# SSAS | THE POWER TO KNOW

# THE QUALITY IMPERATIVE: SAS INSTITUTE'S COMMITMENT TO QUALITY

*A corporate statement of SAS' commitment to product and service quality and to customer satisfaction*

*The version of this paper is October 2012.*

*Unless otherwise indicated, this document relates only to SAS 9.3 and the solutions that are available with SAS 9.3. 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 9.3. If you are using SAS 9.3 and have questions about processes in that release, send e-mail to qualitypaper@sas.com.*

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## Introduction

*When celebrating the 35$^{th}$ Anniversary of SAS, Jim Goodnight, CEO of SAS, said to employees,"SAS was, is and always will be a collection of people who put the needs of the customer first, produce quality software unmatched by any other, and thrive in an innovative workplace that serves as a model across the globe."*

SAS is the world's largest privately held software company with over 13,000 employees at over 400 offices worldwide.  The company was founded on a philosophy of investing in the future; we invest heavily in research and development (R&D).  We also develop close, lasting relationships with our customers.  We listen and respond to their needs.  And we partner with other leading information technology (IT) companies so that our software always stays on the leading edge of the industry.  In a statement to customers on the SAS Web site, Goodnight noted that "Our longevity is a testament to the strong customer relationships we have developed over the years.  When a customer is successful, SAS is successful.  We maintain this loyalty by focusing on customer needs, by continuously investing at least 24 percent of revenues into research and development."

In a web announcement about our financials for 2010, Goodnight talked about our growth.

"Analytics is used in virtually every industry and branch of government," Goodnight said. "The predictive power of analytics can make a difference by helping you see further into the distance so you can make adjustments faster and with more confidence. We've experienced 35 years of unbroken revenue growth and high customer loyalty because our customers get value from our software and trust the results."

While procedures and processes to achieve quality are always evolving and improving, SAS' commitment to quality is constant. This paper discusses the role of quality in SAS products and services.

## Our software

SAS comprises an integrated suite of information delivery tools that enable companies to transform the wide variety of data in their organizations into information that business users need to make decisions.  SAS software collects data from virtually every operating environment and data format, cleans and transforms data into information that users can understand, and stores that information in an open and efficient data warehouse structure.  To explore that information, SAS software employs technologies such as online analytical processing (OLAP), query and reporting, enterprise information systems (EISs), data mining, analysis, data visualization, and application development interfaces.  These technologies can be used as building blocks for enterprise solutions that are tailored to industry or departmental needs including customer relationship management, supply chain management, financial consolidation and reporting, enterprise quality improvement, balanced scorecard, e-intelligence, and more. SAS software is also client/server-enabled and Web-enabled.  Moreover, SAS solutions can enable dynamic organizations to address enterprise decision-support requirements as those requirements grow and mature.

This paper focuses on SAS 9.3, which contains over fifty-four million lines of code including twenty million lines of C code, and over thirty-four million lines of Java code. SAS®9 is funded by SAS investing 24 percent of its revenue in research and development—the largest R&D investment rate in the software industry.  A list of the products that make up SAS®9 and other products distributed by SAS are included at the end of this paper (see Appendix 11:  SAS products).

## The quality imperative

At SAS, assuring the quality of our products and services is more than a goal.  It is a requisite for our business survival and an expectation of management.

SAS, the company, runs on SAS software.  Many operational systems from order entry and fulfillment systems to HR systems are built from SAS technology.  The decision support systems and solutions implemented to run the business include SAS Business Analytics, Business Intelligence, Customer Intelligence, and Performance Management Solutions.  It is hard to find a better example of an organization that relies on its own products for virtually every business function.  The success of SAS is tied to our commitment to deliver reliable products and services because one of the largest customers of SAS software is SAS itself.

The company's renewal income, generated by installed products, accounts for more than half of the company's annual revenue.  Because SAS software is an annually licensed product, customers have the opportunity every year to evaluate their SAS software investment.  Every year, the majority of our customers choose to reinvest in the software that they depend on for unmatched usefulness and reliability of support.  As a company that must earn the ongoing loyalty of customers for its success, SAS is committed to developing the most reliable data warehouse and decision-support software that is available and to providing the outstanding service that is necessary to support our software.

For more information about our company and our customers, read our most recent annual report found on our Company Information page (http://www.sas.com/company/) and our customer success page (http://www.sas.com/success/index.html).

## FDA-regulated industries

Many of our customers who are regulated by the United States Food and Drug Administration (FDA) are required to comply with the United States Code of Federal Regulations (CFR), Title 21 Part 11.

21 CFR Part 11, or the Electronic Records; Electronic Signatures Rule, 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.

SAS has staff focused on understanding these regulatory requirements as well as various related guidance documents provided by the FDA.

To help our customers meet regulatory requirements, SAS has assembled answers to commonly asked FDA-related questions.  Questions that we receive generally fall into the following categories:

- The SAS software development life cycle

- Numerical accuracy and correctness

- Validating a statistical procedure

- Using SAS

- Availability of source code

- Complying with the United States Code of Federal Regulations, Title 21 Part 11

- Installation and operational qualification of SAS®9

- Health Insurance Portability and Accountability Act of 1996 (HIPAA)

- Clinical Data Interchange Standards Consortium (CDISC)

For more information, see Appendix 1: FDA-related issues.

## Independent recognition of SAS software

SAS software has received recognition from a variety of independent industry experts.  See our Web site for information about other independent awards and recognition of SAS software (http://www.sas.com/awards/index.html).

# Our employees

## Human resources

As a software developer himself, SAS CEO Jim Goodnight knows well that designing software is a creative process, and that SAS' continued success is built on "products of the mind." The creativity and puzzle-solving behind great software – and the caring professionalism behind great customer service – are essential resources in an intellectual property enterprise.  "Our employees are the lifeline of our success. As we enter our 36th year of business, we look forward to continuing our deep investment in employee satisfaction, wellness, and creativity." Jim Goodnight CEO, SAS.

SAS management believes that workplace culture, company values, and employment practices can transform the work experience in ways that are not only good relations but good business. 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 stimulated, engaged, appreciated, and supported. They need to 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 allows them to be the most productive. And they should be freed from many of the distractions and difficulties of day-to-day life, so they can focus on doing their best work.

The 2011 metrics point to success in achieving this vision. Average tenure is 10 years; 464 employees have worked 25 or more. Annual turnover averages 3 percent, compared with the average in the software industry of about 22 percent.

To become a SAS employee, candidates must demonstrate that they have what is at the very heart of SAS – innovation and creativity. SAS also looks for candidates whose qualities match our company values:

- **Approachable**. We are accessible to our customers and business contacts, and make it easy for them to do business with us.

- **Customer-driven**. We work closely with our customers to understand and solve their business issues, exceed their expectations, and deliver exceptional value.

- **Swift and agile**. By being responsive, flexible, and action-oriented, we seek to reduce complexity in a constantly changing world.

- **Innovative**. We champion excellence by creatively and constructively challenging the status quo.

- **Trustworthy**. Because we act with transparency and openness, and always keep our promises, we inspire confidence and respect.

The company's work-life programs and unique corporate culture continue to receive accolades. SAS is No.1 on FORTUNE magazine's annual "100 Best Companies to Work For" list for 2010 and 2011 and No. 3 for 2012. SAS was listed as one of the best for health care, child care, and work-life balance. SAS has made the list every year since it was first established in 1998. SAS' culture transcends the globe. Many of our country offices have also been recognized for their workplace culture including  SAS Belgium and SAS Sweden, who have achieved the No. 1 ranking on their countries' 100 Best Companies to Work For list by the Great Place to Work Institute.  In addition, SAS secured the No. 2 spot on the first ever Top 25 World's Best Multinational Workplaces list from Great Place to Work in 2011.

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 draws strength from the unique talents and abilities of a diverse work force and commits to creating a safe environment where the best workers do their best work. It is SAS policy to foster an environment characterized by respect for lifestyle, cultural, and ethnic differences. This policy is put into action through a variety of internal initiatives, community outreach programs, and scholarship opportunities.

SAS values diversity not because it is legally required, but because it makes good business sense. The best products and services come from a workplace where varied viewpoints are welcomed and encouraged.

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 Department has implemented a number of programs and standards.  Here are 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 needed for a particular position. This competency-based interviewing helps identify core values as well. Additionally, numerous interviews are conducted with an applicant, allowing SAS to be as inclusive as possible and also allowing the interviewee an ample opportunity to experience the culture and the people who create the culture.  Using multiple sources increases the likelihood of selecting the best candidate for the position.

- There is a performance management program that emphasizes the accountability of managers and employees for SAS' success and their need to work together as a team to achieve individual and corporate goals.  Therefore, the program's focus is on mutual goal setting and on understanding what the company needs in order to be profitable.  The performance process has four components: objective setting, competency assessment, overall assessment, and development planning.  An online tool automating the process has been fully implemented globally.

At SAS, analytical and statistical software is designed and written by highly specialized statisticians to make sure that the proper numeric algorithms are selected and implemented.  In fact, of the employees working on our statistical products in SAS Foundation, 85 percent of the development and testing staff have advanced degrees and 64 percent of the employees with advanced degrees have PhDs in fields such as statistics, mathematics, and operations research.

Of the analysts who are working in our Advanced Analytics Lab, 98 percent have advanced degrees in fields such as statistics, mathematics, and operations research. Of those who have advanced degrees, 34 percent have PhDs.

Of the analytics developers and testers who work in the JMP division, 78 percent have advanced degrees, and 55 percent of those have PhDs.

Product-area expertise is also important.  Product developers have experience in operations research, time-series analysis, as well as the finance, pharmaceuticals, and other fields gained 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 activity that begins during new employee orientation and continues throughout employment.  Many training courses are archived on the SAS video portal 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.

## Quality begins 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 13,000 employees in 56 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. The primary internal communications vehicle is the company's intranet, the SAS Wide Web (SWW).

Procedures, standards, regular communication updates, and reports are distributed through the SWW.  This enables employees to access the current version of vital information while reducing paper costs and eliminating the distribution of obsolete information. The SAS Wide Web provides access to corporate goals and our mission statement, news, a comprehensive search engine, and the corporate calendar.

SAS continues to use the familiar methods of communicating with employees – webcasts, town hall events, etc. – but also strives to explore new ways for management to share information with staff and for employees to share information with one another.

The use of social media has continued to expand – from blogs to online contests and peer-to-peer award nominations – to create a tight-knit virtual community. Increasingly, employees also are using RSS feeds that allow them to select particular topics of interest and have news delivered to them daily.  SAS' first-ever internal social media network, called The Hub, was launched in February 2011. More than 9,200 employees have registered for accounts.

In addition, most major divisions have regular internal webcasts that enable employees to obtain updates on divisional priorities, as well as to ask questions of upper-level management.  Several divisions also deliver periodic newsletters, support dedicated Microsoft SharePoint sites or wikis or both, and may produce podcasts. These media are updated regularly with information about divisional priorities, goals, news, and changes.  "Take 5" manager announcements are sent via e-mail to managers with information that they are encouraged to share with their staffs.

Employees have e-mail and voice mail accounts, and all are invited to have their own blogs as a way to share ideas, questions, and insights with fellow employees across the globe. Fax machines feed to an online server that delivers faxes to the desktop.  An online scheduling system is available to all employees to reserve meeting space with the appropriate audio-visual equipment.

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. There are no "planted" questions at the CEO webcast, for example. People in the audience or watching online can and do 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.

A variety of multimedia channels are used to disseminate information and facilitate two-way communication among employees, including:

- Daily articles on the company intranet, the SAS Wide Web (SWW)

- Daily Update (an e-mail that provides a sales summary)

- Sales and marketing news (an internal Web portal)

- Targeted e-mail communications

- Divisional meetings

- Cross-divisional mass communications (For example, newsletters, mass e-mails)

- The Hub

- Podcasts

- Videocasts

- Webcasts

- Take 5 manager e-mails

- Blogs

- Bulletin boards in break rooms

A communications survey was conducted in May 2011. Summary of results: 95 percent agree - I am adequately informed about the company from direct internal sources (e.g., webcasts, podcasts, SAS Wide Web articles, blogs, etc.); 85 percent agree - Our senior company executives communicate openly; 92 percent agree - I am adequately informed about the company from CEO Jim Goodnight's quarterly Executive Update webcasts.

When SAS conducted its first worldwide employee satisfaction survey, 78 percent of all employees responded.  Human Resource Partners worked with Division Heads and Country Managers to address the most notable concerns and proposed recommended courses of action. Since then, the company has implemented new programs and continues to measure employee satisfaction through participation in the annual Great Place To Work survey.   Many divisions conduct their own feedback surveys to follow up on areas of specific concern to them.  For the overall question of "Taking everything into account, I would say this is a great place to work." there was 97 percent  positive responses.  The next Global Employee Survey is currently being planned for 2013.

## Protecting privacy

Privacy legislation has established standards to protect certain individual information, particularly personal, financial, and health information.  SAS protects our customers' personal information.  For details, see our Privacy Statement at http://www.sas.com/Privacy.html.   Health care reforms made by HIPAA provide federal protections for the privacy of individually identifiable health information.  The U.S. Department of Health and Human Services has issued regulations governing HIPAA that require health care organizations and other covered entities to meet specific minimum standards of confidentiality with respect to health care data and databases and to regulate how such data and databases are stored, viewed, accessed, and shared.  SAS is committed to helping its customers satisfy these regulations.  For more information, see HIPAA in Appendix 1: FDA-related issues.

## Work environment

## Corporate Services

The groups in this division are responsible for the safe and secure work environment of over 5,000 employees on the SAS Cary campus and regional offices throughout the United States.  Departments within the Corporate Services Division and offices globally adhere to SAS' Statement on Sustainability.  For more information see http://www.sas.com/company/csr/index.html.

### 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 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. Almost all 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. Private office configuration is also used in regional locations. SAS has adopted a Flexible Work Arrangement (FWA) in 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 over 240 employees, who work in Facilities Management, Facilities Services, Housekeeping, Interior and Exterior Landscaping, Food Services, and Regional Office Operations.

## Security

SAS' Security and Safety Department provides a safe and secure work environment at SAS' Worldwide Headquarters by measures such as these: restricting access to the campus through staffed security gates and restricting access to buildings through badge readers and staffed security reception desks. Uniformed company security personnel patrol the grounds and assist employees in various emergency and non-emergency (customer service) situations. Security and Safety also oversees badge reader access to regional locations as allowed by the landlord.

## Safety

SAS' Security and Safety Department provides a reasonably safe and secure work environment at SAS' Worldwide Headquarters and supports worldwide operations. To minimize the risk to employees, invitees, and operations, Security deploys physical, personnel, electronic, and procedural measures such as these: 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 system; uniformed security personnel for both proactive deterrent patrols and various emergency and non-emergency (customer service) responses; and similar efforts.

Security 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 reasonably 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.

Security is also the point of contact for the following:

- Federal, state, and local government compliance for security-related matters.

- Environmental safety issues such as air quality and mold.

- Coordination of many safety programs such as CPR, first aid, defensive driving, child safety, life safety, and similar initiatives.

- Loss control services.

## Information Systems

It takes a team of information systems developers in the Information Systems Division (ISD) to keep the hardware and software at SAS running smoothly.  ISD is increasing the amount of automation in many areas of the company.  Applications and solutions are written for internal use only and "off-the-shelf" software must be validated before it is integrated into our working environment.  Also, changes to existing software must be qualified prior to achieving production status.  ISD customers are SAS employees.  Customer Quality Services (CQS), a group within ISD, provides a service for these developers.  Specifically, the group writes and maintains quality standards.  Although responsibility for quality always remains with the development team, the CQS group is there to facilitate the process and test the applications throughout the development process.  The CQS group can also conduct Section 508 and World Wide Web Consortium (WC3) testing.

## Continuity of business

> "At SAS we develop enterprise-class analytics software that guides our customers' decisions about their business operations, their products and their customers. We also make an extraordinary investment in our employees, making us one of the top-ranked workplaces around the world.   We extend this same vision and planning to manage risk in an increasingly interconnected and dynamic business environment.   SAS' Continuity of Business initiative reflects our commitment to our employees, to our customers, and to all of the stakeholders in our global business community to be a responsible and reliable business partner."
> Jim Goodnight, CEO of SAS

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 corporate governance, information security, and corporate social responsibility, the primary factors that customers consider when selecting the strategic vendors to which they entrust their business.  SAS' global COB program evolved from its longtime disaster recovery and crisis management procedures.   Applying an all-hazards planning approach, SAS' event preparedness and response is focused on protecting and recovering core business operations from threat impacts.  Response and recovery teams from Security, Facilities, IT, Communications, and the business units work together proactively to develop resilience and mitigation strategies, and, in an event, coordinate to execute recovery plans.  Under SAS' pandemic plan, cross-functional taskforce members are engaged to coordinate proactive response activities in accordance with public sector guidance.

 The main focal points for SAS' COB program are:

- Protecting employees (life safety)

- Providing customer support

- Restoring the services upon which critical business functions depend.

### Core program components

SAS' COB program continues to develop in alignment with industry best practices and standards for business continuity.  Key components of the program include:

- Executive oversight in risk management and program development

- Risk assessment and Business Impact Analysis (BIA)

- Impact mitigation and business resumption strategy development

- Business resumption and IT recovery plans to support recovery of critical business functions

- Emergency Operations Command (EOC)  for response and event management

- Annual plan maintenance, exercise, and staff training.

