The Quality Imperative: SAS Institute’s Commitment to Quality

A corporate statement of SAS’ commitment to product quality, service quality, and customer satisfaction.
Release Information

The version of this paper is February 2018.

Unless otherwise indicated, this document relates only to SAS 9.4, SAS Viya, and the products that are available with SAS 9.4 and SAS Viya. It also relates to services from the date of this paper forward. Quality processes are continually evolving; therefore, SAS reserves the right to modify the processes described in this document at any time. Most of the processes outlined in this paper are appropriate for SAS 9.4 and SAS Viya. If you are using SAS 9.4 and SAS Viya and have questions about processes in those releases, send email to qualitypaper@sas.com.

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Introduction

Introducing SAS

For SAS, the pursuit of excellence lies at the heart of the products we deliver. Jim Goodnight, CEO of SAS, states that “SAS’ commitment to quality permeates every division and employee throughout our global company. From the software we produce, to the customers we serve, and through our collaboration with each other, quality is at our core. It’s who we are and is the foundation on which our company was built.”

SAS is the world’s largest privately held software company with over 14,000 employees and 83,000 customer sites in 149 countries. Forging strong relationships with our customers have made us a leader in analytics for over 40 years. Our focus on customer needs is demonstrated in our annual re-investment of around 25% of revenues into research and development, where the industry average is 12%.

SAS provides an integrated suite of analytics, business intelligence, customer intelligence, data management, fraud, and risk. Our products transform data into the information organizations use to make good decisions. SAS enables customers to apply analytics wherever they demand—whether in the cloud, on-site, at the device, or with machines as full partners in human decision making. As Goodnight said, “We aim to help every customer turn analytic insights into value. We do so by adapting to changing markets, working with disruptive technologies, and remaining relentlessly committed to innovation. This has allowed us to remain a leader across core markets while providing innovative solutions to our customers’ most challenging business problems.”

SAS, the company, runs our own operational systems on SAS technology. Since SAS software is licensed, we know that customers have a regular opportunity to evaluate their SAS software investment. We understand. As one of the largest customers of SAS software, we live the importance of high-quality, reliable software.

The Quality Imperative

*SAS’ commitment to quality is constant, like our commitment to the customer. The two really go hand-in-hand. When we talk about quality, it’s not just about quality assurance and software testing. The Quality Imperative articulates how quality is in everything we do.* —Oliver Schabenberger, Executive Vice President, Chief Operating Officer and Chief Technology Officer

The SAS Quality Imperative (www.sas.com/qualitypaper) describes the essential role of quality in the creation and delivery of SAS products and services. The products distributed by SAS that are covered by this paper are listed in Appendix 10: SAS Products.

JMP and SAS Solutions OnDemand also have papers to document their unique needs for processes and tools:

- JMP: A Commitment to Quality (http://www.jmp.com/qualitystatement)
To learn more about our company, customers, and our award-winning culture where quality is integrated into all that we do, visit our website:

- SAS company information page (www.sas.com/company)
- Customer success page (www.sas.com/customers)
- Annual report (www.sas.com/annual-report)
- SAS Corporate Social Responsibility (www.sas.com/csr)
- Security Assurance from SAS (www.sas.com/security-assurance)
- Recognition from independent industry experts (http://www.sas.com/awards/index.html)

Human Resources

Our Employees

Our culture is based on three simple things: trust, flexibility and values. SAS is a company built on relationships, and our relationships with customers are only going to be as good as our employees’ experience at SAS. That experience is based on meaningful work, empowering leadership, and a world-class work environment. —Jim Goodnight, CEO of SAS

Focusing on people and relationships—making employees a top priority—leads to more productive, satisfied, and dedicated employees. They take care of the company that takes care of them. To achieve that ideal, employees must be trusted and valued, to feel that they make a difference. To support the creative process and balance work and family, they must be offered a flexible work environment that enables them to be the most productive.

SAS’ strength comes from its culture, which is rich in diverse people, talent, and ideas. Our collective strength and passion for what we do drive innovative solutions that solve the most complex customer problems. —Jennifer Mann, Vice President, SAS Human Resources

The 2016 metrics point to success in achieving this vision. Average tenure is 8 years; more than 1,000 employees have worked 20 years or more. Annual turnover averages 6.5% (US average in the software industry is about 18.4%).

The company’s work-life programs and unique corporate culture continue to receive accolades— at global, regional, and local levels—for being a great workplace. In 2017, SAS celebrated its 20th year as one of Fortune magazine’s best US workplaces. Many of our country offices have also been recognized for their workplace culture by the Great Place to Work Institute or by Top Employer. A full list of corporate awards can be found here: http://www.sas.com/awards/index.html.

The recognition speaks to the employee-focused philosophy behind SAS’ corporate culture since the company’s founding in 1976: if you treat employees as if they make a difference to the company, then they will make a difference to the company. At the heart of this unique business model is a simple idea: satisfied employees lead to satisfied customers.

SAS’ work teams thrive on a diverse interplay of experience, backgrounds and perspectives. Employees’ collective strength and passion for what they do ignites big ideas and powerful bonds. SAS continues to provide equal employment opportunity for all employees regardless of age, race, color, gender identity, religion, creed, ancestry, nation origin, citizenship, marital status, sexual orientation, disability, medical condition, veteran status, pregnancy or any other protected class as defined by federal, state or local law.
Quality Workforce

Designing and implementing SAS software requires a development staff with highly developed programming skills and significant subject-matter expertise. As part of SAS’ effort to attract and retain the best available employees, the Human Resources Division has implemented a number of programs and standards, as shown in the following examples:

- To be considered for an open position, all applicants must meet the specific education, training, and experience qualifications for the open position.

- For each position at the company, there is a written job description, specifying necessary education or experience and job functions.

- Competency-based interviewing is used to identify the ability, experience, and knowledge that is required for a particular position. In addition, numerous interviews are conducted with an applicant. This practice enables SAS to be as inclusive as possible, while also enabling the interviewee to experience the culture and the people who create the culture.

- SAS’ approach to performance management is aligned to business needs, employee skills, and career development. We promote ongoing conversations between managers and employees around expectations, skills, and development. Performance management occurs continually.

- SAS performs pre-employment drug, alcohol, and criminal background screening on every final applicant for employment in accordance with SAS’ Human Resources policy. Additionally, we conduct background checks on contractors and other third parties per the SAS Human Resources policy for contingent workers.

- All SAS staff nominated and assigned to any agreed project role must possess the skills, experience, and knowledge required to meet assigned duties or deliver expected work products. Recognition as a best place to work enables SAS to hire and retain the best employees in the industry.

At SAS, analytical and statistical software is designed, written, and tested by highly specialized statisticians to ensure that the proper numeric algorithms are selected and implemented, as demonstrated by the following metrics:

73% of the development and testing staff working on statistical products in SAS Foundation have advanced degrees, and 74% of the employees with advanced degrees have PhDs in fields such as statistics, mathematics, and operations research.

- Within SAS Solutions OnDemand, 91% of the analysts working in the Advanced Analytics Lab have advanced degrees in fields such as statistics, mathematics, and analytics. Of those who have advanced degrees, 33% have PhDs.

- Within the JMP Division, 51% of the analytics developers and testers have advanced degrees, and 65% of those have PhDs.

- Product-area expertise is also important. Product developers have experience in operations research, time series analysis, as well as in finance, pharmaceuticals, and other fields through previous work experience and education.

Our organization is built on the high quality of our employees and the executives who lead them. See the executive biographical information (http://www.sas.com/presscenter/bios_exec.html) to learn more about SAS executives. We consider our organizational chart to be confidential and do not disclose it.

Employee Training

Employee training at SAS is an ongoing endeavor that begins during new employee orientation and continues throughout employment. Training content can be delivered through a variety of channels, such as instructor-led and e-learning courses, to provide staff with options that are most appropriate for their learning style. Many training courses are accessible through the SAS Learning Management System and are available for viewing at any time. Furthermore, an extensive corporate library contains bound volumes, periodical subscriptions, complete SAS documentation, and
audio and video training materials. The technical training and professional development of our employees is critical to the SAS quality process. For more information, see Appendix 3: Employee Training.

**Employee Certifications**

SAS employees have achieved various professional certifications in hardware and software that enhance their ability to deliver a quality product to customers. These include Certified Information Systems Security Professional (CISSP®), Project Management Professional (PMP), Six Sigma, Information Technology Infrastructure Library (ITIL), American Society for Quality Manager of Quality/Organizational Excellence, Certified Software Quality Engineer (CSQE), and various hardware and software personal certifications.

**Work Environment**

**Quality Starts with Communication**

Employees are influential at SAS because the company’s leadership understands that employees have valuable feedback and are the main drivers of change, momentum, and innovation for the company.

At a company with more than 14,000 employees in 59 countries around the world, connecting with employees is important. The SAS Internal Communications team responds to the challenge by using a broad range of communication tools. Our most recent Internal Communications Survey, conducted in 2016, found that 95% of employees believe company executives (C-level, senior vice president, and vice president) communicate effectively.

The primary internal communications vehicle is the company’s intranet, the SAS Wide Web (SWW). SAS also uses webcasts, podcasts, and town hall events as global communication tools. Lunch-and-Learn sessions provide opportunities for peer-to-peer learning and networking. Innovative BetaLabs invite SAS employees across the company to interact with software before it is released, promoting internal knowledge of SAS products, and generating invaluable feedback for product teams. BetaLabs promote communication on product quality and features within SAS, so that potential issues are found and resolved before the products are released to the market.

Social media use within SAS continues to expand—from blogs to our internal social media network called The Hub—to create a tight-knit virtual community. In addition, most major divisions have regular internal webcasts that enable employees to obtain updates on divisional priorities, and to ask questions of upper-level management. Several divisions also deliver periodic newsletters, support dedicated Microsoft SharePoint sites or wikis or both, and produce podcasts. These media are updated regularly with information about divisional priorities, goals, news, and changes.

Whether executives are hosting a webcast for a global audience, holding a town hall event at a regional office, or meeting informally over coffee with a handful of employees, there is an atmosphere of sharing and openness. Employees in the audience or watching online are encouraged to ask whatever is on their minds. Besides encouraging employee comments in face-to-face meetings with executives, almost every event is followed by a survey, which allows staff to offer feedback anonymously.

SAS also receives feedback from employees via the annual Great Place to Work survey and a company-wide global survey. In 2016, SAS conducted a Global Employee Survey. Human Resource Business Partners worked with division heads and country managers to address the most notable concerns and propose recommended courses of action. The company used this feedback to implement new programs. Many divisions conducted their own feedback surveys to follow up on areas of specific concern to them. To the overall survey question of “Taking everything into account, I would say this is a great place to work,” 94% responded positively.
Corporate Services

The groups in Corporate Services are responsible for the safe and secure work environment of more than 7,000 employees on the SAS Cary campus and at regional offices throughout the United States. A Corporate Services Global Operations group was formed to work with global and regional offices to align operational processes around best practices and related business strategies globally. Departments within the Corporate Services Division and offices globally adhere to SAS’ statement on sustainability. For more information see www.sas.com/csr.

Corporate Real Estate

The Corporate Real Estate Department is responsible for the design and construction of all new buildings on the SAS Worldwide Headquarters campus, leased space in all regional U.S. offices, and coordination of design and leasing for SAS global offices. All U.S. SAS construction is designed and built at or above current building code guidelines and follows environmental guidelines developed through LEED (Leadership in Energy and Environmental Design).

Environmental systems are computerized to reduce energy costs, and all computer operations areas are climate controlled. The majority of U.S. employees have private offices. Currently, SAS has offices in most major U.S. cities and conforms to local building codes and guidelines as directed by the landlord and local regulations. SAS has adopted a Flexible Work Arrangement (FWA) option for regional locations. The FWA program provides support for an employee to work from home and flex space in regional offices to reserve as needed. The FWA program promotes employee work/life balance and provides a smart commute option to reduce traffic congestion.

Facilities

The 300 developed acres that comprise the SAS Worldwide Headquarters campus are maintained by SAS’ Facilities Department. This group has more than 200 employees who work in Facilities Management, Facilities Services, Housekeeping, and Interior and Exterior Landscaping.

Security and Safety

SAS’ Security and Safety Department provides a safe and secure work environment at SAS’ Worldwide Headquarters and supports worldwide operations. The exact combination of safety and security measures is based on the needs of the location. One example of differing needs is based on whether SAS leases a space within a secured building or owns a building. SAS deploys physical, personnel, electronic, and procedural measures, such as the following:

- Pre-employment screening; awareness and education activities.
- Access control through staffed gates, card access readers, and security reception desks.
- Fire detection, alarm, and suppression (protection) systems.
- Closed circuit television (CCTV) system.
- Uniformed security personnel for both proactive deterrent patrols and various emergency and non-emergency (customer service) responses.
- Every U.S. regional office has CCTVs and card access readers.
- Most global spaces have property management companies we rely upon who know the local constraints on securing buildings (i.e., only 11 of our properties are owned by SAS). For example, we ensure that access controls are in place in all global locations, but some countries will not allow CCTV.

SAS strives to continually provide all employees with the safety and health knowledge, tools, and environment needed to have a safe, healthy, and productive work life, minimizing the risk of accidents, injury, and exposure to health
hazards. The Security and Safety Department fulfills these responsibilities by primarily focusing on these organizational goals:

- Prediction and assessment by evaluating the probability, criticality, and business impact of potential security and safety risks.
- Prevention and protection by implementing the necessary controls to minimize the negative business impact of identified security, safety, and fire risks while providing a safe and secure environment.
- Detection and investigation by identifying security-related exposures to emergencies and critical incidents to limit injury to people, as well as damage to property and the environment.
- Compliance with all local, state, and federal environmental regulations.
- In the U.S., our Safety Department is dedicated to ensuring compliance in accordance to the Occupational Safety and Health Administration (OSHA).

Security and Safety is also the point of contact for the following:

- Coordination of many safety programs, such as CPR, first aid, defensive driving, child safety, life safety, hearing conservation, respiratory protection, bloodborne pathogens, and similar initiatives.
- Administering a comprehensive program to prevent, identify, and correct Indoor Air Quality (IAQ) concerns and to strive to reduce our impact on the environment.
- Loss control services.

Access to SAS Data Centers is restricted to authorized employees and contractors tasked with maintaining the hardware or software in those environments, and business partners who support specific business operations.

- SAS Data Center management is responsible for authorizing and reviewing physical access monthly.
- Badge readers are located at each entry point to hosting rooms, and badges must always be worn and visible within the SAS Data Center.
- The SAS Solutions OnDemand environment for hosted customers requires additional badge readers and Personal Identification Number (PIN) codes.

**Continuity of Business**

Continuity of Business (COB) refers to an organization’s plans and procedures aimed at protecting its key assets and continuing its critical business functions in the event of anticipated and unanticipated threats. COB takes into consideration the primary factors that customers consider when selecting the strategic vendors to which they entrust their business: corporate governance, information security, and corporate social responsibility. For information about SAS’ COB Program, see [http://www.sas.com/content/dam/SAS/en_us/doc/other1/continuity-of-business.pdf](http://www.sas.com/content/dam/SAS/en_us/doc/other1/continuity-of-business.pdf). You can also send email to COBProgramOffice@sas.com.

**Availability of Source Code**

A copy of the source code for all supported production products is kept in a secure off-site environment to enable recovery following a disaster. SAS staff has ready access to all nightly backups, and the off-site code is updated weekly to make sure that it is current. Customers have inquired whether source code is available for an FDA audit if required for compliance needs. SAS would allow the FDA to examine relevant portions of the source code on a secure machine at SAS headquarters pursuant to appropriate confidentiality agreements.

**COB in Hosted Environments**

Information Technology

SAS Information Technology (IT) partners with SAS business units to deliver global services that increase business value through trust and partnership. IT is committed to service excellence and has established practices, including continuous service improvement, which provides a framework for measuring and improving performance. The following quality practices are in place to ensure that IT provides and supports quality services:

**Software Engineering**

- Enterprise architecture to drive an integrated environment that is responsive to change and supportive of the delivery of the business strategy.
- Comprehensive enterprise solution testing (unit, functional, usability, load and performance, exploratory, accessibility, etc.) to ensure that solutions meet functional and nonfunctional requirements.
- End-user testing of SAS offerings to provide feedback to R&D groups regarding fit for IT use.

**Security and Compliance**

- Layered industry standard security controls and defenses to protect the business.
- Penetration testing to identify and resolve systemic weaknesses within the overall information security program.
- Security audit and compliance to ensure adherence to security controls and defenses.

**Service Excellence**

- Rich automation with a focus on self-service to ensure repeatable processes and to drive efficiencies.
- DevOps to ensure collaboration and communication of both software developers and operations professionals while automating the process of software delivery and infrastructure changes.
- Operational processes based on the ITIL framework (request, incident, problem, change, configuration management, and knowledge management) to ensure a quality service management approach.
- Supplier qualification and audits against set criteria to ensure that quality requirements are met.
- Project management with strong application of agile to plan, track, and control global projects.
- Strong business relationship management with IT’s internal business partners to ensure business alignment of priorities and initiatives.
- Training and development for SAS employees to ensure that skillsets are strong and relevant.

**Continuous Improvement**

- Root cause analysis to prevent recurring incidents.
- Metrics and analytics to measure, optimize, and forecast.

SAS IT is committed to providing quality services. We have documented IT policies and procedures that outline our approach. All SAS employees with access to the IT environment are required to be trained on these policies and procedures. These policies and procedures are updated and approved by IT Leadership, including our CIO and CISO, on an annual basis.

**Protecting Privacy**

SAS is committed to complying with all applicable global data protection and privacy laws, both with respect to personal information about our employees and with respect to personal information that is collected or received from our customers. To prevent unauthorized access or disclosure, to maintain data accuracy, and to ensure appropriate and
lawful use, we have put in place reasonable physical, electronic, and managerial procedures to safeguard and secure such information.


Quality in Software Development

Technical Industry Standards

Encouraging creativity is important in an R&D environment. Standards, however, are needed so that the resulting software fits together as a whole. Our standards and guidelines cover various aspects of the final product—defining what is needed for the various pieces to work together and making possible common user interface features. At SAS, we monitor external standards, process assessments, and industry requirements, such as the International Organization for Standardization (ISO) and the Institute of Electrical and Electronics Engineers (IEEE) standards, the Capability Maturity Model Integration (CMMI) process assessment, the FDA Code of Federal Regulations, and others. SAS’ internal quality processes have evolved based on our understanding and assessment of such external factors. We also participate in standards development groups to bring the software-only producer voice into the discussion, and we constantly update our standards as technology evolves and customers’ needs change. SAS supports external and industry standards through support of employee activities in the following areas:

- Monitoring external and industry standards, process assessments, and industry requirements, such as ISO and IEEE standards, and the CMMI process assessment.
- Participating in various external standards committees.
- Reviewing IEEE standards and applying those standards that are appropriate to SAS software.
- Playing a key role in many vendor-sponsored, independent software vendor councils so that SAS performs effectively on the latest versions of these vendors’ operating environments.
- Supporting industry-sponsored interfaces.
- Maintaining strategic and cooperative relationships with the leading hardware and software manufacturers.
- Supporting employee membership in professional organizations.
- Making industry information and issues available to employees on the company’s internal website.

R&D Standards

There is a strong business need for consistency in our customer-facing products and documentation. R&D uses internal standards, procedures, and guidelines to ensure that consistent development methods, architectural components, software engineering processes, and tools are used by staff to produce quality deliverables for customers. By adopting standard approaches for customer deliverables and the methods for producing them, we can more efficiently satisfy our customer requirements. These standards, which are continually being refined, expanded, and enhanced, are formally documented and are approved by the Chief Technology Officer.

To provide a foundation for standard coding practices, development teams follow documented standards for software security, globalization, accessibility, interfaces, and others, along with procedures and guidelines that ensure conformance to standards.
Software Security

SAS is committed to delivering and maintaining products that are designed to meet the security requirements of its customers. All product teams must follow software security standards to ensure delivery and maintenance of secure software. Details on software security standards are found in this paper’s Software Security Testing section.

Software Globalization

Software globalization refers to the process of designing and developing applications that function for multiple cultures. This process consists of two core functions: internationalization (i18n) and localization (l10n).

Internationalization entails designing and implementing software so that the English version of the software functions properly and processes data correctly for any locale or region of the world. Internationalization also ensures that the software is designed so that it is ready for the localization process.

Localization, on the other hand, is mostly driven by market demand. It is the process of adapting software for a particular geographical region or locale. Translation of the user interface, system messages, and documentation is a large part (but not all) of the localization process. Most importantly, not all global markets require that the product be localized (translated) into their native language.

