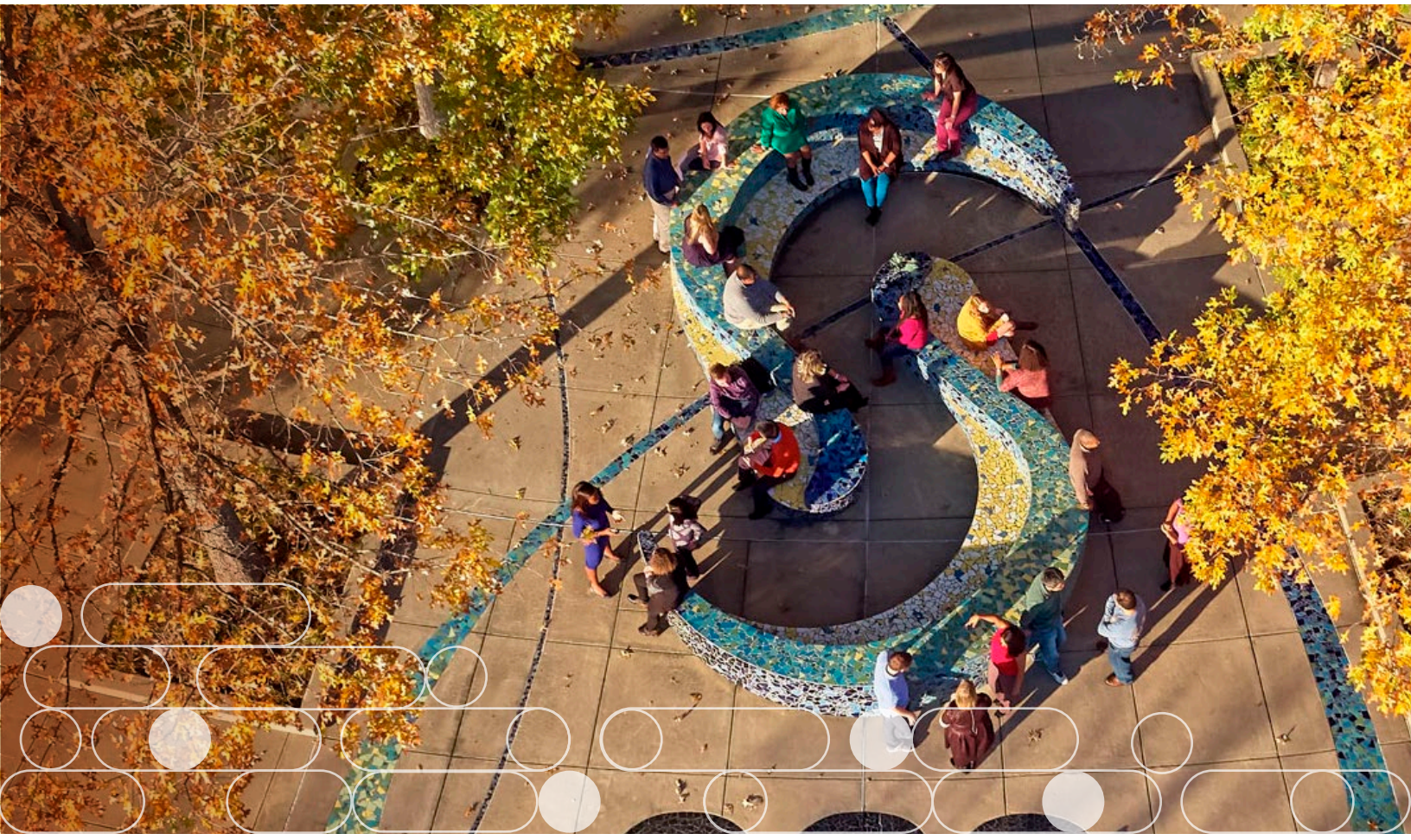
The Quality Imperative: SAS' Commitment to Quality

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



Contents

Introduction

Introducing SAS

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

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

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

To learn more about our company, customers and award-winning culture where quality is integrated into all that we do, visit our website:

- SAS company information page (**sas.com/en_us/company-information/profile.html**)
- Customer success page (**sas.com/customers**)
- Annual Report (**sas.com/annual-report**)
- Diversity and inclusion (**sas.com/diversity**)
- SAS Corporate Social Responsibility (**sas.com/csr**)
- Security Assurance from SAS (**sas.com/en_us/trust-center.html**)
- Recognition from independent industry experts (**sas.com/awards**)

The Quality Imperative

The SAS Quality Imperative (**sas.com/qualitypaper**) describes the essential role of quality in the creation and delivery of SAS offerings, products and services. The paper is organized so that topics flow from broad, corporatewide processes that provide the foundation of quality at SAS to the detailed and technical processes that are used in software development. Overall, the paper is intended to provide the reader with a comprehensive picture of SAS' quality culture and processes that are used to develop the products and offerings listed in **Appendix 8: SAS Offerings and Products**.

The following are papers and sites related to the Quality Imperative that provide in-depth content on targeted areas:

- JMP: A Commitment to Quality (**http://www.jmp.com/qualitystatement**)
- SAS Trust Center: Trust in Compliance (**https://www.sas.com/en_us/trust-center/sas-trust-compliance.html**)
- SAS Managed Services (**https://www.sas.com/en_us/solutions/cloud/sas-managed-offerings.html**)

JMP Statistical Discovery LLC ("JMP") is a wholly owned subsidiary of SAS Institute Inc. ("SAS") and adheres to the commitments outlined in this document, to the extent applicable.

Our Employees

Quality Culture

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

Focusing on people and relationships – making employees a top priority – leads to more productive, satisfied and dedicated employees. To achieve that ideal, employees must be trusted and valued, and they must believe that they can make a difference. To support the creative process and balance work and family, SAS provides a flexible work environment that enables them to be the most productive.

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

The company's Work/Life programs and unique corporate culture continue to receive accolades – at global, regional and local levels – for being a great workplace. Many of our country offices have also been recognized for their workplace culture by various prestigious organizations. A full list of corporate awards can be found at **sas.com/awards**.

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

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

^ CONTENTS

Quality Workforce

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

- To be considered for an open position, all applicants must meet the specific education, training and experience qualifications for the open position.
- For each position at the company, there is a written job description that specifies the necessary education or experience and job functions.
- Competency-based interviewing is used to identify the ability, experience and knowledge that are required for a particular position. In addition, numerous interviews are conducted with an applicant. This practice enables SAS to be as inclusive as possible, while also enabling the interviewee to experience the culture and the people who create the culture.
- SAS' approach to performance management is aligned to business needs, employee skills and career development. We promote ongoing conversations between managers and employees around expectations, skills and development. Performance management occurs continually.
- SAS performs post-offer and pre-employment drug, alcohol and criminal background screening on every final applicant for employment in accordance with SAS' Human Resources policy. In addition, we conduct background checks on contractors and other third parties per the SAS Human Resources policy for contingent workers.
- All SAS staff nominated and assigned to any agreed project role must have the skills, experience and knowledge required to meet assigned duties or deliver expected work products. Recognition as a best place to work enables SAS to hire and retain the best employees in the industry.

At SAS, analytical and statistical software is designed, written and tested by highly specialized and educated engineers. For example, more than two-thirds of the engineers working on analytics products have advanced degrees, and more than two-thirds of those have PhDs in fields such as data science, statistics, mathematics, computer science, econometrics and operations research. Product developers, including product management and engineers, also have domain expertise in operations research, time series analysis, finance, pharmaceuticals and other fields through previous work experience and education.

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

Diversity in the Workplace

Quality benefits from all forms of diversity. SAS has a multidimensional culture that blends different backgrounds, experiences and perspectives from employees around the world. SAS' culture encourages everyone to feel confident in expressing their ideas and to know that they will be respected for their unique contributions and abilities.

Read more about SAS' commitment to diversity and inclusion by visiting **sas.com/diversity**.

We believe a diverse workforce brings unique talents and inspires teams to create software that can change the world. Great minds don't always think alike, so we make it a priority to promote an environment where varied perspectives are encouraged. Big ideas ignite when everyone is treated with fairness and respect.

— **Jim Goodnight**, CEO of SAS

Employee Training

Employee technical training and professional development are critical to the SAS quality process. It is an ongoing endeavor that begins during onboarding and continues throughout employment. Employees continuously set and refine development goals with managers that align with the skills needed to excel at their current or future roles.

SAS provides a variety of resources to help employees succeed with their career training and development. Many training courses are accessible through the SAS Learning Management System and selected external online learning platforms. Training content can be delivered through a variety of channels that provide staff with options most appropriate for their learning style, including self-paced learning and live instructor-led courses. Furthermore, an extensive corporate library contains bound volumes, periodical subscriptions, complete SAS documentation and audio and video training materials.

SAS offers several formal and informal mentoring programs to grow and nurture internal talent. Additionally, we provide tuition reimbursement for degree-seeking employees to support their ongoing higher education development.

For more information, see **Appendix 4: Employee Training**.

Employee Certifications

SAS employees take great pride in achieving professional certifications that enhance their ability to deliver a quality product to customers. These certifications include the following:

- Security certifications, such as Certified Information Systems Security Professional (CISSP®), GSEC – GIAC Security Essentials, CompTIA Security+ and Certified Secure Software Lifecycle Professional (CSSLP).
- Project management certifications, such as Project Management Professional (PMP).
- Quality and compliance certifications, such as Certified Software Quality Engineer (CSQE), Certified Quality Improvement Associate (CQIA), Certified Information Systems Auditor (CISA) and Certified Quality Auditor (CQA).
- Process improvement certifications, such as Six Sigma.
- Information technology certifications, such as Information Technology Infrastructure Library (ITIL), Microsoft Certified Professional (MCP) and various Microsoft Azure certifications.
- **SAS software certifications**.

Quality Starts With Communication

Employees are influential at SAS because the company's leadership understands that employees contribute valuable feedback and serve as the main drivers of change, momentum and innovation.

As a leading data analytics company with a global presence, connecting with employees is essential. The SAS Internal Communications team embraces the challenge by using a broad range of communication tools.

In addition to sharing information through the SAS intranet – the primary internal communication vehicle – SAS also hosts webcasts, podcasts and town hall events. Digital signage with global and local information is now available in most SAS offices as well. Lunch-and-learn sessions provide opportunities for peer-to-peer learning and networking. Other internal forums enable subject-matter experts to instruct, share knowledge and spark creativity. Instant messaging and real-time file sharing tools enable SAS employees to communicate, collaborate and coordinate with each other across the globe.

Social media use within SAS continues to grow — from blogs to internal networking platforms — to create a tight-knit virtual community. In addition, most major divisions sponsor regular internal webcasts that enable employees to obtain updates on divisional priorities and to ask questions of upper-level management. Several divisions also deliver periodic newsletters, support dedicated divisional websites or host collaborative forums. These media are updated regularly with information about divisional priorities, goals, news and changes. A weekly internal news recap email is available. All employees receive a monthly newsletter from the executive leadership team highlighting the most important updates over that period.

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, SAS nurtures an atmosphere of sharing and openness. Employees in the audience or those watching online are encouraged to ask questions and share their feedback and ideas. Besides seeking employee comments in face-to-face and virtual meetings, most major events are followed by a survey, which enables employees to offer feedback anonymously.

SAS also receives feedback from employees via the annual employee experience survey. Working task forces address the biggest issues identified through this survey, making recommendations to enhance existing efforts or create new ones. Many divisions conduct their own feedback surveys to follow up on areas of specific concern to them.

Work Environment

Corporate Services

The groups in Corporate Services are responsible for the safe and secure work environment of all employees on the SAS Cary campus and at regional offices throughout the world. A Corporate Services Global Management team aligns operational processes around best practices and related business strategies globally. The Corporate Services Division works with offices globally to adhere to SAS' statement on sustainability. For more information, see **sas.com/csr**.

Corporate Real Estate

The Corporate Real Estate Department is responsible for global workplace solutions. This includes real estate strategy, space management, lease transactions, design and construction, office branding, art, furniture and ergonomic support.

Facilities

The 300 developed acres that comprise the SAS world headquarters campus are maintained by SAS' Facilities Department. This group is comprised of employees who work in Facilities Management, Facilities Services, Housekeeping and Interior and Exterior Landscaping.

Security and Safety

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

- Security and safety awareness and education activities.
- Access control through staffed gates, card access readers and security reception desks.
- Fire detection, alarm and suppression (protection) systems.
- Closed circuit television (CCTV) system.
- Uniformed security personnel for both proactive deterrent patrols and various emergency and non-emergency (customer service) responses.
- Every leased US regional office has CCTVs and card access readers.
- Most global spaces have property management companies that we rely upon who know the local constraints on securing buildings. For example, SAS ensures that access controls are in place in all global locations, but some countries will not allow CCTV.

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

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

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

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

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

- SAS Data Center management is responsible for authorizing and reviewing physical access monthly.
- Entry controls including loading areas.
- Badge readers are located at each entry point to hosting rooms, and badges must always be worn and visible within the SAS Data Center.
- The SAS Global Hosting and US Professional Services environment for hosted customers requires additional badge readers and PIN codes.
- Discreet signage compliant with security requirements.

Business Continuity Management

SAS' Business Continuity Management (BCM) program refers to the company's plans and procedures aimed at protecting key assets and continuing critical business functions in the event of anticipated and unanticipated threats. SAS' global BCM Program, initiated in 2004, helps inform organizational resilience and focuses on business resumption and crisis management planning. Associated BCM activities include annual plan maintenance and testing, staff training and management program review. For additional information regarding SAS' BCM Program, please refer to **Business Continuity Management**.

Supplier Diversity

SAS is committed to diversity among its suppliers. SAS customers represent a wide range of industries, people and locations – and SAS wants this same level of diversity reflected in the supplier community.

SAS develops and maintains collaborative relationships with suppliers that meet SAS' global business needs. Any supplier that provides the goods and services relevant to SAS must demonstrate a "value-added" benefit. These benefits can include cost savings, competitive pricing, customer focusing, innovative business solutions and a commitment to SAS' values.