### Plan contents

Typical COB plans include:

- Disaster notification/escalation process

- Roles and responsibilities of response and recovery staff

- Internal and external call lists

- Alternative site information

- Application and system dependencies

- Critical third-party supplier information

- Recovery strategies (for example, where appropriate, critical functions will use manual workarounds, staff can work from alternate locations, critical function services can be provided from staff in other geographic locations)

### A global approach to planning

SAS' Continuity of Business initiative extends to all SAS offices.  Its COB methodology is applied corporate-wide, using standardized templates and processes for response and recovery planning, and using knowledge and resources at the local, regional, and headquarter-office levels.  Each SAS office is responsible for developing and implementing continuity planning in accordance with corporate standards to ensure a minimal level of planning required to meet business drivers while mitigating risks. A global collaborative approach to planning also supports the identification, development, and implementation of backup strategies for critical business processes and IT dependencies. This approach ensures a sustained minimum level of care for local and global customers so that if required, support may be provided from another office or from SAS Headquarters.  As was used for crises such as the 2010 Santiago Chile earthquake and Pune India bombing, global communication protocols are in place to support event assessment and activation of local crisis management response teams and SAS' corporate Emergency Operations Command.

**Enhanced company resilience**

In addition to supporting event preparedness, the COB program is also a catalyst for the ongoing improvement and increased resilience of SAS' operations.  In the short term, key business processes are documented, internal and external dependencies are assessed, and employees are cross-trained for key roles within the organization.  However, a long-term result of SAS' COB program is the improvement of business processes and enhanced company resilience because the ability to quickly recover from unforeseen events is closely tied to more efficient and effective day-to-day operations.

**Customer support**

In the event of an emergency, SAS wants its customers to have the support they need to continue using SAS software.  As such, SAS' business recovery plans are focused on services that must continue after an event occurs. SAS' global recovery strategies for several key customer-facing functions are summarized below:

- Communications - During an event, SAS may communicate with customers through company phone messaging, the corporate Web site, social media, personal contact with account managers, and other staff, and through business partners and the media.

- Contracts – SAS designed (and put into place) measures to ensure that customer and software license key support will continue  This support can be provided through multiple channels that can include recovery staff equipped to work from alternate locations or identified back-up staff from other SAS offices.

- SAS Solutions OnDemand - SAS Solutions OnDemand, SAS' hosted solutions, reside in secure world-class data centers which are resilient to many types of potential disaster. Regular off-site rotation of data backups ensures that customers' vital data can be protected during an emergency, and that their services can be restored following the crisis.  For customers with more specific requirements, additional options such as off-site recovery offerings and recovery time guarantees are available. Our Disaster Recover Requirements Planning process is designed to help customers arrive at a solution which is cost-effective for their needs.

- Source code - Copies of the SAS source code for all production product, as well as for the current R&D environment, are kept on-site and off-site to expedite recovery.  On-site copies are stored in a below-ground, fire-resistant vault.  Source code and distributed media for major SAS software releases are archived.

- Technical support - In daily operations, SAS uses a "follow-the-sun" rotation, routing calls to technical support staff in SAS offices around the world to provide support to customers on an around-the-clock basis.  This also provides a baseline strategy for global support during an event. In addition, if SAS headquarters becomes inoperable due to inclement weather or other circumstances, business resumption strategies include local staff working remotely and staff in U.S. SAS regional offices providing support. On-call staff at SAS' headquarters are always available for global customer technical support and infrastructure needs.

**IT recovery**

SAS has a robust IT infrastructure housed in hardened, secure enterprise data centers. When an unforeseen event occurs, there are plans in place to assess, restore, and resume normal operations for affected IT infrastructure.

Recovery procedures include restoring facilities (for example, buildings and electricity) and support services (for example, telephone service and computer infrastructure) to facilitate the recovery of critical business functions.  Critical systems are supported in data centers in separate locations, providing redundancy for critical IT infrastructure. The data centers are equipped with uninterruptible power supplies (UPS), diesel generators, multiple power feeds, and redundant switch gear for maximum reliability.  They are staffed 24 hours a day and systems are monitored and alerted automatically.  SAS uses Wide Area Network (WAN) network infrastructures that avoid the use of dedicated network paths, minimizing the impact of satellite, terrestrial, and undersea cable outages.

Many components of the IT recovery plan are exercised regularly, as they are the same procedures used in maintaining a complex infrastructure for daily operations.  Recovering from system failures and restoring data subsystems are handled by on-call staff.

For more information about SAS' COB initiative, send e-mail to cob@sas.com.  This entire section is available as a stand-alone document at http://www.sas.com/corporate/continuity.pdf.

# The research and development process

## Software development at SAS

The goal of SAS 9.3 is to continue the evolution of an integrated SAS®9 environment.  Ongoing themes include integration and interoperability, enhanced enterprise-class characteristics, improved performance, and expanded functionality and feature sets.  The installation, operation, and maintenance of the SAS Enterprise Intelligence Platform is tremendously important in helping meet the expectations of IT organizations.  As a result, SAS has invested heavily in numerous areas that will be very visible including electronic software delivery, new installation and configuration capabilities, and tighter integration with third-party monitoring technologies.  In addition, SAS is updating our large list of supported operating environments and hardware as well as moving to new support levels for the application servers and platforms.

SAS focuses on quality by design, using mature software engineering principles to build in quality from the beginning.  To achieve its vision of an integrated SAS®9 environment, R&D teams use techniques such as a defined and documented software development life cycle, standard components (intelligent clients, intelligent storage, and intelligent servers), SAS MultiVendor Architecture, and shared libraries of code and processing routines.

The Research and Development Division of SAS drives software research, development, and production for the company.  According to Keith Collins, Senior Vice President and Chief Technology Officer, "At SAS we use a continuous quality process from design to coding onto unit testing and system integration testing where we review and incorporate feedback such that the overall quality process gets better with each new product we ship.  Then we listen to the users of our software and make changes based on their feedback."  To support quality by design, SAS engineering practices emphasize rigorous requirements and architectural design phases, well-documented implementation plans and methodologies, and additional quality assurance and testing activities.

The SAS software development life cycle is explained in the following section.  Based on industry needs, differences in technology, or internal motivation, Research and Development teams for certain software products follow different processes or use different tools.  See Appendix 8:  Quality statements for other SAS product areas.

## The software development life cycle

As shown in Figure 1, our software methodology involves five phases of development: Product Visualization, Product Creation/Innovation, Code Research 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 presented in Figure 1.
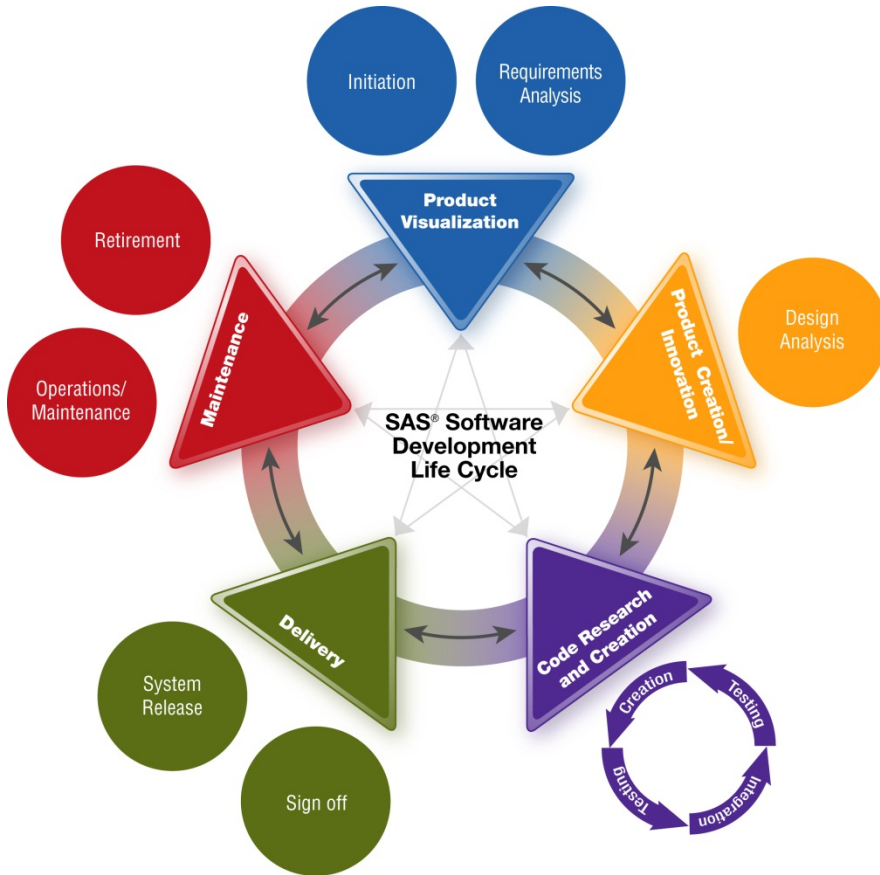


*Figure 1.  SAS software development life cycle*

The stages associated with each phase of SAS software development are explained in the following sections of this paper. Underlying the process are the ongoing tasks of project management, integrating with product management, and evaluating for quality and completeness.

## Product visualization

### *Initiation*

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 product development process begins with gathering ideas for a potential new product or function or enhancements that are being considered for subsequent software releases. Suggestions for new or enhanced functionality and problem resolution are surfaced 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

- Market research

- Professional conferences and communities

- The SASware Ballot (http://support.sas.com/community/ballot/)

- Technical Support (http://support.sas.com/techsup/intro.html)

- 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 electronically archived and accessible to team members.  This input is used in determining the scope of a project.

### Requirements analysis

During the requirements analysis stage, development requirements are created from the requests that were presented in a project proposal.  Requirements identify a capability, physical characteristic, or quality factor that bounds a product or process problem for which a solution can be pursued.  Development 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 reviewed and prioritized by development team stakeholders.

Some groups are using an agile approach to software development.  This means the requirements are stated in user stories added throughout the development cycle.  The input from Product Management is vital to the inclusion of the functionality most requested from our customers.

Note that project planning and management are initiated during the requirements analysis stage, and then carried out in the Creation/Testing/Integration/Testing stage.  See the following section for details.  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 original plan.  If results significantly deviate from the planned activities, then corrective actions might be taken, such as revising the project plan, reducing enhancements, or reallocating resources to meet the current plan.

## Product creation/innovation

### *Design analysis*

R&D teams create a design and high-level architecture for the software according to the development requirements for the innovation or enhancement request.  The product design is achieved in various methods that might involve one developer or a multi-functional team.  Product group specific strategies are used in design analysis.  R&D 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.

## Code research and creation

### *Creation, testing, integration, and testing*

Development staff begins writing product code and installs based on coding standards.  The testing staff begins writing tests based on test plans and testing guidelines.   Prior to integration, code is tested and evaluated for stability.  Problems are identified, tracked, and resolved.  If testing staff approves fixes to the code, it is promoted to hosts that are scheduled for delivery.  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 Quality and Testing for details about testing).  Problems continue to be identified, tracked, and resolved in this iterative cycle.  Developers and testers work together to make sure that the software meets quality goals.

Early in this stage of software development, user documentation requirements are defined and incorporated into the overall project planning.  Development team members also start planning customer support needs and services.

During this stage, development team members 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.

## Delivery

### *Sign-off*

A team that includes the R&D director, development manager, test manager, documentation writer, and Technical Support representative conduct review and software sign-off according to the due diligence guidelines under the guidance of the Director of Software Quality.

### *System release*

The software enters the system release process.  When a new release is ready for shipment, final media are verified by byte-by-byte comparison.  Customer media are created in-house or sent to an external vendor.  The media and packaging letters are prepared and sent to the Software Distribution Center to fill customer orders.  Because the media and the accompanying letters are customized for each customer site, distribution staff follows an itemized list so that the appropriate materials are included in each shipment.  Project deliverables and source code are archived.

**Maintenance**

### Operations/maintenance

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 version.  All versions of SAS software have some level of support.  We provide problem alerts and hot fixes for selected critical problems in the two most recent, non-current versions and for the current release.  For all versions, regardless of age, we provide technical support, and, if possible, circumventions.  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.  Support for non-current versions is documented at http://support.sas.com/techsup/support.html#non-current.  Source code is archived for at least the previous two releases.  For information about source code archiving and fixes, see IT recovery, and Software fixes in the field, respectively.

### 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.  Customers may continue to license the product as needed and limited support may be provided.  See the web page on non-current releases, available at Support Services for Current and Prior Releases of Software.

## SAS product development process

Our software development lifecycle is implemented using the SAS product development process.  The use of this process is required by R&D policy.  The process describes a series of milestones with expected deliverables that are clearly defined.  Phase-exit gates are interspersed in the process to define the required quality checkpoints.  It is the role of the Release Management Council to assess the progress through the project lifecycle and to report findings to upper management.

The initial gate is achieved when the initiation phase is complete, and the final gate signifies the release of the product and includes the sign-off and system release phases. Interim checkpoints occur throughout the project lifecycle and include milestone reviews, phase-gate reviews, and other reviews as appropriate for the project or program. When all reviews and sign-offs are complete, the product moves into the operations and maintenance phase which continues until product retirement.

## Project management

SAS R&D has a centralized Project Management group whose charter 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 the project plan.  The project plan includes the milestones and gates as defined in the R&D SAS Product Development process.  This plan becomes the foundation for the ongoing tracking and oversight of the project.   As part of the tracking and oversight, the Project Managers track the actual progress against the plan.  On an ongoing basis, they work with the project team to identify project risks and develop mitigation plans to address these risks.  When actual status deviates from the plan, the Project Managers work with development and testing management to determine and implement actions to get the project back on course. Examples of actions include reduction in scope, adjustments of timelines, reassignment of resources, etc.  Throughout the project, the Project Managers ensure adequate visibility into the overall health of the project via status reporting and project reviews to ensure that we are meeting our project goals and objectives.

## Release management council

Release management at SAS is facilitated by the Release Management Council (RMC).  The purpose of the Release Management Council (RMC) is to provide cross-divisional facilitation for the delivery of high quality technology or solution offerings identified in the Corporate Product Release Schedule (CPRS). This council provides input that will help support the asynchronous delivery of these offerings and offer a forum for the communication and resolution of schedules and dependencies.  The RMC performs a number of tasks such as these:

- identifies and promotes project management activities and best practices that support the delivery of R&D offerings

- gathers, analyzes, and triages release management issues through RMC meetings and subteams

- redirects issues to appropriate R&D personnel, groups, or executive management

- communicates status, decisions, and actions to appropriate areas of SAS using status reports, meeting minutes, the RMC Web site, training sessions, and other tools as appropriate.

The RMC advocates the use of an over-arching software development process and other subprocesses that are efficient, easy-to-use and that add value. RMC processes, tools, and the organization function together to improve communications, reduce risk, and drive a higher rate of predictability and dependability from product development. The council tracks the progress of each release of SAS and provides status input to management. The council also sponsors retrospective discussions after products have released.

## Software production status and target audiences

Every new release of SAS software presents many challenges that include developing quality software that meets the needs of our customers and helping our customers see the value of the software so that they will adopt the new release.  SAS meets these challenges by following a clearly defined rollout process for our new releases.  The phases of our rollout process are linked to our internal milestones and are defined by the target audience for each software development release:  Development Partners, Early Adopters, Limited Availability, and General Availability.

- Development partners phase--A pre-production 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. Early Adopter customers are selected by marketing specialists at SAS, according to predefined criteria. Problems that are reported from customers are addressed during later phases of this same release, while features or enhancements are collected for consideration in a future release.

- Limited availability phase--A software development phase that occurs after the software has reached production status. In this phase an offering is provided, on request, to a group of customers who have been identified through a prequalification process.  Limited Availability customers often have an urgent business issue that requires an immediate implementation, rather than waiting for the General Availability release.

- General availability phase--A software development phase in which the final production release of an offering is made available to all customers, often through mass shipment.

## SAS architecture

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 sub-libraries and code reuse

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

- The use of maximum numerical precision

The need for third-party components integrated into our various SAS offerings makes 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 the highly complex tasks of 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 percent 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, such as the "friendliness" of today's desktop graphical user interfaces and the high throughput of the mainframe.  SAS MultiVendor Architecture divides SAS into three layers— Applications, Core, and Host (see Figure 2).
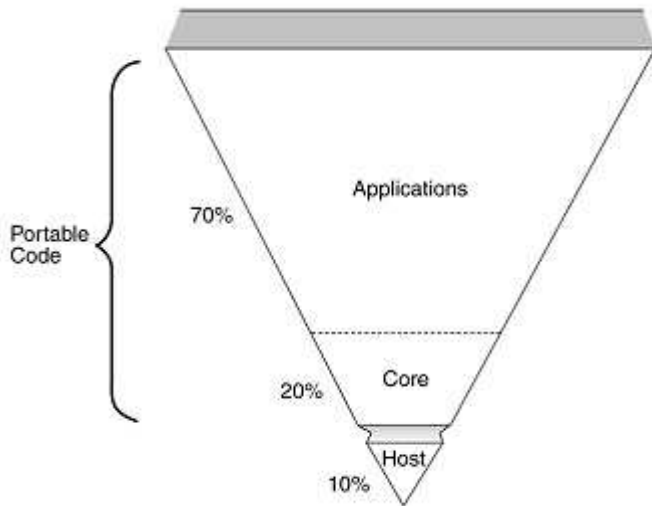


*Figure 2.  The MultiVendor Architecture of SAS Foundation*

The Applications layer is portable across systems and contains code for the various functional modules that make up SAS.  These include the SAS procedures and SAS "layered" products.  Customer-developed SAS applications also reside on top of the Applications layer, providing compatibility across computing environments.

The Core layer provides a variety of subsystems shared by SAS applications, including data set input/output (I/O), messages, and parsing.  The Applications and Core layers are portable across all the computer systems that are supported by SAS.

The Host layer is not portable.  It is implemented for each operating environment that is supported by SAS software.  The Host layer defines a generic or "virtual" operating environment interface to the portable layers of SAS.  Its role is to do the following:

- Deliver operating environment services (such as file I/O and memory management) that are required by SAS.

