

SAS Institute Inc.

*JMP[®] Research
and Development:
A Process for Quality*



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Note: This statement is part of a validation package for JMP (available at www.jmp.com/qualitystatement). This document is an addendum to the SAS quality paper, “The Quality Imperative: SAS Institute’s Commitment to Quality” (available at www.sas.com/qualitypaper).

JMP Quality Statement

The first version of JMP software was released in October 1989. For more than 20 years, the JMP business unit of SAS has continued to refine a research-centric process that is built on development partnerships with customers in key industry segments and leading researchers in universities and academic circles. JMP software is developed at the SAS world headquarters in Cary, North Carolina.

JMP Research and Development (R&D) shares the central mission, philosophy, and software development lifecycle that has been established by SAS. All the information in “The Quality Imperative” about SAS personnel, privacy issues, and work environment pertains equally to JMP.

Our Software

JMP dynamically links statistics with graphics, enabling our customers to interactively explore, understand, and visualize data. Designed for anyone who wants to discover relationships and patterns in their data, JMP provides a comprehensive environment for exploratory data analysis, statistical modeling, and experimental design (DOE) in a single package. Moreover, JMP is designed to work with other SAS software in the SAS Business Analytics Framework, providing an interface to submit SAS code and interpret SAS results. JMP can also read and create SAS data sets, text files, Excel files, and access many relational databases using Open Database Connectivity (ODBC).

The JMP Development Process

The foundations of the JMP development process are: frequent customer contact; prototype releases as code is being developed; and open, informal communication between customers and senior development staff in the JMP development and marketing teams. The JMP development process is innovative, iterative, and highly collaborative. Sales success and customer longevity in key industry segments is strong evidence of the success of this philosophy of development.

Staff, Training, and Skill Sets

The JMP Research and Development (R&D) team consists of the following operational units:

- Statistical Development
- Host and Portable Development
- Testing and Validation
- Documentation
- Source Management/Test Automation/Release Engineering
- Localization/Internationalization

John Sall, co-founder and Executive Vice President of SAS, and primary architect and designer for JMP, leads the JMP business unit and its research and development efforts. Sall is also responsible for

programming many crucial platforms and routines in JMP software. A biographical summary about John Sall can be found at: www.sas.com/presscenter/bios/jsall.html.

A majority of the statistical development, testing, and documentation staff members have master's degrees in statistics or operations research. Almost half of these staff members also hold a Ph.D. in statistics.

A majority of the staff members in the host and portable code development areas have a master's degree or higher in computer science or related fields.

Software Development Tools

JMP software is written primarily in C++, using various development environments that are based on Microsoft Windows and Apple Macintosh. Perforce Software tools provide configuration and source code management.

The testing and validation staff automate testing for much of the JMP software functionality using a proprietary framework that is based in the JMP scripting language (JSL). These tests are run on Windows, Macintosh, and Linux in both 32-bit and 64-bit environments. Testers also use other UI-based automation tools to automate graphical user interface-based tests across the same operating systems. Problems are reported and tracked using the DEFECTS Reporting System. (See "Problem reporting and resolution" in "Research and development tools" in "The Quality Imperative.")

In the JMP R&D Division, a team of technical writers create the JMP documentation and Help system. The documentation is produced using industry standard publishing tools that result in both printed documentation and Help files that are created from a single set of source files.

Software installers for JMP are built by using industry standard tools. The installers for JMP on Windows are built using InstallShield and installers for JMP on Macintosh are built using Installer Vise from MindVision. Linux installers are created using a proprietary development processes.

Localization vendors translate JMP software into French, German, Japanese, Simplified Chinese, and Italian. Translation is done either during the development process or immediately after a major version of JMP is released to production.

The JMP documentation and Help system are translated into Japanese and Simplified Chinese after the production release of a major version. These translations are then included in maintenance updates to the major version.

Software Development Lifecycle for JMP

The process that is used to develop JMP software is modeled generally after the process that is used by the Research and Development Division at SAS, as described in "The software development life cycle" section of "The Quality Imperative." Additional process details that are specific to JMP software development are explained below.

JMP software has major versions scheduled for release on an 18-month cycle, with minor maintenance releases that are scheduled every four to six months as necessary. Maintenance releases contain fixes to

problems that have been reported by customers. Occasionally, maintenance releases also contain minor feature enhancements that are based on requests from customers.

