

# Xerox Reduces Development Time Using MathWorks Tools

With more than 15,000 U.S. patents, including the first automated plain-paper copier, Xerox Corporation is one of the world's top technology innovators. To maintain their technological edge, the company relies on new approaches and methodologies from their internal research and development team, the Xerox Innovation Group.

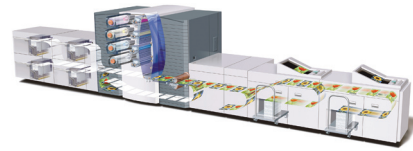
The Xerox Innovation Group, which is striving to improve the printer development process, has extended their use of MATLAB® from simulation and analysis to rapid prototyping based on software prototypes developed with Simulink® and xPC Target.

“It’s our charter to come up with product innovations and printing techniques,” says Marc Daniels, a researcher at Xerox. “MathWorks tools help us develop and control our prototypes in a flexible manner, which results in a reduction in development time that ultimately helps us deliver our products to market faster.”

## THE CHALLENGE

To improve their printer paper path control technology, the Xerox Innovation Group sought to model and simulate the printer’s components and actions, including the paper as it moves through the printer and onto the finisher for collation, printing, and stapling, as well as the running motors. Each piece of paper needs to adhere to strict position and velocity requirements.

“We need to model our prototypes before they are actually built, so that we don’t halt our development process,” explains Dr. Martin Krucinski, a researcher with Xerox. “We also need to measure all signals in real time to validate our simulations.”



Complex printer path technology.

Because traditional instrumentation methods proved tedious and time-consuming, the research group would also require tools for quickly collecting and visualizing data.

## THE SOLUTION

Xerox uses MathWorks tools to develop prototypes of their printers and test their control strategies.

“Simulink and xPC Target let us simulate the printer at various levels,” says Dr. Krucinski. “Conveniently exchanging simulated components to real components lets us experiment quickly.”

Engineers use Simulink to model the printer’s electronic components, including DC motors, solenoids, sensors, and gates that guide the paper flow for duplex printing. This model of the printer serves as the plant model for subsequent control system development.

Xerox verifies the printer plant model by running simulations with Simulink. They use MATLAB and the System Identification Toolbox to analyze experimental data from actual printers. After comparing the data, they tune the models so that the results match.

Using Simulink and the Control System Toolbox, Xerox designs the controllers for the DC motors, gates, and roller releases. They use

## THE CHALLENGE

To verify design ideas for printer paper path control, while streamlining the development process

## THE SOLUTION

Use MathWorks tools to model plants and controllers, automatically generate code, and run the code in real time on target hardware

## THE RESULTS

- Controls development time reduced by up to 80%
- Workflow streamlined with integrated tools
- Tests conducted independently of hardware development schedule

Stateflow® to model operating modes and measure the trajectories and velocity of the paper.

“Stateflow lets us easily model state machines to facilitate specific activation times, which are critical to moving the paper along the path correctly,” says Daniels.

They verify the operation of the controllers by combining the controller model with the plant model using Simulink configurable subsystems. Real-Time Workshop® is used to generate code for the controller and the plant. The xPC Target plant system enables them to run real-time, closed-loop experiments on the hardware-in-the-loop, simulated plant to validate prototype controller operation.

“When the controller runs, it’s unaware of whether it’s connected to a real or simulated plant,” explains Dr. Krucinski. “Even while the machine is being built, we can exchange half the plant with the real plant and continue simulating the second half of the plant that is yet to be built.”

Because xPC Target uses flexible PC configurations, Xerox runs experiments with smaller printers using an office PC containing two I/O cards. For larger applications, they use a PC with a large expansion chassis that supports up to 19 off-the-shelf I/O cards.

“MathWorks tools let us quickly produce reference plots and replace a configurable block with a real hardware block to collect experimental data. We can then compare graphs to validate results,” says Dr. Krucinski. “The massive amount of data logging and signal interrogation that these tools handle is amazing.”

The Xerox Innovation Group is now working with product divisions to implement the controller software in their printers.

“The main advantage in using MathWorks tools for Model-Based Design is that the approach is easy to understand, the models are self documenting, and the tools are completely integrated, which speeds up development.”

Dr. Martin Krucinski, Xerox

## APPLICATION AREAS

- Automatic code generation
- Computers and office equipment
- Control design
- Hardware-in-the-loop simulation
- Model-Based Design
- Rapid prototyping

## PRODUCTS USED

- MATLAB
- Simulink
- Real-Time Workshop
- xPC Target
- Stateflow
- Stateflow Coder
- Control System Toolbox
- System Identification Toolbox

## THE RESULTS

### ■ Controls development time reduced

**by up to 80%.** “We can address many of the control tasks five times faster using Simulink and Stateflow than if we had to hand code state machines,” says Dr. Krucinski. “Because the models we build in Simulink are self-documenting, we expect additional time savings at the implementation stage because engineers in the product divisions will better understand the product specifications.”

### ■ Workflow streamlined with integrated tools.

“MathWorks tools are tightly coupled and flow well together,” explains Dr. Krucinski. “For example, the Simulink environment doesn’t change when you use Stateflow—all the previous parts work exactly the same, and you don’t need to switch between tools.”

### ■ Tests conducted independently of hardware development schedule.

Xerox uses MathWorks tools to model prototypes of systems that have yet to be built. “Now, we test the controllers for a part of the system on the real physical equipment and also simulate components yet to be built,” notes Daniels.

To learn more about Xerox, visit [www.xerox.com/innovation](http://www.xerox.com/innovation)

[www.mathworks.com](http://www.mathworks.com)