- Exploit particular features of the operating environment (such as vector processing on a mainframe) or the underlying hardware (such as a math coprocessor on a PC).

- Implement services where none exist in the native environment (such as a graphical user interface for mainframe systems).

- Optimize performance of the software for each operating environment.

SAS Scalable Architecture has been built to achieve a more scalable, higher performing technology suite.  SAS Scalable Architecture embraces elements from the traditional MVA Server and includes SAS Scalable Performance Data Server and threaded kernel (TK) technology for lightweight threading.

By accomplishing a more scalable, high-performance technology, SAS preserves the superior analytical tools in MVA SAS, while expanding to serve more users.  SAS Scalable Architecture demonstrates innovation in new code and preservation of legacy features.  The Core and Host layers of the traditional MVA pyramid remain unchanged and are bound to a single thread to support a legacy of SAS tasks, such as booting multiple instances of SAS in threads.  In addition, multiple units of work can be performed and scheduled freely by the operating environment.

## SAS intelligence platform architecture

SAS Intelligence Platform architecture is designed to efficiently access large amounts of data, while simultaneously providing timely intelligence to a large number of users.  The platform uses an n-tier architecture that enables you to distribute functionality across computer resources, so that each type of work is performed by the resources that are best suited to the job.

You can easily scale the architecture to meet the demands of your workload. 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.

The SAS Intelligence Platform includes but is not limited to SAS Business Intelligence, SAS Data Integration, and SAS/ACCESS. As stated above they are implemented as Java middle-tier and desktop clients using Java and .NET, and they leverage the capabilities of SAS Foundation.  SAS Business Intelligence integrates data from across the enterprise and delivers self-service reporting and analysis.  SAS Data Integration enables you to attain and manage consistent and trusted data throughout the organization.  You can respond quickly to new data integration requirements, consolidate vendors, standardize on one integration solution, and reduce the overall cost of data integration.

In building our Business Intelligence and domain solutions, SAS continues to expand its middle-tier components to include a service-oriented architecture built around its Web Infrastructure Platform.  Just as the quality principles of portability and reuse influenced the SAS MVA and TK technology adoption decision, so have these same principles influenced the decision to adopt Java J2SE and J2EE technologies for desktop client and Web application components of SAS®9.

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

The opportunity to leverage IT standards and practices extends to integration options that are available with the SAS®9 platform as well.  SAS®9 provides adapters and connectors that enable the integration and interoperability of platform and solution components with relational database management systems, middleware (messaging, Web services, distributed objects, integration brokers), and Enterprise Resource Planning systems that comprise the broader enterprise ecosystem.

For more information, see "Architecture of the SAS Intelligence Platform" in the *SAS Intelligence Platform: Overview, Second Edition*, available at http://support.sas.com/documentation/configuration/biov.pdf.

## The SAS solutions

The SAS solutions provide industry-specific functionality in these key focus areas: customer management, financial management, performance management, IT management, risk management, and supply chain management.  Most solutions extend SAS architecture by using a Java-based component 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 multi-machine 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 leverage the analytical power of SAS to differentiate SAS solutions from those of competitors.

## Shared sub-libraries and code reuse

We have a rich tradition of reuse and regularly use our prior work as the building blocks of innovations in applications.  SAS software products share the same sub-libraries 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: MVA and TK libraries; SAS and SAS Component Language (SCL) code; .NET; Java libraries; 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 sub-libraries 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.

## Numerical accuracy

One of the most critical quality issues in software development, especially for analytical software, is the accuracy and reliability of results.  In this context, *accuracy* describes the degree of agreement between the reported result and the true value.  *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 architectural ability to represent finite precision and finite arithmetic.  Not all real numbers can be represented in binary finite precision, and that means that arithmetic operations might introduce errors due to binary rounding.  The second factor is the software.

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.  Single-precision arithmetic allows only 6 to 7 significant digits.  Most hardware enables arithmetic operations to only 14 significant digits.  In theory, accuracy cannot be pushed beyond this level. Limitations might be created in the selection of algorithms and the coding techniques and practices used to implement them.  Algorithms must be carefully chosen 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.

SAS follows NIST standards regarding numerical accuracy as follows: "In response to industrial concerns about the numerical accuracy of computations from statistical software, the Statistical Engineering and Mathematical and Computational Sciences Divisions of the National Institute of Standards and Technology's (NIST) Information Technology Laboratory are providing data sets with certified values for a variety of statistical methods." (The National Institute of Standards and Technology 2007)  NIST data has been integrated into our automated tests.

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 assure correct functioning for special situations such as daylight savings time or Year 2000 issues.

SAS procedures have numerous options that alter the nature and extent of output, but 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.  As previously mentioned, reliability reflects confidence derived from the accuracy of results.  The extensive use of SAS software in medical and pharmaceutical research, government statistical reporting, and government and academic epidemiological studies attests to the confidence customers have in the ability of SAS to provide accurate results.

For more information about numerical precision, see the Technical Support Document TS-654 *Numeric Precision 101* (http://support.sas.com/techsup/technote/ts654.pdf), the Technical Support document on *Dealing with Numeric Representation Error in SAS Applications* (http://support.sas.com/techsup/technote/ts230.html) and 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®9 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.

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 important, 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 may be issues. SAS users can find a third-party component on the Third Party Software Downloads Web site 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, as well as 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. Typically, it is more likely that minor upgrades and service pack releases have a better chance of integrating successfully with SAS software than major releases. If customers need a third-party component upgrade that is not addressed on our Web site, then they can contact SAS Technical Support for guidance.

## Research and development tools

SAS developers and testers are supported by a variety of software tools. The tool set 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. Testware is managed by the same code management system. 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. All SAS PCs have antivirus software installed, and all run real-time checking of files. The virus signatures are updated automatically at regular intervals.

### The research and development environment

SAS is recognized as the industry leader in research and development, with approximately 24 percent of the company's worldwide revenue spent on development activities. This percentage is nearly twice the average investment that major software vendors devote to research and development.

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. The current portable development environment uses desktop PCs. All SAS proprietary source code is controlled using Concurrent Versions System (CVS) source repositories. 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.  These tools have documentation, reporting, and audit-trail functionality built in.  For cross-developed target hosts, SAS code is built on FreeBSD compute clusters using cross-host tool chains.  For host platforms where native builds are run, the same portable build system and build directive files are used.  Some legacy projects use other build tools; integration into the common build system is planned when possible.

One of the tools in the tool set is iFABS.  iFABS is the production build system used since 9.2 (Platform Release); it has been in production for three years. Here are its main features:

- A well-defined interface for configuration and extension.

- Cross-platform support.

- A functional core.

- Versioned Jar support.

- A generic, Ant-based build that runs the same on Windows and Unix. This means that the results of desktop Java builds closely matches the results of the overnight builds.

- Flex as well as Java build support.

- Integration with Eclipse so that developers can use the power of the Eclipse Development Environment for their work.

For developers, software quality is enhanced by the following tools:

- Special compilers that provide extensive diagnostics

- A debugger (CPR) 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.

**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.  The company's source management systems use industry standard CVS with ease-of-use tooling designed by SAS and maintained by an internal tools group.  This tool set controls development staff access to source code and their ability to make changes and fixes.  As mentioned earlier, the source management system is based on source repositories that use CVS revision control.  Revision history is kept for all modules in source management; in this way, we maintain old versions in addition to a history of who made changes and why those changes were made.

Our version control policies include methods to make sure that each build of the software has a new revision date.  For software that is based on Java, the implementation number includes the build date and time stamp.  For each external release of the software, there is a Technical Support number and release number.  Each solution has an "About" window that includes the version numbers.  Development and production versions are uniquely identified.  Changes in production versions are clearly documented, and a list of changes and enhancements from the previous version is available as part of the online documentation.

Through the source management system, source code segments are checked out to a developer's 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 or else the developer will be 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.

SAS uses a FIXID process that works with its source development system and the DEFECTS System to regulate what changes are made to the software.  Changes are controlled.  The development groups implement the code changes under revision control, and the corrected code or documentation is included in the next image of the software for verification by testers.  After the source code is in source control, authorization is needed to make changes to the code, and the DEFECTS System must be used to track the source code changes.

## Problem reporting and resolution

The online problem tracking system, called the DEFECTS Reporting System, is the central repository for 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.  Problems are tracked through the DEFECTS System until the problem is resolved and verified.

After the source code is in source control, authorization is needed to make changes to the code, and the DEFECTS System must be used to track the source code changes. Changes can be made only with an approved FIXID that is obtained by the developer using the DEFECTS System.  Approval for FIXIDs comes from testers, test managers, division directors, or the Director of Software Quality—depending on the stage of the development cycle.  The development groups resolve the problems and push fixes after obtaining FIXID approval, and the corrected code or documentation is included in the next image of the software for verification by testers.  After a defect is fixed and the associated tests are rerun, a tool can automatically track successful verification of the fix in the DEFECTS System.

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; and problems that depart significantly from the product function specified in 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 Technical Support representatives about the priority of a problem according to past user feedback.

The DEFECTS System links to the Technical Support tracking system by a Technical Support tracking number.  This way any fixes that are requested by Technical Support are tracked in the DEFECTS System.

A DEFECT router tool accumulates data from SAS staff in the field.  They can quickly and easily report problems with installs, third-party integration, and documentation issues, or they can request new features.

## Tools for testers

The testing staff has a broad range of tools available to assist in performing the testing tasks described in this paper.  Internal/proprietary tools include:

- A test driver which executes command-line-based tests on multiple platforms (operating systems and programming environments) A testing framework which uses data-driven engines and the action word approach

- A test driver which executes tests through a memory-leak checking tool and reports the results A coverage analysis tool for C source which highlights potential areas for improved coverage and optimizes regression testing

- A tool (DEFECTS) for tracking defects, enhancements, issues, and suggestions found during and after software development

- A test tracking tool to record test cases and their results history on all platforms

A dedicated tools support team develops and maintains these tools in-house.  Testing staff also augment with third-party or open source testing tools to fulfill product-specific test automation needs.

Various reports are available to testers for evaluating software quality and testing progress, including:

- Queries of the DEFECTS databases about number, age, type and severity of defects, by internal group structure or product

- Stability of code  by tracking the number of test and source files pushed within a given time frame

- Verification status of individual defects as well as responsible tester or testing department

We have an extensive amount of Java code in SAS software.  Testing staff use a variety of internal and external tools to evaluate software quality of Java-based features, including:

- Distributed Java Testing Environment (DJTE), an internally supported tool to validate Java fixes using a continuous integration model

- The Automated Build System (TABS), 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

### Tools for project management

Software-based tools are used to assist R&D project managers. The Corporate Product Release Schedule (CPRS) 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 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.  Examples that project managers refer to include:

   o   template libraries for project artifacts and reviews

   o   tracking systems for measuring outstanding defects and features levels

      o   tools designed for teams employing the Agile Scrum methodology

      o   standardized tooling for defining the product topology and release engineering setup

Project managers also use standard work-breakdown structure tools such as MS Project.

### Software quality tools

The Software Quality Tools and Infrastructure Group has these goals:

- Develop applications to track and report on the quality of the software.

- Maintain testing environments for R&D.

- Support and enhance test automation.

- Write tools for many uses.

## Technology access

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. Developing our rich-client interfaces based on the Oracle (formerly Sun Microsystems) J Java Programming Language, Microsoft Windows technologies, and Worldwide Web Consortium (W3C) Web Accessibility Initiative (WAI) coding specifications, SAS follows the U.S. Access Board's Section 508 – 1194.21 guidelines for Software Applications and Operating Systems. For Web-based content and Internet browser-based applications, SAS aims to meet the W3C WAI Web Content Accessibility Guidelines (WCAG) version 1, Priority 1 items, and the U.S. Access Board's Section 508 – 1194.22 Web-based Internet Information and Applications Guidelines. SAS continues to monitor changes in accessibility guidelines, with the pending refresh of Section 508 and release of WCAG version 2.

Members of the R&D staff receive training in new technologies, such as making Java applications 508-compliant and Accessible Rich Internet Applications (ARIA, a new specification from the W3C). Internal training on Section 508, 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 make our software and e-Learning products more accessible by using available technology advances.

For more information, see the Federal Government Electronic Information Technology Accessibility Standards Web page (http://www.sas.com/accessibility).  To learn how accessibility is integrated into our product development lifecycle, see "Universal Design: A Commitment to Accessible Software from SAS Institute" (**http://www.sas.com/resources/whitepaper/wp_3461.pdf**).

## Standards and certifications

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 that are determined to be appropriate, 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.

### R&D Standards

There is a strong business need for consistency in our customer-facing products and documentation. R&D uses standards to ensure that consistent development methods, architectural components, software engineering processes and tools are employed by staff to produce quality deliverables for customers. By adopting standards 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 defined by various technology boards and subject matter experts and are formally documented.

The following are documented to provide a foundation for standard coding practices:

- The general and specific standards and guidelines for efficient and consistent coding.

- How to prepare for development work, and how to complete common development tasks.

- The process of writing a procedure to interface with core components of SAS.

- Specifications and requirements for host-level code, and how to provide input to host-level routines.  The host-level supervisor code is designed to provide a common set of interfaces across all operating environments in order to implement a virtual operating environment.

- The portable software layer between all engines and the engine supervisor.

- The Java development platform that provides the infrastructure for many of the Java standards.

- Application Programming Interfaces (APIs) for use by other developers.

- Internally developed open metadata standards, which are made available to customers.  See "The Value of Integrated Metadata: SAS Open Metadata Architecture," available at http://www.sas.com/ctx/whitepapers/whitepapers.jsp?code=269.

- The process of installing and configuring SAS products.

- Guidelines used by writers and editors to outline preferred style in documentation.  See Appendix 5: Quality in Publications for more information.

- Guidelines for writing that are designed to make translation to local languages easier and more accurate.

In addition, many individual applications groups have specialized coding standards for consistency within specific spheres of product functionality.

R&D standards are maintained on a Web portal supported by the Software Quality Unit. Any individual or group can identify the need for a standard. The individual or group sponsors the standard and initiates the standards approval process.  The standard is submitted to the R&D Leadership Team for evaluation and approval. Standards are available on many topics including architecture, development technologies, processes, tools, and UI.

## User interface guidelines

The usability analysts at SAS have received formal educational as well as practical training in the areas of human factors, cognitive psychology, and industrial design.  Analysts are an integral part of product design and provide product teams with usability support before, during, and after development across the spectrum of SAS software products.  The role of the usability analyst includes helping to define user profiles and task scenarios, conducting customer site visits to understand user needs from a usability perspective, preparing low- and high-fidelity prototypes that are subjected to iterative rounds of usability testing, and using the aforementioned data to design user-centered interfaces.  Both individual analysts and the usability lab often conduct usability reviews of SAS software via heuristic evaluation and formal testing procedures. Usability analysts also define both rich-client and Web standards via the SAS usability reuse and consistency effort, in addition to providing design support for common components and graphs. For more information about SAS usability and to sign up to participate in any of the activities mentioned here, see the SAS Customer Support page (http://support.sas.com/userexperience).

## Industry standards and interfaces

SAS is committed to supporting industry standards and interfaces that benefit customers.  Industry standards take two forms:

- Standards that are developed by independent groups to enable software and hardware to communicate

- Standards that are supported by vendors for their specific hardware or software applications

We support standards and interfaces, particularly when they support SAS software's portability across different operating environments.  The company recognizes that many user benefits, including uniformity, conformity, and quality, are derived from supporting industry standards and interfaces.  We constantly look to the foreseeable future and update our standards as technology evolves and customers' needs change.

SAS supports industry standards through these activities and initiatives and through support of employee activities in these areas:

- Monitoring external standards, process assessments, and industry requirements that SAS determines to be appropriate, such as ISO and IEEE standards, and the CMMI process assessment.  SAS' internal quality processes have evolved based on the company's understanding and assessment of such external factors.

- Participating in various standards committees.

- Chairing the IEEE P730 working group on Software Quality Assurance

- Maintaining the compliance of SAS compilers with the ISO C standard.

- Maintaining in-house standards that build on the ISO C standard, in addition to in-house tools that enforce the in-house standard.

- 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.

- Monitoring de facto industry standards.

- 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 Web site.

### ISO 9000 certification

Four SAS international subsidiaries have ISO 9001 certification.  The dates of certification and scope of certification are listed below.

SAS UK (SAS Software Ltd.) was certified to ISO 9001 / TickIT in November 12, 1993 by Bureau Veritas Quality International (BVQI).  Ongoing certification is maintained via bi-annual surveillance audits and three yearly recertification audits conducted by BVQI.  The most recent, December 19, 2009 was to ISO 9001:2008 and the scope is as follows:

> *"The end-to-end identification and delivery of products & solutions based on customer requirements and the continued support of customers including training to fully exploit their investment in SAS products and 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 being ISO 9001:2008 on July 12, 2011.  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 Institute S.r.l.) gained ISO 9001:2000 February 6, 2004 by BVQI.  Recertification has been maintained, the most recent being February 22, 2010.  The scope is as follows:

> *"Marketing and licensing SAS software products and solutions to companies and bodies, in the business intelligence and decision support areas.  Providing consulting and project management services to analyze, design, develop, integrate, install, and maintain software applications, information system components, databases and data warehouses, data analysis and reporting systems, implemented with SAS technology.  Supplying training, system consulting and technical support services to use SAS products and solutions."*

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.  The current certification is valid until 2014, and the scope is "Delivery, building and implementation of systems based on SAS software, including consulting and training services as well as technical support."

Memex Technology Ltd, a SAS company, originally gained ISO 9001:2008 in 2010 by The British Standards Institution (BSI).  The current certification is valid until 2013.  The scope is "The design, development supply and support of software for intelligence and information management solutions."