Suppliers interested in doing business through our SAS Supplier Diversity Program must be a socio-economically disadvantaged business, defined as 51% owned and operated by women, minorities, veterans, LGBTQ+ or persons with disabilities. Businesses must be certified as "diverse" by a third-party agency and located within the United States.

As part of the Corporate Services Division, the supplier diversity team advances the goals and objectives of the company's supplier diversity initiatives. SAS is a member or an active participant of the **National Minority Supplier Development Council**, the Women's Business Enterprise National Council, **WeConnect International**, the **National Veteran Owned Business Association**, the **US Pan Asian American Chamber of Commerce**, **Disability:IN** and the **National Gay and Lesbian Chamber of Commerce**.

SAS works directly with organizations that actively support the education and advancement of women, minority, veteran, LGBTQ+ and disabled-owned businesses. Outreach to these organizations includes sponsorships, volunteering and serving on committees and boards. The supplier diversity team and sourcing team collaborate closely with these organizations to create training and opportunities for the diverse businesses they serve. Economic opportunity and sourcing inclusion for diverse businesses is important to our mission and vision.

Protecting Privacy

SAS cares about individual privacy rights and is committed to complying with applicable international privacy and data protection laws concerning the collection, use, maintenance, sharing and disposal of personally identifiable information (PII), including "personal data" as defined by the General Data Protection Regulation (GDPR) and other regulated data. These privacy laws encompass from sector-specific regulations in the United States, such as the Health Insurance Portability and Accountability Act (HIPAA), to comprehensive data protection regulations such as GDPR in the European Union and other similar laws worldwide.

The SAS Privacy Office, under the leadership of the SAS Chief Privacy Officer, utilizes a risk-based approach to drive compliance along with the needs of the company through regular assessments against privacy frameworks and defined metrics. Common privacy frameworks are utilized to guide privacy management and inform privacy-relevant decisions for the company. These privacy frameworks include principles and standards such as the International Organization for Standardization (ISO); laws, regulations and programs such as Personal Information Protection and Electronic Documents Act, the GDPR and HIPAA; and privacy program management solutions such as Privacy by Design and National Institute of Standards and Technology (NIST).

The program's design follows a hybrid model, in which the privacy function is partly centralized (in SAS' Privacy Office) and partly decentralized with distributed responsibility within geographies and business units via SAS Privacy Champions Network. As such, SAS' Privacy Office works with stakeholders across the company to develop, implement and maintain an organization wide governance and privacy program intended to ensure compliance with applicable privacy laws and regulations.

To prevent unauthorized access or disclosure, maintain data accuracy and to ensure appropriate and lawful use, SAS has put in place reasonable physical, electronic and managerial procedures to safeguard and secure such information. We respect individual privacy rights and only use data in compliance with our Privacy Statement. For more information, use the following resources:

- **SAS Code of Ethics**
- **SAS Trust in Privacy site**
- **SAS Privacy Statement**
  - Persons in the European Union should access the **EEA version of this Privacy Statement** applicable to processing of personal information subject to the General Data Protection Regulation.
  - For enterprise hosting managed by SAS, see the **SAS Hosted Managed Services Privacy Policy**.

Cloud and Information Services

SAS' IT organization, Cloud and Information Service (CIS), partners with SAS business units and customers to deliver global technologies and services that increase business value through trust and partnership. CIS is committed to service excellence and has established practices, including continuous service improvement, that provide a framework for measuring and improving performance. The following quality processes ensure adherence to the quality standards established by SAS, CIS and as required by security and compliance standards.

Software Engineering

- Enterprise architecture to drive an integrated environment that is responsive to change and supportive of the delivery of the business strategy.
- Adherence to software engineering guidelines and industry best practices to ensure that quality is built into the design and implementation. This includes a strong focus on the total experience.
- Comprehensive enterprise solution testing (unit, functional, usability, load and performance, exploratory, accessibility and others) to ensure that solutions meet functional and nonfunctional requirements.
- End user, customer-zero testing and deployment of SAS offerings to provide feedback to SAS product development.

Managed Services

- Technical reviews that evaluate customer requirements to ensure that hardware sizing, costing and resourcing align with customer project requirements.
- Dedicated and trained build and operations resources that follow quality best practices when deploying and maintaining customer environments.
- Deployment testing to validate that a newly deployed or updated environment is properly installed and configured according to customer requirements.
- System monitoring to track server health and capture metrics of server and solution availability.
- Dedicated project owners to ensure optimal cloud delivery and overall customer experience throughout the life of the project.
- Required change management training and established change management processes to identify, measure and control changes to managed customer environments.
- Required security awareness training for all Managed Services employees and partners to ensure that customer's legal and regulatory requirements are met.

For more information about the quality processes and controls in Managed offerings, see **https://www.sas.com/en_us/solutions/cloud/sas-managed-offerings.html**.

^ CONTENTS

Security and Compliance

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

Service Excellence

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

Environmentally Responsible IT

In today's business landscape, sustainability is a crucial aspect of SAS' corporate responsibility and part of our overall quality focus. Information technology (IT) has become an integral part of business operations, but it also has a significant environmental footprint. The increased demand for computing resources, coupled with the rise of electronic waste, energy consumption and carbon emissions, are causing negative consequences for the planet.

SAS Cloud and Information Services' Green IT Strategy is a key component of SAS' corporate sustainability strategy. We actively manage IT assets to extend asset life and reduce material impacts. We optimize and monitor energy use over the entire life cycle to more efficiently consume and produce energy. We procure energy-efficient and/or eco-certified IT assets from suppliers with strong sustainability goals. Lastly, we enable these activities through operational excellence and IT Operations Management to ensure the reliability, performance and availability of IT systems and services.

Continuous Improvement

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

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

^ CONTENTS

The Foundation of Quality Development

This section outlines key underpinnings of quality software development at SAS, including external and internal standards, reliability and accuracy in algorithms and AI and project team organization and oversight.

Technical Industry Standards

SAS continuously monitors external technical industry standards and engages with regulatory and governing organizations to inform the evolution of SAS' internal quality processes, including the following:

- Standards and process organizations such as International Organization for Standardization (ISO), National Institute of Standards and Technology (NIST) and System and Organization Controls (SOC).
- Government regulations and programs such as the US FDA Code of Federal Regulations, the Federal Risk and Authorization Management Program (FedRAMP®), Cybersecurity Executive Order 14028 and all applicable trade and export controls.
- Security organizations and frameworks such as Open Web Application Security Project (OWASP), National Vulnerability Database (NVD), Common Vulnerability Scoring System (CVSS) and Forum of Incident Response and Security Teams (FIRST).
- Global privacy laws such as General Data Protection Regulation (GDPR) and California Consumer Privacy Act (CCPA).

SAS continuously updates internal policies and standards as technology evolves and customers' requirements change, through:

- Continuous monitoring of industry standards, such as ISO, NIST, DORA and FedRAMP, and incorporating relevant processes and controls across SAS where applicable.
- Maintaining strategic and cooperative relationships with leading hardware and software manufacturers to establish effective integration and performance.
- Contributing to legislation and requirements through active participation in committees and organizations.
- Encouraging and supporting employee membership in professional organizations and committees.
- Requiring and enabling advanced cybersecurity training and certifications for staff, such as software developers and technical support engineers.

R&D Policies, Standards and Processes

R&D uses internal policies, standards and processes to ensure that consistent development methods, architectural components, software engineering processes and tools produce quality deliverables for customers. Figure 1 illustrates the relationship between policies, standards and processes and the software development life cycle.

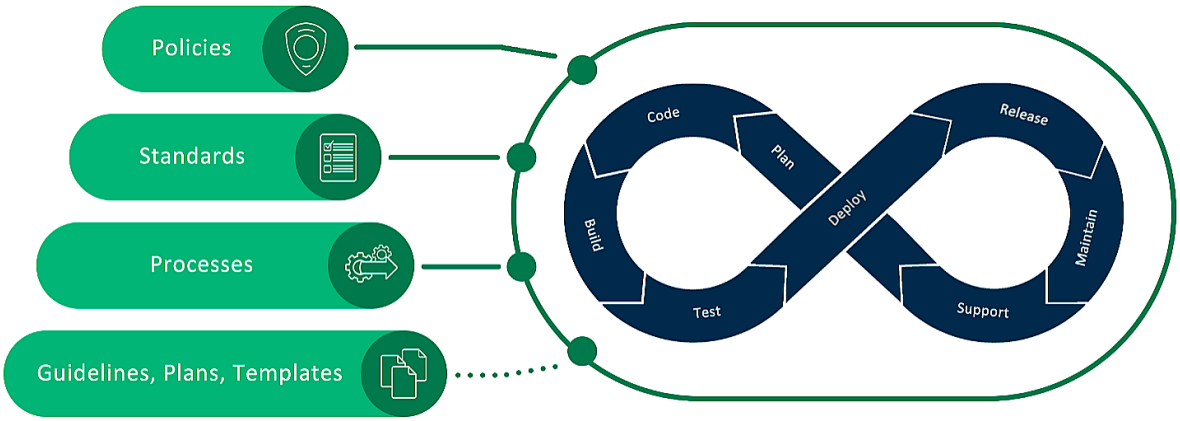


Figure 1: R&D Policies, Standards and Processes

R&D policies, standards and processes are required aspects of software development and provide foundational consistency for coding practices, software security, accessibility, user interfaces and other factors. They are formally documented and continually reviewed, refined, expanded and enhanced. Guidelines, plans and templates are less formal documents, as indicated by the dotted line in Figure 1. They are specific to the software that is under development, and they help ensure conformance to required policies, standards and processes.

Accessibility

SAS is committed to enabling people of all abilities to access the power of analytics. To that end, SAS has established standards, provided centralized accessibility leadership within R&D and created development and testing support structures for teams. The internal standard for the accessibility of products, documentation, training and support materials uses the **Web Content Accessibility Guidelines (WCAG) version 2.1** at the A and AA levels of conformance.

There is a central accessibility team within R&D. This team defines product requirements, coordinates training, establishes guidelines and checklists, assists in testing applications for compliance and works with customers to address accessibility questions.

R&D staff receive training in understanding how people use assistive technologies, testing for accessibility conformance in web content and how to develop accessible web applications. Product teams incorporate automated and manual accessibility testing methodologies into their development processes. The central accessibility team works with the product teams to define accessibility priorities and develop plans for improving the accessibility of the products. Additionally, testing and user experiences are designed alongside people with disabilities so that their lived experience helps move us beyond conformance to enable people with disabilities to make better decisions using data.

The SAS Disability Support Center (**https://support.sas.com/accessibility/**) provides direct access to the latest information about the accessibility of SAS products. It includes links to user documentation for accessibility features, webinars, training and much more. Users with disabilities can also directly email the central accessibility team at **accessibility@sas.com.**

Application Programming Interfaces (API) Standard

The SAS API Standard was developed to guide developers in creating usable, consistent and secure APIs.

APIs are protocols that allow for communication and data transfer between separate applications or between components of the same application. Private APIs are accessible only between software components of the same family of software, while public APIs are accessible to external third parties for use in their applications.

All new network interfaces must be Representational State Transfer (REST) APIs or a binary protocol that supports tunneling over HTTP approved by the API Developer Experience Team. REST APIs are preferred because they enable ease of use, reuse, consistency, security and interoperability between all SAS REST APIs and access from heterogeneous clients. In addition to the REST architecture requirement, the API Standard also defines how underlying domain resources are accessed, what media types are accessible, which status codes may be used and other guidelines.

Software Globalization

Internationalization is the process of designing and developing software so that it functions properly anywhere in the world without requiring re-engineering. Internationalization ensures that the software can be adapted to meet the language and cultural needs of SAS customers.

Localization is driven by market demand. It is the process of adapting software for a particular country or region. Localization includes the translation of text for the user interface, system messages and documentation.

Software globalization is the combination of internationalization and localization to ensure that products are global-friendly and can be rolled out worldwide at a moment's notice.

All SAS software products must be internationalized. The globalization team produces standards and guidelines that enable product teams to develop software for users around the world.

Internationalization:

- Develop software components that handle character data correctly, regardless of the character encoding.
- Support collation of data according to expected linguistic or cultural guidelines.
- Present dates, times and numbers in a format that is culturally correct.
- Test English and other locales simultaneously during the software development life cycle to verify that products follow the internationalization standard.
- Support the ability for customers to translate a single report into many languages.

Localization:

- Localize software on a schedule that allows for simultaneous delivery in English.
- Maximize reuse of translations to ensure consistency and a higher-quality user experience.
- Be the voice for the non-English-speaking customer.

Software Security

To design, deliver and maintain products that meet customers' security requirements, all R&D product teams are required to comply with internal software security policies, standards and processes. SAS uses the following publications to help product teams evaluate and remediate security weaknesses and vulnerabilities:

- Common Weakness Enumeration (CWE) list
- Open Web Application Security Project (OWASP) Top Ten lists
- CWE/SANS Top 25 list
- Known Exploited Vulnerabilities Catalog from US Cybersecurity and Infrastructure Security Agency (CISA)
- Mitre ATT&CK framework

For more information, see the papers and links highlighted on the SAS Security Assurance website (**sas.com/en_us/trust-center/sas-trust-security.html**). Details on testing for compliance with internal software security policies, standards and processes are found in this paper's **Software Security Testing** section.

Third-Party Software and Open Source Contributions

The Third-Party and Open Source Software standard mandates a process for evaluating and managing third-party and open source software that is used internally for development activities and/or incorporated into production offerings. This process applies to any software (whether open source or proprietary) that is developed by an entity other than SAS. It plays an important part in protecting SAS and SAS customers by evaluating third-party software against a predefined set of legal, business and technical guidelines. Additionally, the Open Source Contribution process provides guidance for releasing SAS-owned software to the public under an open source license.

Terminology

The SAS Terminology Standard specifies that all SAS software and supporting materials must be written in a way that does not contribute to social biases with the use of insensitive language. SAS uses bias-free language guidelines, incorporating style and grammar that reflect the diversity of the wider SAS community, both internally and externally.