At SAS, software globalization teams around the world spearhead efforts to drive quality and best practices in this area in the following ways:

Internationalization:

- Executing formal test plans simultaneously with the development cycle in order to detect cultural or language bias in all SAS software as early as possible
- Handling data represented in character encodings that are supported by modern technologies
- Supporting collation of data according to expected linguistic or cultural guidelines
- Supporting formatting of dates, times, and numbers according to cultural expectations
- Supporting multi-lingual data processing
- Supporting SAS products in multiple languages to meet the needs of international customers
- Supporting a report model that allows one report to be translated into many languages
- Testing in non-English environments
- Testing with non-English data
- Testing with multilingual data

Localization:

- Localizing software on a schedule that allows for simultaneous shipping with English
- Maximizing reuse of translations to ensure consistency and higher quality user experience
- Testing localized versions of the software in country to provide higher quality translations

Accessibility

SAS is committed to improving accessibility in its software products and solutions. For all new product development, SAS designs products as guided by U.S. and international standards for accessibility. Our primary target for all software is the Web Content Accessibility Guidelines (WCAG) 2.0 at the A and AA levels as defined by the World Wide Web Consortium (W3C). We also follow the U.S. Access Board’s Section 508 – 1194.21 and 1194.22 guidelines.
Members of the R&D staff receive training in accessibility technologies, such as Accessible Rich Internet Applications (ARIA, a specification from the W3C). Internal training on WCAG, keyboard operations, software accessibility, and web accessibility is available. Internal training on effective testing with assistive technologies, such as screen readers and voice input devices, helps testers validate adherence to accessibility standards. Product test suites include an accessibility test plan: using a standard test case, products are tested to evaluate functional performance with assistive technologies. By making our products accessible, exposing interface information (for example, name, state, methods), not only do we promote interoperability with assistive technologies, but we also enhance our ability to automate testing.

There is a central contact within R&D for accessibility-related issues. This person looks at available tools, coordinates training, establishes guidelines and checklists, assists in testing applications for compliance, and works with customers to address accessibility questions. We provide alternate means for accessing support services, along with alternate formats of support documentation to accommodate the communication needs of users with disabilities. We will continue to refine the software development process so that accessibility is considered at every step in the process.

For more information, see http://www.sas.com/accessibility.

Interface Standards

SAS follows user interface standards that are based on research, usability testing, and other disciplines. The standards are compiled with input and approval from the user experience design, visual design, accessibility, documentation, internationalization, and legal teams. SAS user interface standards govern the following areas:

User interaction and visual design
- Accessibility
- Embedded user assistance (including legal information) and terminology
- Internationalization

Following these standards promotes these results:
- Ensures that SAS products are usable
- Establishes a consistent look-and-feel for SAS products
- Provides a high-quality user experience to all users

Ensuring Reliability

Testing

One measure of reliability is obtained by testing. See the Software Testing section of this paper for details on the processes, tools, and types of testing that we use to ensure reliability.

Secure Development Process

We scan all of the components of our software, including third-party components, against VulnDB, as well as the National Vulnerability Database (NVD) maintained by the U.S. government’s National Institute of Standards and Technology (NIST). This enables us to detect potential security vulnerabilities and weaknesses so that they can be remediated as quickly as possible. We publish security bulletins on our website as part of our formal Product Security Incident Response Team (PSIRT) process. For details, see Software Security.
Shared Sublibraries and Code Reuse

We have a rich tradition of reuse and we regularly use our prior work as the building blocks of innovations in applications. SAS software products share the same sublibraries or components. As a result, there is a high incidence of code reuse. Developers are encouraged to reuse routines when possible. Each routine is tested in the development environment and then across supported operating environments. We have several reuse categories of shared components: MultiVendor Architecture (MVA) and threaded kernel (TK) libraries; SAS and SAS Component Language (SCL) code; .NET; Java libraries; JavaScript; and FLEX libraries. Low-level, reusable modules are unit tested and then these modules are used in developing more complex modules. Shared components are tested on machines with multiple SAS releases and are also tested after installing or uninstalling releases. The benefit of shared sublibraries is that a significant percentage of code has been tested collectively across a wide variety of operating and computing environments. SAS is built with source code and components that are reused from release to release. This adds stability to the software because each successive release of SAS software inherits code that has been tested and used in prior releases.

We also benefit from the reuse of third-party components that SAS has licensed. For details, see Third-Party Components. The benefits include using well-tested components. Such widely used components are easier for customers to manage and administer because they are known entities. Furthermore, when new staff use familiar libraries, fewer defects arise.

Numerical Accuracy

Two of the most critical issues in software development, especially for analytical software, are the accuracy and reliability of results. In this context, accuracy describes the degree of agreement between the reported result and the unique true value, if such exists. Sometimes, rather than a unique solution, any solution from a set of solutions is also acceptable. Reliability is a more subjective measure, taking into account the degree of confidence in the accuracy of the result.

There are two factors that affect the accuracy of a computed result. The first factor is the hardware’s ability to represent real numbers in finite precision. Not all real numbers can be represented in binary finite precision, and that means that representation of real numbers might introduce errors because of binary rounding. Arithmetic operations might also introduce rounding errors.

The second factor is the software itself. Internally, for analytical computations in SAS software, all numeric representations, functions, and operations are calculated by using double-precision, floating-point arithmetic that offers the maximum level of precision provided by the underlying architecture. Although single-precision arithmetic allows only 6 to 7 significant digits, double precision arithmetic allows 15 to 16 significant digits. Accuracy might be further limited by the algorithms that are selected and by the implementation strategies. Algorithms must be chosen carefully and coded to achieve optimal performance, as measured by speed, efficiency, and precision.

At SAS, developers carefully select and code efficient algorithms for numeric operations to guarantee a reasonable number of correct digits and the maximum domain of evaluation on most machines. When the software cannot guarantee this predetermined level of accuracy, the software is designed to return a missing result rather than a potentially inaccurate result.

In response to industrial concerns about the numerical accuracy of computations from statistical software, the National Institute of Standards and Technology's (NIST) Information Technology Laboratory provided data sets with certified values for a variety of statistical methods (NIST 2007). As one of many approaches to ensure accuracy, SAS integrates NIST data into automated tests and compares SAS results to the results that are supplied by NIST.
Our developers take steps to see that SAS works correctly with operating system datetime functions. In general, we rely upon operating system datetime values and perform checks to ensure correct functioning for special situations, such as daylight savings time.

SAS procedures have numerous options that alter the nature and extent of output. However, the same output is always produced with the same options, even across hardware and operating systems within standard machine precision limits (typically 1E-12 or smaller). This assumes that the same random number seed is specified for algorithms requiring pseudo-random number generation.

SAS’ uncompromising pursuit of accuracy has firmly established SAS software as one of the most reliable products on the market today. Extensive use of SAS software in medical and pharmaceutical research, government statistical reporting, and government and academic epidemiological studies attests to customers’ confidence in the accuracy of SAS software.

For more information about validating a statistical procedure, see Appendix 6.

For more information about numerical precision, see:
- The paper "Assessing the Numerical Accuracy of SAS Software" (http://support.sas.com/rnd/app/stat/papers/statisticalaccuracy.pdf)

Algorithm Choices

SAS staff reviews the relevant literature and evaluates established algorithms for numerical stability, time requirements, and space requirements. We choose one or more algorithms that provide the best combinations of these sometimes conflicting requirements. If we cannot find satisfactory algorithms in the literature, then we might perform research to develop better algorithms in-house. All algorithms that we use are extensively tested. Furthermore, our statistical software documentation provides sections covering computational details and references to source literature.

Third-Party Components

SAS integrates with a number of third-party software components, including Java Runtime Environments (JREs), application servers, web servers, webDAV servers, browsers, and databases, to name a few. Some of these components are provided by SAS and are installed along with SAS products. Others must be acquired directly from the third-party software vendor either on media that is shipped directly to users or ordered over the internet. We review licenses for all our third-party components, including open-source components, to ensure that we comply with all requirements. Just like SAS, our partners are continually updating and improving their software to address customer-reported problems, performance issues, new operating system releases, and the latest security threats. Keeping up with all these changes is a challenge for us and, more importantly, it is a challenge for our customers. We have a defined process for identifying and integrating third-party products into our software. We test most of the baselines with a large number of configurations. We also test above some of the baseline releases if we are aware of issues or believe there might be issues.

SAS users can find third-party components on the Third-Party Software Downloads website at http://support.sas.com/resources/thirdpartysupport/baseline_plus.html. This page contains links to third-party software that we have tested but do not redistribute with our products. It also contains links to our latest release recommendations for all of our components. The page also has important customer bulletins related to the components that we have shipped, are recommending, or have evaluated.
In general, it is our intent to treat the components that are shipped with our products as a minimum version, rather than as an absolute requirement. If customers need a third-party component upgrade that is not addressed on our website, they can contact SAS Technical Support for guidance.

**Software Quality**

At SAS, quality is integrated into each step of the software development process. Every executive, manager, and staff member who plays a part in software development and support is responsible for building quality into our products and services. Senior executives, including the CEO, monitor key quality indicators throughout the software development life cycle.

The Chief Technology Officer of R&D is accountable for the overall quality of SAS software. The Vice President of Quality User-Driven Enterprise Software Testing (QUEST) reports directly to the Head of R&D as do many of the leaders of product development groups. The Software Quality group reports to the Vice President of QUEST as do many of the product testing groups. The software quality group, led by the Director of Software Quality, serves as a center of excellence for researching, monitoring, and initiating responses to quality issues across all product lines.

![Figure 1: Independent Quality Organization](image)

**Software Quality Analysts**

Software quality analysts engage and collaborate with R&D staff to define, document, and integrate quality processes, technologies, and best practices. Here are examples:

- Consolidation and sharing of key quality indicators
- Publication and communication of R&D guidelines and best practices
- Education and mentorship of new staff
- Facilitation of requirements, retrospectives, and process improvement efforts
- Preparation of external quality documents and participation in customer meetings
Promotion of continuous quality improvement in SAS processes and technologies

Process Improvement

R&D uses retrospectives facilitated by the Software Quality team to improve processes and the quality of the software. During the retrospective process, teams discuss project details and identify opportunities for improvement. The data about what worked well and what to change is available to analyze for the improvement of future projects. The Software Quality team assists the work groups with developing a concrete plan of action for implementing the changes and following up on the results.

Retrospectives are performed at any or all of these times during development:

- Periodically within a release cycle
- On a release boundary
- On an ad hoc basis to immediately address a specific issue

Over the course of the software development cycle, teams might engage in one, some, or all of these retrospective types.

Our development teams use several inspection techniques. Best practices are shared among the teams and added to an evolving checklist. Teams have several feedback loops to improve software quality and the customer experience. Examples include customer interviews, usability interface reviews, internal feedback, customer feedback from the Technical Support Division, and internal testing throughout the development cycle.

Reviews

The SAS software development process incorporates reviews throughout the software development life cycle. Completion criteria for development deliverables—such as requirements, design, and test plans—include reviews by appropriate stakeholders. Teams perform ongoing reviews during periodic planning sessions. Team managers provide details to executive leaders in the project scope and planning review early in a release to ensure that plans and processes are in place for a successful implementation. Near the end of a release, team managers and executive leaders meet again to evaluate the quality of the software and its readiness to ship. Executive leaders must give approval at the first review for product development to progress, and at the second review for the product to ship.

SAS Architecture

The SAS Platform

The SAS Platform includes both SAS Viya and SAS 9.4. SAS Viya modernizes elements of the SAS Platform and can coexist with SAS 9.4 or stand on its own. This section describes SAS Viya, SAS 9.4, and it illustrates how the SAS Platform achieves quality by design through architecture.

SAS Viya

SAS Viya was created to deliver an elastic and scalable cloud-ready analytics engine that includes an open analytics coding environment. SAS Viya provides a unified environment for the entire analytical life cycle, with powerful analytic techniques accessible from a variety of interfaces including programming, scripting, and visualization. These include:

- A Multi-Cloud Architecture with no infrastructure lock-in. SAS Viya can scale to accommodate growing data volumes, more users, or more complex analytics. SAS Viya supports both public and private cloud deployments.
• Supporting a single, consistent platform for management of the entire analytical life cycle which is open to both SAS and other programming languages such as Python, R, Java, and Lua calling into a single, underlying analytics code base.

• Providing access to analytic techniques (machine learning, descriptive statistics, forecasting methods, optimization algorithms, and so on) from a variety of interfaces—programming, scripting, and visualization.

• Automatically distributing data and analytical workloads across the cores of a single server or the nodes of a massive computing cluster, taking advantage of parallel processing regardless of data size.

Consolidated Analytic Environment

SAS Viya can be accessed via REST APIs and interfaces from other programming languages. The SAS Viya analytic procedures are consolidated in the Cloud Analytic Server (CAS), to provide a single point of administration and management. All interfaces to SAS Viya access this layer for analytical processing, so that no matter how users interact with SAS Viya, they receive correct and consistent results.

Cloud-Ready Technology Stack

SAS Viya is built on a cloud-ready technology stack. From the SAS Cloud Analytic Services that power SAS Viya analytics at the core to the microservices that supply the REST APIs and functional interfaces, SAS Viya is built to be cloud native. SAS Viya uses open-source technologies such as Java and Spring Boot to deliver a set of microservices. These microservices support common functionality such as login and authorization, identity management, preferences, auditing, data management, data access, and more. SAS Viya uses the OAuth open standard for authorization, allowing SAS Viya to integrate with third-party clients and services. SAS Viya also provides public REST APIs and uses TLS to secure communications. SAS Viya can deploy on the open-source Cloud Foundry platform and it uses standard deployment technologies such as Ansible and RPMs.

SAS 9.4

At SAS, quality by design is evidenced in a number of areas such as these:

• The use of intelligent components (intelligent clients, intelligent storage, intelligent servers)

• SAS software’s MultiVendor Architecture

• Shared sublibraries and code reuse

• A scalable performance data server that increases performance by enabling parallel processing

• The use of maximum numerical precision

Third-party components are often integrated into SAS offerings, making intelligent architecture a necessity. Our intelligent architecture is used for SAS Foundation, the SAS Intelligence Platform, and SAS solutions.

SAS Foundation

SAS Foundation is based on MultiVendor Architecture, which facilitates developing, managing, and maintaining the source code of the system and enabling quality to be built in at the structural level. Because the SAS Foundation development process is built around SAS MultiVendor Architecture, the amount of code that is rewritten for each operating environment on which our software runs is minimized. Thus, the chance for errors decreases because about 85% of the code is reused on all operating environments that are supported by SAS software.

The fundamental goal of SAS MultiVendor Architecture is to provide the highest degree of portability across a broad range of operating environments while exploiting the particular advantages of each.
SAS Intelligence Platform

SAS 9.4 uses an n-tier architecture that enables distributed functionality across computer resources, so that each type of work is performed by the resources that are most appropriate to the job. For a large company, the tiers can be installed across a multitude of machines with different operating systems. For prototyping, demonstrations, or very small enterprises, all of the tiers can be installed on a single machine. The architecture consists of the following four tiers: Data Sources, SAS Servers, Middle Tier, and Clients.

SAS 9.4 middle-tier components include a service-oriented architecture built around its Web Infrastructure Platform. Java J2SE and J2EE technologies, which are portable and reusable, are used for desktop client and web application components of SAS®9.

The adoption of J2SE and J2EE technologies allows SAS to use the development, testing, and customer acceptance baselines of the broad Java vendor and customer community. These technologies use to advantage Java’s portability to operating system and application server deployment environments. This further enables customers to use the IT standards, acceptance testing, support staffing, and operating practices established within their organizations for this class of application.


SAS Solutions

SAS solutions provide industry-specific functionality in these key focus areas: Analytics, Business Intelligence, Customer Intelligence, Data Management, Fraud, and Risk. Most solutions extend SAS architecture by using a component based on Java for the business logic and surface the functionality through web-based thin-client and rich-client presentation layers. Using SAS architecture gives SAS solutions several advantages:

- Solutions can scale from one machine to multimachine implementations to meet the performance needs of the customer.
- The common metadata repository allows common data sharing and management across systems.
- Most important, the SAS architecture enables the solutions to draw upon the analytical power of SAS to differentiate SAS solutions from those of competitors.

SAS Cloud

SAS Cloud is a globally available environment, managed centrally by SAS Solutions OnDemand. SAS products are delivered from SAS R&D after being created and tested using the same quality process described in this paper. For more information about SAS Solutions OnDemand quality processes and controls, see http://www.sas.com/content/dam/SAS/en_us/doc/whitepaper1/quality-in-sas-solutions-ondemand-107370.pdf.

The Research and Development Process

Software Development at SAS

The Research and Development Division of SAS drives software research, development, and production for the company. SAS focuses on quality by design, using mature software engineering principles to build in quality from the beginning. To support quality by design, SAS engineering practices emphasize rigorous requirements and architectural design phases, implementation plans and methodologies, and additional quality assurance and testing activities. R&D teams use a defined and documented software development process as described below. The following section describes the overall SAS software development process.
Because of customer needs, industry requirements, and technology differences, JMP and SAS Solutions OnDemand have specific refinements and differences in the processes and tools they use, as described in:

- JMP: A Commitment to Quality (http://www.jmp.com/qualitystatement)

The SAS Software Development Life Cycle

As shown in Figure 2, our software development life cycle involves four phases of development: Product Visualization; Code and Product Research, Innovation, and Creation; Delivery; and Maintenance. Software development at SAS does not always follow a formal order. However, it typically begins with the initiation tasks of the Product Visualization phase and includes all phases and tasks shown below.
Each phase of the SAS software development life cycle is explained below. Executive reviews are interspersed in the process to define the required quality checkpoints. It is the role of the Executive Team, product development management, and testing management to assess the progress through the project life cycle and to report findings to upper management. Underlying the process are the ongoing tasks of project management, integrating with product management, and evaluating for quality and completeness.
Product Visualization

Delivering high-quality software is made possible by a fact-based, customer-focused, repeatable process that gathers customer requirements, refines them into a realistic product plan, and implements the plan on schedule. The SAS software development process begins with gathering ideas for a potential new product, function, or enhancements that are being considered for subsequent software releases. Suggestions for new or enhanced functionality and problem resolution are gathered from sources such as these:

- Customer Advisory Board, councils, and focus groups
- Feedback from development partners and early adopters
- Analyst research
- Consultant feedback
- Internal tracking system reports
- Enhancement requests
- Internal user feedback, including feedback from BetaLabs
- Market research
- Professional conferences and communities
- Technical Support (www.sas.com/support)
- Feedback from SAS Education Division courses
- Usability and accessibility studies
- SAS Global Forum, as well as regional, international, and special interest user group meetings

This feedback is collected in various input documents that are archived and accessible to team members. This input is used in determining the scope of a project. Project managers, product managers, and development teams meet to plan the release. Planning the release includes determining the scope of the release and its main themes as well as creating a listing of suggested updates.

Planning and managing software development projects makes it possible to achieve the intended project outcomes. Project planning involves estimating project tasks, identifying milestones, determining resource needs, producing a timeline, identifying risks, and verifying that the project team and management are committed to the plan. Project managers track and review the progress of the project, comparing it to the plan for the release. If results deviate from the planned activities, then corrective actions might be taken, such as revising the plan for the release, reducing enhancements, or reallocating resources to meet the current plan.

Code and Product Research, Innovation, and Creation

Planning and Scoping

During the release planning sessions, the themes for the release are determined and a preliminary prioritized product backlog is created. The prioritized product backlog is continually refined throughout the project. The entire development team, often including representatives from other divisions such as Product Management, meets to plan their work. This includes determining what resources are available and agreeing which requirements to work on from the prioritized product backlog. Project managers monitor the team’s progress against the plan using project management tools. See R&D Project Management for more details.
During this stage of software development, user documentation requirements are defined and incorporated into the overall project planning. Development team members start planning customer support needs and services. They also begin creating the materials that will be included in the software packaging. As the product matures, customer support materials are created and reviewed for accuracy.

Requirements

During the requirements stage, development requirements are created from the prioritized backlog that was created during the release planning sessions. Requirements identify a capability, physical characteristic, or quality factor that bounds a product or process problem for which a solution can be pursued. Requirements are analyzed to determine whether they are necessary, understandable, achievable, complete, unambiguous, and verifiable. This process validates the requirements for the innovation or enhancement request. Requirements are documented through various electronic means, and are continually reviewed and prioritized as described above in Planning and Scoping.