To obtain a copy of the most recent certificates awarded to SAS, send e-mail to qualitypaper@sas.com.

### U.S. Government Configuration Baseline

As a vendor of desktop software products to the U.S. Federal Government, through our release management process, SAS validates 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/govedu/fdcc-compliance.html.

### Software globalization

Software globalization is a methodology that combines internationalization and localization so that, from a U.S. standpoint, the English version of software could be used by all world markets, and national language data will be processed correctly. 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.  Localization is the process of adapting the software to meet cultural needs by developing culture-specific components and translations that can be accessed by the software at run time.  With ever-expanding world markets, software globalization is an important part of the quality of our software.  SAS products are extensively tested for internationalization and localization quality.

The Software Globalization Division spearheads globalization efforts at SAS in a number of ways, including these:

- Localizing software simultaneously with the development cycle in an effort to uncover defects as early as possible

- Supporting transcoding functions

- Supporting multi-lingual data processing based on the Unicode standard

- Supporting SAS products in multiple languages to meet the needs of international customers

- Delivering reports in the local language to clients from different locales attaching to a single server.

- Testing localized versions of the software

- Testing in non-English environments

- Testing with non-English data

- Testing with multi-lingual data

## Employee certifications

SAS employees have achieved personal certifications that enhance their ability to deliver a quality product to customers.  These include 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.

## Quality

At SAS, quality is not simply added to the software product through testing at the end of development. Instead, it 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 development cycle.  The Chief Technology Office and Senior Vice President of BI R&D are accountable for the overall quality of SAS software, while the company's Software Quality Unit provides a focal point for researching, monitoring, and initiating responses to quality issues across all product lines.

### Software quality

The Software Quality Unit is part of R&D and reports to the Director of Software Quality.  The group supports the production of quality software by integrating staff, process, and technology.  Software Quality members engage and collaborate with R&D staff to define, document,  and seamlessly integrate quality processes and good practices.  This includes:

- Inspections for code and technical documents

- Development, adoption, and publication of R&D standards

- Facilitation of requirements, retrospectives,  and process improvement efforts

- Education and mentorship of new staff

- Review of internal documentation and quality practices

- Preparation of external quality documents and participation in customer meetings.

### Process improvement

R&D uses retrospectives facilitated by the Process and Research Group to improve processes.  At the end of a release cycle or major project milestones, teams might hold a retrospective to discuss project details and identify what needs to change.  The data about what works well and what should be improved is available for all teams to analyze for the improvement of future projects.  The facilitators assist the work groups with developing a concrete plan of action for change.

Our Java development teams use several inspection techniques.  Best practices are shared among the teams and added to an evolving checklist.

The Installation Technologies Team has several feedback loops to improve installation and deployment experience, such as customer interviews, usability interface labs, internal feedback from system engineers, customer feedback from the Technical Support Division, and internal testing throughout the development cycle.

The Planning, Operations, and Strategy Division Development and Deployment Testing (POS-DDT) team consults with system engineers, consultants, and our customers regarding issues encountered in receiving, deploying, and managing SAS BI and SAS BI Server software.  They communicate the information to SAS R&D and file defects as appropriate.  Additionally, they work with teams to design prototypes or workflows (or both) that address the problems.  The team works closely with SAS R&D, as they are a primary stakeholder.  They also work closely with Technical Support and the Customer Experience Testing Team.

**Reviews**

The SAS product development process identifies numerous reviews throughout the development life cycle. Completion criteria for development deliverables—such as requirements documents, design documents, and test plans—include reviews by appropriate stakeholders. Two formal reviews are held for each major release.  Development managers provide details to executive leaders in the Project Scope and Planning Review early in a release to ensure plans and processes are in place for a successful implementation. Near the end of a release, development managers meet and executive leaders meet again to evaluate the quality of the software and its readiness to ship.  Executive leaders must approve each product to pass through each of the reviews.

## Testing

Software testing processes launch early in the development life cycle and persist until R&D development and testing managers sign off.  Testing teams try to verify the successful implementation of new features and to validate the continued baseline of existing features. The SAS product 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 possess 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, among them requirements-based testing, use-case testing, white-box testing, integration testing, and systems testing.  Testing tasks may 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 end-user documentation

- Testing for performance, 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 225,000 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.   Most testers do not report to the product managers—for independence, they report to a testing manager or director who reports to the division head.

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 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 signoff.  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 may 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 may 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 understand changes in the current release.  Little or no formal documentation is created for this kind of testing, although defects may be entered if anomalies are uncovered.  As the software matures, testers generate more robust test documentation to cover 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 which contain both automated tests and manual test scripts.  The automated tests are grouped into categories according to the level of complexity.  Both manual and automated 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 may consist of SAS programs that generate logs and listings for comparison against benchmark results, or they may 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 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 may 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 prior to system integration.

- Baseline testing verifies that the software functions in the same way as in previous releases.  At times, the functionality will change 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. Web applications to function within 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 assures 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 might include data, logs, and output) may 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 data base 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 may 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 may be repeated on several different 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 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.

The weekly Release Management council meetings include a status report on current projects – including the testing status.

### Performance testing

Performance regression testing is done port-to-port and relative to other versions of SAS.  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, large data set effectiveness, algorithm effectiveness against third-party databases, and SAS internal data sets.  Much of the work is automated, with parameters set such that out-of-bound performance results are flagged for analysis.

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 LoadRunner to identify performance bottlenecks, memory leaks, and scalability problems.

### Security testing

SAS carries out a wide variety of authentication testing on all platforms with all supported authentication mechanisms.  We have a suite of tests for metadata server authorization testing as well.  Among the types of security testing conducted are these:

- Firewall tests and password cracking tests

- Testing with users of different security levels to make sure that each has the appropriate access levels

- Use case testing that exercises some level of security

- Row level permissions, making sure that each user has the appropriate data authorization

- Password and encryption security for SAS and for SAS Scalable Performance Data Server data sets

- SAS/ACCESS engines that test security (for example, user ID and password) during connection testing

- Product teams that conduct security tests for appropriate user authorization and error testing

### Testing the installation

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 interface requires the release engineering analyst 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, test plans are written for each operating environment to describe how the 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.

After a product has been installed, it is validated by using various validation technologies.  The SAS Installation Qualification Tool (SAS IQ) completes a checksum comparison on all files installed on a target machine to make sure that those files are exactly the same as the files on the installation media and 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.

### Customer experience testing

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, then installs, configures, and deploys SAS®9 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 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 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, Consulting, and Tech 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 may 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*

Prior to R&D signoff, the packaging and related materials (excluding final product image) that the customer will receive are examined by the R&D groups and Technical Support.  This is to make sure that the materials that ship with the software are correct.  There is a checklist available to assist R&D groups in verifying the validity of the package materials. DEFECTS is used to report any issues found.

## Release

### *R&D signoff*

Product signoff occurs when the following conditions have been satisfied:

- All planned new functionality has been implemented and tested.

- All requested fixes have been implemented and tested.

- Newly reported problems are not high priority.

- The rate of newly reported problems has declined below a designated threshold.

- Appropriate deferred items have been documented in the SAS Notes database, which is available on the Web for every release of the software.

Product signoff includes the division director, development manager, test manager, documentation staff, and Technical Support.  A due diligence list signifies what each signature means.  The Release Management Division determines when the signed-off product is declared production.

A copy of the final tested image is forwarded to the Software Production Systems (SPS) Department, which creates the final installation image.  The work of SPS is verified by the Software Release Engineering Testing Group through the media verification process.  At this point, the Release Management Division can declare that the products and the installation process are production-certified.

### *Production media*

Production software is available by software download for most releases.* If physical media is being produced it is either cut at SAS or sent to an external vendor for duplication.  Internal quality checks by SAS or the vendor assure that the media contains the correct image of the software.

* SAS 9.1.3 and earlier are available only on media.

*Virus protection*

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.  When we use an outside vendor for media replication we send the vendor master discs produced from our product files.  When they produce the "mother" disc to stamp the copies, they verify that the data on the mother disc matches the content of our masters (in other words, their processing has introduced no changes to our content).

*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

The SAS Technical Support Division acts as the central clearinghouse for customer-reported problems regarding production products.  Problems are entered into the DEFECTS System by SAS employees.  The problems then become items to consider for action in the ongoing process of refining and improving test plans.

SAS Notes are a source of information used by Technical Support consultants to answer questions from our customers.  The SAS Notes contain the following types of information about SAS software:

- Known problems (and fixes or workarounds where applicable)

- Usage issues and tips

- Documentation errors and corrections

- Installation and migration issues

SAS Notes are available to our customers from our SAS Customer Support Web site (http://support.sas.com/notes/index.html).  The SAS Notes knowledge base is updated using an internal Technical Support application and, where appropriate, is linked to the DEFECTS System.

For alert-priority problems in SAS software, Technical Support issues Problem Alert Notices to customers who subscribe to TSNEWS-L.  Information about TSNEWS-L is available on the SAS Customer Support Web site (http://support.sas.com/techsup/news/tsnews.html).  The Alert Notes provide additional details about the problem, propose viable workarounds, or outline strategies and plans for rapid resolution.  These notes are e-mailed via TSNEWS-L and are also provided on the SAS Customer Support Web site (http://support.sas.com/notes/index.html).

SAS uses a "hot fix" process for software fixes.  Technical Support initiates a request for a software update.  The information about the issue is entered into the DEFECTS 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 determine which fixes will be made.  Technical Support then authorizes the fix.  After a fix has been approved through the DEFECTS System, it enters the fix process.  Technical Support uses an internal Web application to track source code changes during the process.  The fixes are tested by Technical Support and Testing to verify that the reported problems have been corrected and that new problems have not been introduced.

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 they need from the Technical Support Hot Fixes Web page (http://ftp.sas.com/techsup/download/hotfix/hotfix.html).

SAS also uses maintenance releases to update and support SAS software.  Maintenance releases are available to SAS customers via electronic or physical media and include fixes and enhancements, documentation updates, and localizations.

The maintenance process for SAS 9.3 will follow the same process as SAS 9.2. Details about SAS 9.3 maintenance will be posted to support.sas.com when it is available. Information about the current maintenance release is available on the Maintenance Release Announcement Web page (http://support.sas.com/software/maintenance/).

# Quality in Customer Services

SAS provides customer support in many forms, including technical support, customer education, 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 technical support

SAS' award-winning technical support is conducted over the telephone, in writing, or electronically under the terms of the company's software license agreement.  For North American customers, technical support is 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 acts as the central clearinghouse for customer-reported problems regarding production software products.  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 customer education

For SAS Education, delivering high-quality training support for SAS software technology and solutions isn't limited to the classroom. SAS Education is comprised of several teams of people 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 callers are answered, by a real person, we feel 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 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 multiple formats, performs extensive testing, and ports the final document to multiple operating system and delivery environments.

Currently, we produce the following types of documentation:

- Online Help that is built into the software

- Books with examples and how-to information that are available in hard copy from SAS Publishing (http://www.sas.com/apps/pubscat/booklist.jsp?attr=category&val=SAS+PRESS) and electronically through e-tailer partners

- Reference and usage documentation on the Web and CD-ROM

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 Consulting 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.

We've 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 tailored services to solve our customers' unique business requirements. We have amassed in-depth industry knowledge and domain expertise, and we leverage industry and technology best practices and proven methodologies. For more information about our quality processes and methodologies, see Appendix 9:  Quality in Consulting.

## Quality in SAS Solutions onDemand

SAS Solutions OnDemand provides software-as-a-service (SaaS), results-oriented solutions, and enterprise hosting solutions for customers who want to deploy SAS solutions rapidly. The OnDemand team is a customer-focused division that integrates quality processes and controls into all areas of our organization. For more than 10 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 procedures and processes are always evolving, SAS Solution OnDemand's commitment to quality is constant.  See Appendix 10: Quality in SAS Solutions OnDemand for more information.

## Conclusion

The greatest measure of SAS' success is customer satisfaction and loyalty.  This loyalty is demonstrated by the commitment of more than 50,000 customer sites in over 100 countries around the world as well as by the recognition bestowed by numerous industry experts.  The loyalty of SAS software users can also be measured by their commitment to use SAS software to address strategic business needs year after year.  Since the company was founded in 1976, the number of SAS software users has grown rapidly as business, government, and educational organizations have deployed applications that are based on SAS software throughout their operations.  These organizations depend on the company's software solutions to assist them in successfully meeting their information needs.

If you have questions about this paper, send e-mail to qualitypaper@sas.com.

## References

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# Appendix 1:  FDA-related issues

According to SAS' 2009 annual report, about 6 percent of our revenue comes from life science companies.  Information about SAS customers in FDA-regulated industries is located on the Web.  See the "Life Sciences" section on the Customer Success Web site (http://www.sas.com/success/indexByIndustry.html#1900) for details.  This appendix answers commonly asked questions from pharmaceutical customers and others regulated by the FDA.

## The SAS software development life cycle

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.  See The software development life cycle section for details.

## Numerical accuracy and correctness

We use a variety of methods to verify the accuracy and precision of the results generated by our software.  See the Numerical accuracy section for details.  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.  See the Testing section for details.

## 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.  Frequently, a combination of methods is used to validate a single SAS procedure.  These methods include the following:

- **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 cross validated against 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 in cross 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**

  When applicable, examples and results from sources such as journal articles, text books, and scientific Web sites are used to add verification support.

- **comparing to other software vendors' applications**

  Comparison against other software vendors' applications is frequently 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 in Appendix 6:  Validation example.

## Using SAS

When using any SAS procedure, users should check the SAS Notes (http://support.sas.com/techsup/search/sasnotes.html) for any outstanding issues. SAS Notes contain the following types of information about SAS software:

- Known problems (and fixes or workarounds where applicable)

- Usage issues and tips

- Documentation errors and corrections

- Compatibility issues.

SAS customers need to install SAS on appropriate hardware and software according to the installation instructions. When running SAS 8.2 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.

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 Web sites:

- Migration: Lead Your Organization to SAS®9 at http://support.sas.com/rnd/migration/

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

The FDA does not certify software tool vendors. We consider SAS a tool:  our customers need to validate systems they build with SAS, but they do not need to validate SAS software. 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 write their own validation process for any tools that they use. This paper documents the quality processes used in developing SAS software.

## Availability of source code

Two areas of concern for an FDA-regulated industry are disaster recovery and audits. Some customers have inquired about whether our software is recoverable after a disaster and also whether it is available for an FDA audit if required for compliance needs. A copy of the source code for all supported production products as well as for the current R&D environment is kept in a secure off-site environment to enable recovery following a disaster. SAS staff has ready access to all backups (completed nightly), and the off-site code is updated weekly to make sure that it is current. (See the Continuity of business section for details.) 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.

## Complying with Title 21 CFR Part 11

The United States law known as Title 21 CFR Part 11, or the Electronic Records; Electronic Signatures Rule; and the Guidance for Industry, 21 CFR Part 11, Electronic Records; Electronic Signatures—Scope and Application (http://www.fda.gov/downloads/Drugs/GuidanceComplianceRegulatoryInformation/Guidances/UCM0723 22.pdf ) provides information about what constitutes trustworthy and reliable electronic records and electronic signatures.

Part 11 does not outline details such as whether a signature is required, who signs it, and so on, because these requirements vary by the type of electronic record. Instead, industry has been directed to apply the "predicate rule" by referring to the relevant regulation or guideline that specifies these details. CFR Title 21 serves as the predicate rule. It has been in force for some time and is written for the paper record. Industry has been directed to refer to these requirements for paper systems and to apply them to electronic records.

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.

While SAS includes features that enable users to comply with 21 CFR Part 11, simply using SAS software 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 if 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 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 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. The SAS output will have date and time information embedded.  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 and SAS Technology Web page (http://www.sas.com/govedu/fda/index.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 also accepting the CDISC Study Data Tabulation Model (STDM) for exchanging electronic data.  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/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 trail can be enabled to assist in this process.  All this functionality is supported by metadata manager applications such as Warehouse Administrator, the Extraction, Transform, and Load Studio (SAS Data Integration Studio) or the SAS Drug Development Process Editor 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 Drug Development software (see http://www.sas.com/industry/pharma/develop/index.html).  SAS Drug Development 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.  See the SAS Drug Development white paper, "Developing, executing and managing the transformation, analysis and submission of clinical research data with SAS Drug Development" (http://www.sas.com/reg/wp/corp/20846) for more information.

## Installation and operational qualification of SAS 9.3

SAS 9.3 includes three tools for information technology administrators to verify that installation and configuration were performed correctly and to test operations of SAS at their sites.  The tools are SAS IQ, SAS OQ, and Deployment Tester.  They are included with SAS 9.3 software.  The SAS installation qualification tool (SAS IQ) assists FDA-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 BI.  See Appendix 7:  Installation verification using SAS IQ, SAS OQ, and Deployment Tester for more information about these tools.

SAS Consulting can provide support to 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

- Assist the customer in developing and/or reengineering the necessary Standard Operating Procedures so that the validated environment is maintained

- 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.

## Statement on Auditing Standards No. 70

For information about Service Organization Control (SOC) and Systrust certifications, see Appendix 10: Quality in SAS Solutions OnDemand.

## HIPAA

The health care reforms made by Title II of the Health Insurance Portability and Accountability Act of 1996 (HIPAA) 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 that require health care organizations and other covered entities to meet certain minimum standards of confidentiality with respect to health care data and databases and regulate how such data and databases are stored, viewed, accessed, and shared.  SAS software includes security and other built-in features that provide users with the capability to implement HIPAA-compliant applications.  At present, there is nothing in SAS technologies or solutions that would prevent compliance with HIPAA requirements.  Because SAS is used extensively in the health care and pharmaceutical markets, we are actively monitoring evolving legislation and continually evaluating our products for potential issues.  SAS customers who are a covered entity under HIPAA or who receive protected health information from a covered entity might have obligations under HIPAA.  SAS is available to assist with HIPAA compliance issues related to the use of SAS technologies and solutions.

