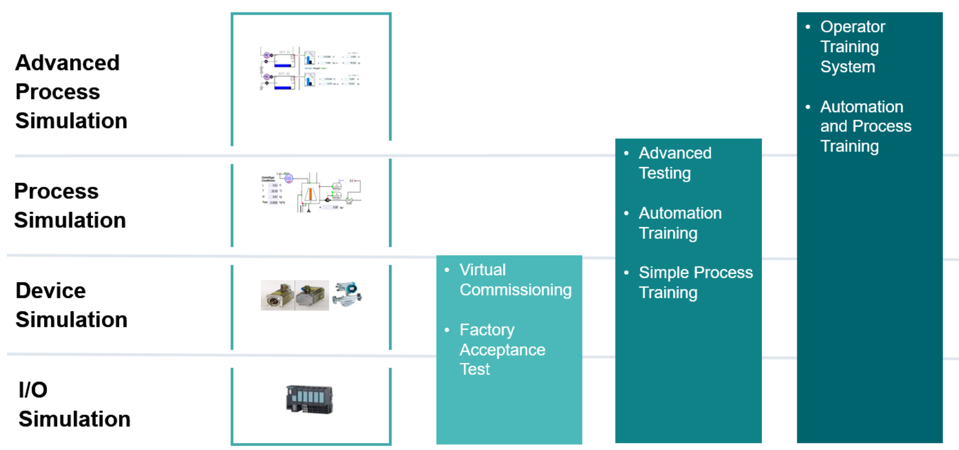


*Figure 1. The degree of fidelity—and development effort—required of a dynamic simulation depends on its intended purpose.*

Finally, with a high-fidelity dynamic simulation, advanced function blocks model the dynamic behavior of valves, transmitters and entire unit operations. At this level, simulators often are integrated with models that bring process-specific information such as reaction kinetics into play. A dynamic simulation at this level often is referred to as an operator training simulator (OTS) and, when paired with a duplicate of the production control system environment, can be used to safely train operators how to conduct infrequently performed procedures and react to abnormal situations.

It's also important to note that the same level of complexity need not be used to model all aspects of plant operation: a tank farm requires a simpler model than a series of interacting distillation towers. Using the appropriate model for each unit operation ultimately will provide the best balance of simulation performance, cost and future flexibility.

**#1. REDUCE PROJECT RISK WITH SIMULATION**

While static, high-fidelity models often dictate the overall physical design of a new processing unit, dynamic simulation development is best started coincident with detailed engineering and development of the automation program (Figure 2). By configuring the simulation and automation programs in parallel, automation logic can be verified in stages as engineering proceeds, and any errors can be detected and corrected along the way.

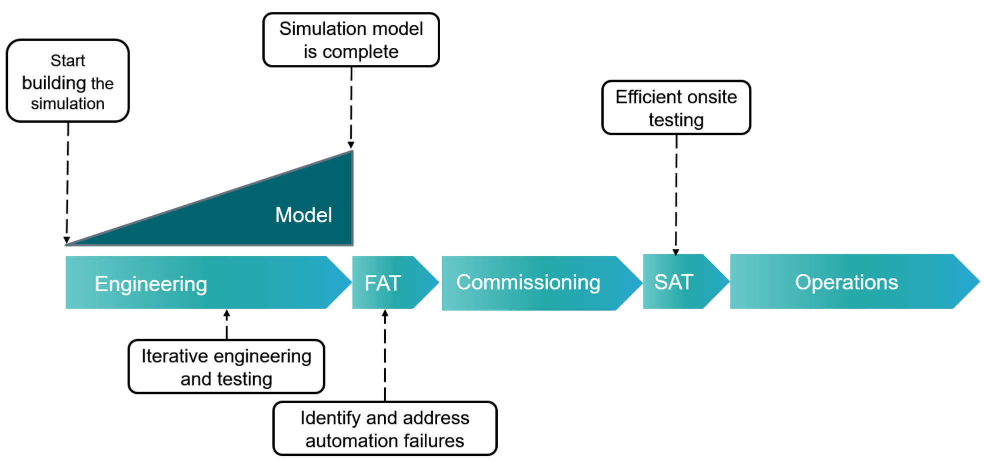


*Figure 2. Early in a project's lifecycle, simulation can help verify automation code as its developed, paving the way for a trouble-free, virtual factory acceptance test and onsite commissioning.*

With this approach, the simulation model will be ready for final testing against the control logic in a virtual FAT. The same automation code and HMI software that will run in the operating plant is matched against a simulation that includes plant behavior, field devices and I/O.

The controller hardware itself can be emulated in software, or a physical controller of the same model to be used in the plant can be coupled with the simulation for a "hardware in the loop" setup. In either case, the control system hardware, discrete and analog I/O and instruments can already have been shipped to the site and installed. Then, the pre-tested software need only be downloaded to the installed hardware, streamlining final commissioning and site acceptance testing (SAT).

**#2. TEST OPERATIONAL CHANGES WITH SIMULATION**

Once a process plant has progressed through its design, commissioning and start-up phases, dynamic simulation can continue to reduce risks to ongoing plant operations. One important contribution is in the offline testing of potential changes to control strategy (Figure 3).