User Interfaces

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

- User interaction and visual design
- Accessibility
- Embedded user assistance and terminology
- Internationalization
- Legal notices

Following this standard promotes these results:

- Ensures that SAS products are usable
- Establishes a consistent look-and-feel for SAS products
- Provides a high-quality user experience to all users

Algorithm Choices

SAS staff reviews the relevant literature and evaluates established algorithms for numerical stability, time requirements and space requirements. Algorithms are chosen that provide the best combinations of these sometimes conflicting requirements. If satisfactory algorithms are not found in the prevailing literature, then SAS staff may perform research to develop better algorithms in-house. All algorithms in SAS software are tested extensively. Furthermore, the analytical and statistical software documentation provides sections that cover computational details and references to source literature.

Numerical Accuracy

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

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

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

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

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

In response to industrial concerns about the numerical accuracy of computations from statistical software, NIST's Information Technology Laboratory provided data sets with certified values for a variety of statistical methods (NIST 2007). As one of many approaches to ensure accuracy, SAS integrates NIST data into automated tests and compares SAS results to the results that are supplied by NIST.

Developers take steps to verify that SAS works correctly with operating system datetime functions. In general, developers rely upon operating system datetime values and perform checks to ensure correct functioning for special situations, such as daylight savings time.

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

For more information about validating a statistical procedure, see **Appendix 2: Validating an Analytical Component**.

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

Trustworthy AI

SAS continues our rich tradition of leading the growth of responsible innovation in the field of analytics. Trustworthy AI and responsible innovation are an integral foundation of SAS and have been for decades. Customers in every industry capitalize on SAS' innovations to gain insight and help responsibly operationalize their business strategy. At SAS, we are guided by our core principles of human-centricity, inclusivity, accountability, robustness, transparency and privacy and security in creating our analytic capabilities, products and platform. We believe that trustworthy design, development, deployment and use of analytics and AI-driven solutions help ensure sustainable improvements for our customers, the economy and society.

SAS' commitment to trustworthy AI builds on our already strong foundation in AI, which includes:

- Machine learning
- Advanced analytics
- Deep learning
- Natural language processing
- Optimization
- Forecasting
- Fraud detection
- Computer vision
- Data lineage
- Model governance
- Decisioning

SAS' innovation and capabilities aim to address the imperative toward the responsible development and implementation of AI. SAS engages with policymakers, regulators, stakeholders and like-minded organizations to help shape the future of AI regulations and ensure that SAS and our customers remain at the forefront of these developments.

Organizations should operationalize AI in fair, transparent, accountable and carefully managed ways. SAS has the resources, expertise and products to help our customers meet their business objectives while considering applicable legal requirements. SAS supports customers with comprehensive training on the responsible use of AI, model interpretation and model management.

Furthermore, diverse teams are more likely to create solutions that anticipate unfair bias and take steps to avoid or mitigate it. SAS' diversity and inclusion efforts encourage multidimensionality both within SAS and beyond, for example, through SAS' investments in fostering diversity in STEM talent and traditionally socially disadvantaged businesses.

Shared Sublibraries and Code Reuse

We have a rich tradition of reuse, and we regularly use our prior work as the building blocks of innovations in applications. SAS software products share the same sublibraries or components. As a result, there is a high incidence of code reuse. Developers are encouraged to reuse routines when possible. Each routine is tested in the development environment and then across supported operating environments. We have several reuse categories of shared components:

- Golang libraries
- MultiVendor architecture (MVA) and threaded kernel libraries
- SAS Component Language code
- .NET
- Java libraries
- JavaScript libraries

Low-level, reusable modules are unit-tested and then used in developing more complex modules. Shared components are tested on machines with multiple SAS releases and are also tested after installing or uninstalling releases. The benefit of shared sublibraries is

that a significant percentage of code has been tested collectively across a wide variety of operating and computing environments. SAS is built with source code and components that are reused from release to release. This adds stability to the software because each successive release of SAS software inherits code that has been tested and used in prior releases. Features such as security and compliance are centralized, ensuring they're implemented and tested by domain experts, while providing consistent functionality across SAS software.

R&D Engineering Standards

In addition to the other policies, standards and processes in this chapter, there are additional mandatory R&D engineering requirements, primarily covering internal CI/CD processes. These various requirements are included as part of the R&D Engineering Standards.

Supporting R&D Quality Development

At SAS, every executive, manager and product team member are responsible for quality. By intelligently structuring teams and promoting a culture of quality throughout the company, SAS can support and encourage the innovation and creativity that our customers have come to expect.

Product Teams

Product teams are the heart of software development at SAS. Product teams are cross-functional, typically including developers and testers, product and project managers, and other roles determined by product functionality and development phase. A loose matrix organization among diverse product teams enables each team to customize processes in an agile manner, while guided by internal policies, standards and processes. This flexible relationship encourages high degrees of innovation and facilitates knowledge-sharing, while ensuring product consistency and interoperability.

Product teams use retrospectives to improve processes and software quality. During the retrospective process, teams discuss project details and identify opportunities for improvement. Teams then develop a concrete plan of action for implementing the changes and following up on the results. Over the course of the software development cycle, teams may perform retrospectives at any or all of these times:

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

In addition to retrospectives, development teams use other continuous improvement methods to improve software quality and the customer experience. These include a focus on personal and professional development, sharing best practices, conducting both internal and external usability reviews, and acting on customer feedback.

Project Management

SAS R&D project managers play a key role, supporting the product team's agile processes and enabling teams to deliver projects on time, within budget, and according to functional and quality specifications. Each offering is assigned a project manager who works with a product team to scope the work and establish a schedule. The scope of work and planned schedule become the foundation for the ongoing tracking and oversight of the project. On an ongoing basis, they work with product teams to identify project risks and develop mitigation plans to address them. When actual status deviates from the plan, project managers work with team management to determine and implement actions to get the project back on course. Examples of actions can include changes in scope, timelines, resource allocation and so on. Throughout the project, project managers ensure adequate visibility into the overall health of the project via status reporting, project reviews and surfacing project data to a companywide scorecard to ensure that the project is meeting the stated goals and objectives. Status reporting and project reviews occur at both the individual team level, as well as at the executive and enterprise level.

R&D Security and Compliance Team

The R&D Security and Compliance team drives continuous improvement of R&D quality and security practices to minimize risk to SAS and our customers by:

- Expanding and supporting security directives and initiatives throughout SAS through education, collaboration and publication.
- Ensuring that R&D policies, standards and best practices are aligned with corporate vision and are defined, communicated, adopted and measured.
- Achieving, expanding and maintaining information security and related industry-supported compliance certifications.
- Providing expertise on security practices, standards, internal controls and external certifications.

Quality Review and Oversight

The R&D Executive Team consists of executive representatives from across the R&D organization. This team provides cross-divisional management and oversight of all R&D product releases. The team meets regularly to evaluate the progress, quality and readiness of upcoming releases.

Dashboards visible to all R&D employees surface key quality and progress metrics from each development project. The R&D Executive Team reviews these dashboards regularly to anticipate areas of concern and develop targeted mitigation strategies, such as resource-balancing across teams, to better help teams deliver on their schedule, feature and quality commitments. The R&D Executive Team encourages openness and transparency in progress reporting so that teams can comfortably surface project concerns to the R&D Executive Team, confident that the information will be received and dealt with in a fair and positive manner. The Chief Technology Officer is accountable for the overall quality of SAS software.

SAS Architecture: Quality by Design

SAS® Viya®

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

- A multicloud architecture with no infrastructure lock-in. SAS Viya can scale to accommodate growing data volumes, more users, or more complex analytics. SAS Viya supports both public and private cloud deployments.
- Supporting a single, consistent platform for management of the entire analytics life cycle, which is open to both SAS and other programming languages such as Python, R, Java and Lua calling into a single, underlying analytics code base.
- Providing access to analytic techniques (machine learning, descriptive statistics, forecasting methods, optimization algorithms and so on) from a variety of interfaces – programming, scripting and visualization.
- Automatically distributing data and analytical workloads across the cores of a single server or the nodes of a massive computing cluster, taking advantage of parallel processing regardless of data size.

Consolidated Analytic Environment

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

Cloud-Ready Technology Stack

SAS Viya is built on a cloud-ready technology stack. From the SAS Cloud Analytic Services that power SAS Viya analytics at the core to the microservices that supply the REST APIs and functional interfaces, SAS Viya is built to be cloud native. SAS Viya uses open source languages and technologies such as Go, Java and Spring Boot to deliver a set of microservices. These microservices support common functionality, such as login and authorization, identity management, preferences, auditing, data management, data access and more. SAS Viya uses the OAuth open standard for authorization, allowing SAS Viya to integrate with third-party clients and services. SAS Viya also provides public REST APIs and uses TLS to secure communications. SAS Viya can deploy on IaaS providers like AWS and Microsoft Azure, as well as on-premises in private cloud, virtualized and physical machine environments.

^ CONTENTS

SAS Viya 4

SAS Viya 4 is a continuation of SAS' journey to a fully cloud-native and optimized architecture. A system capable of managing the full analytics life cycle requires many different components.

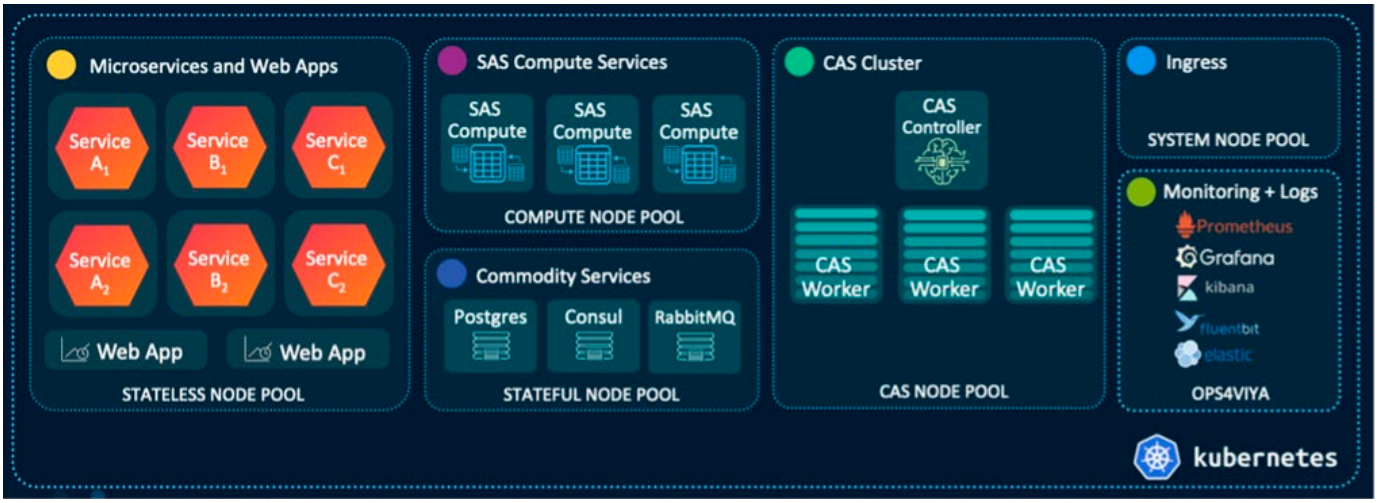


Figure 2: SAS Viya 4 Architecture

Cost-Efficiency

Running enterprise software in a cost-efficient manner is not achieved through a single decision or goal. It requires a coordinated set of tasks that include limiting the baseline cost, allowing scale where necessary, and allowing an "off" switch when the software is not in use. The SAS Viya 4 architecture addresses each of these concerns:

- Many components have been moved from Java to a more memory-efficient platform, Golang.
- Components can be scaled individually, enabling customers to allocate cost where necessary to meet their business goals.
- SAS provides mechanisms within its deployment to turn off (and back on) as much of the system as practical when it is not being used.

Containers and Kubernetes

SAS delivers its Viya 4 software via container images. Container images are a deployment currency of the cloud due to their isolation properties. Using containers enables us to ensure that required libraries are installed correctly and that compute-related resources are utilized and shared appropriately. Containers delivered by SAS use the Open Container Initiative specification and are compliant with it.

Managing many different containers can be a challenge without a framework and tooling in place designed for it. Kubernetes is a standard answer provided for today's cloud. By deploying in Kubernetes, SAS takes advantage of its many features to deliver a solid administrative experience such as automatic handling of restart, managed updates without disruption and the scheduling of diverse workloads on appropriate hardware.

Continuous Delivery

Another characteristic of cloud-native software is increased frequency of updates. Features and fixes are made available to consumers when they are ready rather than waiting for a coordinated roll-out at some predefined interval. To achieve this, SAS has incorporated common continuous delivery practices into its software factory.

As code is being proposed for integration to the mainline branch, it goes through an initial set of validations that include peer review, unit tests, basic integration tests and linting. Once merged, code goes through a set of increasingly narrow gates dealing with complex integration scenarios, performance validation and more in-depth functional tests. Only after passing all of these gates does it make it to a point of being customer-visible.

Frequent releases do not completely remove the need for cross-team collaboration. In these instances, SAS utilizes feature flags to avoid enablement of code prior to the coordinated release.

SAS 9.4

At SAS, quality by design is evidenced in several areas such as:

- The use of intelligent components (intelligent clients, intelligent storage, intelligent servers)
- SAS software's MultiVendor Architecture
- Shared sublibraries and code reuse
- The use of maximum numerical precision

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

SAS Foundation

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

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

SAS Intelligence Platform

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

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

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

For more information, see "Architecture of the SAS Intelligence Platform," in *SAS 9.4 Intelligence Platform: Overview, Second Edition* (**https://go.documentation.sas.com/doc/en/bicdc/9.4/biov/titlepage.htm**).

SAS Solutions

SAS solutions provide industry-specific functionality in these key focus areas: analytics platform, AI and machine learning, customer intelligence, data management, fraud and security intelligence, risk and retail. Most solutions extend SAS architecture by using a component based on Java for the business logic and surface the functionality through web-based thin-client and rich-client presentation layers. Using SAS architecture gives SAS solutions several advantages:

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

Research and Development at SAS

The Research and Development Division of SAS drives software research, development and production. This section provides an overview of information sources used for SAS R&D research and the steps in the development process. Subsequent sections provide details on each step in the software development life cycle. The SAS software development life cycle continuously evolves as R&D embraces proven industry best practices and improvements. This section reflects the software development life cycle currently in operation at SAS.