## CDISC

SAS has been an active supporter and 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 FDA's adoption of the Study Data Tabulation Model (SDTM) as a Study Data Specification for the electronic Common Technical Document (eCTD) as a very significant event.  We recognize the value that data standards will provide to the industry for 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 is exploring and developing standard processes within its production software to facilitate using SDTM, Operational Data Modeling (ODM), laboratory data (LAB), and Analytical Data Set Modeling (ADaM) data models.  We are also developing specific tools to make the CDISC standard easier to implement in and apply to our software.  See the Base SAS XML Web site at http://support.sas.com/rnd/base/index-xml-resources.html for more information about support for XML within SAS software.

# Appendix 2:  Quality in Technical Support

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 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 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 consultants who support North American customers are located in Cary, North Carolina.  The average consultant has over ten years of technical support experience.  Each consultant specializes in one or more areas of specific functionality of SAS.

## Telephone support

On company business days, Monday through Friday, North American customers can reach Technical Support consultants 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 subsidiary or distributor during their business hours, or for critical problems, they can contact the Cary, North Carolina, Technical Support office outside subsidiary or distributor business hours.  When critical problems occur on weekends and holidays, calls to Technical Support are transferred to the Cary Data Center, which then contacts the consultants who are on call from Technical Support in Cary, North Carolina.  Thus, for critical problems, technical support is available on a 24/7 basis.

Technical Support consultants make every effort to answer questions in a timely manner.  On average, more than 58 percent of the questions for Technical Support in the U.S. are resolved on the first phone call; 77 percent are resolved within one day; and 87 percent are resolved within five days.

Questions that are not resolved during the first phone call are assigned a priority and are tracked to a specialist in the particular area involved.  These questions are responded to within 24 hours for all calls and in even less time for higher priority problems.

Technical Support uses a global call tracking system that tracks information about all Technical Support calls and 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 consultants 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 e-mail (http://support.sas.com/techsup/contact/).

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

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

- Searching numerous online databases for solutions to SAS problems

- Downloading fixes for known problems

- Submitting suggestions for and voting on SASware Ballot items

- Obtaining all information that is available through TSNEWS-L and anonymous FTP.

TSNEWS-L is a mail and file list that is maintained by the Technical Support Division.  This facility provides a way for users to receive technical information such as Problem Alert Notices and maintenance availability.

SNOTES-L is a means for SAS Technical Support to distribute information concerning SAS Notes availability in the Knowledge Base of the SAS Customer Support Web site. This is a listserv in that it will send any subscriber mail on a daily basis with information about new and revised SAS Notes.

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

Periodically, Technical Support makes available Problem Alert Notices.  See the section Software fixes in the field for more information about Problem Alert Notices.

# Appendix 3:  Employee training

On their first day on the job, new SAS employees receive an initial orientation that is sponsored by the Human Resources Department.  This day-long session includes information about Security, Health Care, and Human Resources, and covers the company's history, benefits to employees, processes, services, products, and policies.  After this training is complete, new employees report to their assigned departments, who take over management of the new employee's training schedule and content.  Departmental training covers job-specific functions as well as procedures and processes that are specific to the employee's department or group.

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

- Division news and information

- Updates to products

- Tool usage guides

- Operating environment information

- Other information resources

- Software problem reporting and resolution.

The company's corporate research library offers over 10,000 books, 22 paper periodical subscriptions, with access to hundreds more available online.  CDs and DVDs are available in a wide range of topics.  The goal of SAS Library & Information Services is to provide the information our employees need 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 (through two external services) 24 hours a day—so they have an immediate resource whenever questions arise. Individual or group training is offered upon request.  The library's Web site provides links to a variety of online resources and aids.  The library circulates approximately 1,500 items per month and has agreements with local universities and document delivery vendors for a widened information base.  A pool of loaner equipment, such as laptops and projectors, is managed for business trips or demonstrations.

An internal, Web-based course registration system enables employees to see course descriptions and schedules, register online, receive reminders prior to class, sign up for interest and waiting lists, and create and maintain training records.

The company periodically rolls out Web-based training for all employees.  Past topics have included SAS Code of Business Ethics, Respect in the Workplace, and SAS Confidential and Proprietary Information Policy.

## Technical and R&D training

Here are some of the avenues that R&D 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®9 areas of data integration, business intelligence, and analytics as well as topics in installation, configuration, architecture, security, and other advanced SAS®9 administration topics.

In addition to formal classroom training, technical staff can access training from the Global Employee Technical Training (GETT) group.  GETT 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, GETT empowers those in the field with the hands-on experience needed to successfully deploy SAS®9 technology.

R&D has a staff member dedicated to providing guidance, mentorship, and training for both new and experienced staff.   The R&D mentor is available to help staff develop a training program that best meets their needs.  This customized program may include classroom courses, virtual learning, self-guided study, or one-on-one training sessions.

## 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 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 instructor 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 put some of its technology to work by offering its 2010 annual wrap-up 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.

## Leadership and Team Development

This group increases organizational effectiveness at SAS by providing all managers and their teams with leadership and management development opportunities.  This includes a core curriculum of 8 to 10 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 an active management coaching practice where managers can grow their coaching skills one-on-one, in small groups and with their peers.  In addition to the coaching services, Leadership and Team Development offers extensive help in meeting planning, and provides facilitation services.

## SAS Global Sales and Product Training

This team provides programs and services designed to build knowledge and skills that will enhance the performance of SAS' global sales force and partners.  Sales Training offerings are delivered via instructor-led classes and various e-learning formats and are focused on the application of product knowledge, business acumen, industry expertise, and sales skills to the areas of Data Integration, Business Intelligence, Analytics, and SAS horizontal and vertical industry solutions.

## Training and Skills Management

This group provides the tools necessary to monitor 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 on internal R&D good 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 Consultants.

# Appendix 4:  Training SAS users

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 and self-paced e-Learning, 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, thus giving customers access to the latest SAS software without leaving the work environment.

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 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.

## Quality in SAS Education

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 is composed 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. Prior to teaching a new course, they team teach with experienced instructors gaining feedback on a chapter-by-chapter 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 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. Prior to the start of a class, each student could receive multiple communications: a confirmation e-mail 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, additionally, a customer service representative may 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 e-mail 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. Additionally, 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 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 Web site at http://support.sas.com/training/socialmedia.

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.

More information about SAS Education and its offerings is available on the SAS Training Web site at http://support.sas.com/training/.

# 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 subscribe to newsgroups and electronic mailing lists that are related to the products that they are documenting.  They work with new product features as the features are being developed and contact the appropriate developers about anything that is unclear.  As the product matures and the release date is set, writers and their managers begin to plan the documentation that will be needed.

## Planning the documentation library

If a product is new, the writer performs an audience and task analysis to determine what types of documentation will be needed (for example, a user's guide, an administrator's guide, product Help, or a combination of these).  The decisions are based on the complexity and purpose of the product and on the characteristics of the target audience.

If an existing product is being updated, then the writer reviews the documentation set and determines if any new types of documentation are needed or if any of the existing documentation is obsolete.  Writers consult with Technical Support for customer input on how to improve the documentation.  SAS often surveys customers regarding their satisfaction with the documentation.

Next, the writer, in consultation with SAS Publishing, the Worldwide Marketing strategists, and the Publications Deliverables Management Team, determines the appropriate delivery medium based on the type of documentation and the target audience.  For example, it might be most appropriate to deliver task-oriented information in hard copy and reference information in the form of Help.

### Adding changes and enhancements documentation

When existing products are being updated and information is needed about product changes, the documented changes are compiled in a single document that is available from the product Help, SAS OnlineDoc, and the Customer Support Center Web site.  This changes and enhancements document, called What's New, is comprehensive across an entire release; for example, the most recent version for SAS 9.3 contains information about SAS 9.0, 9.1, 9.1.2, 9.1.3, and 9.2.

## Developing content

### Writing the documentation plan

After the individual components of the product library are identified, the lead writer or project manager writes a documentation plan that describes the content of each component in detail, establishes deadlines, and identifies participants and their responsibilities.  The documentation plan also defines the purpose, audience, delivery medium, and type of edit for each component.

Documentation plans also include practical details about the documentation components, such as a description of the print specifications (style, color, size, and graphics) and a description of the tools that will be used to produce the final document.

All participants who are identified in the documentation plan, as well as management representatives, are given the opportunity to review the plan and send comments to the author of the plan.

**Writing, reviewing, and revising documentation**

After the documentation plan is reviewed and approved, the writers and software developers continue to 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 the Standard Generalized Markup Language (SGML), LaTeX, in Microsoft Word, or directly in HTML. When the documentation is ready for review, project managers and writers send out drafts for technical review. Review material can be sent out in hard copy, by e-mail, or through PDF that was initiated for a shared review. Reviewers can send back their comments by hard copy, by e-mail, or by adding comments to the PDF that was initiated for a shared review. Project managers and writers work with development managers to determine which method works most efficiently for each group involved.

Employees in the SAS R&D, Technical Support, Worldwide Marketing, and Education Divisions are asked to review the documentation. Reviews provided by these divisions are valuable to the writer because each reviewer looks at the material from a different perspective and has a different sense of what is important. These reviewers check the documentation for technical accuracy, completeness, and clarity, and send comments back to the writers.

If the review comments are extensive, the documentation is usually reviewed a second time to make sure that complicated changes were made correctly and that additional changes are not needed. A third review might be scheduled if there have been unusual delays in the software development schedule, but such reviews are usually limited to documentation about specific features.

**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 legal issues.

- 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 (or the first review, if two reviews are scheduled).

**Indexing**

After a document has been edited, it is routed to the Indexing Project Manager who determines whether the document will be indexed in-house or sent to an outside indexer. If the document is indexed in-house, then the indexer enters index tags directly into the source files. For documents that are indexed by an outside indexer, the indexer returns a separate file that is used to insert index tags into the source files. Scripts are used to generate the indexes that are used for both printed books and for online documentation. For online indexes, these scripts generate hypertext links to the documentation.

## Converting and testing online help and CD-ROM images

All of our documentation must be written, converted to the appropriate media, and tested on multiple platforms following a schedule that conforms to the software production schedule. 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 documentation that is delivered as HTML, tables of contents (TOC), and indexes are generated automatically during the conversion process.

For the PDF version of SAS OnlineDoc, Technical Publication Specialists (TPSs) create the TOCs by hand. To do this, they place all files for the selected titles in a directory and then link them to a TOC in the CD image. The customer can then navigate the CD via the TOC or the individual fully linked indexes.

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 from the indexes to the text. If the testers find errors, then 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 Department.  After the error or tools problem has been fixed, the testers verify that the error has been resolved.

As soon as the content and the necessary supporting infrastructure is viable for delivery to software product images, it is transformed to the source required for various delivery targets (Help, CDs, the Web) and pushed to those targets via the source management tools and processes that also support the software.  Regularly scheduled transformation, building, and porting processes continue for the duration of the product release cycle until images are locked down for final validation and sign-off.  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.  After the Help is built into SAS, R&D product groups also test the documentation for their specific products.  If they find an error, the tester records the problem in the DEFECTS Reporting System, and the problem is routed to the writer.  The writer fixes the error, and the conversion and testing cycle is repeated.

## Testing product installation

For documentation products produced by the Publications Division, testing is performed to verify that the product installation process works as expected and that the installation instructions have been documented accurately.

## Preparing documentation for printing

To produce a hard-copy book from an XML source, the XIS system will generate an Acrobat 8 file for print. For sources that are created using Microsoft Word, Technical Publishing Specialists will distill the Word files to PDF. Editors review the PDF output for typographical errors and formatting problems and review proofs before the books are sent to be printed.  All interim print deliverables are checked for quality by both the Editing and Publishing Production 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 a customer purchases SAS software or when we ship new releases, the Software Distribution Center assembles the packages of software.  The SAS Help and Documentation product within the software is updated to reflect the enhancements to the software.  New and revised documentation is posted to the Web in both HTML and PDF form.  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 (etailers) in PDF or eBook format or formats.

**Tracking problems after release**

All substantive changes to documentation are tracked in the DEFECTS 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 e-mail or through the SAS Web site.

## Developing the software used to author and deliver documentation

The Publications Technologies 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 Help delivery system software meets the same quality standards across the same operating environments 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 SAS software. The Publications Division continues to lead a corporate-wide initiative in terminology management to help us to 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 data base, 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:  Validation example

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.

```
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:**

| Analysis of Variance | | | | | |
|---|---|---|---|---|---|
| Source | DF | Sum of Squares | Mean Square | F Value | Pr > F |
| Model | 2 | 53845 | 26922 | 5679.47 | <.0001 |
| Error | 12 | 56.88357 | 4.74030 | | |
| Corrected Total | 14 | 53902 | | | |

| | | | |
|---|---|---|---|
| Root MSE | 2.17722 | R-Square | 0.9989 |
| Dependent Mean | 150.60000 | Adj R-Sq | 0.9988 |
| Coeff Var | 1.44570 | | |

| 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 |

## 1.  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:**

| Statistic | Result | Page |
|---|---|---|
| SS Model | 53,844.716 | 256 |
| SS Error | 56.884 | 256 |
| SS Total | 53,901.600 | 256 |
| df Model | 2 | 256 |
| df Error | 12 | 256 |
| df Total | 14 | 256 |
| MS Model | 26,922.358 | 256 |
| MS Error | 4.740 | 256 |
| F* | 5,680 | 257 |
| p-value | < .001 | 257 |

\* 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:**

| Statistic | Result | Page |
|---|---|---|
| R-Squared | 0.9989 | 257 |

**Parameter Estimates:**

| Statistic | Result | Page |
|---|---|---|
| Beta: Intercept | 3.4526127900 | 252 |
| Beta: target population | 0.4960049761 | 252 |
| Beta: disc. income | 0.009199080867 | 252 |
| Std. Error: target pop. | 0.006054 | 258 |
| Std. Error: disc. Income | 0.0009681 | 257 |

## 2.  Direct validation

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

```
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, w/col of 1's for intercept;
 p=ncol(x);                            * number of parameters, including int;
 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;
 dft=n-1;                              * corrected total df;
 dfm=dft-dfe;                          * Model degrees of freedom;
 ssm=cssy-sse;                         * Sum of Squares for Model;
 msm=ssm/dfm;                          * Mean Square Model;
 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:**

| DF | SS | MS | FVALUE | PROBF |
|---:|---:|---:|---:|---:|
| 2 | 53844.72 | 26922.36 | 5679.47 | 0 |
| 12 | 56.88 | 4.74 | _ | _ |
| 14 | 53901.60 | _ | _ | _ |

**Fit Statistics Table:**

| NVALUE1 | NVALUE2 |
|---:|---:|
| 2.177 | 0.99894 |
| 150.600 | 0.99877 |
| 1.446 | 0.00000 |

**Parameter Estimates Table:**

| DF | ESTIMATE | STDERR | TVALUE | PROBT |
|---:|---:|---:|---:|---:|
| 1 | 3.45261 | 2.43065 | 1.4204 | 0.18094 |
| 1 | 0.49600 | 0.00605 | 81.9242 | 0.00000 |
| 1 | 0.00920 | 0.00097 | 9.5021 | 0.00000 |

```
* 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=absolute 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=absolute criterion=1e-6;
  attrib _all_ format = label = '';
  var nvalue1 nvalue2;
run;


proc compare data=reg_parameterestimates compare=iml_parameterestimates
  error briefsummary note method=absolute 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=ABSOLUTE, 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. Some variable or data set attributes
      differ. However, all comparisons are equal for the values of the
      variables specified.




                        The COMPARE Procedure
       Comparison of WORK.REG_FITSTATISTICS with WORK.IML_FITSTATISTICS
                    (Method=ABSOLUTE, 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=ABSOLUTE, 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.
```

## 3. Crossvalidation

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

```
* run the corresponding model with PROC GLM;
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;
proc compare data=reg_anova compare=glm_anova
   error briefsummary note method=absolute criterion=1e-6;
   attrib _all_ format = label = '';
   var df ss ms fvalue probf;
run;
proc compare data=reg_parameterestimates
             compare=glm_parameterestimates
   error briefsummary note method=absolute 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;
proc print data=reg_FitStatistics; run;
proc print data=glm_FitStatistics; run;
```

**PROC REG Results:**

| Obs | Model | Dependent | Label1 | cValue1 | nValue1 | Label2 | cValue2 | nValue2 |
|---|---|---|---|---|---|---|---|---|
| 1 | MODEL1 | sales | Root MSE | 2.17722 | 2.177222 | R-Square | 0.9989 | 0.998945 |
| 2 | MODEL1 | sales | Dependent Mean | 150.60000 | 150.600000 | Adj R-Sq | 0.9988 | 0.998769 |
| 3 | MODEL1 | sales | Coeff Var | 1.44570 | 1.445699 | | | 0 |

**PROC GLM Results:**

| Obs | Dependent | RSquare | CV | RootMSE | DepMean |
|---|---|---|---|---|---|
| 1 | sales | 0.998945 | 1.445699 | 2.177222 | 150.6000 |