Requirements and Planning

Early requirements are gathered through several channels:

- Customer and development partner requests
- Marketing analysis and requests
- Technical support requests
- Development and testing staff discussion and recommendations

Requirements are tracked informally on a JMP R&D wiki site. Technical Support and other customer-facing staff also enter requirements into the DEFECTS system as suggestions from customers. These requirements are prioritized with other development work as development progresses on a new version.

Requirements and design evolve iteratively through a process of prototyping and pre-production beta releases to select customers and academic advisors across multiple industries and disciplines. Input is gathered through e-mail, and problems with the software are tracked through the DEFECTS system.

Major Release Development and Testing

Milestones and goal dates are reviewed throughout the release in weekly management meetings, and adjusted within the cycle based on code stability, quality, testing coverage, and additional product needs.

R&D management meets weekly throughout the development cycle to track internal development phases:

1. **Early Development:** During this phase, new features are implemented. New feature development can involve peer code reviews, interaction with customer development partners, or experts in a particular discipline. There are peer code reviews during this period in which the developer selects one or two other developers to explain their code modification and get feedback on coding and implementation. Each code change that is submitted is followed by an e-mail notification to the development and management team with details about the implementation. Automated regression testing begins on existing features at this phase, and development testing begins on new features as they become functional.
2. **Feature Freeze:** When this phase is reached, new features have been implemented but have not been fully tested. Fixing bugs becomes the primary focus.
3. **Code Review:** After continued testing and bug fixing, the software is fairly stable and the code review phase is reached. At this phase, all new code changes are reviewed to ensure that the changes address the intended issue and do not introduce additional errors. The review is conducted by one or two peer developers. The peer reviewers are noted in code push reports as code is checked into the source management system.

4. **Code Approval:** In this phase the software release is imminent and code changes are made only with permission from an approval board. Approval by at least four of the eight board members is required before a code push. The approvers are named in the push report that is created when the code is checked into the source management system with comments that explain the code change. An e-mail is sent to the development and testing team explaining the change and push.
5. **Handoff to release engineering groups:** Final release engineering and package validation is completed before shipment to customers.

Pre-Production Feature and Usability Testing

The JMP research and development process relies heavily on customer data and on customer feedback as a mechanism for providing input regarding usability and feature validation within specific and unique customer environments.

Throughout the development cycle, as the software becomes stable and as new features are ready for user testing, pre-production releases are made available to internal users and external customers under non-disclosure agreement. Customers provide input to JMP research and development regarding usability, installation, feature implementation, and any other challenges that are presented by their environment. Using the DEFECTS system, issues are evaluated and prioritized, and then either fixed within the remaining cycles of the release or deferred to a future version.

Testing and Validation

Throughout the development process, JMP testing and validation specialists continually test updated versions of the software. A specialized statistical team verifies statistical results from JMP. Results from JMP are compared to the SAS System and other sources to ensure the highest level of accuracy that is possible. Methodology for testing the JMP software's numerical accuracy is effectively the same as the SAS approach. See "Validating a statistical procedure" in Appendix 1 of "The Quality Imperative" for more information.

An automated process compiles and tests JMP software every week night. After the build process is completed, automated tests are run against an installed image. When this process is complete, user-ready installs are built and delivered to the JMP testing department. Testing results are published to a development Web site for investigation daily. Bugs are entered and if larger scale issues are discovered, they can prompt a rebuild of the system or another action.

Testing of new features is done manually and ad hoc in early development and tests are added to the automated frameworks as the code becomes more stable.

Automated regression testing and manual testing of new features begins when the development track for a major version is established and new feature development begins. JMP testing and development groups maintain a set of more than 20,000 programmatic tests that run in a proprietary framework. These tests and the automated test framework are written by quality assurance engineers and developers using the JMP scripting language (JSL). The tests are run regularly across all releases and exercise code at the unit, system, integration, and regression levels. Tests are also written at the unit level in C++. Test coverage for numerical tests is monitored at the branch/decision level from within the C++ source files by tools that were written using JMP proprietary code. To ensure that important

combinations of options and system testing considerations are developed efficiently, the experimental design features of JMP software itself are used for generating testing coverage matrices. There is an additional suite of performance tests for basic JMP functionality. This full suite of automated tests runs nightly on all operating systems that JMP supports.

