



# Improving Process Control at HP

*Using statistical data analysis to design, monitor and optimize processes in the development of printers and print cartridges.*

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he quality of a printed image, whether it's words on a page or your favorite photograph, is at the root of Hewlett Packard's (HP) imaging and printing business. All products, including but not limited to printers, digital projectors, scanners and digital cameras are designed, developed and manufactured with visual acuity in mind!

Part of HP's Imaging and Printing Group focuses on the design and development of thermal inkjet printers and print cartridges. It's a small army of engineers and technicians working together to refine processes and improve quality throughout the design and manufacturing of inkjet technology. The results of these labors produce the quality products found in offices around the world.

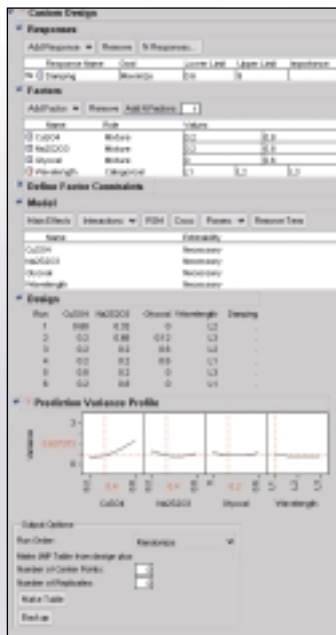
Corvallis, OR, is home to HP research and development teams that focus on perfecting next generation processes related to inkjet technology. Minimal manufacturing is done in Oregon, most of which serves to test a prototype. Once a prototype is perfected, it is shipped to hub sites in Singapore, Puerto Rico, and Ireland, as well as Idaho and California, for mass production.

New product development is based on trends in the marketplace. Significant factors that influence product design are competition, increased quality standards, and ultimately the cost incurred to bring a new design to the market.

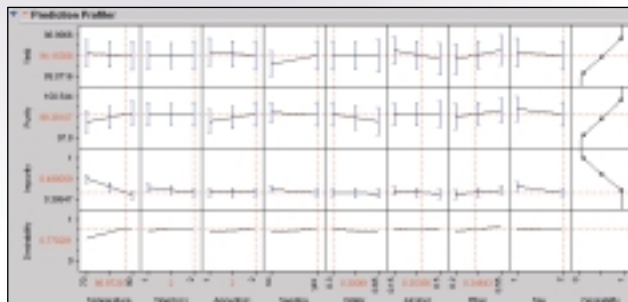
HP's Imaging and Printing Group uses statistical data analysis to design, monitor and optimize processes in order to identify ways to improve process control throughout the development stage of printers and print cartridges. The challenge has been finding a software tool that is easy to use and allows engineers to customize design experiments for discovery of optimal design elements.

Courses offered through HP's education department introduced engineers to several statistical software tools, none of which provided a complete feature set. The software either lacked a custom design option, or was simply too complicated to learn; consequently, the engineers reverted back to the software they had been using prior to attending the class.

An onsite demo from JMP, A Business Unit of SAS, caught the eye of an HP statistician. He was intrigued by JMP's Design of Experiments (DOE) rich feature set, ease of



I-Optimality for DOE



Prediction Profiler for DOE

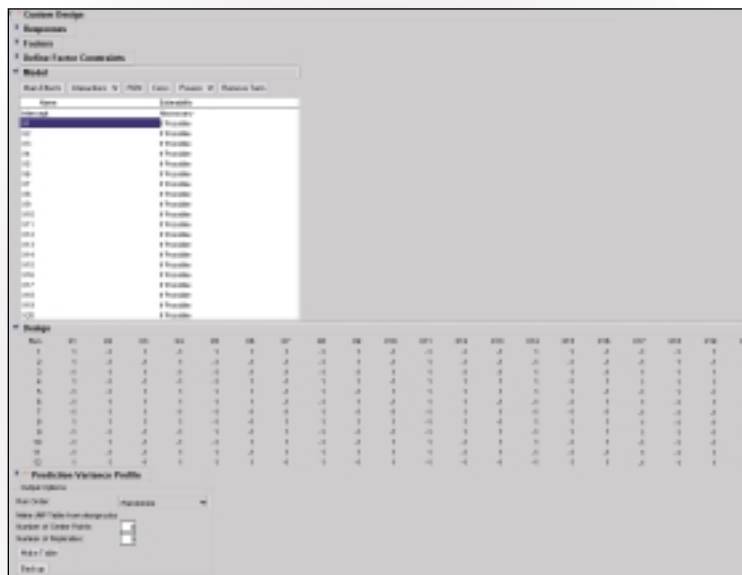
use, and Windows-based compatibility, so he recommended the product to the education department as a software tool that could address the needs of the design and process engineers.

After testing and comparing the JMP product to the other software packages used in these HP classes, the education consultant for the class determined that JMP provided the capabilities to help them do their jobs more efficiently — a critical need expressed by engineers in the Imaging and Printing Group. Shortly thereafter, JMP was incorporated as a statistical software tool that enables customization of design experiments, is easy to use, and operates on Windows and Macintosh operating systems.

The ultimate goal of HP statistical classes is to provide flexibility of software tools to help users meet varying needs. Instructors want to equip engineers with software tools that provide practical data analysis, custom design of experiments and statistical process controls.

In August 2001, HP implemented a new “JMP Design of Experiments” class. It highlights methods by which this feature enables design engineers to customize experiments — by testing various factors and responses — so more relevant information can be gathered about a given process. The benefit is minimized guesswork involved in finding ways to refine and control processes, which reduces the time spent in prototyping.

An HP manufacturing development engineer shared his experience with JMP software. The engineer is tasked with refining a process step in the production of a thermal inkjet



Supersaturated for DOE

printhead, one of three components that comprise the print cartridge. The other two components are the flex circuit and pen body. The printhead delivers ink from the ink supply to the paper. The flex circuit links the electrical connections from the printer to the printhead in addition to attaching the printhead to the pen body while the pen body holds the ink supply.

In order to manufacture the printhead, there are several process steps, including thin film depositions, etches, implants and photolithography. For any one of these processes, the statistical capabilities of JMP provide quantifiable support for analyzing designed experiments in response to process or product changes. As part of his work on the thin film deposition process, the engineer utilizes JMP's DOE functionality to analyze experiments for variations in the process, and looks for ways to reduce costs by determining the least amount of resources needed to make process changes. Additionally, JMP is employed to analyze metrology repeatability and reproducibility to measure quality and maintain consistency over the years. These capabili-

ties ensure that ink properties remain constant so that customers always see a quality image.

Based on user feedback, JMP is very easy to use. Its graphically enhanced analytics help users easily visualize outliers and trends that might affect process controls, and enable engineers to determine the best processes for optimized throughput. This leads to better product performance and increased customer satisfaction — two key factors that position HP

ahead of the competition.

Starting in April 2002, Hewlett Packard introduced a full JMP course that incorporates all features of the statistical analysis tool, not just the DOE functionality. If all goes according to plan, the classes will be expanded to hub sites in Singapore, Puerto Rico, and Ireland, as well as Idaho and California, beginning later this year.

The introduction of JMP into the Imaging and Printing Group of HP has proven to be a valuable tool for asserting checks and balances that ensure streamlined processes are in place to boost product performance and reinforce quality standards expected by customers. This consistency establishes a worldwide quality perception of the HP brand, which ultimately builds brand loyalty and lasting customer relationships.

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