## 4.  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;
data check_weight; set Zarthan_Company;
   weight=1;
run;


 * run PROC REG with the weight variable;
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;
proc compare data=reg_anova compare=reg_anova_weight
   error briefsummary note method=absolute criterion=1e-6;
   attrib _all_ format = label = '';
run;

proc compare data=reg_fitstatistics
     compare=reg_fitstatistics_weight
   error briefsummary note method=absolute criterion=1e-6;
   attrib _all_ format = label = '';
run;

proc compare data=reg_parameterestimates
             compare=reg_parameterestimates_weight
   error briefsummary note method=absolute 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=ABSOLUTE, 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=ABSOLUTE, 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=ABSOLUTE, 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.
```

# Appendix 7: Installation verification using SAS IQ, SAS OQ, and Deployment Tester

SAS 9.3 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. 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 SAS BI although any of the SAS OQ tests or customer-written tests can be run using this tool.

## Syntax and operation

The testing process for the installation of the SAS®9.3 components 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. The third phase is the execution of the SAS Operational Qualification Tool 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/). For the 9.3 release SAS has increased its commitment to install qualification tools. As a result all files that are installed in SASHOME will be validated; in previous releases only those files that were installed into SASROOT were checked.

## Phase 2

Using command-line interfaces and return code validation, the operational qualification process is automated, which provides a greater volume of test cases. When SAS IQ is run, it checks the installation data files against the installed files and produces XML data files that describe any differences between them. SAS IQ provides a binary signature for each file in the SAS System in the form of a 128-bit checksum. These checksums are used to compare the files placed on media with the files in the customer image. A program is provided that converts the XML data into a report that contains a summary page for the installation, a status of pass or fail for each product installed, and any discrepancies between the installation and the existing image. The user can drill down into the product information to obtain more detail. The bottom level of data consists of the individual files and the comparison points. Reports on the outcome of each SAS IQ execution are provided in the form of traversable HTML and printable PDF. Additional documentation for SAS IQ is included in the *SAS 9.3 Qualification Tools User's Guide*
**http://support.sas.com/documentation/installcenter/en/ikinstqualtoolug/64480/PDF/default/qualification_tools_guide.pdf**

## Phase 3

The SAS Operational Qualification Tool is a flexible framework for managing, processing, and reporting results from the testware that assures users that their SAS products are functioning correctly. SAS OQ provides the execution, processing, and reporting on tests provided by SAS. These tests are self-validating and require no benchmark file. Customers can extend these tools to provide tests to meet their specific needs. The tool set provides the necessary means for comparing test output with benchmark files that are maintained in a customer-written test suite. The reporting aspect of the tool set provides traversable HTML and printable PDF files. More information is available about SAS OQ in the "SAS Operational Qualification Tool (SAS OQ)" section of the *SAS 9.3 Qualification Tools User's Guide*
**http://support.sas.com/documentation/installcenter/en/ikinstqualtoolug/64480/PDF/default/qualification_tools_guide.pdf**

SAS Deployment Tester is a framework that can run tests of any kind against the SAS BI configuration. The interface is a SAS Management Console plugin; from SAS MC, the Deployment Tester plugin allows an administrator to run validation, performance, or any other kind of test against the BI install. Deployment Tester may also have a batch client interface that allows either manual or automated execution of the tests. Running test suites generates reports detailing what tests were run, and if any failed, why the failures occurred.

The tests are shipped with the BI products, not with Deployment Tester. This allows the tests to be dynamic and tailored specifically to the install and configuration.

Further, after Deployment Tester is installed, it can be extended. Since DT is separate from the test suites it runs, new test suites can be added at any time. If a customer site is experiencing a problem with a BI deployment that cannot be reproduced by SAS Technical Support, a new test suite can be sent to help diagnose the problem at the customer location. The report generated from those tests would be sent to SAS Technical Support for analysis.

SAS Deployment Tester will also run any of the tests run by SAS OQ.

## 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 different 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 testware, 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.  Following 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, SYSINFO.  Users should check these macro variables in their test programs at every opportunity.

PROC COMPARE can be effectively used 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 output.  Users can execute a simple DATA step with DATALINES input to accomplish this or any number of straight-forward DATA step techniques.  Then they can use PROC COMPARE to verify that the procedure-generated data set matches the one 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 is also available under OpenVMS Alpha.  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 statements for other SAS product areas

## JMP

JMP is our desktop product that performs analytics, graphics, and dynamic visualization in memory on the desktop, dynamically linking statistics with graphics to enable SAS customers to interactively explore, understand, and visualize data.  For more information about JMP and its quality processes, see http://www.jmp.com/qualitystatement.

## DataFlux quality statement

DataFlux was acquired by SAS in 2000 to extend its data warehousing capabilities by integrating data quality technology.

### Research and development

The DataFlux R&D team follows the SAS software development life cycle that is outlined in the body of this paper.  During the development cycle, testers are involved in reviewing requirements, design, and specifications.  The software goes through a usability review for new products or user interfaces.  The R&D team uses a set of development tools including Perforce for source control, Defects for defect tracking, Madcap Flare for product Help, and a Wiki for internal documentation sharing.

### Testing

We follow the testing practices that are described in the body of this paper. Here are details about testing that is specific to DataFlux major and minor releases.   The Early Adopter program is normally available only for major product releases:

**Test planning** – building test plans based on the development plan.  Members of the Quality Assurance team are involved from the beginning of each planned release.

**Test design** – composing test cases based on system requirements and specifications.  These tests generally cover validation, error-handling capabilities, boundary and negative testing, stress testing, and performance benchmarks.  In addition to the standard test cases we also allocate time for non-scripted ad-hoc testing.

**System testing** – verifying that individual modules are functioning according to specification.

**Integration testing** – verifying that the modules integrate together and function as designed from end-to-end.

**Regression testing/defect verification –** After each build in the product development cycle we run a series of manual and automated regression tests to make sure that no new issues were introduced to areas that have already been tested and certified.

**Internal DataFlux user testing (Alpha)** – Prior to a major release, and in coordination with the customer Beta program, internal DataFlux users (solution engineers, trainers, Professional Services, and Technical Support) spend a significant amount of time testing the product in real-world installations.

**Early Adopter customer program (Beta) –** DataFlux has a core group of customers that participate in early release testing prior to making the product generally available.  Customer feedback related to product defects and enhancement requests is evaluated and, when appropriate, incorporated into the products prior to the General Availability release.

**Installation/final inspection** – Upon completion of the testing cycle, a final phase it entered in which Quality Assurance verifies the installation of the final release candidate.  Installation testing covers upgrades from previous versions as well as from new installations.

To supplement the testing process outlined above we use an internal defect tracking system, weekly reviews with development managers, and the rational product suite for test management and regression test automation.

## Technical support

The SAS Technical Support Division provides technical assistance for DataFlux software on all supported platforms 24 hours a day.  For second-level support, technical support is available via DataFlux consultants from 9:00 a.m. to 5:00 p.m. Eastern time.  Users who want to communicate electronically with the Technical Support Division about a DataFlux problem or question have three choices:

- Go to the Technical Support home page on the SAS Web site at http://support.sas.com/techsup/.

- Use the Electronic Mail Interface to Technical Support (EMITS) (see the Mail and electronic support section)

- Use the DataFlux Technical Support interface at http://www.dataflux.com/Techsupport/.

Technical Support acts as the central clearinghouse for customer-reported problems and enters previously undocumented problems (those not discovered in the development testing process and the quality assurance process) into the Defects tracking system.  Each report is assigned a priority.  Highest priority problems, which include incorrect data analysis or transformations, as well as crashes, are addressed first by Development.  These problems are typically corrected by providing users with a maintenance upgrade to the current version of the software or by releasing an updated software version.  Problems classified as lowest priority, which are typically cosmetic in nature, are fixed as time permits.

## Software fixes/new releases

Periodically, DataFlux releases maintenance upgrades that contain software fixes.  Upgrades are available to current customers on our maintenance program from the software downloads area of the DataFlux Customer Care Center (http://www.dataflux.com/Customer-Care/index.asp).

## Training

A comprehensive curriculum of DataFlux courses, for novice to expert DataFlux users, is available through the DataFlux Professional Services organization.  Instructor-based training is provided in public courses in Cary, NC, regional locations and at customer locations.  Developed and taught by DataFlux technical training specialists, courses use the most current DataFlux software.  Lectures, software demonstrations, hands-on computer workshops, and a copy of course notes are included.

The Training Services Web site (http://support.sas.com/learn) provides information about all facets of DataFlux training.

## SAS Merchandise Planning quality statement

MarketMax was acquired by SAS in 2003 and has been renamed SAS Merchandise Planning.  The R&D team continues to incorporate the SAS R&D tools.

Procedures for design, functional specifications, code review, quality assurance review of projects, and builds have been written.  Testers are involved in the early stages of development and sign off on the requirements.  Testers use requirements and design to write test cases.

Many of the SAS R&D tools described in this paper have been incorporated into the development process for Merchandise Planning.  These tools include CaliberRM, PRISM, and the DEFECTS Reporting System.  The group is incorporating the release engineering processes as well.  Although the Merchandise Planning suite of solutions has historically been tested using manual tests, there is now an emphasis on automating testing and incorporating SAS testing tools where possible.

In Merchandise Planning testing, a test design document is written for each component.  This document is reviewed by other testers and then by Development and by other team members.  After this review is complete, testers start building test cases that break down the component into smaller testable scenarios.  The test cases are next reviewed by other testers on the team.  For a recent release, Merchandise Planning prepared 7,000 test scenarios.  LoadRunner is used for performance testing.  A growing library of reusable functional tests is being built using Software Automation Framework Support (SAFS) (http://safsdev.sourceforge.net/Default.htm).  The test cases and results are organized in Excel spreadsheets for each component.  The spreadsheets are kept on a SharePoint site for version control.  After the tests are written, they can be run by testers in the group.  Defects are entered in the DEFECTS Reporting System when they are found, and the defects are followed through the process described in this paper (see Problem reporting and resolution section).  QA and Development perform a code review for all code check-ins.

Some releases of Merchandise Planning are benchmarked.  There is a white paper produced for each benchmark that has been undertaken.  Copies of the white papers are available upon request from the SAS Middleton regional office.

# Appendix 9: 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.  To do that, we use project methodologies that include quality management (quality assurance and quality control), project governance, and we provide highly qualified consultants.

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

## SAS project methodologies

SAS project and delivery methodologies are the basis for all SAS Consulting 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.

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

- 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 Keane's methodology.

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:

- 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.

## 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 or OLAP solutions.

Covering a complete implementation of the SAS Business Analytics Framework, the methodology contains the quintessential knowledge and best practices of SAS' more than 35 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:

- Project planning, estimation, and execution.

- Project phases, activities, tasks, and sub-tasks.

- Work breakdown structures.

- Assignment of roles and responsibilities.

- Questionnaires and templates.

- Project deliverables.

- Key objectives.

## SAS quality management knowledge area in the 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 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 may on occasion look at the same product but from different perspectives. Product quality is, thus, a key measure of the software process.

## Quality assurance

Quality assurance (QA) is focused 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, reporting performance, and taking action when performance deviates from standards. QA is accomplished by:

- 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. 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.

The document should be:

- 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 if required internal and external work products have been produced. Quality audits do not test the work products for accuracy; they only determine if the work products have been produced and if they contain the appropriate authorization signatures.

## Quality assurance procedures

### *Create a quality assurance plan for each project*
The contents of this document may include such items as:

- 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***

Reviews may include:

- 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 through the project.

- User documentation review conducted with the customer.

- Test plan review performed at peer review sessions unless they involve acceptance testing, in which 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 re-use 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 pre-approved 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 such items as:

- 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, there needs to be:

- 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

1. Unit testing: Testing at the lowest level sufficient to ensure that every source statement has been executed at least once under test.

2. Integration testing: Testing the interfaces between otherwise correct components to ensure that they are compatible.

3. 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.

4. Testing to requirements: Testing from the users' perspective, typically end-to-end, to verify the operability of every feature.

5.  Stress testing: Subjecting a software system to an unreasonable load while denying it the resources needed to process that load.

6.  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.

7.  Beta testing or acceptance testing: Testing that is usually done by representative users typically in the final stage of testing prior to 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 recommend using 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:

- 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 and/or reduce 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:
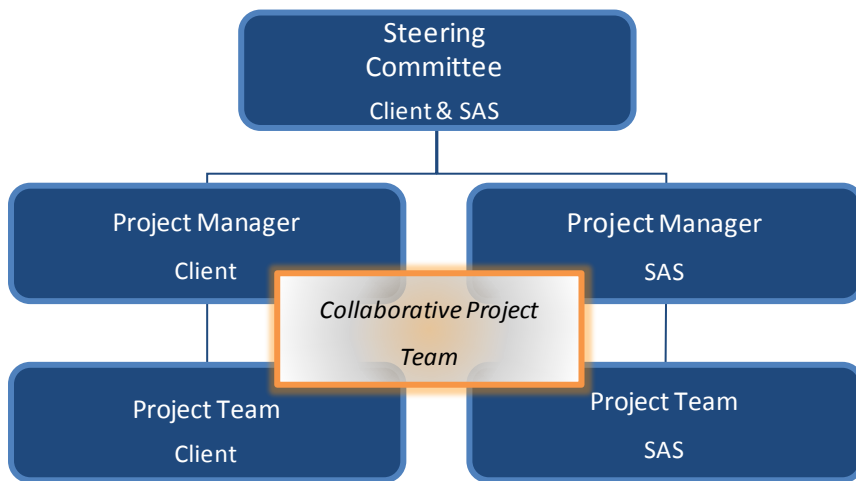


*Figure 3: Example of formal project organization*

## 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 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 project expected work products according to the agreed specifications.

Communications are always customized to meet the jointly agreed information needs of the project and of the stakeholders.

## Our experience, our consultants

SAS Consulting offers experienced domain and industry thought leaders in the world of business intelligence and predictive analytics.

What makes SAS Consulting exceptional?

- SAS Consulting has the experience and know-how to manage the continual life cycle of SAS implementations.

- SAS Consulting 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 Consulting 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 Consulting 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 Consulting brings the contextual experience needed to drive value and project success. Over 70% of SAS Consulting employees possess 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 tailored 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 Consulting information is available at http://www.sas.com/consult/usconsult/intro.html.

# Appendix 10: Quality in SAS Solutions OnDemand

## Overview

SAS Solutions OnDemand provides software-as-a-service (SaaS), results-oriented solutions, and enterprise hosting solutions for customers who want to deploy SAS solutions rapidly. The OnDemand team is a customer-focused division that integrates quality processes and controls into all areas of our organization. For more than 10 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 procedures and processes are always evolving, the SAS Solution OnDemand commitment to quality is constant.

The offerings are:

- Based on the industry's leading business analytics

- Deployed on a distributable and scalable infrastructure that is specifically designed for the solution at hand

- Rooted in industry best practices across a wide breadth of domains

- Backed by a 99 percent uptime warranty for near around-the-clock availability