Design and Prototyping

Development teams create a design and high-level architecture for the software according to the requirements for the innovation or enhancement. The product design is achieved through various methods that might involve one developer or a multifunctional team. Development team members develop a testing strategy to support customer-focused product development. Test plans might include descriptions that outline testing strategies, tools, and processes. These plans are electronically archived and are accessible to all development team members.

Creation

Development teams write product code, unit tests, and installs based on SAS coding standards. The testing members of the development team begin writing tests based on test plans and testing guidelines. Before integration, code is tested and evaluated for stability. Problems are identified, tracked, and resolved. If fixes to the code are approved, the code is promoted to source management and scheduled for the software build.

Integration

During integration, stable code is merged into an image on the platforms that are scheduled for delivery. Code is available through a source management system. Testing continues according to the testing strategy (see the sections on Software Quality and Software Testing for details about testing). Problems continue to be identified, tracked, and resolved in the development cycle. The development team ensures that the software meets quality goals.

Delivery

Sign-Off

A team that includes the R&D director, development manager, test manager, documentation writer, and Technical Support consultant conducts reviews and software sign-off according to the due diligence guidelines under the guidance of the Director of Software Quality. A due diligence list signifies what each signature means. When the product completes sign-off, the Release Engineering Division provides external access to the software. See R&D Sign-Off for additional details.

System Release

After sign-off, the software enters the system release process. The software is made available for electronic download using a promotion process to secure repositories. The promotion process is validated as correct using a checksum process.
Maintenance

Operations

The current version of SAS is the most current release in General Availability status. We provide Problem Alert Notices and source level maintenance (executable modules or "hot fixes") for selected critical problems occurring in this release. We also provide problem alerts and hot fixes for selected critical problems in the two most recent, non-current versions. For all versions, regardless of age, we provide technical support in accordance with the Technical Support policies. However, if a customer chooses not to install the most current release of the software, then the level of support available will diminish over time. More information can be found in the links below:

- Support services for current and prior releases of software are documented at http://support.sas.com/techsup/support.html#non-current.
- The process for software fixes in the field is outlined in the section Software Fixes in the Field.

Retirement

The R&D division directors, Marketing, and Technical Support management work together to determine when a product or host should be retired. Any remaining customers are notified of product status, and limited support might be provided. See the web page on noncurrent releases, available at http://support.sas.com/techsup/support.html#non-current.

R&D Project Management

The mission of SAS R&D project managers is to provide services to increase the likelihood of delivering projects on time, within budget, and according to functional and quality specifications. Each shipping commercial product is assigned a project manager who works with the project team to scope the work and establish a schedule. In some cases, project managers are assigned to internal projects that improve the supporting infrastructure that shipping products use. The scope of work and planned schedule become the foundation for the ongoing tracking and oversight of the project. On an ongoing basis, they work with the project team to identify project risks and develop mitigation plans to address them. When actual status deviates from the plan, project managers work with development and testing management to determine and implement actions to get the project back on course. Examples of actions can include changes in scope, timelines, resources allocation, and so on. Throughout the project, project managers ensure adequate visibility into the overall health of the project via status reporting, project reviews, and surfacing project data to a company-wide scorecard to ensure that the project is meeting the stated goals and objectives. Status reporting and project reviews occur at both the individual team level as well as at the executive and enterprise level.

R&D Quality Review and Oversight

The R&D Executive Team, led by the Head of R&D, is composed of vice president-level representatives from across the R&D organization. This team provides cross-divisional management and oversight of all R&D product releases identified in the Corporate Product Release Schedule (CPRS) system. The team meets regularly to evaluate the progress, quality, and readiness of upcoming releases.

The SAS R&D Scorecard, visible to all R&D employees, surfaces key quality and progress metrics from each development project. The R&D Executive Team reviews this scorecard regularly to anticipate areas of concern, and develops targeted mitigation strategies, such as resource-balancing across teams, to better help teams deliver on their schedule, feature, and quality commitments. The Head of R&D encourages openness and transparency in progress
reporting so that teams can comfortably surface project concerns to the R&D Executive Team, confident that the information will be received and dealt with in a fair and positive manner.

Research and Development Tools

SAS developers and testers are supported by a variety of software tools. The toolset includes tools that are developed, tested, and maintained internally and software that is acquired to meet specific R&D needs. We have built audit procedures into the development environment; our process has been designed so that development cannot move forward without following the required procedures. Furthermore, we maintain a set of tools for each development operating environment.

We have developed processes to automate most of our source code management activities. Developers and build managers have tools to check out, check in, compare, and build the source code. Test ware is managed by the same source code management systems. Testers have automation tools for writing, executing, and evaluating tests. All documentation about source code and test program changes is kept in the source code management system. Antivirus software is installed on all SAS PCs, and all run real-time checking of files. The virus signatures are updated automatically at regular intervals.

The Research and Development Environment

To provide consistency and to facilitate communication between various development groups, SAS has established a common development environment for use wherever it is practical and appropriate. Authorized developers and testers use various in-house tools or repository access commands to make changes to files held in the repositories. All developers and all specific hosts to which SAS is ported have access to the same repositories.

Tools for Developers and Build Managers

For consistency and repeatability, developers and build managers use tools to access, compare, and build the source code for both internal testing and customer delivery. Our automated tools facilitate our processes. Documentation and audit-trail functionality are built into these tools. The database also includes change control information about the pushed code. For developers, software quality is enhanced by the following tools:

- Special compilers that provide extensive diagnostics
- A debugger that provides the same user interface on multiple operating environments
- Tools to detect run-time errors such as memory leaks or incorrect memory access
- Timing tools that provide detailed analysis of the performance of sections of code
- Automated testing to make sure that only successfully tested code enters the production build process
- Semantic versioning for JAR files in the SAS Viya build environment

Change Control

Throughout the software development life cycle, strict control is maintained over all source code, which the company protects as a principal asset and trade secret. Our toolset, which is routinely updated to take advantage of the latest technologies, controls development staff access to source code and their ability to make changes and fixes. Revision history is kept for all modules in source management; in this way, we maintain earlier versions in addition to a history of who made changes and why those changes were made.

Our version control procedures include methods to make sure that each build of the software has a new revision date. For each external release of the software, there is a Technical Support number and release number. Solutions have an
“About” window that includes the version numbers. Development and production versions are uniquely identified, and changes and enhancements for the production versions are documented.

Through the source management system, developers can check out source code segments into their private work area for changes and fixes. During this time, other developers can simultaneously check out the same files. Changes are evaluated automatically at check-in and merged appropriately. Otherwise, the developer is asked to resolve the difference. Each source code change is logged for audit purposes. Those items that are shared or called by other modules are kept in libraries that allow multiple accesses. The corrected code or documentation is included in the next image of the software for verification by testers.

**Problem Reporting and Resolution**

Problems are tracked through online problem tracking systems until the problem is resolved and verified. The systems allow testers and software developers to report problems and to request software changes. If a test fails during formal testing, the tester determines whether it is a problem with the test, the documentation, or the code. If the test has an error, the test is updated. If the documentation or software has an error, the tester reports the problem.

High-priority problems include those that cause system failure or that produce incorrect, unreliable, or misleading results. Problems that result in the loss or corruption of data, performance degradation, and potential security vulnerabilities are also considered high-priority. The same is true of problems that depart significantly from the product function that is specified in the user documentation. Low-priority problems include nonfunctional cosmetic features or problems for which there are convenient workarounds. Minor problems might be deferred for fixes in later releases of the software. Testers can consult with Technical Support consultants about the priority of a problem according to past user feedback. In all cases, problems are tracked through problem tracking systems until the problem is resolved and verified.

**Testing Tools**

The testing staff has a broad range of internal and proprietary tools maintained by dedicated tool support teams:

- A test driver that executes command-line-based tests on multiple platforms (operating systems and programming environments).
- A test driver that executes tests through a memory-leak detection tool and reports the results.
- Coverage analysis tools for C and Java source that highlight potential areas for improved coverage and optimize regression testing.
- Problem tracking tools for tracking defects, enhancements, issues, and suggestions found during and after software development and testing.
- A test management and tracking tool to record test cases and their results history for all platforms.
- Multiple internal or proprietary testing tools and processes targeting key features and functions not otherwise available.
- Multiple third-party and open-source test automation tools that are maintained and supported by internal dedicated support teams and contributors.

We have an extensive amount of Java code in SAS software. Our testing staff uses a variety of internal and external tools such as the following to evaluate software quality of features based on Java:

- An internally supported tool to validate Java fixes using a continuous integration model
- An internal tool to execute unit, integration, and acceptance tests nightly
- Industry standard unit test tools
• Java coverage analysis
• Enhanced static analysis
• Performance monitoring tools

Various reports such as the following are available to testers for evaluating software quality and testing progress:

• Queries of the problem tracking databases about number, age, type, and severity of defects, by internal group structure or product
• Verification status of individual defects as well as responsible tester or testing department
• Stability of code by tracking the number of test and source files pushed within a given time frame

Project Management Tools

Software-based tools are used to assist R&D project managers. The Corporate Product Release Schedule (CPRS) system is used to register all products that are planned for production release. Projects in CPRS contain key metadata that is needed to move the product and its dependent products through our internal processes. CPRS is integrated with our product release sign-off process. This process ensures that all leaders for each project refer to a set of criteria before issuing their sign off. This promotes a high and consistent level of due diligence that helps SAS ensure that only high-quality products are released to customers. Other tools are targeted for specific purposes and together they provide comprehensive coverage of all aspects of the project under development. Here are examples of tools that project managers use:

• Template libraries for project artifacts and reviews
• Tracking systems for measuring outstanding defects and features work
• Standardized tooling for defining the product and release engineering setup
• Project management software for planning, tracking, and managing the release

Software Testing

Overview

Software testing processes launch early in the development life cycle and persist until R&D development and testing managers sign off. Testing teams work to verify the successful implementation of new features and to validate the continued baseline of existing features. The SAS software development process follows a formal approach that involves planning, developing, executing, and documenting the testing process.

Highly skilled and knowledgeable team members perform the testing of sophisticated software. Test teams have both product and testing expertise. Guidance is available online through our Quality Portal and numerous internal testing sites maintained by our testing community. Representatives from test teams meet regularly to discuss best practices, test automation techniques, and process improvement opportunities. R&D and Corporate training staff offer a variety of education courses to broaden the technical and domain skills of the testing staff. Testing managers participate in formal reviews and provide a key signature for the product sign-off before the software can ship.

As they strive to evaluate quality, R&D test teams choose from an evolving set of testing methodologies, including requirements-based testing, use-case testing, white-box testing, integration testing, and systems testing. Testing tasks include the following steps:

• Providing feedback into the design phase of the software development process
• Designing test plans or strategies
• Writing and maintaining test procedures and test tools
• Completing early exploratory manual testing
• Writing automated tests or manual test scripts
• Maintaining reusable libraries of tests
• Running tests and reporting results
• Performing manual testing per scripts
• Reporting defects
• Verifying fixes
• Analyzing and improving test coverage
• Monitoring quality metrics
• Reviewing customer documentation
• Testing for performance, security, national language support, and usability issues
• Writing and supporting qualification tests and samples

Test directors and test managers are responsible for making sure that the testing process is followed. A library of almost 275,000 unique tests is run multiple times during a release cycle. Many factors go into determining the size of the testing staff for each software product; however, the overall ratio for R&D is one tester for every three developers. To foster independence, most testers report to directors of product testing under the Vice President of Quality User-Driven Enterprise Software Testing.

Testing involves software developers and testers. Developers and testers work together early in the design process to exchange ideas and strategies. Developers are expected to perform unit testing on the software that they are writing. Early testing by the development groups assures a constantly improving baseline of software quality that gives the platform and solution developers a stable work environment.

After developers are satisfied with the implementation of the code, they collaborate with testing groups to begin a period of more formalized testing. Testers give developers feedback about their product’s functionality, compatibility with other products, stability, and compliance with company standards. Testers work closely with developers to improve the usability and testability of our products. Sometimes the testers’ work in one area can benefit work in another area. For example, by making our products accessible, we promote interoperability with assistive technologies while enhancing our ability to automate testing.

Test Planning and Documentation

Testing organizations maintain a hierarchy of test plans and documentation. The overall testing strategy for the release is outlined in a Master Test Plan. The R&D testing community collaborates on a division-wide due diligence checklist to ensure consistency at testing sign-off. This checklist serves as a source document for formal test plans at the department, project, or feature level.

Group test plans document the testing strategy for an entire group or department. Testers might develop individual test plans for specific projects, products, solutions, or features. Testing organizations make their test plans available through our company intranet. In addition to test plans, test teams might also create test inventories, matrices, or design specifications.

Part of the planning and documentation process is early exploratory testing. This technique allows the tester to get acquainted with the software and to understand changes in the current release. Little or no formal documentation is
created for this type of testing, although defects can be entered if anomalies are uncovered. As the software matures, testers generate more robust test documentation. This documentation covers the functionality of the product being tested, error-handling capabilities, cross validation, stress or performance testing, consistency checks, boundary checking, and simulation of user applications.

Test Cases and Test Programs

Product groups maintain baseline suites of legacy tests to verify and regress functionality shipped in previous releases. Product development groups—developers and testers alike—design and write tests to validate new functionality. Dedicated testing staff support test suites that contain both automated tests and manual test scripts. The automated tests are grouped into categories according to the level of complexity. Tests are kept in the same source management system as the software.

Test programs for most portable software are constructed to be portable across all operating environments. Tests might consist of SAS programs that generate logs and listings for comparison against benchmark results, or they might consist of scripts that outline manual, hands-on testing. Test data is created through a variety of techniques, such as self-generated, within-test programs, or is accessed from existing data sources in R&D test data libraries.

Test programs are designed to determine whether specific components of the software perform correctly. Test programs consist of at least one test case and its expected results. Correctness of a test program’s results is evaluated against existing documentation, knowledge of past performance, expected behavior, and an understanding of the software’s design. The correct result is captured in a benchmark or identified in self-verifying functions.

In establishing the correctness for each test, the important task of validating results is accomplished in one or more of the following ways:

- Comparison of results to expected results as identified in the requirements documentation
- Comparison of results to known published results
- Hand calculations
- Cross validation by comparing results to those produced by other procedures
- Independent coding of algorithms

For interactive applications, tests are designed to verify the application’s behavior against documented functionality. This testing can be accomplished manually when automation is not feasible. Some manual testing is documented in testing scripts and performed on various operating environments. We continue to automate an increasing number of these tests. We use an end-to-end test automation framework for functional regression testing of GUI applications based on the action word approach.

Programs can be written to test software in several ways. A list of commonly used test development techniques follows:

- Analytical testing includes numerical validation.
- API testing produces tests for the behavior of components of a product to verify their correct behavior before system integration.
- Baseline testing verifies that the software functions in the same way as in previous releases. At times, the functionality changes, based on new features.
- Build verification testing validates the presence of key procedures or modules in image builds. These tests are basic acceptance-level tests. Build verification tests do not test the full functionality of SAS software; rather, they touch critical portions of the software to ensure it is ready for more rigorous testing.
• Compatibility testing assesses the ability of software or web applications to function across different browsers, operating systems, configurations, or hardware platforms.

• Error testing examines how syntax and run-time error conditions are handled.

• Functional testing validates syntax and determines whether components of the software are operational.

• Migration testing makes sure that customers are able to move to current versions of the software without problems. Migration testing also ensures that there is a migration path from one release to the next. This can include procedures for moving data sets and catalogs from one release to another. Backward compatibility is not guaranteed.

• Performance testing evaluates memory and throughput performance. This might involve using an automated test suite as this allows easy simulation of a variety of normal, peak, and exceptional load conditions.

• Regression testing makes sure that changes to the software do not introduce errors.

• Security testing encompasses authentication testing, authorization testing, and web application penetration testing.

• Stress testing creates an overload situation to determine how the software product, procedure, or module functions under the stressed condition.

• Usability testing and accessibility testing evaluate how easy it is to use a particular feature for all customers, regardless of ability.

• Validation testing evaluates how data is processed and determines whether processing is done correctly.

Test Execution
Automated testing involves running tests in large groups, with little human interaction, to check the language-oriented parts of SAS. Automated tests are executed using various methods of test automation, both internally written and commercially produced. During testing, files (which can include data, logs, and output) might be compared against benchmarks or evaluated with self-verifying functions. Results are reported to help in diagnosing and correcting problems. Our test automation system sends results to the person running the test and writes results to a database that is archived. In some cases, the system both sends and writes results. Some tools identify test differences and load the output to an internal test results tracking system. This application can also serve as a difference resolution tool in addition to tracking the progress of the executing automated tests.

Manual testing is performed by following the test script on a customer-like test image. Testers execute manual test scripts to verify both the user interfaces and language-oriented features of SAS offerings. Such testing might be repeated on several host or test configurations. The results of manual testing are documented using a method appropriate to the testing group.

Most groups run test libraries and scripts at least once on each production operating environment. After the completion of the initial testing pass and resolution of reported problems, selected automated and manual tests are repeated for areas that are affected by code fixes. Code reviews and fix descriptions might be used to guide the selection of regression tests. The results of this regression testing are evaluated. Any problems found during testing that seriously affect customer use are resolved by code fixes, customer usage notes, or alert notes.

Performance Testing
Performance regression testing is done across releases and relative to other versions of SAS. For new releases and redeveloped solutions, the group tests against performance requirements that are provided by product management. Each major hardware platform is also tested for performance characteristics by many of the product groups. Performance testing results are kept for future release comparison.
The testing groups use internal and third-party tools to test compiler effectiveness, Java code performance, C code performance, I/O performance, big data scalability, algorithm effectiveness against third-party databases and SAS internal data sets, and so on. Much of the work is automated, and parameters are set so that performance bottlenecks are flagged for analysis. We also check how computer resources are being used (that is, memory, I/O, and CPU). For deep analysis, monitoring and profiling tools such as HP Diagnostics and Compuware dynaTrace are used.

Performance, load, system, and endurance testing are conducted on web-based, Java applications and rich clients. This testing is based on multi-user scenarios driven under load conditions using application load testing tools such as LoadRunner and Performance Center. This ensures software quality by identifying performance bottlenecks, memory leaks, and scalability problems.

We provide advice to development and product management on code changes, data architecture changes, application architecture changes, and technical architecture or hardware.

**Software Security Testing**

**Testing in the SAS Software Security Framework**

SAS performs a variety of security tests with the goal of providing software with maximum security assurances and minimum risk of security vulnerabilities. Security testing includes security function testing, black-box application vulnerability testing, dynamic scanning of applications, and static source code testing. SAS performs vulnerability testing before delivering feature releases and maintenance releases. This testing is integral to the development standards that are the basis of the SAS Software Security Framework that we use to implement our secure software development lifecycle. For more information about the SAS Software Security Framework, see the papers and links highlighted on the SAS Security Assurance website ([www.sas.com/security-assurance](http://www.sas.com/security-assurance)).

In addition to scanning web applications and the web application server environment (using guidance from leading security organizations), SAS uses a suite of tests that are specific to SAS technology. Depending on the type of software being tested, these tests can include any of the following:

- Industry-recognized security scanning approaches to flag common security issues, such as those identified in OWASP Top Ten and CWE/SANS Top 25.
- Testing with users of different role-based security access to make sure that each has the appropriate access levels.
- Data access, based on row-level permissions, to confirm that data authorization is applied appropriately for each user.
- Password and encryption security.
- Correct behavior with Transport Layer Security enabled protocol (HTTPS).
- Validated credential protection when using SAS/ACCESS engines to connect to data sources (for example, user ID and password).
- Product-specific security tests for appropriate user authorization and error testing.
- Firewall tests.
- Integration tests with some common industry tools such as IBM Security Access Manager (which includes WebSEAL) and CA Single Sign-On (formerly SiteMinder).
- Penetration tests for some configured deployments.
Application Vulnerabilities Testing

Software resilience to external threats is important to our customers, and our security testing tools are focused on eliminating known application vulnerabilities. Our analysis uses input from the Open Web Application Security Project (OWASP) and the CWE/SANS Top 25 Most Dangerous Software Errors. The OWASP and CWE/SANS groups produce lists that describe common vulnerabilities and methods to avoid them. Issues that are detected during security testing are entered into the problem reporting system and evaluated promptly for appropriate fixes and resolutions.