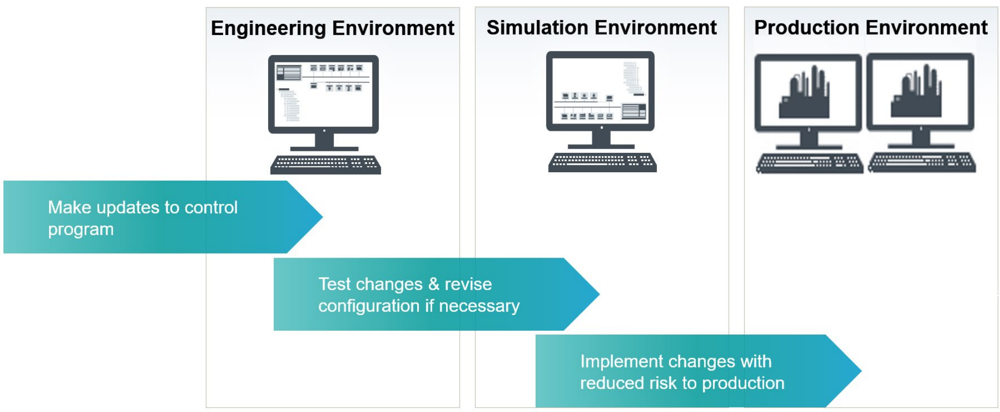


*Figure 3. After production has begun, an offline simulator can help reduce risks by providing a safe platform to test out potential changes in control strategy before they are deployed.*

This offline environment allows one to make changes to control configurations and then see just how the process will respond—within the model's resolution limitations, of course. This helps to make sure that the proposed changes have the intended effect, as well as to make sure those changes have been implemented correctly.

This is especially important if those making the changes don't work with the control system on a day-to-day basis. Indeed, adding a new device, modifying an interlock or making a sequence change on an operating unit can be a stressful exercise even for those very familiar with the environment. Once it's been verified in the simulation environment that the change has the desired effect and has been implemented correctly, one can download the change to the production system with a high degree of confidence that it will work as expected.

One important architectural consideration is the logical separation of the simulation package from the offline replica of the production control system. Resist the temptation to wedge a dynamic simulator into the control system environment, or to emulate the control system within the dynamic simulator. Both functions will suffer—initially and into the future—from this sort of compromise. Process control systems are designed for control: they don't include the tools needed to readily build and manage a dynamic simulation, and attempting to do so will likely cause the performance of the off-line control system to diverge from its production counterpart. A dynamic simulator, in turn, will likely fall short in trying to emulate the subtleties of a given manufacturer's process control system—initially and over the course of time.

Maintaining these domains as separate applications allows the offline control system to faithfully duplicate the operation of the production control system complete with identical operator graphics, alarms and control strategies. This provides an environment where the control system can run in a manner identical to the actual plant, and updates to the production control system can be readily synchronized across the two platforms.

In turn, modeling of the transmitters, final control elements, and the process itself in a dedicated dynamic simulation environment allows the user to easily develop and maintain process models to the level of complexity or fidelity required by the task at hand.

#### #3. BOLSTER OPERATOR SKILLS WITH SIMULATION

Our third way in which dynamic simulation can reduce lifecycle risk is in the training of plant operators. With the same simulator and offline replica of the control system described in our first two use cases, new operators can be brought up to speed in an interactive, immersive OTS environment in which learnings are most likely to be retained. Current operational staff can be refamiliarized with sequences that are seldom performed, such as start-ups, shutdowns and emergency procedures. An OTS can even be used to train personnel before a plant is commissioned, ensuring that operators hit the ground running upon start-up.

Despite a lack of on-record reports of cost savings due to the use of dynamic simulators, anecdotal figures in an ARC Advisory Group report from 2006 continue to impress: up to $500,000 saved per day in reduced commissioning and validation time; $1 million in savings per production run due to higher on-spec product; $100,000 per hour in operating cost savings due to more proficient operators; and $1 million in risk mitigation per incident through better identification and addressing “dormant errors” in automation systems.

For example, Ron Cisco, now an operations & maintenance manager at Salt River Project's Coronado Generating Station, reported at the 2013 ARC Advisory Group Industry Forum that the company was able to bundle an operator training simulator into a larger control system migration project because it represented a relatively small additional cost. Even so, the simulator was justified based on the demographic crunch of retiring operators that has only intensified in the years since.

What surprised Cisco and the rest of company management even more was the 144 control logic issues that were discovered and resolved with the aid of the dynamic simulator before operation began and "before we even started operator training," Cisco said. These were issues that were not seen during the FAT with simple, non-dynamic I/O tiebacks. It was only when the true process dynamics were simulated that these issues appeared. Management consensus was that the dynamic simulator "already paid for itself" before the new control systems even came on line.

In the end, an investment in dynamic simulation is much like an insurance policy. It represents a known upfront cost that can pay for itself many times over when a hidden automation system error is exposed or when an operator in unfamiliar territory finds he knows what to do because of the training and preparation he's received on the plant's dynamic simulator.

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