To meet customer needs and industry requirements, JMP uses specific refinements, processes and tools, as described in JMP: A Commitment to Quality (**jmp.com/qualitystatement**).

Research

The SAS software development process begins with gathering ideas for a potential new product, function or enhancement. Ideas for new or enhanced functionality and architecture are collected from information sources such as:

- Customer Advisory Board, councils and focus groups.
- Feedback from consultants, development partners, early adopters and customers.
- Analyst research.
- Market research.
- Professional conferences and communities.
- The SASware Ballot (**https://communities.sas.com/t5/SASware-Ballot-Ideas/idb-p/sas_ideas**).
- Technical Support (**sas.com/support**).
- Feedback from SAS Education Division courses.
- Usability and accessibility studies.
- SAS Innovate, SAS Explore, and regional, international and special interest user group meetings.

This information is collected in various input documents and made accessible to team members. Teams work together to evaluate emerging technologies and architectures, exploring and experimenting to determine optimal solutions.

Software Development Life Cycle

SAS' software development life cycle involves the phases shown below in Figure 3. As part of continuous improvement, SAS is actively and rapidly refining software development life cycle methods to align with DevOps principles and continuous integration/continuous delivery approaches more closely.

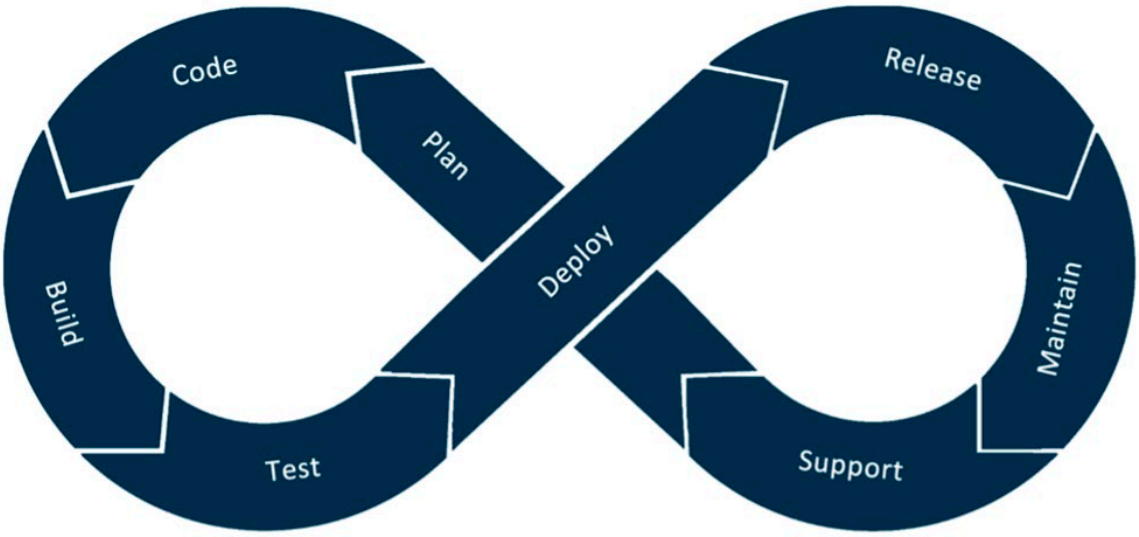


Figure 3: The Software Development Life Cycle

Subsequent sections describe each phase of the diagram in detail:

- Plan (see the **Planning and Requirements** section)
- Code (see the **Code and Build** section)
- Build (see the **Code and Build** section)
- Test (see the **Testing** section)
- Deploy (see the **Deployment** section)
- Release (see the **Release** section)
- Maintain (see the **Maintenance and Support** section)
- Support (see the **Maintenance and Support** section)

Planning and Requirements

In the planning phase of SAS' software development cycle, product teams estimate tasks, determine resource needs, identify risks and verify that the project team and management are committed to the plan. Product teams create road maps to capture longer-term plans, including the main themes of upcoming releases. Prioritized features, requirements and updates are captured in a product backlog. This prioritized product backlog is continuously refined throughout the software life cycle.

Project managers monitor, track and review progress with the team. Planning and managing software development projects enable product teams to achieve the intended project outcomes. Teams continuously revise release plans, prioritize enhancements and allocate resources based on progress. See **R&D Project Management** for more details.

The product development team works closely with product management to create detailed requirements from the prioritized backlog. Requirements identify a capability, technical characteristic, or quality factor that bounds a product or process problem for which a solution can be pursued. Requirements analysis and validation include determining whether they are necessary, understandable, achievable, complete, unambiguous and verifiable. Requirements are documented and continuously reviewed and prioritized as described above.

The product team translates requirements into user-interface concepts and interaction designs. They may design APIs, create user flows and build interactive prototypes that anticipate end user behavior. Product teams create a high-level architecture for the software based on the requirements and designs.

Code and Build

Product development teams write code and tests based on R&D policies, standards, processes and coding guidelines. Product development teams also write, update and implement automatic and manual testing based on test plans and testing guidelines, as explained in more detail in the Testing section. Working code, automated tests and documentation are managed in a centralized source management system. Code is tested and evaluated for stability on an ongoing basis. After passing all automated tests and audit procedures, code is then integrated into the build image on the platforms that are scheduled for release. This process iterates continuously throughout the code and build phases of the software development life cycle.

Problem Reporting and Resolution

Coding includes testing, both automated and manual. If tests fail, the problem is reviewed to determine 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 has an error or needs additional clarity, documentation resources are notified and make updates. If the problem is in the code, testers and developers determine the root cause, identify potential solutions and implement fixes as needed. All problem reporting and resolution activities are tracked in a ticketing 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, performance degradation and potential security vulnerabilities are also considered high-priority. The same is true of problems that depart significantly from intended product function. Low-priority problems include nonfunctional cosmetic features or problems for which there are convenient workarounds. These problems might be deferred for fixes in later releases of the software. Product teams consult with Product Management and Technical Support to prioritize the urgency of a problem given their understanding of current customer use and user feedback. In all cases, problems are tracked through problem tracking systems until the problem is resolved and verified.

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 toolset, which is routinely updated to take advantage of the latest technologies, controls development access to source code and the ability to make changes and fixes.

Through the source management system, developers can check out source code into their private work area for changes and fixes. During this time, other developers can simultaneously check out the same files. The source management system automatically evaluates changes at check-in and flags differences. Code is merged automatically unless the differences require manual intervention. Teams may also rely on capabilities such as role-based access control, linking changesets to ticketing systems and mandatory code reviews before code can be merged. The source management system logs all source code changes.

Revision history is kept for all modules in source management, thereby maintaining earlier versions in addition to a history of who made changes and why those changes were made.

Version control methods, such as semantic versioning, assign each software build a unique identifier.

Testing

Overview

SAS R&D staff embrace both the benefits and challenges of measuring software quality throughout its life cycle. Through the use of continuous integration techniques and continuous automated testing, the effort to ensure that our software meets or exceeds customer expectations never ends.

Testing software requires skilled software professionals, effective development and testing processes, and robust test automation tools. Given our CEO's core philosophy that staff are the company's greatest asset, SAS actively recruits, trains and retains highly qualified Software Development Engineers in Test (SDETs). These SDETs are skilled in incorporating domain and product expertise into the development of automated testing. Early in the development life cycle, SDETs engage with product management to understand and refine both functional and non-functional software requirements and to increase their testability. Team members jointly contribute to enhancing test strategies, including how to best automate and implement a cohesive testing program for their product.

Software development and testing team engineers meet regularly to discuss process improvement opportunities and test automation innovations. A central quality portal and internal testing site provides guidance and best practices. Key management roles participate in formal quality reviews and must attest to the product's quality before the software may ship.

Testing professionals work closely with software engineers and product management to verify the successful implementation of new features and to validate the continued baseline of existing features. Teams choose from an evolving set of testing methodologies, including requirements-based testing, use case and misuse case testing, exploratory testing, consumer-driven contract testing and systems testing. Product teams also collaborate with specialized teams within SAS to ensure their testing incorporates key areas such as software security, performance, accessibility, localization and other dimensions of quality.

When defining a test strategy for their products, product teams perform these tasks:

- Provide feedback on software requirements and design.
- Validate acceptance criteria for product requirements.
- Write and support test procedures, automation tools and reusable test libraries.
- Perform early exploratory testing.
- Execute automated tests and manual test scripts.
- Report test results, including discovered defects.
- Verify fixes and perform regression testing.
- Report test results.
- Monitor quality metrics.
- Analyze and improve test coverage.
- Review customer documentation.
- Test nonfunctional requirements, such as performance and security.
- Test for adherence to R&D policies and standards.
- Write and support qualification tests and samples.

^ CONTENTS

Directors and managers are accountable for ensuring that product development teams follow SAS' quality procedures.

Test Documentation

Each product team is responsible for planning the overall testing strategy for their projects. Teams also use agile approaches for maintaining project-specific test plans and documentation. The entire R&D community collaborates on a due diligence checklist to ensure consistency for testing sign-off. This checklist serves as a source document when planning the test strategy for a software release.

Teams may use a variety of approved test tools and processes – both internal and third party – to document and manage test artifacts and test results. Group test plans document the testing strategy for an entire group or department. Teams may develop individual test plans for specific projects, products, solutions or features.

Where appropriate, teams may perform early exploratory testing during the planning and documentation process. This technique enables teams to get acquainted with the software, understand changes in the current release and begin designing automated tests. Little or no formal documentation is created for this type of testing, although defects can be entered if anomalies are uncovered. As the test automation matures, teams generate more robust documentation of expected results and permutations of use cases under test. Test documentation covers not only product functionality, but also input validation, error-handling capabilities and stress or performance testing.

Test Cases

Teams maintain baseline suites of legacy tests to verify product functionality delivered in previous releases. Engineers continuously improve test suites by designing and writing tests to validate new functionality and store the versioned tests in a source code repository.

Engineers design test cases to determine if specific components of the software perform correctly. Correctness of a test result is evaluated against existing benchmarks, knowledge of past performance, expected behavior as identified in documented requirements, known results as published and an understanding of the software's design.

Product teams employ a variety of testing methodologies to verify and validate software, based on the specific needs of the product under test, such as:

- Analytical tests, including statistical and numerical validation. See **Appendix 2: Validating an Analytical Component** for details on how SAS handles this critical testing step.
- API and unit tests to verify the correct behavior of components before system integration.
- Compatibility testing to assess the ability of software or web applications to function across different browsers, configurations or cloud platforms.
- Error testing examines how syntax and run-time error conditions are handled.
- Functional testing determines whether the software functions as expected.
- Internationalization testing checks the software readiness for any required localization development. Localization testing is done by native language users.
- Migration testing checks that customers can move to current versions of the software without problems.

- Performance testing evaluates whether the software performs at levels that are consistent with customer requirements in production.
- Regression testing identifies whether software changes have introduced errors or unintended behavior.
- Security testing can include verifying role-based access control and least privilege; evaluating susceptibility to risks such as OWASP Top 10 weaknesses, CWEs, Common Vulnerabilities and Exposures, encryption mechanisms; and assessing error handling, input handling and application programming interface security.
- Stress testing creates an overload situation to determine how the software product, procedure or module functions under the stressed condition. Stress testing also evaluates the ability of the software to recover from overloaded conditions, to measure how the project performs under peaks and ebbs in use.
- System testing validates the complete and fully integrated product in a production-like environment.
- Usability testing and accessibility testing evaluate usability of a particular feature for all customers, regardless of ability.

Testing Tools

Teams employ a broad range of testing tools:

- Multiple industry-standard third-party and open source test automation frameworks, such as Selenium, Microsoft Playwright and others.
- Coverage analysis tools for C, Java, Go and JavaScript source code to highlight potential areas for improved coverage and optimize regression testing.
- Test drivers that execute command-line-based tests on multiple platforms (cloud platforms, operating systems and programming environments).
- Internal and third-party continuous testing tools to use unit, integration and acceptance test suites for continuous quality.
- Test management and tracking tools to record test cases and their results history for all platforms.
- Internal and third-party tools for continuous integration and validating software fixes.
- Security testing tools that scan for common software security vulnerabilities under both static and dynamic conditions. For more detail, see the Security Testing section.
- Performance monitoring tools.
- Problem tracking tools such as Jira for tracking defects, enhancements, issues and suggestions found during and after software development and testing.

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

- Queries of the number, age, type and severity of defects by product.
- Verification status of individual defects and responsible individuals or departments.
- Trending quality of code by tracking the rate of incoming defects versus the rate of resolving defects.
- Stability of code by tracking the number of test and source files pushed within a given period.

Test Execution

Automated test suites are executed using both internal and commercially available tools. Such testing is typically repeated on several test configurations. Engineers may also execute manual test scripts to verify more complex aspects of the software that do not lend themselves easily to automated testing. Test results are available, typically in graphical or dashboard format, and are saved to a repository for traceability and diagnostic purposes.

Performance Testing

Performance testing consists of applying specific loads and then examining various aspects of the system under test. As part of this effort, exploratory testing and regression testing is executed across releases and relative to other versions of SAS. For new releases and redeveloped solutions, performance requirements are provided by product management. One primary cloud platform is tested for performance characteristics by many of the product groups. Other platforms are tested based on customer usage and technological differences in architecture and resources. Performance testing results are retained for future release comparison.

The testing groups use internal and third-party tools to test code and I/O performance, big data scalability, algorithm effectiveness against third-party databases and SAS internal data sets. Much of the work is automated, and parameters are set so that performance bottlenecks are flagged for analysis. The utilization of computer resources is also assessed, including memory, I/O and CPU. For deep analysis, monitoring and profiling tools are used.

Performance of baseline, peak, concurrent and endurance load-levels are conducted on desktop, mobile and web applications. This testing is based on multiuser scenarios driven under load conditions using application load testing tools. This ensures software quality by identifying performance bottlenecks, memory leaks and scalability problems.

Performance engineers provide advice to product development teams and product management on code changes, data architecture changes, application architecture changes and technical architecture or hardware. Performance engineers also provide recommendations for cloud provider infrastructures that are most appropriate for SAS' software offerings.