## Quality management system

The SAS Solutions OnDemand quality management system (QMS) provides a framework for managing the activities that enable our organization to create solutions and provide services that consistently exceed customer expectations.  All members of the SAS Solutions OnDemand staff must adhere to the policies and methodologies, standard operating procedures (SOPs), - processes, and templates that are described within the QMS. The SAS Solutions OnDemand QMS promotes a philosophy of continuous improvement that is driven by quality objectives and customer feedback.

The QMS framework describes SAS Solutions OnDemand quality control checkpoints across the range of our business, including:

- Management Controls

- Purchasing Controls

- Environment Controls

- Process Controls

- Solution Development Controls

- Document Controls

- Customer Care Controls

- Change Controls

- Incident Management and Corrective Action / Preventative Action (CAPA) Controls

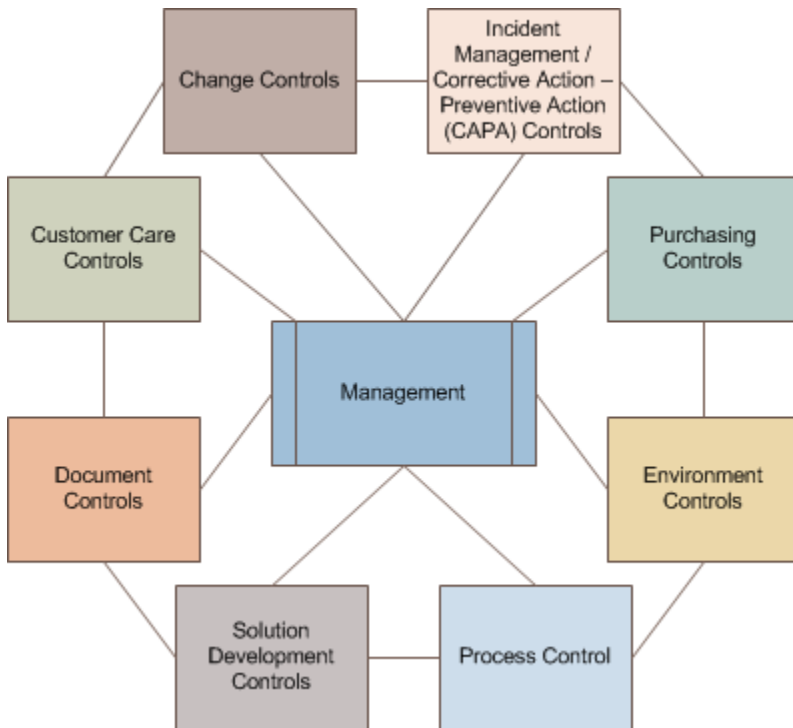Figure 4 illustrates how these quality control checkpoints operate within SAS Solutions OnDemand.



*Figure 4:  QMS categories*

## Management controls

Management communicates quality goals and objectives, reviews and revises the QMS, and provides the resources that are necessary to create and maintain the quality of our solutions and services. SAS Solutions OnDemand senior management serves on the QMS board. QMS board members are responsible for discussing new QMS documents and approving changes, including retirement, to existing QMS documents. SAS Solutions OnDemand management is ultimately responsible for ensuring that the QMS is followed.

### Communication

Management is responsible for communicating all additions and changes to the QMS.  Effective communication is an essential component of the SAS Solutions OnDemand comprehensive support model.  To ensure quality standards are met, processes and controls are in place that guide how information is shared and distributed both internally and externally.

Each customer engagement is assigned a single point of contact for customer liaison and project management.  In addition, written communication is facilitated through documentation. All documentation deliverables undergo a comprehensive review process to ensure they are complete, understandable, and appropriate for the audience (see **Document controls** for details). Regularly scheduled meetings serve as the primary driver for communicating project activities, status, and risks throughout

the solutions delivery methodology. SAS Solutions OnDemand project teams also leverage online tools for issue tracking and document management in order to easily:

- Collaborate

- Report issues

- Manage change

- Share knowledge

- Deliver and maintain documentation

### Training

Education and training activities expand the skills and knowledge of individuals so they can effectively and efficiently perform their roles. In addition to the educational opportunities provided by SAS Education (See **Appendix 4: Training SAS Users**), internal training focuses on the SAS Solutions OnDemand mission, policies, and procedures.  This internal training enables team members to effectively use and access tools and resources within SAS Solutions OnDemand.  Regulatory training provides SAS Solutions OnDemand staff with an understanding of the regulations, guidelines, and industry references that are provided by regulatory authorities such as the FDA for developing and maintaining computerized systems in a regulated environment.

Records of training, education, and experience are documented and maintained by the SAS Solutions OnDemand Quality team. SAS Solutions OnDemand Compliance audits these records annually to ensure conformity with standard operating procedures. Audit reports are provided to senior management who leverage this information to assist employees in determining their training needs in order to be successful team contributors.

## Purchasing controls

As part of the discovery process, SAS Solutions OnDemand partners with the customer to determine and define appropriate key purchasing controls, including, but not limited to:

- Business, operational, and security requirements

- Number, type, and concurrency of users

- Data size and processing requirements

- Memory footprint, network, server, and bandwidth requirements

- Reporting requirements

After this information is compiled, SAS Solutions OnDemand prepares an assessment that contains the appropriate hardware and software configuration to address the customer's current and future needs.  This assessment addresses:

- Business challenges

- Critical issues

- Software component recommendations

- Workload (prime time and non-prime time)

- Hardware sizing recommendations

- Recommended I/O throughput rates for work areas (for example, warehouse, SAS work space, and so on)

As projects evolve, technology improves, or customer needs change, hosted environment requirements are reassessed to best ensure optimal performance. Hardware and software configurations are documented through electronic tracking systems. Any changes to these configurations are defined through the contractual agreement. Change control procedures are used. (See the **Change controls** section for details.)

## Environment controls

SAS Solutions OnDemand has detailed policies and procedures regarding equipment and facilities control, automated hardware, and system monitoring that are maintained as part of our certifications. (See the SOC 2 / SOC 3 Type II processes and controls provisions section for details.)

### Equipment and facilities control

Physical security controls that protect the hosting equipment and facilities include, but are not limited to the following:

- Physical hardware and associated containers (servers, network, racks, and backup tapes) are protected by electronic locks.

- Access to SAS campus and data center facilities is limited.

- Cameras record all activity into and out of the hosting rooms.

- The data center is patrolled by security and data center employees. For more information about SAS Campus security – see the Security section of this paper.

### Server access monitoring

Access to the servers is restricted to those individuals who perform essential maintenance, development, and testing tasks. To further enforce these access restrictions, SAS Solutions OnDemand monitors and logs the following:

- Changes to permissions, permission settings, and access control templates (ACTs).

- Changes to passwords for objects such as tables and connections, including adding, deleting, and modifying passwords, as well as failed attempts to perform these actions.

- Changes to group or role membership, including adding and removing members, and failed attempts to perform these actions.

- Changes to users, groups, roles, logins, and authentication domains, including adding, deleting, and modifying these objects, as well as failed attempts to perform these actions.

- Changes to server logging levels that are initiated by remote client applications.

In addition, SAS Solutions OnDemand has the following logical security controls in place:

- Firewalls and DMZs are configured to restrict all traffic that is not approved.

- Host-based intrusion detection services are employed.

- Elevated privileges are granted only by approval.

- Access logs are summarized on a daily basis. Logical security is discussed in more detail in the Security section.

### Automated resource utilization monitoring

The availability of each server and application component within a hosting instance is monitored using redundant network-based monitoring tools. These automated monitoring tools provide:

- Alerting for server and application availability

- Resource utilization metrics for CPU, memory, and disk

- Resource availability metrics for applications including SAS, HTTP, and FTP

- Reports on server availability

- Access to resource utilization metrics

### On-call support

On-call support includes both application and IT support resources. The primary focus of on-call support is to manage and resolve issues that directly affect a customer by:

- Risking an SLA (Service Legal Agreement) violation

- Failing to run a production process

- Blocking critical work

On-call staff carry a paging device 24 hours a day and are automatically alerted by automated monitors or production processes that have detected an issue.

## Continuity of business (COB) planning

The SAS continuity of business (COB) program describes event preparedness activities as well as response and recovery of core business operations.  The SAS Solutions OnDemand business recovery plan (BR plan) operates under the SAS COB Program. The focal point of the SAS Solutions OnDemand BR plan is providing customer communications support to restore the services upon which critical business functions depend. If customers have more stringent requirements in terms of recovery time objectives and recovery point objectives, they have the option to purchase enhanced recovery services at any time.

## Process controls

To ensure the integrity of the hosted solutions, process controls are in place for software quality assurance (QA) and data quality (DQ). These controls extend to IT procedures for software installation, security, data backup and restore procedures, hot fix management, and outages.

### Software quality assurance (QA)

All hosted solutions that include custom software components undergo a rigorous quality assurance process throughout the solutions delivery methodology as illustrated in Figure 5. The quality assurance process follows the Quality Management Methodology, discussed in section Quality management methodology (QMM).
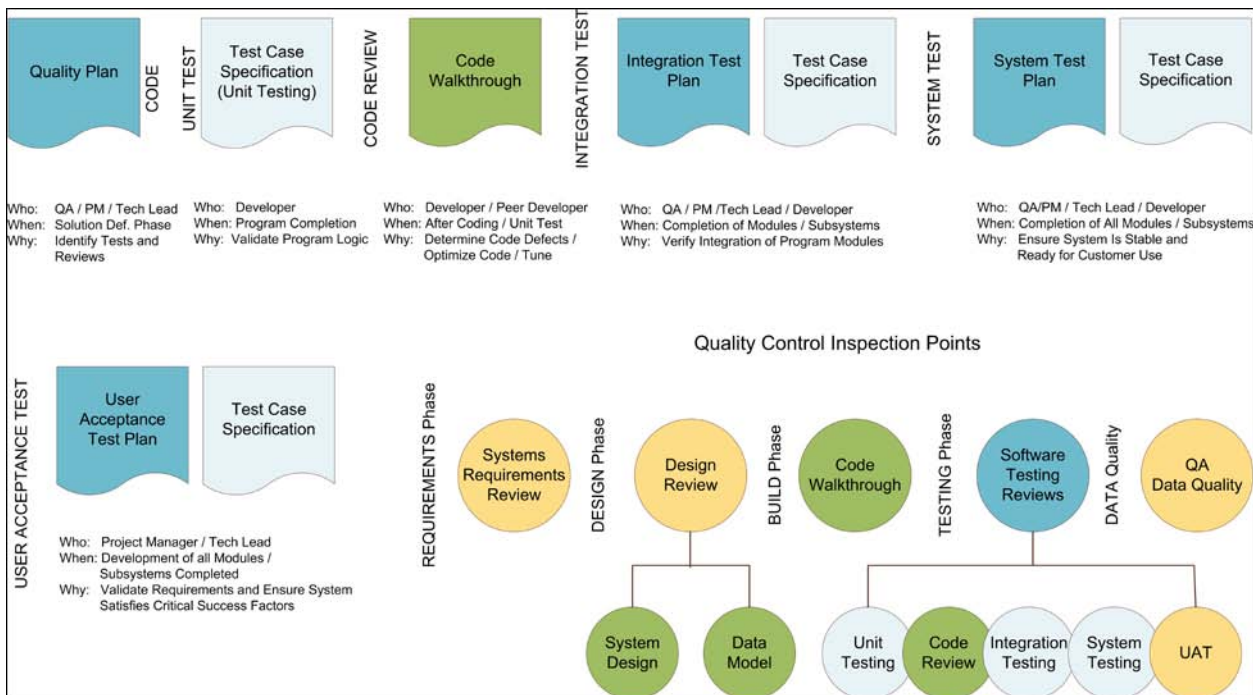


Figure 5: Quality control inspection points

QMM activities include the following steps:

- Develop a quality plan that defines the quality tasks to be performed.

- Develop a test plan that provides additional detail about testing activities, which include:

    - Describing the type of testing to be performed

    - Specifying the testing environment and test data

    - Defining the features to be tested

    - Providing traceability to customer requirements

    - Identifying risks

    - Describing defect tracking

- Execute multiple software testing activities, including

    - Unit testing: This is the first testing event that occurs during project development. This testing begins after a single program module has been developed and continues while the program is under modification.

    - Peer code reviews: Reviews are completed by a peer or colleague developer or developers following completion of program coding. SAS uses peer reviews to verify the correctness and completeness of program code before any actual testing takes place.

    - Integration testing: This testing focuses on the relationship between pairs of components and groups of components within the system that is under test.

    - System testing: This testing ensures the system meets the functional requirements. System testers execute system test plans and associated test cases in an environment that resembles the final production environment.  The testing team carefully reviews the results and forwards recommendations to the developers to make the required changes to the code where discrepancies are found.

    - User acceptance testing: This testing is managed and conducted by the customer. This testing verifies that the system meets all stated requirements and performs according to business requirements and design specifications.

- Conduct quality control inspections to validate that project deliverables and review cycles have been completed. These inspections are described below.

    - Code walk-throughs and reviews monitor compliance with development methodologies and standards.

    - A system requirements review involves an evaluation of the System Requirements Specification provided by the customer.

    - A test results review is conducted at the conclusion of each type of testing. This review evaluates the results to ensure all testing was completed as planned.

    - A system design review involves an evaluation of a series of design documents that collectively define the complete solution to meeting customer requirements.

- Implement automated monitoring and scheduled QA checks after a project moves to production to ensure the following:

- Service level agreement (SLA) obligations are met.

- The system is functioning as expected.

- Data loads are completed as expected.

Problem reporting during testing promotes the management of all testing-related issues and defects in a consistent and effective manner. This includes the recording, tracking, and disposition of system issues and defects. After a system is in production, SAS Solutions OnDemand maintains a change control management plan that provides the following capabilities:

- Records defect information

- Establishes severity and priority

- Assigns responsibility for resolution

- Records expected completion date for resolution

- Tracks ongoing status

- Provides notification on defect status

- Documents the resolution

Defects are recorded as soon as practicable after discovery. The technical leads assign newly entered defects to application developers for research and resolution. Quality assurance and development resources meet on a regular (typically weekly) basis to review and assign priority and severity for each new defect, review the status of each unresolved defect, and determine additional testing needed after a defect is corrected. Quality assurance resources also work with developers to help identify the root causes.

A final disposition of reported defects is made before the system under test is certified for release to production. SAS and customer project teams review test results and defect disposition and provide final approval for release to production. QA metric reports are available that provide graphical representation of defects and test cases over time, as well as summary listings that provide one row per defect with a textual summary of the defect.

### *Data quality*

If requested and within the scope of the project, automated data quality processes are built into hosted solutions. This provides a foundation for profiling data sources, identifying data issues, and designing processes and programs that address those data issues. The monitor component of the data quality package provides the ability to extend data quality processes beyond traditional project-based application and ensures the accuracy and reliability of information sources over time. Monitoring may include simple data profiling trend analysis, or it may include specific, complex business rule analysis. By implementing rules that define acceptable data quality values, monitoring can be used to automatically identify records that violate quality standards and alert users of the violations. Monitoring allows the team to take action well before the data anomaly affects business decisions, processes, or projects and thus improve data quality over time.

*Installation*

For each hosted application instance, validation procedures are performed according to a documented plan to install the SAS Solutions OnDemand system in the intended manner and to further ensure that it is operational. After the installation and validation procedures are completed, the system is declared production-ready. Following formal sign off, the new customer instance is promoted to production, and monitoring begins to ensure compliance with the service level agreement (SLA). The new instance is also added to the list of systems that are monitored by the responsible functional area of the on-call staff. At this point, formal configuration management, change management, and monitoring procedures are available.

*Security*

SAS Solutions OnDemand employees are trained to comply with Company-wide computer security policies as well as the SAS Solutions OnDemand Data Classification Policy, which must be re-reviewed and re-accepted every six months. This security training includes:

- initial and annual SAS Solutions OnDemand security training

- initial and annual training for updates to the SAS Solutions OnDemand Hosting Policies and Procedures Manual

- initial and update data privacy training

All data transmissions to and from SAS Solutions OnDemand are completed over secure and encrypted channels. The user interface is encrypted using transport layer security, and the hosted systems are guarded against intrusion through the use of dedicated DMZs and intrusion detection systems. Distributed communications for the SAS multi-tier architecture are supported over a TCP/IP network that transports a variety of application layer protocols as necessary based on the implementation. All desktops and servers that are based on Microsoft Windows have an antivirus solution that is updated daily.

Open Web Application Security Project (OWASP) best practices and security analysis are employed to ensure applications that are hosted at SAS Solutions OnDemand are secure. Peer code reviews and security testing tools are used to ensure alignment with OWASP best practices. Data integrity is assured by use of industry standard best practices with respect to databases and database administration, and backup and restore procedures as described in the following topic.

All SAS-supplied initial passwords require that the password be changed through a secure Web interface at first use. All passwords must meet three of four complexity rules. In addition, a history of 24 passwords is kept to prevent reuse of those passwords.

As a hosted service provider, SAS is subject to many laws and regulations, including those in the areas of privacy and security and the use of global resources. For example, the European Union (EU) and Switzerland have established strict protections regarding the handling of EU and Swiss personal data. As documented in the SAS Solutions OnDemand Business Customer Privacy Policy, SAS Solutions OnDemand follows privacy practices that comply with the U.S. -EU Safe Harbor Program, as established by the U.S. Department of Commerce in consultation with the European Commission, regarding the collection, use, and retention of data from the EU. See the **TRUSTe Privacy Certification/US-EU Safe Harbor Certification** section for more details.

Physical security is discussed above in the Equipment and facilities control section.

***Backup and restore procedures***

- Backups of the SAS Solutions OnDemand hosting system are generated regularly and stored securely and safely for specified periods. Backup policies are summarized as follows:

  o  Backup tapes contain customer encrypted data stores.

  o  Backup tapes are clearly labeled with bar code numbers, not customer names.

  o  Backup tapes are stored off site in locked boxes, per individual customer, for two weeks, and then returned to SAS for further storage in a locked vault.

  o  Tapes that are damaged or unusable are marked as such and stored in boxes per individual customers. Depending on customer requirements, the tapes can be degaussed or shredded.

  o  Access to backup tapes is granted only to authorized personnel.

SAS Data Center Operations staff generates and stores backup tapes in a manner that enables the complete restoration of system services in the event of a total loss of functionality in the SAS Data Center. Requests to restore customer data can be made by approved customer resources and SAS employees or both.

Four types of backups are generated for each customer.

- Incremental backups: These backups are scheduled a minimum of four days a week. Cumulative incremental backups capture system, data, and metadata changes from the previous full backup.  Differential incremental backups capture changes from the previous backup (whether incremental or full). Typically, the retention period of incremental backup data is 14 days, unless otherwise negotiated.

- Full backups: These backups are scheduled once a week, unless otherwise negotiated. Full backups capture a snapshot of the entire system, including all customer data and metadata and the operating system configuration. Typically, the retention period of full backup data is two months, unless otherwise negotiated.

- Monthly backups: These backups are scheduled once a month. Monthly backups are similar to full backups, except that monthly backups typically have a retention period of 18 months, unless otherwise negotiated.