SAS has taken the following steps to deliver secure SAS applications:

- Train our developers. SAS provides ongoing developer training in techniques to mitigate development errors and vulnerabilities. SAS licenses tools designed to generate test cases for security vulnerabilities, including those on the OWASP Top 10 and CWE/SANS Top 25 lists as well as other lists.
- Deliver shared security components across SAS products. SAS develops shared components and coding guidelines, such as cross-site request forgery (CSRF) whitelists, and an input sanitation filter to provide strong security protection across SAS products.
- Monitor and analyze industry issues. SAS monitors and analyzes industry issues regularly, including the evolving OWASP and CWE/SANS lists, to determine applicability to SAS applications. In some cases, the vulnerabilities do not apply to SAS software. We evaluate whether any of these vulnerabilities apply to SAS software applications and address as appropriate.
- We keep our tools and techniques for security analysis current. SAS performs vulnerability testing for feature releases and for maintenance releases.

Results of vulnerability tests and scans that are conducted by SAS are company confidential. By policy, SAS does not share the tests or the individual results.

SAS provides several forums that customers can use to get information about updates to SAS products, including security fixes. The SAS security bulletins page [http://support.sas.com/security/alerts.html](http://support.sas.com/security/alerts.html) provides updates about security issues. Security fixes for released products are highlighted through the standard technical support process for hot fixes, including the SAS support community. Customers can subscribe to the community or sign up for support newsletters (or both) in order to receive regular updates about hot fixes and other important news from SAS.

- To subscribe to the SAS support community, see [https://communities.sas.com/t5/Getting-Started/How-to-learn-about-hot-fixes-to-SAS-software/ta-p/283553](https://communities.sas.com/t5/Getting-Started/How-to-learn-about-hot-fixes-to-SAS-software/ta-p/283553). Note that you can filter the results using the keyword SECURITY.

Installation Testing

There are two approaches to testing and validating the installation for SAS software. The first approach involves testing the installation interface, and the second approach involves testing the proper operation of the installation.

Testing the Installation Interface

Testing the interface requires a test engineer to invoke the installation interface, to follow the installation instructions, and to exercise the different options of the installation process. Each option is exercised using invalid values, to make sure that the installation program handles error conditions correctly, and using a range of valid values, to verify that these values are accepted and processed appropriately. Because the interface to each operating environment is different, we document how each operating environment interface is tested. All options are covered, and each option is validated for proper operation.

To enhance testing of the user interface and to accommodate more extensive testing of the installation process, many operating environment development groups use their installation program to deliver test images. Thus, the install
process is exercised dozens of times each week during the development cycle by a wide variety of users, accommodating more comprehensive testing of the interface and validation of product delivery.

Interface testing is often joined with installation testing. During the installation testing phase, each product is installed with Base SAS software, which is required for all SAS products. This testing enables validation of the installation of each individual product as an autonomous unit.

**Testing the Proper Operation of the Installation**

After a product has been installed, it is tested using various validation technologies. The SAS Installation Qualification Tool (SAS IQ) completes a checksum comparison on all files installed on a target machine. SAS IQ ensures that those files are exactly the same as the files on the installation media and that they are installed in the proper location on the user’s computer. In addition to SAS IQ, operational validation is assisted by using the SAS Operational Qualification Tool (SAS OQ) and the BI Platform is tested using SAS Deployment Tester. While not available for all products, these tools verify that the product is present and works correctly, and that all components for the product are functional. Originally developed for use by install testers at SAS, these tools are now shipped to customers to assist in the qualification of installation and operation of SAS®9 at the customer site.

Installation testing also encompasses testing the systems that produce the software for the customer. This testing is done during the release candidate phase of testing. See [Appendix 7: Installation and Operation Qualification](#) for more information about these tools.

**Customer Experience Testing**

An important aspect of testing is customer-like testing. Product testers perform this type of testing during the R&D cycle. The Customer Experience Testing (CET) group uses the Act-Like-A-Customer testing method to focus on whole product quality. To find and report defects likely to be found by customers in daily usage, CET places a software order, and then installs, configures, and deploys SAS products in a customer-centric test environment. They identify typical use cases and execute them against the software, focusing on the full end-to-end flow necessary to complete such tasks and identifying challenges encountered along the way. CET looks at the overall experience of using the software, from installation to final report generation. The testing is performed in phases to coincide with development milestones. CET findings are reviewed by R&D division heads and product managers as well as Worldwide Marketing. The group also carries out these additional tasks:

- Identifies inconsistencies between products.
- Enters defects when product issues are found.
- Looks at the integration of SAS with products from third parties.
- Orders and tests customer packages on the ship date to validate a package after it passed through the production distribution system.
- Addresses upgrading software versions, add-ons, and migrating to new environments.
- Assesses the helpfulness of various documentation, such as installation guides, product-specific documents, and online Help.
- Evaluates the manageability of implementation.
- Works closely with Product Management, Professional Services, and Technical Support.
- Gathers customer experience knowledge by attending SAS user group meetings.
Final Regression Testing and Inspection

After completing the initial testing pass and resolving reported problems, selected automated and manual tests are repeated for areas that are affected by code fixes. Code reviews and fix descriptions can be used to guide the selection of regression tests. The results of this regression testing are evaluated. Any problems found during testing that seriously affect customer use are resolved by code fixes, customer usage notes, or alert notes.

Package Validation

Before R&D sign-off, the packaging and related materials (excluding final product image) that the customer will receive are examined by the R&D groups and Technical Support. R&D checks that the materials are correct, and Technical Support makes sure they are customer ready. There is a checklist available to assist R&D groups in verifying the validity of the package materials. Any issues found are captured in the problem reporting system.

Release of Software

R&D Sign-Off

Product sign-off occurs when the following conditions have been satisfied:

- Planned new functionality has been implemented and tested
- Requested fixes have been implemented and tested
- Newly reported problems have been reviewed and are deemed non-critical
- The rate of newly reported problems has declined below a designated threshold
- Appropriate deferred items have been documented in the SAS Notes knowledge base, which is available on the web for every release of the software

A team that includes the R&D director, development manager, test manager, documentation writer, and Technical Support consultant conducts reviews and software sign-off according to the due diligence guidelines under the guidance of the Director of Software Quality. A due diligence list signifies what each signature means.

After sign-off is complete, the software and the data that defines the software is locked down so that no further changes can be made. The software is then replicated externally to our third-party network provider for customer access, and checksums are verified to ensure that the software still matches the locked-down version. When the product sign-off is complete, the Release Engineering Division provides external access to the software.

Production Media

Production software is available by software download for most releases. If physical media is being produced, it is cut at SAS after internal quality checks. No physical media is available for SAS Viya.

Software Production for Target Audiences

SAS meets the challenges of delivering high-quality software by following a clearly defined rollout process for our new releases. The phases of the rollout process are linked to internal milestones and are defined by the target audience for each software development release: Development Partners, Early Adopters, and General Availability.

- Development Partners phase—A preproduction software development phase in which software is provided to customers who have contractually agreed to use the software, and to provide feedback to SAS about its features and functionality. The goal of this phase is to validate that the software is being developed according to the
requirements that have been identified by marketing specialists. This phase is optional, but is often applied to newly developed offerings, and for major enhancements to an existing offering.

- Early Adopters phase—A preproduction software development phase that occurs after much of the development has been completed. In this phase, a copy of a software offering is provided to a customer who has contractually agreed to install and use the software, and to provide feedback to SAS. Problems that are reported from customers might be addressed during later phases of this same release, and features or enhancements are collected for consideration in a future release.

- General Availability phase—A software development phase in which the final production release of an offering is made available to all customers.

Virus Protection

For SAS 9.4 releases, we run our compiles and links on Windows nodes that are run with minimal network access. The nodes have Symantec Endpoint protection running on them to ensure that the nodes remain virus free. After the files are compiled and linked, the rest of the processing through delivery to the production code repository is done on our FreeBSD build bubble nodes, where there is little chance of Windows virus infection. When we replicate the software, we use only blank media (write-once media). The SAS machines that do the replicating are based on Microsoft Windows, with real-time antivirus checking. All SAS product components for all platforms that are ready for customer delivery are stored on file servers that are based on UNIX and that do not allow writing from Windows OS hosts. After a product becomes production, its components are protected so that only a limited number of UNIX hosts can write to them as well.

Digital Signatures

Digital signatures ensure the integrity of SAS software. All SAS components that interact with the operating system (or that otherwise require digital signatures to work properly) are signed using a trusted SAS certificate. We sign Windows executables, installation files, Outlook plug-ins and extensions, various Java files, and other pieces as required.

Changes and Enhancements

A list of changes and enhancements for each release is available when you select What’s New in SAS at http://support.sas.com/documentation or when you access the Help that is provided with the software.

Software Fixes in the Field

Hot Fixes and Maintenance Releases

This section describes the process for software fixes in the field that is being used for SAS 9.4; note that there might be changes in this process for SAS Viya. For the most recent information, check http://support.sas.com/techsup/.

SAS releases regular updates to software products in the form of hot fixes and maintenance releases. Hot fixes are SAS' timely response to customer-reported problems, as well as a way to deliver occasional security-related updates that can affect any software product.

The SAS Technical Support Division acts as the central point of contact for customer-reported problems regarding production products. When a customer reports a problem that requires a hot fix, Technical Support enters the information about the issue into the problem reporting system (described in the Problem Reporting and Resolution section) noting that a hot fix is requested. R&D, Testing, and Technical Support work together to review the requested hot fixes and determine which fixes will be made. Technical Support then authorizes the fix, and it enters the hot fix process. Technical Support uses an internal web application to track source code changes during this process. Once R&D provides the fix, it is tested to ensure that the defects are verified. Regression testing that is appropriate to the
scope of the fix is also performed. If the solution is web surfaced and the fix includes UI changes, the R&D groups also evaluate the need to rerun vulnerability testing.

Fixes are cumulative. If a new fix requires a change to an appendage that is included in an existing fix, then the existing fix is replaced or updated with a newer fix that contains the original fix, plus any new fixes.

Fixes for individual defects are available on the web. All customers have access to the download pages and can download the fixes that they need from the Technical Support Hot Fixes web page located at the following URL: (http://ftp.sas.com/techsup/download/hotfix/hotfix.html).

SAS also uses maintenance releases to update and support SAS software. Maintenance releases include fixes and enhancements, documentation updates, and localizations. Maintenance details are posted to http://support.sas.com when they are available. Information about the current maintenance release is available on the Maintenance Release Announcement web page located at the following URL: (http://support.sas.com/software/maintenance/).

### Alerting Customers

To get the latest news on SAS Software, downloads, SAS Notes and more, we recommend that customers sign up for SAS Technical Support News at https://support.sas.com/en/technical-support.html#ask-the-community. Customers also receive alerts and notifications in their email inbox when they subscribe to SAS Technical Support News. For alert-priority problems in SAS software, Technical Support issues Problem Alert Notices to customers who subscribe to SAS Technical Support News. SAS Technical Support News provides additional details about the problem, proposes viable workarounds, or outlines strategies and plans for a rapid resolution. SAS Notes, which are also delivered via SAS Technical Support News, are a source of information used by Technical Support engineers to answer questions from our customers. The SAS Notes knowledge base is updated using an internal Technical Support application and, where appropriate, is linked to the problem reporting system. The SAS Notes contain information on known problems (and fixes or workarounds where applicable), usage issues and tips, documentation errors and corrections, and installation and migration issues. Customers can also learn about all published SAS hot fixes by visiting the SAS Hot Fix Announcements page (https://communities.sas.com/t5/SAS-Hot-Fix-Announcements/bg-p/hf).

We also encourage customers to join the SAS Support Community, found at https://communities.sas.com/, which provides peer-to-peer support for SAS users and is a place to find answers, share technical knowledge, and connect with others in the worldwide SAS Community.

### Migrating to New Releases

For information about moving from one release of SAS to another (or when you are changing operating systems), see the guidance provided on the following websites:

- Migration: http://support.sas.com/rnd/migration/
- Migration validation: http://support.sas.com/rnd/migration/planning/validation/index.html

To assist with migrating data and catalogs, you can use the MIGRATE procedure, which has validation macros associated with it. Migrating code is a bit more involved, so you will need to develop a migration plan that encompasses a sampling strategy based on the total number of programs that need to be migrated and the acceptance level. You might want to consider using the ANSI/ASQC Z1.4, ISO 2859 standard (Military Standard 105E) to determine your sample size.

### Quality in Customer Service

SAS provides quality customer support in many forms, including SAS communities, customer education, technical support, SAS communities, user documentation, and consulting. Nationally and internationally, SAS User Group
meetings are held for peer-to-peer support. SAS provides both assistance and speakers to the annual SAS Global Forum conference as well as to several regional and international conferences.

Quality in SAS Education

For SAS Education, delivering high-quality training support for SAS software technology and solutions isn’t limited to the classroom. SAS Education consists of several teams, all dedicated to providing the best customer service possible. From instructors who help design our courses to a customer service group who makes sure all calls are answered by a real person, we are confident that each customer is getting the quality training that will help them make better, fact-based decisions specific to their business—small or large.

For more information about SAS Education, see Appendix 4: Quality in Education.

Quality in Technical Support

SAS’ award-winning technical support is conducted over the telephone, in writing, or electronically as described on the SAS Technical Support Services and Policies page, found at http://support.sas.com/techsup/support.html. For customers in the United States and Canada, technical support is primarily provided from SAS headquarters in Cary, North Carolina. For international customers, SAS subsidiaries and distributors provide technical support for customers in their local languages.

Technical Support’s mission is to "help our customers make the best use of our software products through effective and responsive support, active advocacy, and a broad and flexible range of self-help resources." Technical Support also coordinates fixes for production software. This is facilitated by the high level of contact maintained between Technical Support and our customers.

For more information, see Appendix 2: Quality in Technical Support.

Quality in SAS Communities

Helping SAS customers connect with each other facilitates knowledge and information sharing, so SAS provides the following communication avenues for connecting with the broader user community:

- SAS Communities: Collaborate with SAS and other SAS users about programming, data analysis, and deployment issues, tips, and successes at https://communities.sas.com/t5/community/communitypage?nouser
- SAS Users Groups: network, teach, and collaborate with other SAS users. SAS users groups are independent, volunteer organizations run by SAS users. SAS partners with these groups and provides a wide range of services. See https://www.sas.com/en_us/connect/user-groups.html
- SAS Global Forum is an annual conference planned and sponsored by the SAS Global Users Group, which is open to all SAS software users throughout the world. See https://www.sas.com/en_us/events/sas-global-forum.html
- SAS Social Media Portal: Stay connected with SAS and other SAS users through our social channels including: Knowledge Exchanges, sasCommunity.org, Facebook, YouTube, and Twitter. http://www.sas.com/social/

Quality in Customer Documentation

Documenting SAS software is much like developing the software itself. Publications Division staff researches new features, plans the library that is needed to document these features, develops the documentation, converts it to the necessary formats, performs extensive testing, and distributes the final documents.

Currently, Publications produces the following types of documentation:

- Reference and usage documentation, administration guides, and migration guides on the web
• Books with examples and how-to information that are available in hard copy from the SAS Bookstore
(http://www.sas.com/store/books/cBooks-p1.html?attr=category&val=SAS+PRESS) and electronically through e-tailer partners
• Online Help that is built into the software

In addition to documentation, how-to videos are produced and made available on the web. For more information about SAS’ documentation processes, see Appendix 5: Quality in Publications.

Quality in Consulting

SAS provides consulting services that enable organizations to reap the maximum benefits from their investments in technology. SAS Professional Services and Delivery Division offers the experience of domain and industry thought leaders in the world of business intelligence and predictive analytics, armed with SAS' commitment and heritage of solving the most complex business challenges facing the industry today.

SAS has been partnering with our customers to solve their business problems for more than a quarter-century. Our consultants take the time to listen and learn about our customers’ business challenges and enterprise goals to establish a foundation for strategic advancement. This enables us to deliver the right SAS technology and customized services to solve our customers’ unique business requirements. We have amassed in-depth industry knowledge and domain expertise, and draw upon industry and technology best practices and proven methodologies. For more information about our quality processes and methodologies, see Appendix 8: Quality in Consulting.

Quality in SAS Solutions OnDemand

SAS Solutions OnDemand provides SAS Cloud Analytics delivered as software as a service (SaaS), SAS Results solutions, remote managed software and services (RMSS), and enterprise hosting for customers worldwide who want to deploy SAS solutions rapidly. The SAS Solutions OnDemand team is an international, customer-focused division that integrates quality processes and controls into all areas of its organization. For more than 15 years, SAS Solutions OnDemand has established a successful track record of providing organizations with state-of-the-art outsourced applications, as well as the subject-matter experts to manage them. Although policies, processes, and procedures are always evolving, the SAS Solutions OnDemand commitment to quality is constant. See http://www.sas.com/content/dam/SAS/en_us/doc/whitepaper1/quality-in-sas-solutions-ondemand-107370.pdf for more information.
Appendix 1: Regulated Industry Issues

Introduction

SAS is not a publicly traded nor a regulated company; however, many large customers rely on SAS to enable their compliance with regulatory requirements. SAS Global Government Affairs, SAS Corporate Legal Staff, and Senior Management in Consumer Risk and Fraud Solutions monitor regulatory affairs on a constant basis. This appendix answers commonly asked questions from pharmaceutical customers and others regulated by government agencies.

Note that the FDA does not certify software tool vendors. We consider SAS a tool: our customers need to validate systems that they build with SAS, but they do not need to validate SAS software. SAS is developed using a controlled process that consists of distinct development phases. Quality control activities are performed during various phases to make sure that quality is built into the software. SAS understands FDA requirements for computerized system validation and can identify existing practices and procedures that conform to FDA expectations. SAS also understands the FDA-regulated industry’s motivation to assess technology providers like SAS. Some validation methods for SAS procedures (PROCs) that are used extensively by pharmaceutical companies are covered in the section Validating a Statistical Procedure. The methods described might be useful in designing test cases to validate programs or applications built using SAS components. Companies must develop their own validation process for any tools that they use. For further details, see The SAS Software Development Life Cycle section in this paper, as well as the "Life Sciences" section on the Customer Success website (www.sas.com/customers).

ISO 9001 Certification

Six SAS international subsidiaries have ISO 9001 certification, as listed below. To obtain a copy of the most recent certificates awarded to SAS, send email to qualitypaper@sas.com.

- SAS UK (SAS Software Ltd.) was originally certified to ISO 9001/TickiT by Bureau Veritas Quality International (BVQI). This certification has been replaced by ISO 9001:2015 certification on September 29, 2016 by Approachable Certification Ltd. The current certification is valid until November 23, 2018, and the Scope of Registration is “The provision of SAS software and associated services.”

- SAS Institute Australia Pty Ltd. gained certification to ISO 9001:2000 in 2001 by Benchmark Certification, certification number FS 520337. Recertification has been maintained; the most recent is ISO 9001:2008, which expires on September 14, 2018. The scope is as follows: “For the licensing, distribution, and technical support of SAS software and the provision of education and consulting services.”

- SAS Italy (SAS InstituteSRL) gained ISO 9001:2000 February 6, 2004 by BVQI. Recertification has been maintained; the most recent is ISO 9001:2015, which expires on February 19, 2019.

- SAS Poland (SAS Institute Sp. zo.o) originally gained ISO 9001:2000 on June 9, 2005 by TUV CERT TUV Rheinland InterCert Kft and was recertified in 2011. Recertification has been maintained; the most recent is ISO 9001:2015, which expires on July 6, 2020. The scope is as follows: "Delivery, building and implementation of systems based on SAS software, including consulting and training services as well as technical support."

- SAS Institute, S.A.U. (Spain) received ISO 9001:2008 certification on June 23, 2014. The current certification is valid through June 22, 2020. The scope is “Provision of consultancy IT services, implementation and technical support of products and SAS Software Solutions, as well as the sale and supply of the mentioned licenses. Provision of training services on SAS Solutions and tools.”

- SAS Hungary (SAS Institute Kft.) originally gained ISO 9001:2009 certificate on August 26, 2010 by Marton Szakértő Iroda Kft. The current certification is ISO 9001:2009, which shall remain in effect until August 17, 2019. The scope is as follows: "Design and development of Business Analytics Applications."
Complying with Title 21 CFR Part 11

The United States law known as Title 21 CFR Part 11 (http://www.ecfr.gov/cgi-bin/text-idx?SID=ea01d0a91871a45dca2497b337f677c4&m=true&node=pt21.1.11&rgn=div5), or the “Electronic Records; Electronic Signatures” rule, provides information about what constitutes trustworthy and reliable electronic records and electronic signatures. Many of our customers who are regulated by the United States Food and Drug Administration (FDA) are required to comply with this rule, which sets forth the criteria under which the FDA considers electronic records and electronic signatures to be trustworthy, reliable, and generally equivalent to paper records. CFR Title 21 serves as the predicate rule and has been in force for some time. Although the requirements of CFR Title 21 were written for the paper record, industry has been directed to apply them to electronic records.