Software Security Testing

Overview

Product teams are required to perform security tests in accordance with internal software security policies, standards and processes. Security testing includes security function testing, application vulnerability testing, dynamic scanning of applications, static source code scanning and container image scanning. All software components, including third-party components, are required to be scanned against Common Vulnerabilities and Exposures published in the National Vulnerability Database, maintained by the US government's National Institute of Standards and Technology.

In addition to scanning web applications and the web application server environment, SAS uses a suite of tests that are specific to SAS technology. Depending on the software type, these tests can include:

- Industry-recognized security scanning approaches to flag common security issues, such as those identified by OWASP and CWE.
- Testing with users of different role-based security access to make sure that each user has the appropriate access levels.
- Data access, based on row-level permissions, to confirm that data authorization is applied appropriately for each user.
- Password and encryption security.
- Correct behavior with Transport Layer Security enabled protocol (HTTPS).
- Validated credential protection when using SAS/ACCESS engines to connect to data sources (for example, user ID and password).
- Product-specific security tests for appropriate user authorization and error testing.
- Integration testing of security features and controls.
- Penetration tests for some configured deployments.

SAS software security testing tools are focused on eliminating known application weaknesses such as those described in OWASP, CWE, CAWE and CAPEC. Issues that are detected during security testing are entered into the problem reporting system and evaluated promptly for appropriate fixes and resolutions.

SAS takes the following steps to deliver secure applications:

- Education and training: SAS provides ongoing training in techniques to mitigate development errors and vulnerabilities. SAS licenses tools designed to generate test cases for security vulnerabilities, including those described on OWASP and CWE lists as well as other lists.
- Deliver shared security components across SAS products: SAS develops shared components and coding guidelines for common issues and robust input sanitization to provide strong security protection across SAS products.
- Monitor and analyze industry issues: SAS monitors and analyzes industry issues regularly and draws on the evolving information from OWASP, CWE, CAWE and CAPEC to evaluate and remediate identified security weakness and vulnerabilities.
- Frequently update security analysis tools and techniques: SAS performs vulnerability testing using the most current tools and techniques for feature and maintenance releases.

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

Customer Notification

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

- To subscribe to SAS Technical Support News, go to **http://support.sas.com/techsup/**.
- To subscribe to the SAS support community, see **https://communities.sas.com/t5/Getting-Started/How-to-learn-about-hot-fixes-to-SAS-software/ta-p/283553**. Note that results can be filtered using the keyword SECURITY.

Release

Sign-Off

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

- Planned new functionality has been implemented and tested.
- Requested fixes have been implemented and tested.
- Quality metrics meet release criteria.
- Due diligence completed.

The R&D director, development manager, test manager and other key roles conduct reviews according to due diligence guidelines. The due diligence guidelines include enterprise attributes and other quality expectations that all software must meet before the software can be released. Once everyone agrees, the product team completes the required sign-off and the DevOps Division provides external access to the software.

Production Media

Production software is available by software download for most releases.

Software Production for Target Audiences

SAS meets the challenges of delivering high-quality software by following a clearly defined rollout process for our new releases. The phases of the rollout process are linked to internal milestones and are defined by the target audience for each software development release: development partners, early adopters and general availability.

- **Development partners phase.** A preproduction software development phase in which software is provided to customers who have contractually agreed to use the software and to provide feedback to SAS about its features and functionality. The goal of this phase is to validate that the software is being developed according to the requirements that have been identified by marketing specialists. This phase is optional but is most frequently applied to newly developed offerings or major enhancements to an existing offering.
- **Early adopters phase.** A preproduction software development phase that occurs after much of the development has been completed. In this phase, a copy of a software offering is provided to a customer who has contractually agreed to install and use the software and to provide feedback to SAS. Problems that are reported from customers might be addressed during later phases of this same release, and features or enhancements are collected for consideration in a future release.
- **General availability phase.** A software development phase in which the final production release of an offering is made available to all customers.

Virus Protection

To mitigate the risk to our customers, SAS has defined an architecture that mitigates the risk of viruses being introduced during the release process. Compilation and linking are performed on Windows nodes protected with the Cisco Secure Endpoint management software and with minimal network access. After files are compiled and linked, the remainder of processing is completed on FreeBSD build bubble nodes.

Once products are ready for customer delivery, all components for all platforms are stored on protected UNIX file servers, which do not allow uploads from Windows hosts. After a product goes into production, additional restrictions are placed on the components so that only a limited number of UNIX hosts can write to them.

Digital Signatures

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

What's New

A list of changes and enhancements for each release is available by selecting What's New in SAS at **http://support.sas.com/documentation/whatsnew/index.html** or accessing the Help menu provided with the software.

Deployment

SAS Viya

SAS Viya applications are deployed as containerized applications, improving deployment efficiency and configuration flexibility. Deploying containers allows SAS to ensure that required libraries are installed correctly and that compute-related resources are utilized and shared appropriately. The high-level steps in a SAS Viya deployment are:

- From my.sas.com, customers download deployment assets for their order.
- Customers create a manifest based on a file that is customized to their environment.
- To deploy the software, customers run a command against the manifest that they created.

For all details on how to deploy SAS Viya, see the SAS Viya Deployment guide at **https://go.documentation.sas.com/doc/en/itopscdc/v_012/dplyml0phy0dkr/titlepage.htm**.

SAS®9

SAS®9 can either be deployed on-premises or hosted as a managed application. For more information about SAS' managed application services, see **https://www.sas.com/en_us/solutions/cloud/sas-cloud/managed-application-services.html**.

Whether installed and configured on a single machine or in a distributed environment, the SAS deployment process involves the following high-level steps:

- Planning the deployment.
- Creating users and groups and designating ports.
- Creating a SAS Software Depot.
- Installing required third-party software.
- Installing and configuring SAS.

For all details on how to deploy SAS®9, see the SAS®9 Administration Guide at **https://go.documentation.sas.com/?cdcId=bicdc&cdcVersion=9.4&docsetId=biwlcm&docsetTarget=home.htm&locale=en**.

^ CONTENTS

Maintenance and Support

Quality in SAS Technical Support

SAS provides customers with 24-hour, follow-the-sun technical support via telephone, email, chat and online support as part of the annual licensing fee. Customers with questions and problems that are related to SAS software can contact Technical Support as follows:

- Telephone (9 a.m. – 8 p.m. ET)
- Chat (9 a.m. – 6 p.m. ET)
- SAS Customer Support site at **https://support.sas.com/en/support-home.html** (available 24/7/365)
- Email (available 24/7/365)

Problems that cannot be resolved immediately are routed to subject-matter experts, who prioritize problems based on severity. SAS Technical Support strives to return initial calls within a two-hour period for severe problems and up to a maximum of 24 hours for less severe problems.

Customers experiencing critical software problems should contact SAS Technical Support by phone. The average telephone hold time is fewer than 30 seconds, and approximately 60% of questions are resolved within 24 hours. For critical problems that occur outside of the business hours listed above, customers are directed to one of SAS' worldwide support centers in North America, Europe or Asia/Pacific. Using global resources, SAS can provide customers with 24-hour, follow-the-sun support.

SAS Technical Support takes pride in providing fast and accurate responses to customer-reported questions and problems. However, a key goal of SAS Technical Support is to empower customers with the tools they need to find answers and resolve problems on their own. Therefore, a full range of electronic support services and a variety of self-help resources are available on the SAS Customer Support site (**http://support.sas.com/**). From this website, customers can do the following:

- Contact SAS Technical Support for help at **https://support.sas.com/en/technical-support/contact-sas.html**.
- Search the knowledge base at **https://support.sas.com/en/knowledge-base.html** which contains SAS Notes, sample programs and user documentation.
- View SAS Viya administrator resources at **https://support.sas.com/en/documentation/install-center/viya/administration.html** and SAS 9.4 and earlier administrator resources at **https://support.sas.com/en/documentation/install-center/94/intelligence-platform.html**. Administrator resources include downloads, hot fixes, maintenance updates, security bulletins and system requirements.
- Suggest ideas for software enhancements at **https://communities.sas.com/t5/SASware-Ballot-Ideas/idb-p/sas_ideas**.
- Obtain documentation about technical support services at **https://support.sas.com/en/technical-support.html**, including information about support levels (Standard and Premium) and support services and policies.

^ CONTENTS

- Interact with other SAS customers through our SAS Support Communities at **https://communities.sas.com/**.
- Find SAS Training information at **http://support.sas.com/training/**, including classroom training (on-site, web and mentor training), free tutorials, certification programs, e-learning and the SAS Learning Subscription.

All these details and more, including the most up-to-date services and content, can be accessed on the SAS Customer Support website at **https://support.sas.com/en/support-home.html**. For the most current, detailed information about SAS Technical Support, see SAS Technical Support Policies, available at **https://support.sas.com/en/technical-support/services-policies.html**.

Software Fixes in the Field

Hot Fixes and Maintenance Releases

Overview

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

SAS Technical Support acts as the central point of contact for customer-reported problems regarding production products. When a customer reports a problem that requires a hot fix, Technical Support enters the information about the issue into the problem reporting system, noting that a hot fix is requested. R&D and Technical Support work together to review the requested hot fixes and determine which fixes will be made. Technical Support then authorizes the fix, and it enters the hot fix process. Once R&D provides the fix, it is tested to ensure that the issues are resolved. In addition, regression testing that is appropriate to the scope of the fix is performed. If the problem solution is surfaced on the web and the fix includes UI changes, the R&D groups also evaluate the need to rerun vulnerability testing.

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

While SAS strives to provide fixes for all serious problems, there might be cases where it is impractical or impossible to generate a fix. For example, a fix might not be possible because of compatibility issues or because of the potential for the introduction of unwanted side effects.

SAS Viya Platform

Releases on the SAS Viya platform are delivered in short, continuous-delivery cycles called cadences. New Stable cadence releases are delivered once a month. Long-Term Support (LTS) cadence releases are delivered once every six months.

SAS recommends that customers update to the current cadence releases as they become available in order to keep software up to date with the latest functionality and software fixes.

The list of available versions for the deployment assets from your software order are available at My SAS at **my.sas.com**.

Patch updates can be released as soon as they are ready rather than waiting for the next Stable or LTS scheduled release and can include critical fixes and security updates.

To learn more about cadence releases, visit the SAS Technical Support Policies page at **https://support.sas.com/en/technical-support/services-policies/sas-viya-platform.html**.

For more information about updating SAS Viya software, see SAS Viya Platform Operations: Updating Software at **https://go.documentation.sas.com/doc/en/itopscdc/default/k8sag/titlepage.htm?fromDefault=**.

SAS Viya 3.*x*

For SAS Viya 3.*x*, software updates replace some or all the existing deployed software with the latest releases of that software. Updates are performed with the same commands that are used to install SAS Viya 3.*x*, using the same software order and the same playbook. More details about updating SAS Viya 3.*x* software are available in the "Managing Your Software" section of the SAS Viya 3.*x* deployment guide for specific SAS Viya releases and operating systems at **https://support.sas.com/en/documentation/install-center/viya/deployment-guides.html**. Updates are posted on the Technical Support Hot Fixes web page at **https://tshf.sas.com/techsup/download/hotfix/hotfix.html**.

SAS 9.4

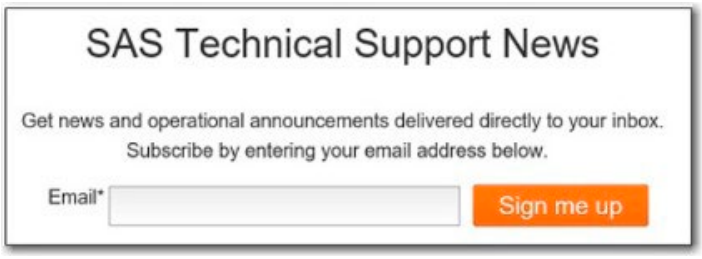
For SAS 9.4, available hot fixes are automatically included when downloading an order from the SAS Software Depot. If there is a significant time lapse between order download and deployment, additional hot fixes may have become available. All customers have access to the download pages and can download individual fixes from the SAS Technical Support Hot Fixes web page, available at **https://tshf.sas.com/techsup/download/hotfix/hotfix.html**. For more hot fix information, see the "Applying Hot Fixes" section of the SAS 9.4 Guide to Software Updates and Product Changes at **https://go.documentation.sas.com/?cdcId=pgmsascdc&cdcVersion=9.4_3.5&docsetId=whatsdiff&docsetTarget=p1vm9m5b9znanwn1vsr3bi4f1iog.htm&locale=en**.

In addition, SAS uses maintenance releases to update and support SAS 9.4. Maintenance releases include fixes and enhancements, documentation updates and localizations. Maintenance details are posted to the SAS Customer Support site at **https://support.sas.com** when they are available. Information about the current maintenance release is available on the Maintenance Release Announcement web page at **https://support.sas.com/software/maintenance/**.

Alerting Customers

To stay informed about new hot fixes and to receive notifications when they are available, visit the Communities: SAS Hot Fix Announcements page at **http://communities.sas.com/t5/SAS-Hot-Fix-Announcements/bg-p/hf**.

To sign up for SAS Technical Support News and to request that operational announcements be delivered via email, visit SAS Technical Support at **https://support.sas.com/en/technical-support.html** and look for the following sign-up area:



SAS Technical Support News and operational announcements can be obtained by:

- Logging on to a SAS profile.
- Clicking Edit Profile: **https://www.sas.com/profile/ui/auth.html#/edit**.
- In the Subscriptions section, clicking Technical Support Updates – News and Operational Announcements.

SAS documents Alert Priority issues, as well as problems that are not alert status, in the form of SAS Notes and SAS KB articles. Customers can search for Alert Priority issues at **https://support.sas.com/en/knowledge-base.html**.

Migrating to New Releases

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

- Compatibility and Migration: **http://support.sas.com/rnd/migration/**

The MIGRATE procedure, which has validation macros associated with it, can assist with migrating data and catalogs. Migrating code is more involved. Therefore, SAS recommends that customers develop a migration plan that encompasses a sampling strategy based on the total number of programs that need to be migrated and on the acceptance level. The ANSI/ASQC Z1.4, ISO 2859 standard (Military Standard 105E) can help customers determine the appropriate sample size.