- Legal backups: These backups, if contracted, are scheduled in January and in July. Legal backups are similar to full backups, except that legal backups typically have a retention period of seven years, unless otherwise negotiated.  Legal backup tapes are securely stored in the SAS tape vault or in off-site storage such as Iron Mountain.

If the most recent full backup tape is on site when the event occurs, the next most recent tape is retrieved from the off-site tape storage vendor and then used as the backup.

***Off-site storage***

Full, monthly, or legal backup tapes are shipped weekly in a secured, locked box to our offsite tape storage vendor.  The lock box is then returned to SAS and stored in a locked vault for one week. At that point, the tapes are removed from the box and placed in a secure area, returned to the library for reuse, or stored for the remainder of their retention period. This is based on the type of backup tape and contract requirements. The type of backup (full, monthly, or legal) is defined by the time of month or year that the backup is performed.

### *Patch management*

For all appropriate customer-hosted systems, SAS Solutions OnDemand patches servers as quickly as possible for critical vulnerabilities. The timing of the application of the patches depends on the security vulnerability, the assessed business and technical risk, and how quickly an outage can be scheduled, if required. The need to implement a patch is formally communicated to the customer by the SAS Solutions OnDemand project manager. Implementation of the patch is also tracked, including the specification of what customer-hosted servers and services will be affected as well as the scheduling of any required outages.

### *Maintenance*

SAS Solutions OnDemand schedules periodic outages to make non-emergency changes such as maintenance on operating environments of servers, networks, and Web connectivity devices. SAS Solutions OnDemand notifies customers at least two to three business days before a planned maintenance is scheduled to occur, and communicate the status of the maintenance activities to the customer. If a planned maintenance exceeds the planned outage window, it is then converted to an unplanned maintenance activity.

Unplanned maintenance activities (for example, power failure) are communicated to customers in a timely manner. Details concerning the outage may be sent in a postmortem Incident Report if that information is not immediately available.

## Solution development controls

The software delivery life cycle for a hosted solution is divided into distinct phases: definition, design, build, test, implementation, and close-out / maintain. SAS Solutions OnDemand staff use the following solution development controls to ensure quality within all deployed hosted solutions.

### *Solutions delivery methodology (SDM)*

Solutions delivery methodology (SDM) provides guidance for developing custom hosting solutions by forming a common foundation to build new solutions and to support its drive toward repeatable engagements.

The SAS Solutions OnDemand SDM approach leverages rapid development techniques in the development and implementation of hosted solutions. Collection, management, and organization of data assets of an organization are key to successful decision support system implementations. This approach is usually coupled with business analytics that includes, but is not limited to, analysis, querying, reporting, and presentation needs.

The SDM incorporates processes for developing analytical models in understanding and explaining relationships that exist within large amounts of data. These models provide organizations with knowledge to help them solve a wide range of problems, such as reducing customer churn ratio, increasing direct marketing response rates, fraud detection, credit card scoring, market basket analysis, and so on.

### *Software configuration management (SCM)*

Software configuration management includes a set of activities designed to control change by:

- Identifying the work products that have planned changes or are likely to change

- Establishing relationships among them

- Defining mechanisms for managing different versions of these work products

- Auditing and reporting on the changes that are made

The process is followed for each software work product used to build, maintain, and report upon components. All SAS Solutions OnDemand source code is maintained in a source management system during development, QA, and production phases of a project. The quality assurance manager periodically verifies that the production version of all source code is consistent with what is maintained in the source management system. Audits might involve all work products or a sampling of work products in a particular repository. The quality assurance manager might execute periodic spot checks, as appropriate, to verify that only authorized changes were made in the last 24-hour period.

### *Project management methodology (PMM)*

SAS project management methodology employs the following five basic processes that support effective project management:

- Initiating: These processes authorize the project or phase.

- Planning: These processes define and refine objectives, and select the best alternative course of action to attain the project objectives.

- Executing: These processes coordinate people and other resources to carry out the plan.

- Controlling: These processes ensure the project objectives are met by monitoring and measuring progress regularly to identify variances from plan so that corrective action can be taken when necessary.

- Closing: These processes formalize acceptance of the project or phase and bring it to an orderly end.

### *Quality management methodology (QMM)*

As discussed in the Software quality assurance (QA) section, quality management activities are part of every stage of software development. They include preparation of test plans and test cases, adherence to standards through reviews/inspections, procedures for error reporting and tracking, and proper management of documentation.

These activities provide many benefits including, but not limited to:

- Use of project management guidelines and processes to conduct project implementations in a disciplined, well-managed, and consistent manner

- Formal quality control reviews throughout the development process to assist in problem prevention

- Testing activities during every stage of development to aid in problem detection

- Development of standards and a solutions delivery methodology to contribute to quality and consistency

## Document controls

In order to ensure consistency and efficiency in documentation, SAS Solutions OnDemand has established defined and controlled standards and procedures. Document controls exist to ensure consistency in document templates, documentation structure and content, naming conventions, and version control.  All documents follow an iterative document development cycle, which includes:

1.  Document setup and initial development

2.  Document internal review

3.  Document delivery

4.  Document revision

5.  Document finalization and acceptance

6.  Document archive and removal

## Customer care controls

Solutions OnDemand provides customer support for the hosted solution throughout its lifecycle from the initial implementation to coordination with SAS Technical Support as solutions go into production.  During project implementation, Solutions OnDemand serves as the first level of support for all customer issues using a well-defined support model, escalation procedures, and robust online issue tracking and documentation tools.  As stated in the Communication section, a project manager acts as the single point of contact for each customer engagement to ensure all requests and issues are addressed and resolved in a timely manner. Global resources enable Solutions OnDemand to provide around-the-clock support.

During the final stages of implementation, the Solutions OnDemand project manager begins transitioning first-level support to SAS Technical Support.  This involves a rigorous knowledge-transfer process to ensure that SAS Technical Support has all information that is needed in order to provide quality support to the customer.  The customer is then trained in how to use this new support model.  Solutions OnDemand continues to partner with SAS Technical Support throughout the hosting period to guarantee customer satisfaction.

## Change controls

Change control management is a process that identifies, measures, and controls project changes. Change control management has these components:

*   Establishing the baseline

*   Controlling changes from the baseline

Validated systems are baselined after defined requirements, configurations, and specifications have been qualified and approved. It is also defined as the formal reference point for comparison and verification of subsequent development efforts. Baseline-related deliverables are customer-accepted project collateral that include a definition of scope, source code, qualification plans, scripts/checklists, and other related system qualification work products. Anything that is not included in the baseline or that alters the baseline is, therefore, considered a change.

A change order, also known as a change request, is the basis for managing any changes to the project. A change order can be initiated as a result of a requested change or new feature, or a reported issue or defect. Requests by the customer or SAS Solutions OnDemand project team members for change orders are made through the change control management system that has been set up specifically for the project. Change orders contain the following:

- A reason for implementing the change

- A description of the work under evaluation or any changes to the performance that is required of either party, or both

- A statement of business and technical risk or both to the project

- Proposed and executed SAS Solutions OnDemand and, if applicable, customer testing activities

- The estimated timetable to complete the work that is specified in the change order

A series of approvals is required before, during, and after change execution to ensure that SAS Solutions OnDemand quality standards are effectively met.

## Incident Management and Corrective action / preventative action (CAPA) controls

When an incident occurs that negatively affects a customer's business systems, facilities, or personnel, SAS Solutions OnDemand executes an incident management and corrective action / preventive action (CAPA) response process. The process provides the following:

- A rapid, initial assessment of the extent and severity of the incident

- Coordination with expert resources in it and other areas, as needed

- Technical action to prevent, counteract, and recover from the incident

- Confidential research and evidence gathering

- Documentation

- Status reporting to the customer and management

For managing this process, SAS Solutions OnDemand uses defined, controlled methods and processes to notify customers of any problems. Incident reports are created, if appropriate, to document and control activities during an incident, detail post-incident analysis, and communicate lessons learned. Preventive actions for detecting potential problems and eliminating them in advance of any future occurrence are also documented and executed.

## Awards, certifications, quality notes

Because customers entrust their most important business functions to SAS as their application service provider, SAS Solutions OnDemand must provide a robust, scalable, and secure computing environment. As a result, the SAS Solutions OnDemand proven approach has received validation from external auditors and industry experts. SAS Solutions OnDemand regularly engages third-party consultants to assess our methodologies with the goal of optimizing service delivery and providing continuous improvement.

## Deloitte Consulting

Deloitte Consulting partnered with SAS to perform a formal assessment of the SAS Solutions OnDemand system development lifecycle (SDLC). The scope of the engagement focused on an analysis of critical success factors required for successful hosted solutions using Deloitte Consulting's SDLC proven approach. More specifically, the project team reviewed and then mapped SAS Solutions OnDemand SDLC documentation, including policies, processes, procedures, tools, templates and controls against a series of project work tasks (PWTs) that are considered best practice:

- PWT 2.0 – Understand Client and Information Technology Needs

- PWT 3.0 – Review Project Planning Process

- PWT 4.0 – Analyze System Development Process and Controls

- PWT 5.0 – Review Testing Process and Controls

The Analysis showed that the SAS Solutions OnDemand system development and service-delivery methodology is an "optimal, repeatable and scalable process" that aligns very closely with Deloitte's own "Proven Approach Model" of best practices (In Figure 6).
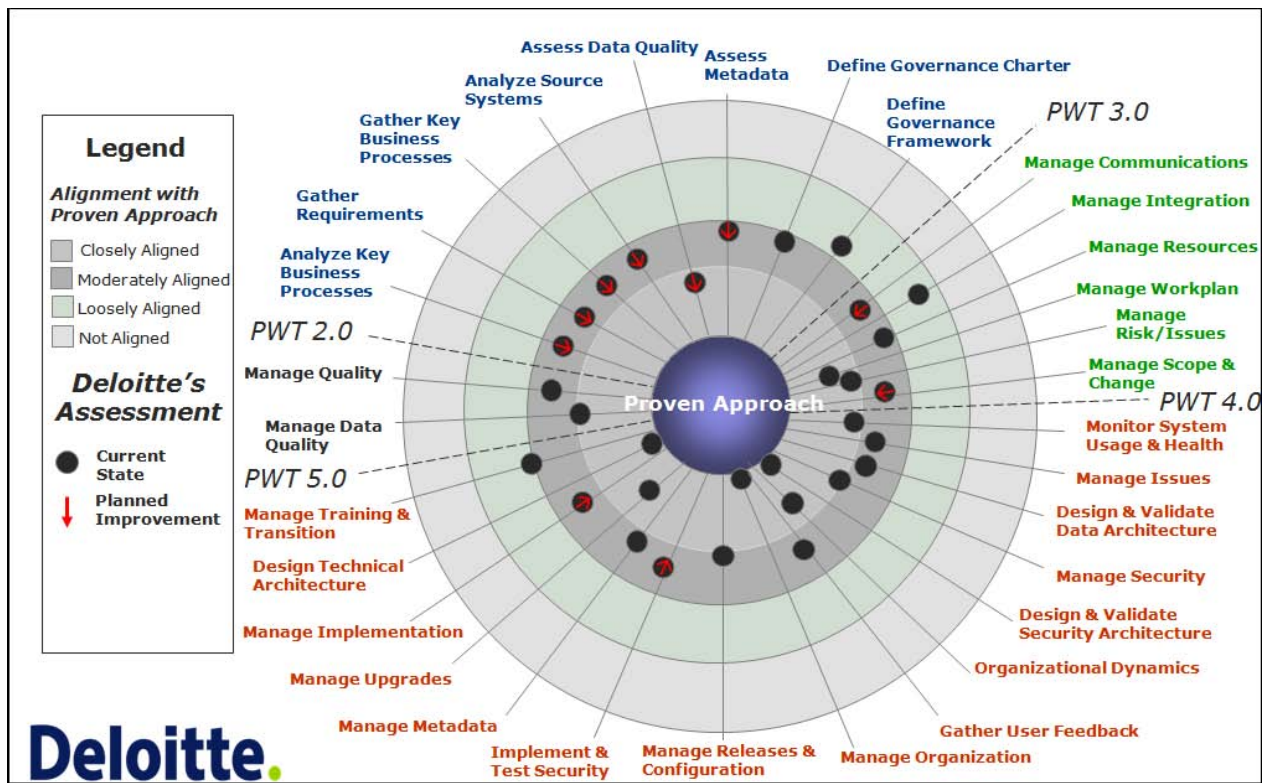


*Figure 6: Deloitte's proven approach*

## SOC 2 / SOC 3 Type II processes and controls

The Statement on Auditing Standards No. 70 (SAS 70), Service Organizations, is an auditing standard from the American Institute of Certified Public Accountants (AICPA). Ernst & Young LLP audited SAS organizational, security, maintenance, and business continuity controls. The favorable SAS 70 Type II examination assured our clients that they can use our services with confidence and in compliance with applicable regulations.

In June 2011, the AICPA replaced SAS 70 with a new standard reporting framework called Service Organization Control (SOC), which focuses on the evaluation of controls in a technology service organization. SOC 2 / SOC 3 engagements are performed in accordance with AT section 101, *Attest Engagements*, using the guidance provided in *Reporting on Controls at a Service Organization Relevant to Security Availability, Processing Integrity, Confidentiality, or Privacy.* The 2011 audit with Ernst & Young LLP successfully focused on attaining this new replacement SOC 2 / SOC 3 standard. This certification is renewed on an annual basis.

These certifications confirm that SAS has effective procedures and controls in place to deliver reliable, safe, and secure services.

**TRUSTe Privacy Certification/US-EU Safe Harbor Certification**

SAS' data handling practices have been successfully audited by TRUSTe and have attained Safe Harbor certification with the U.S. Department of Commerce. Safe Harbor is a system to manage personal data privacy practices between the U.S. and the stricter privacy controls of the European Union and Switzerland. The Safe Harbor Framework was established by the U.S. Department of Commerce in consultation with the European Commission to allow U.S. companies to satisfy EU privacy directives protecting the personal information of European citizens. TRUSTe's privacy certification of SAS Solutions OnDemand includes ongoing platform monitoring and multi-lingual privacy dispute resolution services for consumers.

For more information about Safe Harbor Principles or to access our certification statement, please review the U.S. Department of Commerce's Web site at http://export.gov/safeharbor/.

## Appendix 11: SAS products

The SAS System 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 System.  There are other products distributed by SAS (but not integrated into the product).  SAS products, solutions, and other products that are distributed by SAS and subject to this paper include the following (this list is subject to change over time):

SAS/ACCESS®; SAS® Activity-Based Management; SAS® Add-In for Microsoft Office; SAS/AF®; SAS® Analytics Accelerator for Teradata; SAS® Anti-Money Laundering; SAS® AppDev Studio™; SAS/ASSIST®; Base SAS®; SAS® BI Dashboard; SAS® BI Report Services; SAS Bridge for ESRI; CGI Tools; SAS® Clinical Data Integration; SAS® Collaborative Planogramming; SAS/CONNECT®; SAS® Credit Risk Management for Banking; SAS® Credit Scoring for Banking; SAS® Credit Scoring; SAS Enterprise Miner™; SAS® Customer Analytics for Banking; DataFlux® Accelerator for Customer Data Analysis; DataFlux® Accelerator for Customer Data Improvement; DataFlux® Accelerator for Data Watch List Compliance; DataFlux® Data Management Server; DataFlux® Data Management Studio; DataFlux® dfPower Studio; DataFlux® Integration Server; DataFlux® Solution for Customer Data Integration; SAS® Data Integration Studio; SAS® Data Quality Server; SAS® Data Surveyor for Oracle Applications; SAS® Data Surveyor for PeopleSoft; SAS® Data Surveyor for SAP; SAS® Data Surveyor for Siebel; SAS® Demand-Driven Consensus Forecasting; SAS® Digital Marketing; SAS® Drug Development; SAS/EIS®; SAS® Enterprise Guide®; SAS® Enterprise Case Management; SAS® Enterprise Miner™; SAS/ETS®; SAS® Fair Banking; SAS® Financial Management; SAS® Forecast Server; SAS® Foundation Services; SAS® Fraud Management; SAS/FSP®; SAS/Genetics™; SAS/GIS®; SAS/GRAPH®; SAS® High-Performance Forecasting; SAS® Human Capital Management; SAS/IML®; SAS/IML Studio; SAS/INSIGHT®; SAS/IntrNet®; SAS® Information Delivery Portal; SAS® Information Map Studio; SAS® Integration Technologies; SAS® Inventory Optimization; SAS® IT Resource Management; JMP®; JMP® Clinical; JMP® Genomics; JMP® Pro; SAS/LAB®; SAS® Management Console; SAS® Markdown Optimization; SAS® Marketing Automation; SAS® Marketing Optimization; plug-ins for SAS® Management Console; SAS/MDDB® server; SAS® Metadata Bridges; SAS® Metadata Server; SAS® OLAP Cube Studio; SAS® OLAP Server Monitor for SAS® Management Console; SAS® Merchandise Planning; SAS® Offer Optimization for Communications; SAS® OLAP Server; SAS® Enterprise GRC or Enterprise Governance Risk and Compliance; SAS® OpRisk VaR; SAS/OR®; SAS® Package Reader; SAS® Pack Optimization; SAS® Personal Login Manager; SAS® Profitability Management; SAS® Promotion Optimization; SAS/QC®; SAS® Quality Knowledge Base; SAS® Regular Price Optimization; SAS® Risk Dimensions®; SAS® Risk Management for Banking; SAS® Risk Management for Insurance; SAS® Scalable Performance Data Engine; SAS® Scalable Performance Data Server®; SAS® Scoring Accelerator; SAS/SECURE®; SAS® Service Parts Optimization; SAS/SESSION®; SAS/SHARE®; SAS® Simulation Studio, SAS® Size Profiling; SAS® Social Conversation Center; SAS® Space Optimization; SAS® Space Planning; SAS/STAT®; SAS® StoreCAD Plus; SAS® Strategy Management; SAS® Text Miner; SAS/TOOLKIT®; SAS/Warehouse Administrator®; SAS® Warranty Analysis; SAS® Web Analytics; SAS® Web Parts for SharePoint; SAS® Web Report Viewer; SAS® Web Report Studio

# Appendix 12: Web application vulnerabilities testing on SAS 9.3

SAS realizes that software resistance to external threats is important to our customers. The Open Web Application Security Project (OWASP) has published a list of the top ten critical Web security risks. The list has raised the awareness of both the need to be aware of these vulnerabilities, and the methods to properly address them during development and testing. SAS tests our Web applications against common Web-based malicious attacks by performing testing that specifically targets the OWASP list.

SAS has taken the following steps for SAS 9.3 EBI Web applications:

- SAS tests maintenance releases by using the AppScan product.

- SAS acquired tools and provided training to mitigate development errors and vulnerabilities. SAS licensed IBM Rational AppScan software, which is designed to generate test cases for known security vulnerabilities, including the OWASP Top 10 and others.

- SAS analyzed the OWASP Top 10 Web application security vulnerabilities and developed a special filter called the Request Sanitization Filter.

- The Request Sanitization Filter was employed by all SAS 9.3 EBI Web applications to screen out most of Cross Site Scripting (XSS) related vulnerabilities.

- During the SAS 9.3 EBI test cycle, SAS 9.3 EBI applications passed all OWASP Top 10 vulnerability criteria as tested by the AppScan product.

- New tools that facilitate vulnerability testing have been developed for groups to use on those solutions that have Web exposure on SAS 9.3.

- SAS receives AppScan updates periodically for coverage for new threats.

- SASWebDoc for SAS 9.3 employed the Request Sanitization Filter and has passed the AppScan XSS test.

SAS tests maintenance releases by using the AppScan product.