Part 11 does not outline details such as whether a record or signature is required, who signs it, and so on, because this is determined by the underlying predicate rules. Predicate rules are the rules that are set forth by the Federal Food, Drug, and Cosmetic (FD&C) Act, Public Health Service (PHS) Act, and FDA regulations. Part 11 governs the treatment of these records and signatures that fall under predicate rules when they are created and maintained electronically.

We recognize that the FDA is revising Part 11 and certain specifications might change including validation, audit trails, legacy systems, and copies of records. Therefore, we continue to monitor FDA regulations and guidelines that pertain to SAS or using SAS software.

SAS technologies provide the capability to use SAS and implement SAS solutions in a way that is compliant with 21 CFR Part 11. We provide tools to help customers build a Part 11 compliant application. Compliance with this regulation will ultimately depend on how your application or the SAS solution is installed and used, how users are trained, and other factors. Customers need to use SAS according to the system requirements, install it according to the installation instructions, and use the DATA step and each procedure or solution according to the user documentation.

Although SAS includes features that enable users to comply with 21 CFR Part 11, simply using SAS software or any of SAS’ solutions will not automatically render a user compliant. All elements must be present in a proper environment to be 21 CFR Part 11 compliant. Users should refer to the predicate rule or consult the FDA or its guidance documents to determine whether their particular system is in compliance with regulatory expectations.

SAS customers can use SAS products to build data collection and other systems that can be used in compliance with Part 11. They can also use programming languages such as the Java Programming Language, C#, and Visual Basic. We enable these clients to access SAS using the Integration Technologies API. Developers of such systems would need to determine which features are needed for the particular system that they are designing and then build the appropriate checks into the system. Such features could include audit trails, security checks, and electronic signatures.

Regarding audit trails and integrity constraints, the audit trail feature of Base SAS has the essential elements to address and enable the controls and procedures for a 21 CFR Part 11 audit trail. For more information about audit trails and integrity constraints, see the paper “Integrity Constraints and Audit Trails Working Together” (http://www2.sas.com/proceedings/sugi25/25/aa/25p008.pdf).

Customers need to be able to re-create analyses, and this can be done by archiving SAS programs. Customers can use the editor window while working on the program. When the program is working appropriately, submit the program in batch mode or as a SAS job. The SAS output will have date and time information embedded. A SAS manifest file is created when a SAS job is executed in the solution, and that file will capture all details needed to reproduce the result. Keep the file with the code and the output in the source control system as read-only. If any changes are needed to the program in the future, use the source control system to check the file out, make the changes, and check it back in. Run the SAS program only from the read-only file in source control to create an audit trail of any changes.
The FDA accepts a SAS transport format as a method for accepting and archiving data sets. Information about the transport format is available on the FDA Submission Standards page (http://www.sas.com/industry/government/fdcc-compliance.html).

The SAS transport format is an open format, has a free viewer, is used extensively in the industry, and has long-term support. Other software vendors can write transport format using the specifications described on the FDA and SAS Technology web page.

The FDA is piloting an alternative to version 5 transport files, CDISC Dataset-XML. SAS was a key participant in the initial (and successful) pilot (http://www.fda.gov/ForIndustry/DataStandards/StudyDataStandards/ucm380756.htm#CDISCDSXMLPilotEval). SAS provides the current implementation of Dataset-XML read/write functions. Access via download in the Health Care and Pharma community forum (https://communities.sas.com/t5/Health-Care-and-Pharma/ct-p/sas_health Pharma) and via SAS Clinical Standards Toolkit (version 1.7), SAS Life Science Analytics Framework (version 4.7), and SAS Clinical Data Integration (version 2.6).

The FDA now requires all new CDER and CBER study submissions to use industry standard data structures (http://www.fda.gov/ForIndustry/DataStandards/default.htm). The FDA requires the CDISC Study Data Tabulation Model (STDM), Standard for Exchange of Nonclinical Data (SEND), and Analysis Data Model (ADaM) for exchanging electronic data and report-ready tables. See the CDISC section for more information about how SAS supports CDISC.

SAS interfaces well with other revision control software or filing systems (for example, Microsoft products, UNIX, LINUX, MAC, and Documentum), but it is the interface with SAS tools, applications, procedures, and custom application interfaces (APIs or engines) that addresses revision control. For example, custom engines for interfacing with clinical data management systems (ClinTrial is one example) have been developed. SAS/ACCESS can also be used to obtain repetitive versions of data from a Laboratory Information Management System (LIMS) or Clinical Data Management System (CDMS). The COMPARE and CONTENTS procedures can be used to monitor changes or revisions regarding content in data. Functionalities such as data integrity constraints and audit trails can be enabled to assist in this process. All this functionality is supported by metadata manager applications such as SAS/Warehouse Administrator, the Extraction, Transform, and Load Studio (SAS Data Integration Studio) or the SAS Life Science Analytics Framework that provides a real-time assessment of metadata structure and revisions.

Alternatively, SAS has developed a 21 CFR Part 11 enabling technology known as SAS Life Science Analytics Framework. (See http://www.sas.com/en_us/industry/life-sciences.html#clinical-research) SAS Life Science Analytics Framework software was designed and introduced to specifically address the issues associated with 21 CFR Part 11 and the FDA’s Guidance for Industry. The software provides these capabilities while offering an enhanced operating environment for managing clinical data, programs, logs, documents, and reports. Careful consideration was given to the intended performance with respect to data warehousing, analysis and reporting, electronic submissions, and related e-signature requirements. Application of both process and quality management has enabled the software to meet the intended requirements of the system’s 21 CFR Part 11 functionality. The Health and Life Sciences (HLS) R&D organization follows the SAS software development process. To meet the needs of their FDA-regulated customers, they have implemented an additional Quality Management System (QMS) to govern their software development. HLS R&D might use additional tools that are not generally used by SAS R&D but that are validated for use through the HLS QMS.

CDISC

SAS has been an active supporter and platinum member of the Clinical Data Interchange Standards Consortium (CDISC) since 2000 with both resource and administrative support. For details, see http://www.cdisc.org/. SAS views the FDA’s adoption and requirement of the Study Data Tabulation Model (STDM), Standard for Exchange of Nonclinical Data (SEND), Analysis Data Model (ADaM), Define-XML, and other CDISC data standards for the electronic Common Technical Document (eCTD) as very significant events. We recognize the value that data standards will give the industry
in providing the key elements for improving global public health. Implementing and applying the CDISC standard in commonly used pharmaceutical industry software will make it possible for both product sponsors and regulatory authorities to benefit from the value of standard data structure and elements.

SAS provides standard processes within its production software to facilitate using SDTM, SEND, and ADaM data models, Define-XML, Dataset-XML, Operational Data Modeling (ODM), and laboratory data (LAB). See the SAS statement on CDISC support at http://www.sas.com/en_us/industry/life-sciences/sas-cdisc.html for more information.

**HIPAA and HITECH**

The health care reforms made by Title II of the Health Insurance Portability and Accountability Act of 1996 (HIPAA) and the Health Information Technology for Economic and Clinical Health (HITECH) Act of 2009 provide federal protections for the privacy and security of individually identifiable health information. The United States Department of Health and Human Services has issued regulations governing HIPAA/HITECH that require health care organizations and other covered entities, as well as their business associates, to meet certain minimum standards of privacy and security with respect to health care data and databases. These regulations also direct how such data and databases are to be stored, viewed, accessed, and shared. SAS software includes security and other built-in features that customers can use to implement HIPAA/HITECH-compliant applications though each customer must assess its specific needs in the context of its own computing environment. See “SAS Software Security Framework: Engineering Secure Products” (http://www.sas.com/content/dam/SAS/en_us/doc/whitepaper1/sas-software-security-framework-107607.pdf) for an overview. SAS is available to assist with HIPAA/HITECH compliance issues related to the use of SAS technologies and solutions.

**Sarbanes-Oxley Compliance**

Satisfying the various requirements of the Sarbanes-Oxley Act generally requires management of data, processes, and technologies to ensure appropriate internal controls associated with financial risk. Compliance with SOX often involves a review of multiple systems and application of software tools and technologies that, among other things, must address configuration and change management, business process management, and documents and records management. SAS software can help customers achieve SOX compliance, though each customer must assess its specific needs in the context of its own computing environment.

**U.S. Government Configuration Baseline**

As a vendor of desktop software products to the U.S. Federal Government, SAS validates, through our release management process, that our desktop software products on the Microsoft Windows platform comply with the U.S. Government Configuration Baseline, formerly known as the Federal Desktop Core Configuration (FDCC). R&D validates the software and archives the validation reports as a part of due diligence before releasing the software. For more information, see http://www.sas.com/en_us/industry/government/accessibility/accessibility-compliance.html.

**Statement on Auditing Standards No. 70**

For information about Service Organization Control (SOC) and SysTrust certifications, see http://www.sas.com/content/dam/SAS/en_us/doc/whitepaper1/quality-in-sas-solutions-ondemand-107370.pdf, which applies only to SAS Solutions OnDemand.
Appendix 2: Quality in Technical Support

Our Approach

Unlike companies that regard Technical Support as a training ground for other areas, we encourage Technical Support as a long-term career. To do this, we have developed job descriptions and classifications over six different levels that provide well-defined career paths. This enables Technical Support staff to advance to the highest levels without having to enter a management track, and offers advanced positions for those who have expertise in a wide range of areas, rather than specialized knowledge in a single area.

Our extraordinary efforts to retain the most skilled Technical Support personnel are evident in our low employee turnover rates. Technical Support’s turnover rate is under 4 percent (with only 2 percent actually leaving the company), significantly lower than the industry standard for support organizations. Despite the rapid growth of our company, we have developed a seasoned Technical Support staff, with an average tenure of more than 12 years. To prevent burn-out, front-line consultants average three hours or less per day on incoming calls. This has enabled us to maintain a consistent level of support with a motivated, experienced staff.

SAS Installation Representatives

When licensing SAS software, each customer designates one or more of its employees to act as the SAS Installation Representative and on-site SAS support personnel. These people serve as the primary interface between the users at the site and SAS. SAS Installation Representatives receive installation materials and are generally responsible for performing or overseeing the installation and maintenance of the software. On-site SAS support personnel receive documentation for the licensed SAS software components and provide initial support for one or more SAS software products.

By performing preliminary support, the on-site SAS support personnel and the SAS Installation Representative are able to more fully understand the ways in which SAS software is being used at a site. They also know the needs of the business users and can therefore answer questions or advise about problems that the users might have encountered. Users are more efficiently supported because their minor problems can be resolved quickly and other questions can be reported to SAS’ Technical Support staff more accurately and completely. This arrangement enables the customer to track all reported problems and to resolve minor problems. It also helps establish a formal, ongoing relationship between the customer and SAS.

Questions that are not answered by the local SAS Installation Representative or the on-site SAS support personnel can be referred to the SAS Technical Support Division. The Technical Support engineers who support customers in the United States and Canada are primarily located in Cary, North Carolina. Each engineer specializes in one or more areas of specific functionality of SAS.

Telephone Support

On company business days, Monday through Friday, customers in the United States and Canada can reach Technical Support engineers by telephone between the hours of 9:00 a.m. and 8:00 p.m. Eastern time. Outside these hours, for critical problems, customers are transferred to other Technical Support centers in North America, Europe, or Asia/Pacific. International customers can contact the appropriate local office or distributor during their business hours, or for critical problems, they can contact the Cary, North Carolina, Technical Support office outside local office or distributor business hours. When critical problems occur on weekends and holidays, calls to Technical Support are transferred to the Cary Service Desk, which is manned 24x7x365. The Service Desk then contacts the engineers who are on call from Technical Support. Thus, for critical problems (as defined in http://support.sas.com/techsup/support.html#response), technical support is available on a 24/7 basis.
Technical Support engineers make every effort to answer questions in a timely manner. On average, more than 41% of the questions for Technical Support in the U.S. are resolved on the first contact; 60% are resolved within one day; and 80% are resolved within five days.

Questions that are not resolved during the first contact are assigned a priority and are assigned to a specialist in the particular area involved. These questions are responded to within one business day for all tracks and in less time for higher priority problems.

Technical Support uses a global tracking system that maintains information about all problems and questions that are reported. This global tracking system permits problems to be seamlessly transferred between international support offices. Management gets status reports on problems being handled in their areas, and special notification is given if user contact is not made within a specified period.

Mail and Electronic Support

Written correspondence is assigned to a team of Technical Support engineers who are experts in the area of the problem. Users can again expect to be contacted in a timely manner concerning their problems.

Users who want to communicate electronically with the Technical Support Division have two choices:

- Use the SAS Technical Support Form (http://support.sas.com/ctx/supportform//createForm)
- Contact Technical Support through email (http://support.sas.com/techsup/contact/)

The SAS Technical Support Form and email interface enable customers to report new problems and provide additional information about previously reported problems.

In addition, the Technical Support home page enables customers to carry out tasks such as these on their own:

- Searching numerous online databases for solutions to SAS problems
- Downloading fixes for known problems (see the section on Software Fixes in the Field for more detail)
- Submitting suggestions for and voting on SASware Ballot items
- Obtaining all information that is available through anonymous FTP
- Subscribing to SAS Technical Support News to get emails on hot fixes, downloads, SAS Notes and more
- Connecting with other SAS users through the SAS Support Communities

Anonymous FTP enables users to perform file transfer without prior registration. This service is most useful for transmitting large files or binary files. In addition, this service can be used to upload information as requested by a Technical Support consultant.

SAS Support Communities enables SAS users to connect with other SAS experts, get tips, and share knowledge. For information about joining SAS Support Communities, see https://communities.sas.com/t5/community/communitypage?nobounce/.

Appendix 3: Employee Training

On their first day on the job, new SAS employees receive a training plan with the first “class” of an initial orientation, sponsored by the Human Resources Department. This day-long session includes high-level company information about SAS history, culture, compliance training, company policies, and employee programs and services. After this training is complete, new employees report to their assigned departments, who take over management of the new employees’
training schedule and content. Departmental training covers job-specific functions as well as procedures and processes that are specific to the employees’ departments or groups.

To help our employees get the right skills, teams across the organization, including HR, Learning and Development, and functional subject-matter experts, create development paths to accomplish the following:

- Employees have a guide that shows how to progress within their role and across the organization.
- Managers have a framework for how to grow talent within the organization.

Online training materials—including a growing selection of on-demand and user-paced e-learning modules—are readily available through the company’s learning management system (LMS) and the corporate library. Online resources such as the following are linked from the company’s intranet:

- Corporate vision, culture, organizational structure, and history
- Division news and information
- Product tutorials
- Updates to products
- Tool usage guides
- Operating environment information
- Other information resources
- Software problem reporting and resolution

The company’s corporate research library offers more than 10,000 books and provides access to thousands of online periodicals through subscriptions and databases. CDs and DVDs are available on a wide range of topics. The goal of SAS Library & Information Services is to provide the information our employees need to do their work in software research and development, customer service, and support. Library staff is available to help with research, and staff conducts about 30 information searches per month. Employees can also access online books and training videos (through two external services) 24 hours a day so that they have an immediate resource whenever questions arise. Individual or group training is offered upon request. The library’s website provides links to a variety of online resources and aids. The library circulates approximately 300 items per month and has agreements with local universities and document delivery vendors for a widened information base. A variety of loaner equipment, such as laptops, tablets and hotspots can be borrowed, for business trips or demonstrations.

The LMS uses a web-based course registration system to enable employees to see course descriptions and schedules, register online, receive reminders before class, sign up for interest and waiting lists, and maintain training records. The company periodically rolls out web-based training for all employees. Topics include SAS Code of Business Ethics, Respect in the Workplace, SAS Confidential and Proprietary Information Policy, and Protecting Our Information (cybersecurity).

**Skills Development**

As part of SAS’ culture and benefits for employees, the company continues to provide training for leadership development, sales, technical, and interpersonal development. Training ranges from instructor-led classrooms to e-learning and Live Web training. Having several options enables employees to find their best learning method and to meet work and career goals.
Interpersonal Development

Interpersonal development assists employees in enhancing how they communicate with one another to build understanding and effective relationships. SAS provides workshops that help employees develop effective communication and conflict resolution techniques, as well as demonstrate coaching conversations, to ensure that these skills are transferred to the job.

Manager Essentials Program

When an employee becomes a manager, he or she receives an email welcome that provides resources and an invitation to participate in the New Manager Essentials program. The two-day program educates new managers on their roles and responsibilities and trains them in areas such as communication, conflict, coaching, and other topics (HR policies, talent acquisition, and so on). Participants also learn about energy management and taking care of their physical selves as they continue their management duties. SAS also partners with local universities for development and delivery of manager content.

Technical Training

There are several avenues that the SAS staff can use to enhance their knowledge, job performance, and technical or managerial skills. Technical employees can attend SAS Education courses offered to customers. In these formal classes, staff can learn SAS areas of data integration, business intelligence, and analytics as well as topics in installation, configuration, architecture, security, and other advanced SAS administration topics.

In addition to formal classroom training, technical staff can access training from the LMS. This web-based environment provides many self-directed offerings, including self-study materials, Live Web training, and archived and downloadable video webcasts. By providing the earliest available training, often before a product is released, the LMS empowers those in the field with the hands-on experience needed to successfully deploy SAS technology. In addition, dedicated training specialists engage with internal subject matter experts to coordinate and record workshops on technical topics.

R&D has dedicated a senior staff member to provide guidance, mentorship, and training for both new and experienced staff. This resource is available to help staff develop a training program that best meets their needs. A customized program might include classroom courses, virtual learning, self-guided study, or one-on-one training sessions. Particularly with new staff, the dedicated R&D mentor complements training provided by group mentors within the new employee’s work group.

Education Division Training

For SAS Education, delivering a broad spectrum of high-quality training support for SAS software technology and solutions is a goal not just for external customers, but also for SAS employees and partners. SAS employees are encouraged to attend any SAS training class offered by SAS Education as a way to expand their knowledge of the software. Employees are welcome in courses that are offered publicly to our customers in the traditional classroom, via the Live Web classroom, and they are also welcome to learn on their own with SAS’ e-Learning options. When demand warrants, groups can request employee-only courses to cover a SAS tool that benefits their current business needs.

SAS Education has high standards for training instructors and has one of the most rigorous instructor screening and training programs in the industry. To make sure that each instructor has the necessary expertise in the areas that they teach, SAS encourages each instructor to become SAS certified. In addition, instructors are required to team teach with experienced instructors before teaching a new course. The purpose of this team teaching is to gain feedback on a chapter-by-chapter basis, allowing the new instructors to learn ways to improve before teaching a course on their own.
This is invaluable experience for all of our instructors, both new and seasoned, and enables them to be sounding boards and to keep each other motivated.

In addition to individual training programs, the SAS Education staff has traditionally participated in annual face-to-face meetings designed to introduce them to new SAS technology. The Education group has put some of its technology to work by offering its annual wrap-up meetings and global divisional meetings via Live Web. Specialized boot camps and training sessions are also offered throughout the year to keep instructors abreast of changes and enhancements to the software.

Technical Support Training

The award-winning Technical Support staff goes through an extensive mentoring process in order to develop the skills and knowledge necessary to answer customer queries about our products. Formal training for Technical Support staff begins with a checklist of introductory activities that familiarizes them with the support policies, procedures, and tools of our company. They might then attend courses offered by other departments, as well as seminars, or one-on-one training offered within the division. In addition, there are ongoing opportunities for them to remain current on technology issues and customer service skills through customized classes and web-based e-learning courseware.

Technical Support also provides a Technical Support Academy when hiring recent college graduates. This is a four-month program that involves rigorous technical training, case studies to reinforce learning, and the opportunity to achieve four SAS certifications. Academy members shadow with existing staff in their areas and work with a mentor once they leave the Academy and join their teams.

Leadership Development

This team increases organizational effectiveness at SAS by providing all managers and their teams with leadership and management development opportunities. This includes a core curriculum of 10 to 12 classes that individuals might participate in alone or with their intact teams. Ultimately, we aim to increase their competence in leadership and interpersonal communication skills, as well as their commitment to developing the overall performance of their individual staff members and teams. Both the transfer of training and the consistent use of new skills are fostered through action plans, skills coaching, and varied follow-up opportunities to embed learning in day-to-day behaviors. In addition, Leadership Development offers coaching and consultation in leadership, conflict management, team development, energy management, meeting planning, and facilitation.

SAS Global Sales Training

The SAS Global Sales Training organization provides programs and services to enhance the sales effectiveness of SAS' global sales force and partners. Sales, pre-sales, and sales management professionals receive training on topics such as: sales processes and methodologies, critical selling skills, business acumen, industry/domain knowledge, and messaging and positioning of SAS solutions and services in the areas of data management, business intelligence, analytics, and other SAS' horizontal and vertical industry solutions.