Operations

SAS provides technical support in accordance with the Technical Support policies. However, if a customer chooses not to install the most current release of the software, then the level of support that is available diminishes over time.

For more information about support, hot fixes and source code archiving, see the following resources:

- For documentation on support services and policies for current and prior releases of software, see the SAS Technical Support Policies web page at **https://support.sas.com/en/technical-support/services-policies.html**.
- For more on source code archiving, see the *Business Continuity Management* white paper at **http://www.sas.com/content/dam/SAS/en_us/doc/other1/continuity-of-business.pdf**.

Product 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. To learn more about product support levels, see the following resources:

- The Support Levels by Product page: **https://support.sas.com/en/technical-support/support-levels.html**.
- For the SAS Viya platform, complete the steps in the "View the Update Checker Report" section in the SAS Viya Operations software guide at **https://go.documentation.sas.com/?cdcId=itopscdc&cdcVersion=v_001LTS&docsetId=k8sag&docsetTarget=p1it185kd37v25n1aoybu799tpk4.htm&locale=en**.
- The table in the section "Support Levels for SAS 9.4 & Earlier Releases by Release Number" at **https://support.sas.com/en/technical-support/services-policies/sas-94-earlier.html**.

Quality in Customer Service

Quality in SAS Communities

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

- **SAS Communities:** Collaborate with SAS and other SAS users about programming, data analysis and deployment issues, tips and successes at **https://communities.sas.com/t5/community/communitypage?nobounce.**
- **SAS Users Groups:** Network, teach and collaborate with other SAS users. SAS users' groups are independent, volunteer organizations run by SAS users. SAS partners with these groups and provides a wide range of services. See **https://www.sas.com/en_us/connect/user-groups.html**.
- **SAS Social Media Portal:** Stay connected with SAS and other SAS users through our social channels, including Knowledge Exchanges, communities.sas.com, Facebook, YouTube and X (formerly Twitter): **http://www.sas.com/social/**.
- **SAS Innovate:** An annual conference planned and hosted by SAS for developers, data scientists and analysts and IT professionals featuring demos, hands-on workshops, tutorials, speakers and networking opportunities. Learn more at **https://www.sas.com/en/events/sas-innovate.html**.

Quality in SAS Education

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

For more information about SAS Education, see **Appendix 5: Quality in SAS Education**.

Quality in Customer Documentation

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

Currently, SAS Documentation produces the following types of documentation:

- Reference and usage documentation, administration guides and migration guides on the web.
- Online help that is built into the software.

For more information about SAS' documentation processes, see **Appendix 6: Quality in SAS Documentation**.

Quality in Consulting

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

SAS has been partnering with our customers to solve their business problems for more than three decades. Our consultants take the time to listen and learn about our customers' business challenges and enterprise goals to establish a foundation for strategic advancement toward those goals. This mutual collaboration enables us to deliver the right SAS technology and customized services to solve our customers' unique business requirements. We have amassed in-depth industry knowledge and domain expertise while drawing upon industry and technology best practices and proven methodologies.

Appendix 1: Regulated Industry Issues

Introduction

Many large customers rely on SAS to enable their compliance with regulatory requirements. SAS Legal Services, in conjunction with teams providing solutions for regulated industries, continuously monitor regulatory affairs worldwide. This appendix answers commonly asked questions from regulated customers, including those from the life sciences and other industries.

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

Customers have inquired whether source code is available for an FDA audit if required for regulatory compliance needs. SAS would allow the FDA to examine relevant portions of the source code on a secure machine at SAS headquarters pursuant to appropriate confidentiality agreements.

ISO 9001 Quality Management Systems Certification

The SAS entities with ISO 9001 Quality Management Systems certification as of this document's publication date are listed below. To obtain a copy of a specific certificate received by SAS, send email to **qualitypaper@sas.com**.

- SAS UK (SAS Software Ltd.)
- SAS Institute Australia Pty Ltd.
- SAS Italy (SAS Institute SRL)
- SAS Poland (SAS Institute Sp. zo.o)
- SAS Spain (SAS Institute, S.A.U.)

ISO 27001 Information Security Management Systems Certification

The SAS entities with ISO 27001 Information Security Management Systems certification as of this document's publication date are listed below. To obtain a copy of a specific certificate received by SAS, send email to **qualitypaper@sas.com**.

- SAS UK and Ireland (SAS Software Ltd.)
- SAS Event Stream Processing R&D
- SAS Italy (SAS Institute SRL)
- SAS Spain and Portugal (SAS Institute, S.A.U.)
- SAS Finland (SAS Institute Oy)

ISO 14001 Environment Management Systems Certification

The SAS entities with ISO 14001 Environment Management Systems certification as of this document's publication date are listed below. To obtain a copy of a specific certificate received by SAS, send email to **qualitypaper@sas.com**.

- SAS Spain (SAS Institute, S.A.U.)

Complying With Title 21 CFR Part 11

The United States regulation known as Title 21 Code of Federal Regulations (CFR) Part 11 (**https://www.ecfr.gov/current/title-21/chapter-I/subchapter-A/part-11**), or the "Electronic Records; Electronic Signatures" rule, provides information about what constitutes trustworthy and reliable electronic records and electronic signatures. Many of our customers who are regulated by the FDA are required to comply with this rule, which sets forth the criteria under which the FDA considers electronic records and electronic signatures to be trustworthy, reliable and generally equivalent to paper records. CFR Title 21 serves as the predicate rule and has been in force since its inception in 1997. Although the requirements of CFR Title 21 were originally written for the paper record, CFR Title 21 now explicitly applies to electronic records and signatures as well.

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

The FDA has issued industry guidance for the use of electronic health record data in clinical investigations (**https://www.fda.gov/media/97567/download**). In issuing such guidance, the FDA sought to assist sponsors, clinical investigators and other interested parties in using electronic health records (EHRs) in clinical trials. This guidance clarifies recommendations on applying Part 11 electronic records regulations to electronic data capture (EDC) systems. Among other things, the FDA provides guidance on the use of interoperable or fully integrated EHR and EDC systems, appropriate validation methods, recordkeeping requirements and the use of certified and noncertified EHR technology.

However, we recognize that this guidance provides non-binding recommendations and that certain specifications may change. Therefore, we continue to monitor FDA regulations and guidelines that pertain to SAS or to customers using SAS software.

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

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

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

Regarding audit trails and integrity constraints, the audit trail feature of Base SAS has the essential elements to address and enable the controls and procedures for a 21 CFR Part 11 audit trail.

The FDA accepts a SAS transport format as a method for accepting and archiving data sets. The SAS transport format is an open format, has a free viewer, is used extensively in the life sciences 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 now requires all new CDER and CBER study submissions to use industry-standard data structures (**http://www.fda.gov/ForIndustry/DataStandards/default.htm**). The FDA requires the CDISC Study Data Tabulation Model (STDM), Standard for Exchange of Nonclinical Data (SEND) and Analysis Data Model (ADaM) for exchanging electronic data and report-ready tables. See the **CDISC** section for more information about how SAS supports CDISC.

SAS addresses revision control with SAS tools, applications, procedures and custom application interfaces (APIs or engines). SAS also interfaces well with other revision control software or filing systems such as Documentum. Custom engines for interfacing with clinical data management and electronic data capture systems (Medidata Rave is one example) have been developed. SAS/ACCESS can also be used to obtain repetitive versions of data from a laboratory information management system (LIMS) or clinical data management system (CDMS). The COMPARE and CONTENTS procedures can be used to monitor changes or revisions regarding content in data. Functionalities such as

data integrity constraints and audit trails can be enabled to assist in this process. All this functionality is supported by the SAS Life Science Analytics Framework, which provides a real-time assessment of metadata structure and revisions or through data management solutions such as SAS Data Preparation.

The SAS Life Science Analytics Framework is a 21 CFR Part 11 enabling technology. (See **sas.com/en_us/software/life-science-analytics-framework.html**.) SAS Life Science Analytics Framework software was designed and introduced to specifically address 21 CFR Part 11 and the FDA's Guidance for Industry. The software offers an enhanced operating environment for managing clinical data, programs, logs, documents and reports. Careful consideration was given to the intended use with respect to data warehousing, analysis and reporting, electronic submissions, and related e-signature requirements. Application of both process and quality management has enabled the software to meet the intended requirements of the system's 21 CFR Part 11 functionality.

The Health and Life Sciences (HLS) R&D organization follows the SAS software development process. To meet the needs of their FDA-regulated customers, they have implemented an additional quality management system (QMS) to govern their software development. HLS R&D might use additional tools that are not generally used by SAS R&D but that are validated for use through the HLS R&D QMS.

CDISC

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

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

HIPAA and HITECH

The health care reforms made by Title II of the Health Insurance Portability and Accountability Act of 1996 (HIPAA) and the Health Information Technology for Economic and Clinical Health (HITECH) Act of 2009 provide federal protections for the privacy and security of individually identifiable health information. The United States Department of Health and Human Services has issued regulations governing HIPAA/HITECH that require health care organizations and other covered entities, as well as their business associates, to meet certain minimum standards of privacy and security with respect to health care data and databases. These regulations also direct how such data and databases are to be stored, viewed, accessed and shared. SAS software includes security and other built-in features that customers can use to implement HIPAA/HITECH-compliant applications, though each customer must assess its specific needs in the

context of its own computing environment. See *SAS Software Security Framework: Engineering Secure Products* (**sas.com/content/dam/SAS/en_us/doc/whitepaper1/sas-software-security-framework-107607.pdf**) for an overview. SAS is available to assist with HIPAA/HITECH compliance issues related to the use of SAS technologies and solutions.

Sarbanes-Oxley Compliance

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

US Government Configuration Baseline

As a vendor of desktop software products to the United States federal government, SAS verifies, through our release management process, that our desktop software products on the Microsoft Windows platform comply with the US 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.

Service Organization Controls Certification

SAS engages an independent third party to perform an annual Service Organization Controls (SOC) 2 Type II audit certification for SAS Managed Cloud Services hosting environments, which includes a SOC 3 general-use report. The SAS SOC 2 Type II and SOC 3 reports pertain to the security, availability and confidentiality trust principles and include controls related to the in-scope data centers' physical security and environmental safeguards, logical access, change management, monitoring, risk assessment and management, communication and information, systems operations, and availability over network devices as described in the report for the defined effective period. Learn more by visiting the SAS Trust Center (**sas.com/en_us/trust-center/sas-trust-compliance.html**).

Appendix 2:
Validating an Analytical Component

Numerical Accuracy

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

Validating an Analytical Component

Our development staff has the education, training and experience to perform their assigned tasks. They use a variety of methods to verify, to the extent possible, that the software produces accurate, reliable and numerically precise results. A combination of methods is used to validate an analytical product and the algorithms in it. These methods are listed below.

Writing Independent Validation Code

Except when similar results are available within existing and previously tested SAS analytical software, independent verification of numerical results via SAS/IML®, DATA step code or hand calculations is performed whenever possible and practical. SAS/IML is a powerful matrix programming language that is used to recreate the numerical output, or pieces of the output, produced by the SAS software being validated. Sometimes the same algorithm used by the procedure, action or other component being checked is coded into SAS/IML, but occasionally a different algorithm is used if the two algorithms are expected to produce the same results. Replication of results via SAS/IML or DATA step code is the most reliable method for validation, because it is an independent and verified confirmation of the numerical output.

Comparing to Similar Results in Other Algorithms in SAS

Many SAS components produce equivalent output, such as parameter estimates, covariances or solutions to modeling problems. Similar output produced by new components is validated by comparing it to these previously validated results. Similarly, when a macro program exists that produces some of the same results as the new component, it can be used for validation.

Running Simulation Studies

Simulation studies may be performed in instances where closed-form solutions do not exist or used as checks when computations are extremely time- and memory-intensive.

Verifying Against Published Results

Comparison against other software vendors' applications is sometimes made, especially in those cases where the vendor's application is highly regarded as producing quality results. Comparison is also sometimes made versus results published in books or journal articles. Note that matching another vendor's results or just verifying a match versus a published result is not usually considered sufficient validation.

^ CONTENTS

Comparing Against Open Source Software

Numerical validation against open source software is sometimes performed to ensure that the results are as accurate or more accurate than comparable open source software and that the performance is at least comparable, if not better. Our numerical validation test suites include a representative set of test scenarios running comparable algorithms for accuracy comparisons. Numerical results are compared for accuracy when the true or optimal model or solution is known.

Validation of SAS Components That Consume Open Source Technology

SAS software in some cases uses open source technology in its components. To make sure that the components that use these open source routines work seamlessly, SAS aims to recreate the same results across a variety of scenarios as those derived from directly applying an equivalent wrapper directly to the open source technology. Validating by simultaneously using replication and comparison ensures that SAS components are using open source technology effectively.

Completing Consistency Checks Within the Component

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

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

An example of our validation techniques for the REG procedure is included below.

Example of Validation Techniques

While many analyses and results require complex code to validate, the following simple example is used to provide a basic illustration of some of the validation techniques that are 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

Comparison to Textbook

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

ANOVA Results

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

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, augmented for intercept;
 p=ncol(x);                           * number of parameters;
 beta=inv(x`*x)*x`*y;                 * parameter estimates;
 yhat=x*beta;                         * predicted values;
 resid=y-yhat;                        * residuals;
 sse=ssq(resid);                      * Sum of Squares for Error;
 dfe=nrow(x)-ncol(x);                 * error degrees of freedom;
 mse=sse/dfe;                         * Mean Square Error;
 cssy=ssq(y-y[+]/n);                  * Corrected Total Sum of Squares;
 rsquare=(cssy-sse)/cssy;             * R-Square;
 stdbeta=sqrt(vecdiag(inv(x`*x))*mse);* Std error of estimates;
 t=beta/stdbeta;                      * parameter t-tests;
 df=j(nrow(t),1,1);                   * parameter degrees of freedom;
 t_prob=1-cdf('F',t##2,df,dfe);       * p-values for t-tests;
 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;
```

^ CONTENTS

```
* 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=relative(1) criterion=1e-6;
  attrib _all_ format = label = '';
  var df ss ms fvalue probf;
run;

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

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

PROC COMPARE Results

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

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

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


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

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

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

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

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

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

Comparison to Other SAS® Procedures

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

* run the corresponding model with PROC GLM;

```
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=relative(1) 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=relative(1) criterion=1e-6;
  attrib _all_ format = label = '';
  var estimate stderr tvalue probt;
run;
```

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

```
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

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;
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=relative(1) criterion=1e-6;
  attrib _all_ format = label = '';
run;


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


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

PROC COMPARE Results:

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

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

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

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

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

NOTE: The data sets WORK.REG_FITSTATISTICS and WORK.REG_FITSTATISTICS_WEIGHT
      compare equal.

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

NOTE: All values compared are within the equality criterion used.
NOTE: The data sets WORK.REG_PARAMETERESTIMATES and
      WORK.REG_PARAMETERESTIMATES_WEIGHT compare equal.
```

References

National Institute of Standards and Technology 2007. "NIST STRD Background Information." Accessed November 6, 2015. See **http://www.itl.nist.gov/div898/strd/general/bkground.html**.