As new features are developed, testers, writers, and programmers meet to review the functionality. As they are developed, new features are demonstrated weekly in meetings that involve Development, Documentation, Testing, Technical Support, Education, and Sales and Marketing. These demos include discussion and collaboration regarding coding and implementation for proposed changes that have wide impact. The demos also enable discussion and understanding of requirements by everyone on the JMP team.

Problems are reported and managed in the DEFECTS system. Automated reports categorize problems by priority, developer name, area of code, and version number where the problem was found. As fixes are made and verified, the current status is updated in the DEFECTS system. Verification of code fixes is done by the testing group using a DEFECTS verification tool. Documentation regarding the verification of the fix is maintained in the DEFECTS system.

Release Completion and Package Validation

When development and testing of a new version of JMP are complete, a production release candidate version is delivered to the release engineering groups who then create release package candidates.

The JMP testing and validation team, development, technical support, and product management review the package candidates to ensure that all requirements are met. After signoff by all reviewers, under the direction of the SAS director of quality assurance, the software is released to production.

Maintenance Releases

After a major version is available to customers, customer-reported bugs and issues are reported primarily through the SAS Technical Support Division. These issues are tracked in the DEFECTS system. When appropriate, fixes to these problems are made in the next major release track in the source management system. The approval board also evaluates fixes for inclusion in a scheduled maintenance release.

Code for maintenance releases is reviewed and approved by the approval board. Fixes are tested before inclusion in the maintenance track, and automated tests are updated appropriately.

To ensure that issues are not introduced as a result of fixes that are made in the maintenance track, automated regression testing on the maintenance version is done throughout a maintenance cycle.

Maintenance releases occur every four to six months as needed to address customer reported bugs and issues.

Technical Support

The SAS Technical Support Division supports JMP software. See Appendix 2: “Quality in technical support” in “The Quality Imperative” for details about SAS Technical Support.

Training

A comprehensive curriculum of JMP courses, prepared for novice to expert JMP users, is available through the SAS Education Division. Instructor-based training is provided in public courses at SAS regional training facilities across the United States or through SAS Live Web. On-site courses can also be provided at the customer's location. Developed and taught by JMP technical training specialists, these courses use the most current JMP software. Content lectures, software demonstrations, hands-on computer workshops, and a copy of course notes are included with each course.

The Training portion of the JMP Web site (www.jmp.com/training) provides detailed information about all facets of JMP training courses.

FDA-Regulated Industries and Compliance with CFR Title 21 Part 11

For purposes of U.S. Food and Drug Administration (FDA) validation, JMP should be considered a tool, just as SAS is considered a tool.

JMP customers who are FDA-regulated might be expected to validate the systems they build with JMP. Because JMP is a tool, the user must show the FDA that JMP is being used correctly. See “Complying with United States Code of Federal Regulations, Title 21 Part 11” in Appendix 1: “FDA-related issues” in “The Quality Imperative” for more information.

Customers can recreate analyses by saving JMP Scripting Language scripts with a JMP data table. Customers can then use JMP to explore and analyze. When the analysis is complete, customers can save the JMP script to the data table. The JMP report can have date and time information embedded. Customers should keep the data table with the JMP script attached and the JMP report in the source control system as a read-only file. If any changes are needed in the future, customers can use the source control system to check the data table out, make the changes, and check the file back in.

The FDA has adopted a SAS transport format as the standard for accepting and archiving data sets. See the FDA and SAS Technology Web page (www.sas.com/govedu/fda/index.html). Note that JMP software can read and write transport format.

Because JMP provides interfaces to SAS software, all of the techniques that are described in Appendix 1: “FDA-related issues” in “The Quality Imperative” are available to JMP customers who also have SAS installed.

Operational Qualification (OQ)

To facilitate customer validation, JMP provides both a set of baseline tests and also an extendable test framework that are written in the JMP scripting language (JSL). The tests are written to an external standard for validation of statistical software, provided by the National Institute of Standards and Technology (NIST). These tests are not designed to cover every statistical function in JMP. Customers are encouraged to use these tests and framework as a basis for their own validation work. The JMP NIST tests are available on the JMP Web site (www.jmp.com/qualitystatement) and described in a white paper that is also available on the JMP Web site: “Assessing the Numerical Accuracy of JMP”.

Additional Assistance

Questions regarding the JMP quality initiatives and validation should be directed to qualitypaper@sas.com.