Intensive Sales and Pre-Sales Academy programs are tailored for recent university graduates. Starting Block workshops are provided for experienced sales professionals newly hired to the company. Existing sales teams increase their knowledge and sharpen their skills through a blended approach of instructor-led classroom training, self-directed e-learning, Live Web training, and certification programs, intended to provide flexible development options to fit each employee’s schedule, regardless of time zone or location.
Training and Skills Management

SAS provides the tools necessary to monitor employee training, assess skills, recommend training paths, and identify resources. Getting the right training at the right time is critical to achieving professional and personal development goals. Project success and customer satisfaction often depend on acquiring the most qualified resource based on skill set and experience. The Learning Management System is the mechanism by which these goals can be obtained. The system empowers individuals to develop a path for growth based on their roles, identify and schedule the best learning options, and track progress along the way. The group is the focal point for the development of training paths by role for new hires, consulting, sales, system engineers, product marketing, R&D, and others.

Knowledge Sharing

This is a continual exchange of best practices, lessons learned, and subject matter expertise to optimize the development, sale, and delivery of SAS products and solutions. Various knowledge-sharing sessions provide real-time information about internal R&D best practices, the latest SAS product releases, and tips for optimizing usage of SAS®9 technology to an ever-widening audience of field sales and technical personnel, R&D developers, marketing, sales and product managers, and Technical Support engineers.
Appendix 4: Quality in SAS Education

Keeping our customers’ needs in mind, SAS Education offers technical training and professional development in a variety of training mediums that allow all learning styles, budgets, and curriculum needs to be met. With traditional classroom, Live Web, self-paced e-Learning, books, and free SAS tutorials, we offer more than 200 technical courses in training centers across North America or in a customer’s own work environment.

Our web-based learning options have grown, and they serve many different needs.

- SAS e-Learning courses are self-paced, on-demand educational products that offer customers a way to learn at their own pace. Choose from full courses or short, one-subject tutorials.
- Our Live Web classroom courses allow interaction between instructors and other students while working together in a virtual lab, giving customers access to the latest SAS software without leaving the work environment.
- SAS Education now offers connected classroom environments in Cary, New York, and San Francisco that bring full-day training content to Live Web students from those sites.
- We have nearly 400 free SAS tutorials available, as well as several e-Learning courses that are free to users. Free course topics include Programming, Statistics, Administration, Open Source Integration, and SAS Viya.

SAS Education supports the professional development needs of its users by offering industry-specific seminars and conferences throughout the year.

- Business Knowledge Series courses provide knowledge and experience from a global network of industry experts through focused, in-depth seminars.
- Conferences and events, such as the Analytics Experience Conference Series and Discovery Summit, provide group settings for knowledge transfer, training, and certification.

The SAS Certified Professional Program enables users to earn globally recognized credentials that confirm their expertise in using the software. These credentials, in turn, provide companies with a very valuable resource: highly skilled personnel.

Education is involved in rollout and enablement of major new software initiatives to support sales and adoption. The recent rollout of SAS Viya continues to be supported by SAS Education in the following ways:

- A free SAS Viya Enablement e-Learning course, found at https://support.sas.com/edu/schedules.html?ctry=us&crs=EVIYAEN.
- Tutorials, Hands-on Workshops and courses for SAS Global Forum and the Analytics Experience conference.
- Video tutorial libraries for Early Adopter releases and trials as needed.

Quality in SAS Training Courses

To make sure that SAS training courses are useful for our customers and meet the ever-changing needs of their business, SAS Education employees design and develop training courses at both the individual course level and the curriculum level. Our process is based on established instructional systems design theory and practice and incorporates the process areas of the Capability Maturity Model (a software development methodology). Further, it provides a
framework for continuous quality improvement. The analysis, design, and development phases of this process are of particular importance.

The analysis phase begins with significant input from a variety of internal and external sources specific to the industry and to the proposed training objectives. The development team collects pertinent data from related courses, students, customers, and resources across SAS and works with the course Project Sponsorship Team to develop training programs that will be helpful to our users.

In the design phase, SAS instructional designers use the results of the analysis phase to plan the instructional sequence of individual courses. During this phase, the work plan is written, course structure and flow are considered, and a detailed course outline is developed. Perhaps what is most important to quality in this phase is course design and content review. Subject-matter experts review course design plans and provide feedback to the Project Sponsorship Team about topics such as instructional flow, course data, delivery methods, and technical issues. The feedback received helps course developers finalize the training content while exposing potential weaknesses in the instructional flow and examples. This constructive feedback allows for additional quality improvement as the project moves forward.

In the development phase, the input that is received during the course design and content review sessions is used to create the training content. At numerous points during the process, the project development team consults with the technical reviewers, who look for accuracy and instructional flow while testing the demonstrations and programs on appropriate platforms. Typically, technical reviewers include at least two instructors and numerous subject-matter experts from a variety of sources.

The test teach is another opportunity to validate the course content, flow, and style. This exercise delivers the new course to students in a setting that is as realistic as possible. The audience of each test teach consists of a combination of students whose main objective is to learn the material and of subject-matter experts who critique the training content.

A final quality check is performed when a lead editor (or multiple editors) conducts a comprehensive review of the course. Then, the production lead who is assigned to the course development project performs quality checks on the final materials.

The Education Project Office tracks each course development project to see that documented processes are followed and offers project quality assurance, project status reporting, and project management support.

Quality in Instructor Training and Certification

SAS instructors are not only recognized for their outstanding teaching skills, but often are considered to be thought leaders in their areas of instruction. To make sure that our instructors have the necessary expertise in the subjects that they teach, SAS holds each instructor to very high standards. Every instructor is encouraged to become SAS certified. Before teaching a new course, they team teach with experienced instructors gaining feedback on a chapter-bychapter basis before teaching on their own.

A lengthy process for developing SAS certification examinations makes sure that exams are valid and reliable: valid means that they measure what they are supposed to measure, and reliable means that they are consistent in how accurately they measure a candidate’s skills. Because they follow a rigid, 10-step process of test development, SAS certification exams are considered well-developed and defensible examinations. As a leader in the IT certification industry, the SAS Certified Professional Program also provides a forum for other organizations to exchange ideas and to discuss the latest research in test development.
Quality in Customer Service

Serving more than 30,000 students a year, SAS Education has remained dedicated to the users of SAS products and services. Our commitment to quality extends beyond the technical aspects of the division’s work. Because SAS Education regards the relationship that it develops with each student as its greatest resource, the same high standards for quality that are built into course development, instructor training, and certification are part of its customer care.

SAS Education’s Customer Service Department communicates with students multiple times during the student life cycle. Before the start of a class, each student could receive multiple communications: a confirmation email with information about what to expect during the course, reminders closer to the date of the course, verification that the particular course will run and, in addition, a customer service representative might contact a student to learn about any special requests or needs. During a course, students enjoy an educational environment with the latest technology staffed by experienced training-center professionals who engage in open communication with each student.

Perhaps the most important communication, however, is the post-class contact. Each student receives an email or phone call three weeks after attending a class to find out how successfully the student was able to apply what he or she learned and to discuss any suggestions for improving the class. Completing the cycle of customer care, SAS Education instructors provide contact information to their students so that a student can contact the instructor after class to ask questions or to receive consultation about the material covered during a course. In addition, students have access to Extended Learning Pages, which allows each student to take course knowledge a step further. By accessing the Extended Learning Pages for the course, students can download the course data, access extra practice, examples, papers and FAQs, and find additional resources to help them develop the skills that they learned in class. Outside the classroom, SAS Education offers many social media venues where instructors and customers can share tips and tricks, ask and answer questions, and share information about events. For examples, see the SAS Training social media website at http://support.sas.com/training/socialmedia.html.

At SAS Education our commitment to quality, coupled with a desire to develop lasting relationships with our students, has enabled us to become a model for other industry training providers.

Appendix 5: Quality in Publications

Researching New Features

Project managers and writers in the Publications Division are in constant contact with product developers to keep abreast of new features as they are being developed. Writers attend development meetings and also subscribe to and participate in newsgroups and blogs that are related to the products that they are documenting. They work with new product features as the features are being developed and work with the appropriate developers to ensure that the documentation is clear, complete, and accurate.

Planning the Documentation Library

If a product is new, the writer analyzes the audience and its task workflow to determine what types of documentation are needed (for example, a user’s guide, an administrator’s guide, product Help, or a video or slideshow).

If an existing product is being updated, the writer reviews the documentation set and determines whether new types of documentation are needed or existing documentation is obsolete. Writers consult with Technical Support for input on how to improve the documentation. SAS regularly surveys customers regarding their satisfaction with the documentation and provides a Feedback link from the documentation on the web.

As products are updated, the changes are compiled into a single What’s New topic that is delivered with the product documentation. A What’s New summary document (called What’s New in SAS) provides a high-level overview of all the changes and new products in a SAS release. For example, the most recent version for SAS 9.4 contains information from the initial release in July 2013 and any subsequent SAS 9.4 releases, such as SAS 9.4M5. This summary document is available (as HTML, PDF, and EPUB) from the web. Also, documentation that is available on the web is updated as needed and is labeled with the date of the update.

Developing Content

Writers and software developers work closely together to produce new documentation. The writer studies the software specifications and works with the software that is in development. The writer also develops and tests examples.

Most documentation is authored in the Extensible Markup Language (XML) authoring environment, although some documentation is authored in LaTeX, in Adobe FrameMaker, in Microsoft Word, or directly in HTML. When a first draft of the documentation is ready, project managers and writers send it out for technical review.

Employees in the SAS R&D, Technical Support, Worldwide Marketing, and Education Divisions are asked to review the documentation. These reviewers check the documentation for technical accuracy, completeness, and clarity, and send comments back to the writers.

Editing

All documentation is edited. There are three types of edits:

- Substantive edits occur early in the development of the documentation. These edits address the overall structure, organization, and writing style of the document.
- Copy edits concentrate on spelling, grammar, punctuation, consistency, and style.
- Policy edits check for trademark issues and glaring errors in text such as misspellings.

Most of our documentation receives a copy edit. All of our documentation receives at least a policy edit. As project schedules permit, a substantive edit occurs at the same time as the review.
Indexes and Searching

We provide indexes for many of our PDF documents, including the books that are sold through the SAS bookstore. For online documents, we provide search functionality. Both indexes and the search functionality are tested for accuracy.

Converting and Testing Documentation

After documentation is written, it is converted to the appropriate media, and tested. To produce quality products, informal conversion and testing begins several months in advance, before the content is final, and continues throughout the remainder of the content development cycle.

For both the HTML and the PDF, editors and testers use automated tools to test the integrity of the hypertext links between sections of the document and to test links to other documents. If the testers find errors, these errors are sent back to the writers for resolution. If the conversion tools have generated the error, a problem report is submitted to the Publications Technology Development Department. After the error or tools problem has been fixed, the testers verify that the error has been resolved.

As soon as the new and revised content has been tested, it is transformed to the source required for various delivery targets (for example, Help, the web) and pushed to those targets. Regularly scheduled transformation, building, and porting processes continue for the duration of the revision cycle. An iterative cycle of content updates and verification is used until errors in content, formatting, and doc delivery systems are resolved to satisfaction within the boundaries of the scope and schedule of the software release.

Up to this point, testers in the Publications Division have performed all the testing. For documentation that is part of the SAS Help, R&D product groups also test the documentation for their specific products. If they find an error, the tester records the problem in the problem reporting system, and the problem is routed to the writer. The writer fixes the error, and the conversion and testing cycle is repeated.

Preparing Documentation for Printing

To produce a hard-copy book from an XML source, the XIS system generates an Acrobat file for print. For sources that are created using Microsoft Word, Technical Publishing Specialists distill the Word files to various formats including PDF, HTML, and EPUB. Editors review the output for errors before the books are sent to the printer. All print deliverables are checked for quality by both the Editing and User Publishing Support Departments.

Controlling Changes to the Documentation

Our source files are under a revision control system that is similar to the source management system used for SAS source code. The revision control system maintains a revision history for all files, and previous versions can be restored if needed.

Distributing Documentation to Customers

When we ship new or updated software, our documentation is updated to reflect the enhancements to the software. New and revised documentation is posted to the web in HTML, PDF, and EPUB formats. Selected titles are printed on demand and are available in hard copy for purchase from the SAS Bookstore. Documentation is also available from our business channel partners (e-tailers) in PDF or EPUB formats.

Tracking Problems after Software Updates

All substantive changes to documentation are tracked in a problem reporting system, including changes to existing information and information about new features. When we either revise or reprint a document, technical errors are
corrected, revisions are reviewed, and changes are made, as appropriate. The Publications Division encourages feedback from users by email or through the SAS website.

Developing Software Used to Author and Deliver Documentation

The Publications Technology Development Department develops and supports both the SAS Documentation Delivery System and the software used by the Publications Division to create Help content for online delivery and printed books. The developers and testers involved in this work use the same tools, processes, and protocols for software development that are described in the main body of this document so that our documentation delivery system software meets the same quality standards for a worldwide audience.

Managing Terminology

Quality documentation depends on “quality at the source.” This means following standards for correct, consistent, and clear words and phrases as we describe and explain how to use SAS software. The Publications Division continues to lead a corporate-wide initiative in terminology management to help us provide quality communication and documentation for our customers. This initiative includes managing a central repository for SAS terminology, as well as processes to establish terminology quality checks throughout product development and delivery.

Terminologists in the Publications Division have the primary responsibility for researching, creating, and updating entries to the terminology database, which serves as a resource for the entire company. Technical writers and editors use a customized application that checks documents for clarity and for correct terminology. Publications is also working closely with R&D to develop quality terminology in software error messages and in user interface text. Finally, Publications is involved in collaborative work with our European and Asia-Pacific localization offices. By focusing on quality at the source, translation of SAS software and documentation can be accomplished more accurately and efficiently.

Terminology management is recognized as critical to quality offerings in a global market. Publications is committed to continuing its leadership role in establishing quality terminology across SAS products.
Appendix 6: Validating a Statistical Procedure

Numerical Accuracy

We use a variety of methods to verify the accuracy and precision of the results generated by our software. Libraries of regression tests using automated tools are run periodically throughout the testing cycle to test functionality and data integrity. These reusable libraries of tests cover syntax, options, functionality, valid and invalid data, errors, stress, and results for the procedure/function/solution. These tests are run, and differences are resolved, before the release is declared production.

Validating a Statistical Procedure

Our development staff has the education, training, and experience to perform their assigned tasks. They use a variety of methods to see, to the extent possible, that the software produces accurate, reliable, and numerically precise results. A combination of methods is used to validate a single SAS procedure. These methods are listed below.

Writing Independent SAS/IML (Interactive Matrix Language) or DATA Step Code

Except when similar results are available within an existing and previously tested SAS procedure or application, independent verification of numerical results via SAS/IML, DATA step code, or hand calculations is performed. SAS/IML is a powerful matrix programming language that is used to re-create the numerical output, or pieces of the output, produced by the procedure being validated. Sometimes the same algorithm used by the procedure is coded into SAS/IML, but occasionally a different algorithm will be used if the two algorithms are expected to produce the same results. Replication of results via SAS/IML or DATA step code is the best method for validation because it’s an independent and verified confirmation of the numerical output.

Comparing to Similar Results in Other SAS Procedures, Applications, or Macros

Many procedures produce the same types of parameter estimates, covariances, and other statistics. Similar output produced by new procedures is validated by comparing it to these previously validated results. Similarly, when a macro program exists that produces some of the same results as the new procedure, it can be used for validation.

Running Simulation Studies

Simulation studies are performed in instances where closed-form solutions don’t exist or used as checks when computations are extremely time and memory intensive.

Verifying against Published Results

Comparison against other software vendors’ applications is sometimes made, especially in those cases where the vendor’s application is highly regarded as producing quality results. Note that matching another vendor’s results is not considered sufficient validation.

Completing Consistency Checks within the Procedure or Application

Certain consistency checks are performed to help validate results. Here are some examples:

- Checking that results with a WEIGHT variable that has all weight values equal to 1 are identical to results obtained without using the WEIGHT variable.
- Verifying that results with a FREQ variable match results when not using the FREQ variable but instead repeating each observation by the value of the FREQ variable.
- Verifying that results with a BY statement match those obtained for each value of the BY variable analyzed individually.
An example of our validation techniques for the REG procedure is included below.

**Example of Validation Techniques**

The following example is a basic illustration of validation testing performed at SAS. The test case verifies the results from the REG procedure by comparing them to a classic textbook analysis. The data comes from Neter, Wasserman, and Kutner, (1990), and the test case verifies the ANOVA table, the Fit Statistics, and the Parameter Estimates table that PROC REG produces.

The data consists of sales information from 15 marketing districts, and PROC REG fits a multiple regression model. Besides comparing the results to the textbook results, this example also illustrates validation using the IML procedure and cross validation using the GLM procedure. Finally, the example concludes by illustrating some basic consistency checks.

```r
data Zarthan_Company;
input sales target_population discretionary_income @@;
datalines;
162 274 2450 120 180 3254 223 375 3802 131 205 2838 
67 86 2347 169 265 3782 81 98 3008 192 330 2450 
116 195 2137 55 53 2560 252 430 4020 232 372 4427 
144 236 2660 103 157 2088 212 370 2605 ;
ods listing close;
ods rtf file='Zarthan.rtf';
ods select ANOVA FitStatistics ParameterEstimates;
proc reg data=Zarthan_Company;
ods output ANOVA=reg_ANOVA
FitStatistics=reg_FitStatistics
ParameterEstimates=reg_ParameterEstimates;
  model sales = target_population discretionary_income;
run;
ods rtf close;
```

**PROC REG Results**

<table>
<thead>
<tr>
<th>Source</th>
<th>DF</th>
<th>Sum of Squares</th>
<th>Mean Square</th>
<th>F Value</th>
<th>Pr &gt; F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model</td>
<td>2</td>
<td>53845</td>
<td>26922</td>
<td>5679.47</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>Error</td>
<td>12</td>
<td>56.88357</td>
<td>4.74030</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Corrected Total</td>
<td>14</td>
<td>53902</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Parameter Estimates

| Variable                | DF | Parameter Estimate | Standard Error | t Value | Pr > |t| |
|-------------------------|----|--------------------|----------------|---------|------|---|
| Intercept               | 1  | 3.45261            | 2.43065        | 1.42    | 0.1809 |
| target_population       | 1  | 0.49600            | 0.00605        | 81.92   | <.0001 |
| discretionary_income    | 1  | 0.00920            | 0.00096811     | 9.50    | <.0001 |

### Comparison to Textbook

The results from PROC REG can be compared to those given in the textbook to verify that there are no discrepancies. For this example, the following quantities are reported in the textbook:

#### ANOVA Results

<table>
<thead>
<tr>
<th>Statistic</th>
<th>Result</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>SS Model</td>
<td>53,844.716</td>
<td>256</td>
</tr>
<tr>
<td>SS Error</td>
<td>56.884</td>
<td>256</td>
</tr>
<tr>
<td>SS Total</td>
<td>53,901.600</td>
<td>256</td>
</tr>
<tr>
<td>df Model</td>
<td>2</td>
<td>256</td>
</tr>
<tr>
<td>df Error</td>
<td>12</td>
<td>256</td>
</tr>
<tr>
<td>df Total</td>
<td>14</td>
<td>256</td>
</tr>
<tr>
<td>MS Model</td>
<td>26,922.358</td>
<td>256</td>
</tr>
<tr>
<td>MS Error</td>
<td>4.740</td>
<td>256</td>
</tr>
<tr>
<td>F*</td>
<td>5,680</td>
<td>257</td>
</tr>
<tr>
<td>p-value</td>
<td>&lt; .001</td>
<td>257</td>
</tr>
</tbody>
</table>

* Note that PROC REG reports as 5,679.47. The discrepancy is due to the textbook example rounding the quantities involved in the ratio before the ratio is computed.