Neter J., W. Wasserman, and M. H. Kutner. 1990. Applied Linear Statistical Models, Third Edition. Boston, MA: Irwin.

Appendix 3: Installation and Operational Qualification for SAS 9.4 and SAS Viya

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

Background

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

Customer Considerations

SAS IQ assists regulated customers in demonstrating compliance and qualifying the installation. SAS IQ can be used as part of the installation process, as an interim check on the state of the SAS system, and as an automated tool to maintain an audit history.

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 runs SAS OQ tests and tests for the SAS 9.4 intelligence platform.

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

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

- Gather user and functional requirements and prepare validation documentation inclusive of validation plans, test protocols and test scripts.
- Install and configure SAS software according to the instructions and alert notes that are delivered by SAS as part of the software shipment.
- Execute IQ and OQ according to approved plans and test scripts. Our services personnel can also assist customers with Performance Qualification or User Acceptance Testing if requested.

^ CONTENTS

- Provide knowledge transfer to IT staff and end users on the above, recommending formal SAS training where needed.
- Provide project management for all the above activities.

Operation

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

Phase 1

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

Phase 2

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

Phase 3

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

SAS Deployment Tester is a diagnostic tool used for assessing a SAS 9.4 Intelligence Platform deployment. After an installation or upgrade, you can use SAS Deployment Tester to ensure that your SAS software and critical server components have been installed and configured correctly. To learn more about the SAS Deployment Tester, including prerequisites for use, how to add tests, and how to use the Deployment Tester, see **https://go.documentation.sas.com/doc/en/bicdc/9.4/bisag/n1c1m0fm7gxs54n104kqx33wqgo7.htm**.

Content

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

Verification of Test Results

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

- Human verification
- Programmatic verification
- Self-verification

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

Programmatic verification means that a test program, such as a SAS program, cannot 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 decide whether there is a problem with the program being tested, whether a new benchmark needs to be created, or whether some addition or change to the filter needs to be made. However, programmatic verification is very reliable and requires no special programming skills other than filtering to create the filtered output file.

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

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

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

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

Other Notes

Customers often need to establish a baseline for their tests in a prior SAS release and then verify the results in a new SAS release. The SAS OQ provides a clear migration path for customers who are concerned about moving to a new release of SAS.

Both SAS IQ and SAS OQ are supported for the Windows and UNIX operating environments in SAS®9. SAS IQ and SAS OQ can be used only with files that are provided through the normal R&D delivery process for SAS®9 and later. For example, hot fixes applied by using the normal R&D install process are verified regardless of the delivery mechanism. Files that use post-processing methods, such as ZIP or TAR archives, cannot be verified.

Appendix 4: Employee Training

Just as SAS actively cultivates continuous improvement in products and processes, SAS employees cultivate continuous improvement in the skills and abilities that are critical to developing a quality workforce. By helping employees meet their professional and personal development goals, SAS empowers them to deliver the highest-quality software and services to customers.

New Employees Development

New SAS employees attend an orientation session to learn about SAS history, culture, compliance training, mandatory company policies, and employee programs and services. Afterward, direct managers collaborate with their new employees to tailor a training plan that balances job skill needs with the employee's strengths. A customized program might include live classroom courses, virtual learning, self-guided study or one-on-one training sessions with a mentor. Managers may engage with subject-matter experts, Human Resources and SAS Education to identify the most effective learning options and channels for each new employee.

Leadership and Management Development

The Leadership Development program increases organizational effectiveness at SAS by providing all managers with leadership and management development opportunities through the Manager Journey program. The program includes a core curriculum of six to eight classes that individuals complete within their first months of managing at SAS. The mission is to increase managers' competence in leadership and interpersonal communication skills, as well as their commitment to developing the overall performance of their individual staff members and teams. Both the transfer of training and the consistent use of new skills are fostered through action plans, skills coaching, and varied follow-up opportunities to embed learning in day-to-day behaviors. In addition, Leadership Development offers coaching and consultation in leadership, conflict management, team development, energy management, meeting planning and facilitation.

Existing managers have the option to complete Manager Essentials Plus. The two-day program refreshes managers on leadership essentials and provides information on their roles, responsibilities and communication skills, especially for providing feedback and coaching staff. Participants learn about time and energy management and the need to care for their own well-being as they continue their management duties.

Additional programs are available for employees who are considered to have high potential for a leadership role.

Career Development Planning

Although skills acquisition occurs primarily through experience, exposure to thought leaders and relevant educational opportunities are essential to professional development. SAS' Global Career Mentoring Program fosters employee connections within the SAS global workforce. The program's mission is to accelerate talent development and expand functional expertise and innovation across the company. Additionally, the SAS Career Circle program enables employees to participate in group discussion facilitated by peer leaders who are uniquely prepared to help employees reflect on and explore career options.

^ CONTENTS

Technical Training

Technical Skills + Role-Based Skills + Transferrable Skills + Certifications = Competence + Credibility + Confidence

Since technology skills are crucial to the success of SAS, a wide range of internal and external technical training is offered to employees. Through this training, employees may become accredited in externally recognized certifications relevant to their roles, such as Amazon Web Services, Microsoft Azure, Google Cloud Platform and Kubernetes, as well as role-based certifications such as Project Management Professional (PMP), Information Technology Infrastructure Library (ITIL), The Open Group Architecture Framework (TOGAF), Certified Information Systems Security Professional (CISSP) and many more.

Employees have full access to the catalog of SAS Education classes and workshops. Additionally, SAS provides access to a variety of external learning platforms that offer training on current technologies and practices. These learning platforms feature adaptive skill assessments, custom training plans and interactive learning opportunities.

Lifelong Learning

Live Training

Employees may use several learning channels to enhance their knowledge, job performance, and technical or managerial skills. Live training encompasses technical skill development in areas such as analytics, AI and data management, as well as topics in DevOps, security and cloud services.

Interpersonal development assists employees in enhancing their human skills. SAS workshops help employees strengthen their ability to communicate and resolve conflict, as well as coach them on how to improve understanding and build more effective relationships.

SAS employees may attend any SAS training classes offered by the SAS Education division. These public courses are offered live online or in a traditional classroom setting (when available).

On-Demand Training

SAS employees may take training on demand from our corporate Learning Management System (LMS). The LMS enables employees to view their training records, see course descriptions and schedules, register online, receive reminders before class, and sign up for interest and waiting lists. This environment provides many on-demand offerings, including self-study materials, live web training, and downloadable videos from both external and internal sources. Dedicated training specialists work with internal subject-matter experts to coordinate and record workshops on new technologies – often before products are released. By providing this training early, the LMS empowers those in the field with the hands-on experience needed to successfully deploy SAS technology.

Mandatory Training

Mandatory employee training is delivered and tracked through the LMS, fostering a culture of continuous employee skill development. All employees, and applicable third parties, are required to take appropriate courses to ensure a respectful and ethical culture and to protect critical customer and corporate assets. Mandatory training encompasses subjects such as diversity in the workplace, corporate ethics, and SAS corporate policies, such as policies on data protection, information security, and privacy. Mandatory training can also target specific roles, such as the technical skills program for SAS R&D designed to elevate managers' and engineers' skills in next-generation development methodologies.

The SAS Library

The mission of SAS Library and Information Services is to deliver quality research to support initiatives and encourage data-driven technical and business decisions across every major division of SAS. It offers more than 10,000 books, thousands of online periodicals, and access to premier subscription databases and third-party online learning platforms.

In addition to online journals, magazines and books, the SAS Library provides a research service that assists employees across all divisions with requests of varying complexity. It monitors access to external education providers for training in next-generation development methodologies. The SAS Library maintains agreements with local universities and document delivery vendors for a widened information base.

Collaborative Education and Knowledge-Sharing

Within SAS, employees continually exchange subject-matter expertise to optimize the development, delivery and support of SAS products and solutions. SAS employees are driven to excel and frequently share their knowledge by either plugging into one of the existing channels for collaborative education or by innovating their own. Below is just a small sampling of the many collaborative and knowledge-sharing channels at SAS:

- **Big Ideas** – formal employee presentations designed to enlighten and inspire.
- **Blogs** – SAS hosts a blog site, and employees frequently use blogging to disseminate information.
- **Lightning Talks** – short talks focused on specific topics such as cybersecurity.
- **R&D and DevOps Demo Days** – opportunities for teams to showcase works in progress, proofs of concepts and operational efficiencies.
- **Specialized forums** – employee-driven forums on technical topics such as DevOps, Product Security and software testing that are open to all. Employees with shared interests and skill sets gather to share information and best practices based on their working experience.
- **Unconferences** – gatherings of subject-matter experts around a particular topic, with no set agenda.

Appendix 5: Quality in SAS Education

SAS Education offers technical training and professional development in a variety of training methods that allow all learning styles, budgets and curriculum needs to be met.

Our web-based learning options continue to grow in order to serve all industries.

- SAS Live Web classrooms allow real-time interaction between instructors and students while working together in a virtual lab, giving customers access to the latest SAS software without leaving their work environment.
- SAS Education offers connected classroom environments in Cary, NC on request, which bring full-day training content to in-person and Live Web virtual students.
- SAS digital subscriptions are self-paced, on-demand educational products that offer customers a way to learn at their own pace. They include multiple courses that cover a specific career pathway or certification.
- Whether you're looking to train your team or build your own data skills, we've got you covered with three types of subscriptions designed to meet the needs of individuals or small, medium and large enterprises, including SAS Premium Learning Subscription, SAS Learning Subscription, and many topic-based digital learning subscriptions.
- We partner with third-party learning platforms Coursera and LinkedIn to offer beginning and intermediate SAS training.
- In addition to fee-based training, we offer nearly 400 free SAS tutorials and several free e-learning courses. Free course topics include programming, statistics, administration, open source integration, and SAS Viya.

SAS Education supports the professional development needs of its users by offering a concierge-style approach to learning.

- SAS Education Adoption Services provide expert guidance via a data-driven approach to identifying skills gaps, creating custom learning plans and providing ongoing learning support.
- Business Knowledge Series courses provide knowledge and experience from a global network of industry experts through focused, in-depth seminars.
- Conferences and events provide group settings for knowledge transfer, training, certification and networking.
- 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.

SAS Education is involved in the rollout and enablement of major new software initiatives to support sales and adoption, including supporting SAS Viya education through:

- Free how-to tutorial videos supporting SAS Viya and related products, found at **http://video.sas.com/#category/videos/sas-viya**.
- A free SAS Viya Administration: Getting Started course, found at **https://learn.sas.com/course/view.php?id=6126**.
- An instructor-led SAS Viya Overview course, found at **https://learn.sas.com/course/view.php?id=214**.

^ CONTENTS

- Instructor-led courses for administration, data management, programming, advanced analytics, SAS Visual Analytics and solutions, found at **https://support.sas.com/edu/ilt.html**. Additional courses will be available to support the most recent release of Viya and the related products.
- Tutorials, blogs, hands-on workshops, YouTube videos and courses for SAS Explore.
- Video tutorial libraries for Early Adopter releases and trials as needed.

Quality in SAS Training Courses

To ensure that SAS training courses are useful for our customers and that they meet the ever-changing needs of their business, SAS Education employees design and develop training courses at the topic, course and curriculum levels. 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, the course structure and flow are considered and a detailed course outline is developed. 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 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 instructors and subject-matter experts from a variety of sources.

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 are often considered to be thought leaders in their areas of instruction. To ensure our instructors have the necessary expertise, SAS holds each instructor to exceptionally high standards. Every instructor is encouraged to become SAS certified. Before teaching a new course, they present the teaching material to an internal expert for review. After this, they team teach with experienced instructors, receiving feedback on a lesson-by-lesson basis before teaching independently.

SAS Global Certification follows a rigorous, industry-standard development process, ensuring that all exams are valid and reliable in measuring important SAS skills. As a global program, the knowledge measured in each exam is relevant to employers and practitioners worldwide. SAS is a leader in IT certification, with innovations in performance-based testing and sharing best practices with other organizations in the industry.

Quality in Customer Service

Serving more than 30,000 customers a year, SAS Education has remained dedicated to the users of SAS products and services. Our commitment to quality extends beyond the technical aspects of the division's work. Because SAS Education regards the relationship that it develops with each training 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 is in communication with students multiple times during the student life cycle. Before the start of a class, each student could receive several communications based on when they register: a confirmation email with information about what to expect during the course, reminders closer to the date of the course, verification that the particular course will run, and, in addition, a customer service representative might contact a student to learn about any special requests or needs. During a course, students enjoy an educational environment with the latest technology staffed by experienced training center professionals who engage in open communication with each student.

Perhaps the most important communication, however, is the post-class contact. 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. After attending a class, each student receives a thank you email that provides access to extended learning where applicable and a link to collect all feedback. 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.

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 website at **sas.com/training**.

Appendix 6: Quality in SAS Documentation

Researching New Features

Project managers and writers in the SAS Documentation 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 and participate in newsgroups and blogs that are related to the products that they are documenting. They work with new product features as the features are being developed and work with the appropriate developers to ensure that the documentation is clear, complete and accurate.