#### Fit Statistics

<table>
<thead>
<tr>
<th>Statistic</th>
<th>Result</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>R-Squared</td>
<td>0.9989</td>
<td>257</td>
</tr>
</tbody>
</table>

#### Parameter Estimates
**Direct validation**

SAS/IML can be used to compute the corresponding quantities from the PROC REG output:

```sas
proc iml;
    use Zarthan_Company;
    read all var _all_ into data;
    y=data[,1];                         * dependent variable;
    n=nrow(y);                           * sample size;
    x=j(n,1,1)||data[,2:3];              * x matrix, augmented for intercept;
    p=ncol(x);                           * number of parameters;
    beta=inv(x`*x)*x`*y;                 * parameter estimates;
    yhat=x*beta;                         * predicted values;
    resid=y-yhat;                        * residuals;
    sse=ssq(resid);                      * Sum of Squares for Error;
    dfe=nrow(x)-ncol(x);                 * error degrees of freedom;
    mse=sse/dfe;                         * Mean Square Error;
    cssy=ssq(y-y[+])/n;                  * Corrected Total Sum of Squares;
    rsquare=(cssy-sse)/cssy;             * R-Square;
    stdbeta=sqrt(vecdiag(inv(x`*x))*mse);* Std error of estimates;
    t=beta/stdbeta;                      * parameter t-tests;
    df=j(nrow(t),1,1);                   * parameter degrees of freedom;
    t_prob=1-cdf('F',t##2,df,dfe);       * p-values for t-tests;
    dfm=dft-dfe;                         * Model degrees of freedom;
    F=msm/mse;                           * F statistic;
    F_prob=1-cdf('F',F,dfm,dfe);         * p-value for F statistic;
    root_mse=sqrt(mse);                  * Root MSE;
    mean_y=y[+]/n;                       * Dependent Mean;
    coeff_var=(root_mse/mean_y)*100;     * Coefficient of Variation;
    adj_r=1-((n-1)#(1-rsquare))/(n-p);   * Adjusted R-Square;

    /* create matrices of the corresponding REG tables;*/
    anova_table=(dfm//dfe//dft)||(ssm//sse//cssy)||(msm//mse//{._})
        ||(F//{._ .}_) ||(F_prob//{._ .}_`);   
    fit_statistics=(root_mse//mean_y//coeff_var)||(rsquare//adj_r//{0});
    parameter_estimates=df||beta||stdbeta||t||t_prob;

    /* create data sets of these matrices to be used with the COMPARE procedure;*/
    create iml_anova(label='Analysis of Variance' )
        from anova_table[colname={df ss ms fvalue probf}];
    append from anova_table;
    create iml_fitstatistics(label='Fit Statistics' )
        from fit_statistics[colname={nvalue1 nvalue2}];
    append from fit_statistics;
    create iml_parameterestimates(label='Parameter Estimates' )
        from parameter_estimates[colname={df estimate stderr tvalue probt}];
```
append from parameter_estimates;
quit;

* print the SAS/IML validation results for a visual scan;
proc print data=iml_anova noobs; run;
proc print data=iml_fitstatistics noobs; run;
proc print data=iml_parameterestimates noobs; run;

**SAS/IML Validation Results**

**ANOVA Table**

<table>
<thead>
<tr>
<th>DF</th>
<th>SS</th>
<th>MS</th>
<th>FVALUE</th>
<th>PROBF</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>53844.72</td>
<td>26922.36</td>
<td>5679.47</td>
<td>0</td>
</tr>
<tr>
<td>12</td>
<td>56.88</td>
<td>4.74</td>
<td></td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>53901.60</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Fit Statistics Table**

<table>
<thead>
<tr>
<th>NVALUE1</th>
<th>NVALUE2</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.177</td>
<td>0.99894</td>
</tr>
<tr>
<td>150.600</td>
<td>0.99877</td>
</tr>
<tr>
<td>1.446</td>
<td>0.00000</td>
</tr>
</tbody>
</table>

**Parameter Estimates Table**

<table>
<thead>
<tr>
<th>DF</th>
<th>ESTIMATE</th>
<th>STDERR</th>
<th>TVALUE</th>
<th>PROBT</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>3.45261</td>
<td>2.43065</td>
<td>1.4204</td>
<td>0.18094</td>
</tr>
<tr>
<td>1</td>
<td>0.49600</td>
<td>0.00605</td>
<td>81.9242</td>
<td>0.00000</td>
</tr>
<tr>
<td>1</td>
<td>0.00920</td>
<td>0.00097</td>
<td>9.5021</td>
<td>0.00000</td>
</tr>
</tbody>
</table>
* compare via PROC COMPARE the PROC REG results to the SAS/IML validation results

```
proc compare data=reg_anova compare=iml_anova
   error briefsummary note method=relative(1) criterion=1e-6;
   attrib _all_ format = label = '';
   var df ss ms fvalue probf;
run;

proc compare data=reg_fitstatistics compare=iml_fitstatistics
   error briefsummary note method=relative(1) criterion=1e-6;
   attrib _all_ format = label = '';
   var nvalue1 nvalue2;
run;

proc compare data=reg_parameterestimates compare=iml_parameterestimates
   error briefsummary note method=relative(1) criterion=1e-6;
   attrib _all_ format = label = '';
   var df estimate stderr tvalue probt;
run;
```

PROC COMPARE Results

The COMPARE Procedure
Comparison of WORK.REG_ANOVA with WORK.IML_ANOVA
   (Method=RELATIVE(1), Criterion=0.000001)

NOTE: All values compared are within the equality criterion used.

NOTE: One or both of the data sets WORK.REG_ANOVA and WORK.IML_ANOVA contain
variables not in the other. However, all comparisons are equal for the
variables specified.

The COMPARE Procedure
Comparison of WORK.REG_FITSTATISTICS with WORK.IML_FITSTATISTICS
   (Method=RELATIVE(1), Criterion=0.000001)

NOTE: All values compared are within the equality criterion used.

NOTE: One or both of the data sets WORK.REG_FITSTATISTICS and
WORK.IML_FITSTATISTICS contain variables not in the other. However, all
comparisons are equal for the variables specified.

The COMPARE Procedure
Comparison of WORK.REG_PARAMETERESTIMATES with WORK.IML_PARAMETERESTIMATES
   (Method=RELATIVE(1), Criterion=0.000001)

NOTE: All values compared are within the equality criterion used.

NOTE: One or both of the data sets WORK.REG_PARAMETERESTIMATES and
WORK.IML_PARAMETERESTIMATES contain variables not in the other.
However, all comparisons are equal for the variables specified.
Comparison to other SAS procedures

The PROC REG results can be compared to PROC GLM output:

* run the corresponding model with PROC GLM;

```sas
proc glm data=Zarthan_Company;
  ods output OverallANOVA=glm_ANOVA(label='Analysis of Variance')
          FitStatistics(glm_FitStatistics)
          ParameterEstimates=glm_ParameterEstimates(label='Parameter Estimates');
  model sales = target_population discretionary_income/solution;
run;
```

* compare the REG results to the GLM results;

```sas
proc compare data=reg_anova compare=glm_anova
  error briefsummary note method=relative(1) criterion=1e-6;
  attrib _all_ format = label = '';
  var df ss ms fvalue probf;
run;
```

```sas
proc compare data=reg_parameterestimates
  compare=glm_parameterestimates
  error briefsummary note method=relative(1) criterion=1e-6;
  attrib _all_ format = label = '';
  var estimate stderr tvalue probt;
run;
```

* visually compare the statistics that correspond in Fit Statistics because the two tables have a different structure:

```sas
proc print data=reg_FitStatistics; run;
proc print data=glm_FitStatistics; run;
```

### PROC REG Results

<table>
<thead>
<tr>
<th>Obs</th>
<th>Model</th>
<th>Dependent</th>
<th>Label1</th>
<th>cValue1</th>
<th>nValue1</th>
<th>Label2</th>
<th>cValue2</th>
<th>nValue2</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>MODEL1</td>
<td>sales</td>
<td>Root MSE</td>
<td>2.17722</td>
<td>2.177222</td>
<td>R-Square</td>
<td>0.9989</td>
<td>0.998945</td>
</tr>
<tr>
<td>2</td>
<td>MODEL1</td>
<td>sales</td>
<td>Dependent Mean</td>
<td>150.60000</td>
<td>150.60000</td>
<td>Adj R-Sq</td>
<td>0.9988</td>
<td>0.998769</td>
</tr>
<tr>
<td>3</td>
<td>MODEL1</td>
<td>sales</td>
<td>Coeff Var</td>
<td>1.44570</td>
<td>1.445699</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### PROC GLM Results

<table>
<thead>
<tr>
<th>Obs</th>
<th>Dependent</th>
<th>RSquare</th>
<th>CV</th>
<th>RootMSE</th>
<th>DepMean</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>sales</td>
<td>0.998945</td>
<td>1.445699</td>
<td>2.177222</td>
<td>150.6000</td>
</tr>
</tbody>
</table>
Consistency Checking

A simple check of the WEIGHT statement can be performed. Note that complete testing for WEIGHT would include tests where the weight values are not all equal to 1, with SAS/IML validation performed.

* add a weight variable to the data set, with values all equal to 1;

```sas
data check_weight; set Zarthan_Company;
  weight=1;
run;
```

* run PROC REG with the weight variable;

```sas
proc reg data=check_weight;
  ods output ANOVA=reg_ANOVA_weight
    FitStatistics=reg_FitStatistics_weight
    ParameterEstimates=reg_ParameterEstimates_weight;
  model sales = target_population discretionary_income;
  weight weight;
run;
```

* compare the results from the REG run without a weight to the REG run with weights all equal to 1;

```sas
proc compare data=reg_anova compare=reg_anova_weight
  error briefsummary note method=relative(1) criterion=1e-6;
  attrib _all_ format = label = '';
run;
```

```sas
proc compare data=reg_fitstatistics compare=reg_fitstatistics_weight
  error briefsummary note method=relative(1) criterion=1e-6;
  attrib _all_ format = label = '';
run;
```

```sas
proc compare data=reg_parameterestimates compare=reg_parameterestimates_weight
  error briefsummary note method=relative(1) criterion=1e-6;
  attrib _all_ format = label = '';
run;
```

PROC COMPARE Results:

The COMPARE Procedure
Comparison of WORK.REG_ANOVA with WORK.REG_ANOVA_WEIGHT
(Method=RELATIVE(1), Criterion=0.000001)

NOTE: All values compared are within the equality criterion used.

NOTE: The data sets WORK.REG_ANOVA and WORK.REG_ANOVA_WEIGHT compare equal.

The COMPARE Procedure
Comparison of WORK.REG_FITSTATISTICS with WORK.REG_FITSTATISTICS_WEIGHT
(Method=RELATIVE(1), Criterion=0.000001)

NOTE: All values compared are within the equality criterion used.

NOTE: The data sets WORK.REG_FITSTATISTICS and WORK.REG_FITSTATISTICS_WEIGHT compare equal.
The COMPARE Procedure
Comparison of WORK.REG_PARAMETERESTIMATES with
WORK.REG_PARAMETERESTIMATES_WEIGHT
(Method=RELATIVE(1), Criterion=0.000001)

NOTE: All values compared are within the equality criterion used.

NOTE: The data sets WORK.REG_PARAMETERESTIMATES and
WORK.REG_PARAMETERESTIMATES_WEIGHT compare equal.

References


Appendix 7: Installation and Operation Qualification

This section covers SAS 9.4. For information about SAS IQ for SAS Viya, go to https://support.sas.com/en/documentation/install-center/sas-viya/deployment-guides.html, click on the appropriate Viya Deployment document, then go to the Validating the Deployment section.

SAS 9.4 includes three qualification tools, the SAS Installation Qualification Tool (SAS IQ), the SAS Operational Qualification Tool (SAS OQ), and SAS Deployment Tester, to help customers verify installation and test the operation of SAS at their sites. These tools provide a consistent, repeatable process for verifying the initial installation and future updates to SAS while also providing a framework for running customer-written tests. Output of SAS IQ and SAS OQ includes a data file that contains the test results and output formatting options. SAS Deployment Tester generates an online report of the success of each test run.

Background

Originally, these tools were conceived as testing tools to assist with the internal testing of the installation processes. However, the feature set has been broadened to allow distribution to customers. The SAS Qualification Tools (SAS IQ and SAS OQ) that are shipped to customers are the same tools that are used in the testing and qualification of the SAS®9 installation software. SAS Deployment Tester was designed to test the complex configuration of the SAS 9.4 Intelligence Platform, although any of the SAS OQ tests or customer-written tests can be run using this tool.

Customer Considerations

The SAS installation qualification tool (SAS IQ) assists regulated customers in demonstrating compliance and qualifying the installation. SAS IQ can be used as part of the installation process, as an interim check on the state of the SAS System, and as an automated tool to maintain an audit history. The SAS operational qualification tool (SAS OQ) also assists in demonstrating compliance and includes tests that are designed to be included in operational qualification. SAS OQ can be used as part of the initial qualification process and as an automated tool to maintain a history when changes are made to the SAS installation. SAS Deployment Tester will run SAS OQ tests and also tests for SAS 9.4 Intelligence Platform.

SAS customers need to install SAS on appropriate hardware and software according to the installation instructions. When running SAS 9 or later, customers should run the SAS IQ and SAS OQ tests after installation. Customers should then write procedures that document how SAS is used at their site. Any systems they have built using SAS might need to be validated with each new SAS release. Many companies do this by running the programs at the earlier release, and then running the tests at the new release and comparing results.

SAS Professional Services and Delivery can provide support to customers, including drug sponsors and contract research organizations, on validation efforts. Consultants take steps such as these:

- Gather user and functional requirements and prepare validation documentation inclusive of validation plans, test protocols, and test scripts.
- Install and configure SAS software according to the instructions and alert notes that are delivered by SAS as part of the software shipment.
- Execute IQ, OQ, and Performance Qualification (PQ) according to approved plans and test scripts.
- Provide knowledge transfer to IT staff and end users on the above, recommending formal SAS training where needed.
- Provide project management for all of the above activities.
Operation

The testing process for the installation of SAS 9.4 has three phases. The first phase is the initial installation process on the target platforms. The second phase is the execution of the SAS Installation Qualification Tool (SAS IQ). The third phase is the execution of the SAS Operational Qualification Tool (SAS OQ) or SAS Deployment Tester.

Phase 1

During this phase, SAS is installed at the customer site. Customers should follow the installation instructions provided in their packages—or see the online instructions provided on the SAS Install Center (http://support.sas.com/documentation/installcenter/).

Phase 2

SAS IQ assists you in demonstrating that the SAS System has been installed and maintained to the manufacturer’s specifications. SAS IQ verifies the integrity of each file in the SAS System 9 and provides the customer a set of reports detailing the results. To execute SAS IQ, follow the instructions in http://support.sas.com/documentation/installcenter/en/ikinstqualtoolug/66614/PDF/default/qualification_tools_guide.pdf

Phase 3

SAS OQ assists you in demonstrating that the SAS System is operational. SAS OQ uses SAS programs provided by the component development groups and will execute, process, and report the program results. To execute SAS OQ, follow the instructions in http://support.sas.com/documentation/installcenter/en/ikinstqualtoolug/66614/PDF/default/qualification_tools_guide.pdf

SAS Deployment Tester is a diagnostic tool used for assessing a SAS 9.4 Intelligence Platform deployment. After an installation or upgrade, you can use SAS Deployment Tester to ensure that your SAS software and critical server components have been installed and configured correctly. To learn more about the SAS Deployment Tester, including prerequisites for use, how to add tests, and how to use the DeploymentTester, see http://support.sas.com/documentation/cdl/en/bisag/68240/HTML/default/viewer.htm#n1cm1j9i99dvyqn1nu3wam8slwu3.htm

Content

The content of the testing tools is generated within the R&D community. During the weekly build process, a data file is created that contains the md5sum values for each file that is used by SAS IQ for each target platform. These values are validated over the course of weekly testing by several testing groups in R&D. The test cases and test tables used by SAS OQ and SAS Deployment Tester are developed by the testing groups that are responsible for the SAS®9 component. The tables and tests are executed and validated on all target platforms during weekly testing by several testing groups in R&D.
Verification of Test Results

Customers can create new tests that fit their unique needs. A test can be constructed in several ways. There are general approaches to determining the result of a test:

- Human verification
- Programmatic verification
- Self-verification

Human verification of a test is the least efficient of the approaches. This method requires that a person visually inspect the results of a test including the SAS log, the SAS output, and the return code from the SAS application. It is time-consuming and very repetitive work to go over the same text files again and again. This can lead to incorrect results interpretation after just a few iterations.

Programmatic verification means that a test program, such as a SAS program, can’t reliably determine its own result status, so it needs additional programs that run after it is completed to help determine the result.

Filtering and comparing with a benchmark is a classic and common example of programmatic verification. When this method is used, the output file is filtered to remove non-deterministic data, of which the current date and time are good examples. Then the filtered version of the output file is compared against a benchmark file in a byte-by-byte manner. If the filtered output file matches the benchmark, then the test is deemed to have passed; otherwise, the test has failed. Benchmarks are problematic in that they require frequent maintenance, host-specific versions, and filtering, which could result in test failures that are not real. These failures require that resources be allocated to analyze the differences and make a determination whether there is a problem with the program being tested, whether a new benchmark needs to be created, or whether some addition or change to the filter needs to be made. However, programmatic verification is very reliable and requires no special programming skills other than filtering to create the filtered output file.

The self-verification approach means writing a test program that can reliably determine whether the feature being tested worked and then reporting that through a simple return code. Self-verification avoids all the problems of benchmarking and produces very reliable, durable, low-maintenance test ware, but it does require additional, up-front investment and programming skills. Tests must be carefully written to make sure that passing results are accurate.

SAS has put a lot of effort into writing as many as possible of the supplied SAS OQ tests in a self-verifying format. We suggest that users follow our example and try to do the same. Here are some suggestions, tips, and best practices.

Every SAS DATA step, procedure, and global statement should set the value of at least one of the automatic SAS macro variables from this list: SYSERR, SYSRC, SYSLIBRC, SYSFILRC, SYSLCKRC, and SYSINFO. Users should check these macro variables in their test programs at every opportunity.

PROC COMPARE can be used effectively to validate many procedures. Any procedure that is capable of producing a SAS data set as output can be reliably validated by directly constructing a SAS data set with the variables and values that are expected to be generated. Users can execute a simple DATA step with DATALINES input to accomplish this or any number of straightforward DATA step techniques. Then they can use PROC COMPARE to verify that the procedure-generated data set matches the one that they’ve created by hand. The result can be quickly checked by looking at the SYSINFO macro variable.

Other Notes

Customers often need to establish a baseline for their tests in a prior SAS release and then verify the results in a new SAS release. The SAS OQ provides a clear migration path for customers who are concerned about moving to a new release of SAS.
Both SAS IQ and SAS OQ are supported for the Windows and UNIX operating environments in SAS®9. SAS IQ and SAS OQ can be used only with files that are provided through the standard R&D delivery process for SAS®9 and later. For example, hot fixes applied by using the standard R&D install process will be verified regardless of the delivery mechanism (web, FTP, and so on). Files that use post-processing methods, such as ZIP or TAR archives, cannot be verified.
Appendix 8: Quality in Consulting

The SAS Professional Services and Delivery Division helps SAS users implement business intelligence solutions. Engaging SAS consultants can help you tap the full power of SAS technology and reap maximum returns on your investment.

To help you gain that return, we deliver services of exceptional quality—across the full range of SAS solutions—in parallel with our expert guidance. We are committed to your satisfaction with our software and services and have a vested interest in making sure that you get the most out of your SAS investment. To do that, we use project methodologies that include quality management (quality assurance and quality control), industry standard project governance practices, and highly qualified consultants. In addition, we have experts in the area of business transformation services to help our customers navigate any organizational changes needed to best use the power of analytics.

Our goal is to become your trusted technology and business partner.

Our Experience, Our Consultants

SAS Professional Services and Delivery Division offers experienced domain and industry thought leaders in the world of business intelligence and predictive analytics. SAS consultants have bachelors, masters, and doctoral degrees, as well as certifications, in such areas as computer science, statistics, operations research, and business administration. SAS consultants are also experienced in performance management, detailed consulting operations, applications development, system analysis and design, and project management.

When we utilize personnel from our alliance partners, we know that our clients will see them as part of the SAS team. We work hard to make sure that partner personnel have the same qualifications and expertise any other member of the SAS project team would have based on the needs of the implementation. Our alliance partners represent a select group of vendors who share the same commitment to implementation excellence that we do.

What makes SAS Professional Services and Delivery Division exceptional?

- SAS Professional Services and Delivery Division has the experience and know-how to manage the continual life cycle of SAS implementations.
- SAS Professional Services and Delivery Division knows “one size does not fit all,” bringing the experience of working with thousands of our clients, addressing each as a new environment with unique needs.
- SAS Professional Services and Delivery Division enables our customers to innovate and drive value from tactical installations to strategic business transformation with a proven methodology that adapts to each client’s capabilities and environment.
- Through the experience of thousands of SAS implementations, SAS Professional Services and Delivery Division brings proven SAS implementation methodologies and roadmaps that have been developed through our collective experiences in successful projects. Available only from SAS, these methodologies and roadmaps are the basis for the customization and implementation for your company that brings proven success and increased business value.
- SAS Professional Services and Delivery Division brings the contextual experience needed to drive value and project success. More than 70% of SAS Professional Services and Delivery Division employees have industry experience as users and business leaders who have used SAS solutions to solve complex business challenges.

SAS consultants take the time to listen and learn about customers’ business challenges and enterprise goals to establish a foundation for strategic advancement. This enables us to deliver the right SAS technology and customized services to solve customers’ unique business requirements. By combining a staff of SAS experts, a product
methodology, quality management, and project governance, we provide an excellent consulting choice for our customers.

SAS Professional Services and Delivery Division information is available at www.sas.com/consulting.

**SAS Project Methodologies**

SAS project and delivery methodologies are the basis for all SAS Professional Services and Delivery engagements; these methodologies ensure that business requirements are aligned with SAS technology and support.

All SAS methodologies feature the following key components, with their respective benefits for project planning and execution:

- Detailed work breakdown structure allows the project team to create project plans faster, and ensures that they have a common approach.
- Roles and responsibilities matrix allows determination of resources for each task, and for the establishment and management of teams that work faster and better.
- Questionnaires and templates shorten time for project planning, assessment, and documentation.
- Estimation, communications, and risk assessment tools help to increase satisfaction.
- Where appropriate, agile techniques and principles such as iterative development and prototyping help optimize the work effort and communicate status.

All of the methodologies’ key components enable SAS to quickly deliver superior projects. Here are the key SAS project methodologies:

- SAS Project Management Methodology, focusing on project management processes
- SAS Intelligence Platform Implementation Methodology, focusing on technical implementation

**SAS Project Management Methodology**

The SAS Project Management Methodology is based on best industry standards including the Project Management Institute’s Body of Knowledge, PRINCE2, and iterative development practices.

The SAS Project Management Methodology supplies the basis on which all SAS projects are executed. Based on industry standard project management principles, it takes into consideration the specific requirements of a SAS project. In short, the SAS Project Management Methodology accomplishes the following:

- Supports the delivery of the project within the agreed time frame, budget, and required features (project scope)
- Helps set and maintain the right expectations with all project stakeholders
- Provides the necessary techniques and tools to monitor and control the project and project risks

**SAS Intelligence Platform Implementation Methodology**

The SAS Intelligence Platform Implementation Methodology is the most versatile of SAS’ implementation methodologies. It is applicable to projects containing any combination or all of the following:

- Data quality evaluation and resolution of issues
- Data integration, or creating a data mart or warehouse
- Data mining, forecasting, and other analytics
- Business intelligence (BI) delivery such as query and reporting solutions
Covering a complete implementation of the SAS Business Analytics Framework, the methodology contains the quintessential knowledge and best practices of SAS’ more than 40 years of experience.

Comprehensive by design, the SAS Intelligence Platform Implementation Methodology is customizable to be adapted to projects with a narrow focus, such as data integration, data quality, data mining, or pure-play business intelligence projects. In such projects, only a subset of phases, activities, and tasks applies, thus avoiding unnecessary overhead.

SAS methodologies contain best practices and recommendations for areas such as these:

- Project planning, estimation, and execution
- Project phases, activities, tasks, and subtasks
- Work breakdown structures
- Assignment of roles and responsibilities
- Questionnaires and templates
- Project deliverables
- Key objectives

**SAS Business Advisory**

It is critical to the success of our clients that implementations deliver the value our clients expect when they engage us to do an installation and development of SAS applications. SAS has a built-in incentive to make sure that these implementations succeed in delivering the business value that motivates our clients to invest in SAS software and services. As a demonstration of our commitment to our clients, SAS can provide business advisory services to help make sure a client achieves their business objectives inherent in the implementation. These services can be delivered as part of the implementation or after the implementation. These services can include:

- Business process transformation
- System optimization
- Analytical model development or optimization
- Data governance or management
- Strategic planning

We recommend that our clients consider these and similar services and ask their SAS representative about how such services can help them get the most out of their SAS investment.

**Quality Management in SAS Project Management Methodology**

One important knowledge area within the SAS Project Management Methodology is quality management. The purpose of quality management activities is to ensure that the development process is carried out in accordance with written approved technical standards and guidelines conforming to corporate policies and SAS methodologies.

Quality management supports the delivery of high-quality products and services by providing the project staff, all levels of managers, as well as SAS with appropriate visibility into, and feedback on, the processes and associated work products throughout the development life cycle. One of the purposes of quality management is to motivate action.

Quality management is a process made of two main components:

- Quality assurance
- Quality control
The first ensures that planned processes are implemented while the latter ensures that the specified requirements are satisfied and that each of the components of the final product performs predictably.

Quality assurance and quality control might occasionally look at the same product but from different perspectives. Product quality is, thus, a key measure of the software process.

**Quality Assurance and Procedures**

**Quality Assurance**

Quality assurance (QA) focuses on the processes used to generate software solutions, and its objective is to prevent defects by continually improving those processes. It is a matter of establishing performance standards, measuring and evaluating performance to those standards, and reporting performance. QA also requires taking action such as the following when performance deviates from standards:

- Ensuring that all projects follow current standards
- Monitoring the results of those projects
- Reporting the results to the management team for evaluation

A quality assurance plan is developed at the beginning of the project depending on the needs of the project. It ensures that appropriate quality activities are built into the development and support process. The QA plan also gives the project team a guideline to use to better meet the quality objectives of the project. The QA plan document defines what activities should be included to meet the quality objectives of the project. This information might be incorporated into other project documents or created as a separate document.

The document should meet these requirements:

- Accessible to all stakeholders
- Refined on an ongoing basis
- Specific to each project
- An approved and controlled document

Quality audits are conducted at specific points in the project to ensure that the appropriate standards, policies, and methodologies are being followed. In addition, these audits also inspect the work products produced to determine whether required internal and external work products have been produced. Quality audits do not test the work products for accuracy; they determine only whether the work products have been produced and whether they contain the appropriate authorization signatures.

**Quality Assurance Procedures**

*Create a Quality Assurance Plan for Each Project*

A Quality Assurance Plan might include items such as the following:

- Purpose
- Definition and acronyms
- Policies, standards, practices, and guidelines including identification of the specific SAS development methodology to be used
- Reviews and audits
- Testing
• Tools, techniques, and methods
• System and user manuals
• Configuration management
• Supplier control (if necessary)
• Education
• Security
• Existing systems
• Operating procedures
• Performance and revalidation
• Specific components covered

Conduct Quality Reviews

Quality Reviews can include steps such as these:

• Requirements specification review conducted with the customer.
• Design specification review conducted with the customer for the user interface portion of the design.
• Code inspections performed at peer-review sessions.
• Configuration audits performed periodically throughout the project.
• User documentation review conducted with the customer.
• Test plan review performed at peer-review sessions unless they involve acceptance testing. In that case, they are conducted with the customer.

SAS projects’ overall performance is reviewed on a regular basis to provide confidence that the project satisfies the established quality objectives. SAS uses a project review process that combines the in-depth knowledge of the proposal and project delivery teams with the experience of senior project managers to provide an objective appraisal of the project’s viability and performance throughout its life cycle.

The project reviews support the following objectives:

• Improve customer satisfaction
• Maintain SAS standards for quality
• Use resources effectively
• Manage and monitor delivery performance
• Reduce project loss
• Enhance project team satisfaction and capabilities
• Support reuse of intellectual capital
• Ensure compliance with SAS Project Management Methodology (PMM) and business best practices

Quality Control

Quality control (QC), on the other hand, is focused on the product being created by the implementation project, on testing that product and attempting to find and correct defects before the product is delivered to the customer. It includes aspects of QA related to monitoring, inspecting, and most especially testing. QC focuses on ensuring that
stakeholder needs are satisfied and on providing a high degree of assurance that the components and system operate according to preapproved requirements and specifications.

The challenge of QC is to ensure that all business requirements have been addressed and that the product functions up to defined success criteria before it is delivered to the customer. A QC/test plan is created well before coding is begun. As are all plans, test plans are strategic directions for the testing process. The test plan includes items such as these:

- Which types of testing will be performed
- Which items will be tested and when
- Which resources will be needed
- What prerequisites are needed to prepare for testing
- How responsibilities will be assigned
- What the expected results are
- What mitigation action will be taken when tests fail

**Quality Control Procedures**

The testing process has three parts:

- Test planning
- Test case development
- Testing

Therefore, before testing can begin, we meet these prerequisites:

- An approved test plan
- Complete test cases for use in the testing
- A signed-off and managed set of requirements to test for
- A documented set of the customer’s success criteria

**Quality Control Tests**

- Unit testing: Testing at the lowest level sufficient to ensure that every source statement has been executed at least once under test.
- Integration testing: Testing the interfaces between otherwise correct components to ensure that they are compatible.
- System testing: Testing an entire software system end to end to discover common system bugs, such as resource loss, synchronization, and timing problems, and shared file conflicts.
- Testing to requirements: Testing from the users’ perspective, typically end to end, to verify the operability of every feature.
- Stress testing: Subjecting a software system to an unreasonable load while denying it the resources needed to process that load.
- Regression testing: More specifically, this is equivalency testing—that is, rerunning a suite of tests to ensure that the current version behaves identically to the previous version except in those areas known to have been changed.
- Beta testing or acceptance testing: Testing that is usually done by representative users typically in the final stage of testing before official release.
Quality Management

To sum up, SAS quality management is a quality assurance approach that involves the following:

- Objectively evaluating performed process, and work products, against the applicable project management methodology and the applicable development methodology process descriptions, standards, and procedures.
- Identifying and documenting noncompliance issues.
- Providing feedback to project staff and managers as well as SAS Professional Services Management on the results of the quality assurance activities.
- A description of the quality assurance reporting chain and how it ensures objectivity of the process and product quality assurance function needs to be defined to ensure objectivity.
- Ensuring that noncompliance issues are addressed.

When local resolution of noncompliance issues cannot be obtained, SAS uses established escalation mechanisms to ensure that the appropriate level of management can resolve the issue.

When noncompliance issues are identified, they are first addressed within the project and resolved there, if possible, with a clear set of action plans. Any noncompliance issues that cannot be resolved within the project are escalated to the appropriate level of management at SAS Professional Services for resolution.

Project Governance

In order to facilitate effective communication and a quality implementation, we use an agreed project governance process throughout the full project life cycle. The recommended approach to governance is outlined below and is integral to the SAS Project Management Methodology.

Outstanding services governance accomplishes these goals:

- Provides a framework to define, refine, and guarantee project success
- Actively engages the project sponsor on an executive steering committee
- Drives the accuracy of schedule estimation
- Increases the likelihood of services engagements on budget
- Improves project execution
- Proactively mitigates or reduces project risks
- Facilitates continuous communication with all project stakeholders

Effective project governance ensures predictability and avoids any unpleasant surprises. Key to this is to secure clarity of roles through a formal project organization and shared project expectations. Formal commitment to the project charter among all stakeholders facilitates effective project governance.

Clarity of Roles: Project Organization

A formal project organization that clarifies each role should be established for the project. The figure below shows an example:
Figure 3: Example of Formal Project Organization

Project Governance: Roles

**Steering Committee**

The steering committee represents the interests of the business (from both a user and supplier perspective) and is responsible for setting the overall direction of the project. The steering committee signs off on a key project governance document or a project charter at the end of the project planning phase.

With its sign-off to the project charter, the steering committee sets the shared expectations for the scope and timelines that the project team will be working to meet. After setting the expectation, the steering committee can control the project by exception—requiring further action to be taken only when events occur or changes are requested that deviate from the agreed project charter.

**Project Management**

The project managers are responsible for planning the project and presenting a draft project charter to the steering committee for its review and sign-off. SAS recommends that the project charter be developed by both SAS and client project managers in partnership, which is done in close liaison with the various experts on the project team. This will ensure that the estimated timelines are realistic and take into account the complexity of tasks.

After the project charter has been signed off by the steering committee, the project managers run the project on a day-to-day basis, according to agreed reporting routines. Typically, steering committee meetings are organized at the end of each project phase to facilitate status reporting and to verify the continued validity of the plan for the next phase.

**Project Team**

The project team plays a crucial role during the planning cycle. It provides expert advice regarding the complexity and duration of tasks. During the project execution phase, the project team is responsible for delivering the various expected work products according to the project’s agreed specifications.

Communications are always customized to meet the jointly agreed information needs of the project and of the stakeholders.
Appendix 9: Other SAS Product Areas

This appendix contains quality statements for other SAS product areas where the processes differ from those defined by the Quality Imperative.

SAS Intelligent Advertising for Publishers

SAS Intelligent Advertising for Publishers software (SAS IA) is built for deployment into Amazon Web Services. SAS IA uses open-source technologies such as C++, Ruby, JavaScript, and Rails, to deliver a set of services. These services support common functionality such as login and authorization, identity management, preferences, auditing, and additional product-specific services. SAS IA supports the SAML 2 open standard for authentication, allowing SAS IA to integrate with third-party identity providers. SAS IA also provides public REST APIs and uses TLS to secure communications. SAS IA deploys on open-source Linux operating systems and uses standard deployment technologies such as Ansible and RPMs.

SAS IA was purchased in 2012, and has been integrated into SAS R&D in Cary, NC. Most of the processes described in the Quality Imperative apply to IA. Below is a list of differences between IA processes and processes defined by the Quality Imperative.

- This solution deploys without the SAS Platform, as it was developed originally outside of SAS and has no dependencies on the SAS Platform at this time.
- The solution’s web interface for administrative functions may not meet all accessibility requirements expressed in the standards referenced by the Quality Imperative.
- Nearly all testing is completely automated. Therefore, test automation source remains the definitive word for the software test plan.
- The release of the software occurs frequently, but only after testing and fixing all critical issues. The SAS sign-off matrix would be inappropriate as defined by the Quality Imperative, and is not used. Test automation includes unit, functional, integration, deployment, and performance tests. Releases to production are made in stages to lessen the chance of material impact to customers.
- SAS IA release engineering and operations is part of responsibilities of most SAS IA R&D staff.
- SAS IA virus scans customer uploaded files intended for eventual distribution through IA.
- SAS IA operations staff apply hot fixes when needed; the customer is not responsible for downloading or applying hot fixes.
- SAS IA releases occur more frequently than SAS updates product documentation available through support.sas.com. Announcements of changes are made through the product user interface or through the product’s community site.
- Customer training is available outside of SAS Education until such time that SAS Education can provide this training.
Appendix 10: SAS Products

The SAS Platform is an integrated system of software products that provide complete control over data access, management, analysis, and presentation. SAS solutions are compatible with the SAS Platform. There are other products distributed by SAS but not integrated into the product. See [http://www.sas.com/en_us/software/all-products.html](http://www.sas.com/en_us/software/all-products.html) for the most recent product list.

The SAS products, solutions, and other products that are distributed by SAS and subject to this document’s publish date include the following (this list is subject to change over time):

- SAS/ACCESS®
- SAS® Add-In for Microsoft Office
- SAS/AF®
- SAS® Analytics Accelerator for Teradata
- SAS® Analytics for Containers
- SAS® Anti-Money Laundering
- SAS® AppDev Studio™
- SAS® Asset and Liability Management for Banking
- SAS® Asset Performance Analytics
- SAS/ASSIST®
- SAS® Banking Analytics Architecture
- Base SAS®
- SAS® BookRunner
- SAS® Bridge for Esri
- SAS® Business Intelligence Dashboard
- SAS® Business Intelligence Portal and Portlets
- SAS® Business Intelligence Report Services
- SAS® Business Rules Manager
- SAS® Campaign Management
- SAS® Capital Planning and Management
- SAS® Capital Requirements for Market Risk
- SAS® Clinical Standards Toolkit
- SAS® Clinical Trial Data Transparency
- SAS/CONNECT®
- SAS® Contextual Analysis
- SAS® Cost and Profitability Management
- SAS® Credit Assessment Manager
- SAS® Credit Scoring
- SAS® Customer Due Diligence
- SAS® Customer Intelligence 360
- SAS® 360 Discover
- SAS® 360 Engage
- SAS® 360 Plan
- SAS® 360 Discover
- SAS® 360 Engage
- SAS® 360 Plan
- SAS® Customer Link Analytics
- SAS® Cybersecurity
- SAS® Data Governance
- SAS® Data Integration Server
- SAS® Data Loader for Hadoop
- SAS® Data Management Enrichment
- SAS® Data Management
- SAS® Data Management
- SAS® Data Quality
- SAS® Data Remediation
- SAS® Data Surveyor for SAP
- SAS® Decision Manager
- SAS® Demand Signal Repository
- SAS® Deployment Tester
- SAS® Econometrics
- SAS/EIS®
- SAS® Energy Distribution Optimization
- SAS® Energy Forecasting
SAS® Enterprise Business Intelligence
SAS® Enterprise Case Management
SAS® Enterprise Guide®
SAS® Enterprise Miner™
SAS® Environment Manager
SAS® Episode Analytics
SAS/ETS®
SAS® Event Stream Manager
SAS® Event Stream Processing
SAS® Event Stream Processing Studio
SAS® Expected Credit Loss
SAS® Factory Miner
SAS® Federation Server
SAS® Field Quality Analytics
SAS® Financial Crimes Monitor
SAS® Financial Management
SAS® Firmwide Risk for Solvency II
SAS® Forecast Analyst Workbench
SAS® Forecast Server
SAS® Forecasting for Desktop
SAS® Foundation Services
SAS® Fraud Management
SAS® Fraud Network Analysis
SAS/FSP®
SAS/Genetics™
SAS/GIS®
SAS® Governance and Compliance Manager (formerly SAS® Enterprise GRC)
SAS/GRAPH®
SAS® Grid Manager for Hadoop
SAS® Grid Manager for Platform Suite
SAS® High-Performance Analytics Server
SAS® High-Performance Entity and Network Generation
SAS® High-Performance Risk
SAS/IML®
SAS/IML Studio
SAS® Information Delivery Portal
SAS® Information Map Studio
SAS® Information Retrieval Studio
SAS® Infrastructure for Risk Management
SAS® In-Database Technologies for Teradata
SAS® In-Memory Statistics for Hadoop
SAS® Insurance Analytics Architecture
SAS® Integration Technologies
SAS/IntrNet®
SAS® Inventory Optimization Workbench
SAS® IT Resource Management
SAS® IT Resource Management Adapter for SAP Server
JMP®
JMP® Clinical
JMP® Genomics
JMP® Pro
SAS® LASR Analytic Server
SAS® Life Science Analytics Framework
SAS® Markdown Optimization
SAS® Market Risk Management for Insurance
SAS® Marketing Automation
SAS® Marketing Optimization
SAS® Merchandise Allocation
SAS® Merchandise Planning
SAS® Metadata Bridges
SAS® Metadata Server
SAS® Mobile BI
SAS® Model Implementation Platform
SAS® Model Manager
SAS® Model Risk Management
SAS® Network Algorithms
SAS® Office Analytics
SAS® OLAP Cube Studio
SAS® OLAP Monitor
SAS® OLAP Server
SAS® Optimization
SAS/OR®
SAS® Pack Optimization
SAS® Peer Group Analysis
SAS® Personal Login Manager
SAS® Production Quality Analytics
SAS® Promotion Optimization
SAS/QC®
SAS® Qualitative Assessment Manager
SAS® Quality Analytic Suite Foundation
SAS® Quality Knowledge Base for Customer Information
SAS® Quality Knowledge Base for Product Data
SAS® Real-Time Decision Manager
SAS® Real World Evidence
SAS® Regular Price Optimization
SAS® Regulatory Content
SAS® Regulatory Risk Management
SAS® Revenue Management and Price Optimization Analytics
SAS® Risk Analytics Builder
SAS® Risk Dimensions®
SAS® Risk and Finance Workbench
SAS® Risk Management for Banking
SAS® Risk Modeling Workbench
SAS® Risk Reporting Repository
SAS® Scalable Performance Data Engine
SAS® Scalable Performance Data Server
SAS® Scoring Accelerator
SAS/SECURE®
SAS/SESSION®
SAS/SHARE®
SAS® Simulation Studio
SAS® Size Profiling
SAS® Social Media Analytics
SAS® Social Network Analysis
SAS® Space Optimization
SAS® Space Planning
SAS/STAT®
SAS® Studio
SAS® Suspect Claims Detection
SAS® Task Manager
SAS® Text Analytics
SAS® Text Miner
SAS® Text Miner for Desktop
SAS® Time Series Studio
SAS/TOOLKIT®
SAS® Transaction Monitoring Optimization