Planning the Documentation Library

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

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

As products are updated, in addition to updates to individual documents, changes are compiled into a single What's New topic that is delivered with the product documentation. A summary document (called What's New in SAS) provides a high-level overview of all the changes and new products in a SAS release. For example, the most recent version for SAS 9.4 contains information from the initial release in July 2013 and any subsequent SAS 9.4 releases, such as SAS 9.4M8. This summary document is available (as HTML, PDF and EPUB) from the web. Also, documentation that is available on the web is continually updated as needed and is labeled with the date of the latest update.

Developing Content

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

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

^ CONTENTS

Editing

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

- Substantive edits occur early in the development of the documentation. These edits address the overall structure, organization and writing style of the document.
- Copy edits concentrate on spelling, grammar, punctuation, consistency and style.
- Policy edits check for legal issues such as trademark violations and glaring grammatical errors that could affect comprehension or translation.

Most documentation receives a copy edit. All documentation receives at a minimum a policy edit. As project schedules permit, substantive edits occur at the same time as technical reviews.

Searching

For online documents, we provide search functionality. Search functionality is tested for accuracy.

Testing and Publishing Documentation

After documentation is written and edited, it is transformed to several output types (HTML, PDF and EPUB) and published to an internal documentation delivery site where it can be accessed for testing.

For all output types, editors and testers use both manual processes and automated tools to test the integrity of links within each document and to test links to other documents. If the testers find errors, they send the errors to the writers for resolution. If the conversion tools have generated the error, a problem report is submitted to the DevOps Documentation Engineering Department. After all errors have been fixed, the testers verify that errors have been resolved correctly. This process is repeated as needed. When documentation is complete and accurate, it is published to our external documentation delivery site on the date that coincides with the release of the software.

For documentation that is part of the SAS help, various R&D product groups also test the documentation for their specific products. If R&D testers find an error, the tester records the problem in the problem reporting system, and the problem is routed to the writer. The writer fixes the error, and the transformation, testing and publishing cycle is repeated as needed.

Controlling Changes to the Documentation

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

Distributing Documentation to Customers

When we ship new or updated software, our documentation is updated to reflect the enhancements to the software. New and revised documentation is posted to the web in HTML, PDF and EPUB formats. Selected titles are available for purchase in print and e-book formats from bookstores and online booksellers.

Tracking Problems After Software Updates

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

Developing Software Used to Author and Deliver Documentation

The DevOps Documentation Engineering Department develops and supports both the SAS documentation delivery system and the software that is used by the SAS Documentation Division to create help content for online delivery and printed books. The R&D developers and testers use the same tools, processes, and protocols for software development that are described in the main body of this document so that our documentation delivery system software meets the same quality standards for a worldwide audience.

Managing Terminology

Quality documentation depends on "quality at the source." This means that we establish and follow guidelines for correct, consistent, culturally sensitive, and clear words and phrases as we describe and explain how to use SAS software. The SAS Documentation Division leads a companywide initiative in terminology management to help us provide quality communication and documentation for our customers. This initiative includes managing a central repository for SAS terminology, as well as managing processes to establish terminology quality checks throughout product development and delivery.

Terminologists in the SAS Documentation Division have the primary responsibility for researching, creating and updating entries to the terminology database, which serves as a resource for the entire company. Technical writers and technical editors use a customized application that checks documents for clarity, consistency and correct terminology. SAS Documentation also works closely with R&D to develop quality terminology in software error messages and in user interface text.

In addition, SAS Documentation collaborates with our European and Asia Pacific localization offices. By focusing on quality at the source, SAS software and documentation can be translated more accurately and efficiently.

Terminology management is recognized as critical to quality offerings in a global market. SAS Documentation is committed to continuing its leadership role in establishing quality terminology across SAS products.

Appendix 7: Quality in Consulting

The SAS Professional Services and Delivery division helps SAS users implement their SAS products, solutions and offerings on-site and in the cloud. We are also well-prepared to help our clients with expert SAS services. Engaging SAS consultants can help you tap the full power of SAS technology or services and reap maximum returns on your investment.

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

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

Our Experience, Our Consultants

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

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

What makes SAS Professional Services and Delivery exceptional?

- SAS Professional Services and Delivery has the experience and know-how to manage the continual life cycle of SAS implementations.
- SAS Professional Services and Delivery knows one size does not fit all. We bring the experience of working with thousands of our clients, addressing each as a new environment with unique needs.

^ CONTENTS

- SAS Professional Services and Delivery 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, business conditions and environment.
- SAS Professional Services and Delivery brings proven SAS implementation methodologies and approaches that have been developed through our collective experiences in thousands of successful projects. Available only from SAS, these methodologies and road maps are the basis for the customization and implementation for your company that brings proven success and increased business value.
- With our industry experience as users and business leaders, SAS Professional Services and Delivery employees bring the contextual experience needed to drive value and 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 a strategic and successful implementation. This is a requirement built into our methodologies. This enables us to deliver the right SAS technology and customized services to solve customers' unique business requirements. By combining a staff of SAS experts, a proven implementation methodology, quality management and project governance, we provide an excellent consulting choice for our customers.

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

SAS Project Methodologies

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

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

- Detailed work breakdown structure enables the project team to create project schedules faster and ensures that they have a common approach.
- Roles and responsibilities matrix enables 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 mutual understanding and satisfaction.
- Where appropriate, agile techniques, processes and principles such as iterative development and prototyping help optimize the work effort and communicate status.

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

- SAS Project Management Methodology, focusing on project management processes.
- SAS Intelligence Platform Implementation Methodology, focusing on technical implementation.
- SAS Agile Plug-In, focusing on the use of agile practices within implementation.

SAS Project Management Methodology

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

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

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

SAS Intelligence Platform Implementation Methodology

The SAS Intelligence Platform Implementation Methodology (IPI) is the most versatile of SAS' implementation methodologies. It is applicable to projects that contain any combination or all the following:

- Data quality evaluation and resolution of issues.
- Data integration, or creating a data mart, data lake or warehouse.
- Data mining, forecasting, model development and other analytics.
- Business intelligence delivery such as query and reporting solutions.

Covering a complete implementation of the SAS Business Analytics Framework, the methodology contains the quintessential knowledge and best practices of SAS' more than 40 years of experience. The IPI is structured as a hybrid approach to implementation activity and includes iterative development in all three of its branches.

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

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

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

SAS Agile Plug-In

In today's fast-paced business environment, it is often necessary to use agile practices to better address business challenges. These proven practices can address unique business situations where requirements for technology may not be well defined or the approach that the client wants to take is entirely new. In such cases, the final deliverables or implementation results may need to be "discovered" rather than prescribed in advance.

SAS has developed an approach that is based heavily on the Scrum framework that enables SAS consultants to work with our clients using agile practices. SAS will work with interested clients to make sure that there is alignment between the business and technology needs of the implementation and the agile approach used on the project. Our approach combines our deep experience with our existing methodologies by borrowing tools, templates and practices where appropriate and using them in an agile context. SAS has made a large investment in training our consultants and managers in the successful use of Scrum and our agile practices.

This commitment, along with our many successful experiences using this approach, can benefit clients who have a need for innovation within our software or solution implementations.

SAS Business Advisory

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

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

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

Quality Management in SAS Project Management Methodology

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

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

Quality management is a process made of two main components:

- Quality assurance.
- Quality control.

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

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

Quality Assurance and Procedures

Quality Assurance

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

- Ensuring that all projects follow current policies, standards and guidelines.
- Monitoring the results of those projects.
- Reporting the results to the management team for evaluation.

A quality assurance plan is developed at the beginning of the project, depending on the project needs. 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 which activities should be included to meet the quality objectives of the project. This information might be incorporated into other project documents or created as a separate document.

The document should meet these requirements:

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

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

Quality Assurance Procedures

Create a quality assurance plan for each project

A quality assurance plan might include items such as the following:

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

Conduct quality reviews

Quality reviews can include steps such as these:

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

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

The project reviews support the following objectives:

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

Quality Control

Quality control (QC), on the other hand, is focused on the product that is 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 especially testing. QC focuses on ensuring that stakeholder needs are satisfied and on providing a high degree of assurance that the components and system operate according to preapproved requirements and specifications.

The challenge of QC is to ensure that all business requirements have been addressed and that the product functions up to defined success criteria before it is delivered to the customer. A QC test plan is created well before coding is begun. Like all plans, test plans are strategic directions for the testing process. The test plan includes items such 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 will responsibilities be assigned?
- What are the expected results?
- What mitigation action will be taken when tests fail?

Quality Control Procedures

The testing process has three parts:

- Test planning.
- Test case development.
- Testing.

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

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

Quality Control Tests

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

Quality Management

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

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

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

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

Project Governance

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

Outstanding services governance accomplishes these goals:

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

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

Clarity of Roles: Project Organization

A formal project organization that clarifies each role should be established for the project. The figure below shows an example:

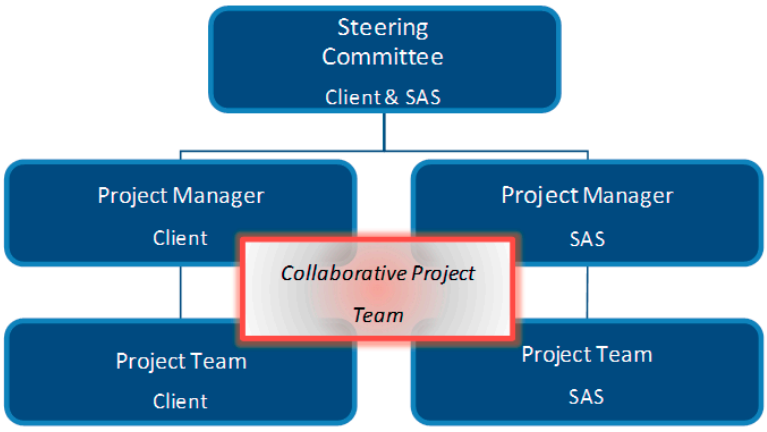


Figure 4: Example of Formal Project Organization

Project Governance: Roles

Steering Committee

The steering committee represents the interests of the business (from both a user and a 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 ensures that the estimated timelines are realistic and consider the complexity of tasks.

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

Project Team

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

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

Appendix 8: SAS Offerings and Products

The SAS platform is an integrated system of software products that provide complete control over data access, management, analysis and presentation. SAS solutions are compatible with the SAS platform. There are other products distributed by SAS but not integrated into the product. For the most recent product list, see **sas.com/en_us/software/all-products.html#all-products-a-z**.

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

Base SAS®

JMP®

JMP® Clinical

JMP® Live

JMP® Pro

JMP® Student Edition

SAS/ACCESS®

SAS/AF®

SAS/CONNECT®

SAS/ETS®

SAS/GIS®

SAS/GRAPH®

SAS/IML®

SAS/IML® Studio

SAS/OR®

SAS/QC®

SAS/SHARE®

SAS/STAT®

SAS® 360 Discover

SAS® 360 Engage

SAS® 360 Plan

SAS® Adaptive Learning and Intelligent Agent System

SAS® Add-In for Microsoft Office

SAS® Analytics for IoT

SAS® Anti-Money Laundering

SAS® Asset and Liability Management

SAS® Asset Performance Analytics

SAS® Assortment Planning

SAS® Banking Analytics Architecture

SAS® Business Intelligence

SAS® Business Orchestration Services

SAS® Business Rules Manager

SAS® Capital Requirements for Market Risk

SAS® Clinical Enrollment Simulation

SAS® Commodity Risk Analytics

SAS® Continuous Monitoring for Procurement Integrity

SAS® Continuous Monitoring Framework

SAS® Cost and Profitability Management

SAS® Credit Assessment Manager

SAS® Credit Scoring

SAS® Currency Transaction Reporting

SAS® Customer Due Diligence

^ CONTENTS

SAS® Customer Intelligence 360

SAS® Data Governance

SAS® Data Integration Server

SAS® Data Loader for Hadoop

SAS® Data Management

SAS® Data Preparation

SAS® Data Quality

SAS® Data Surveyor for SAP

SAS® Decision Manager

SAS® Demand Signal Repository

SAS® Deployment Tester

SAS® Dynamic Actuarial Modeling

SAS® Econometrics

SAS® Energy Forecasting

SAS® Enterprise BI Server

SAS® Enterprise Guide®

SAS® Enterprise Miner™

SAS® Enterprise Miner™ for Desktop

SAS® Environment Manager

SAS® Event Stream Manager

SAS® Event Stream Processing

SAS® Expected Credit Loss

SAS® Factory Miner

SAS® Federation Server

SAS® Field Quality Analytics

SAS® Financial Crimes Monitor

SAS® Financial Management

SAS® Financial Planning

SAS® Forecast Analyst Workbench

SAS® Forecasting for Desktop

SAS® Forecast Server

SAS® Foundation Services

SAS® Fraud Management

SAS® Fraud Network Analysis

SAS® Governance and Compliance Manager

SAS® Government Management

SAS® Grid Manager for Hadoop

SAS® Grid Manager for Platform Suite

SAS® Health

SAS® High-Performance Entity and Network Generation

SAS® In-Database Technologies for Azure Synapse Analytics

SAS® In-Database Technologies for Cloudera

SAS® In-Database Technologies for Databricks

SAS® In-Database Technologies for Hadoop Cloud Services

SAS® In-Database Technologies for Teradata

SAS® Information Catalog

SAS® Information Map Studio

SAS® In-Memory Statistics for Hadoop

SAS® Information Governance

SAS® Insurance Analytics Architecture

SAS® Integration Technologies

SAS® Intelligence and Investigation Management

^ CONTENTS

SAS® Intelligent Decisioning

SAS® IT Resource Management

SAS® IT Resource Management Adapter for SAP

SAS® LASR Analytic Server

SAS® Law Enforcement Intelligence

SAS® Life Science Analytics Framework

SAS® Machine Learning

SAS® Metadata Bridges

SAS® Metadata Server

SAS® Mobile Investigator

SAS® Model Implementation Platform

SAS® Model Manager

SAS® Model Risk Management

SAS® Office Analytics

SAS® OLAP Cube Studio

SAS® OLAP Server

SAS® OLAP Server Monitor

SAS® Optimization

SAS® Personal Login Manager

SAS® Production Quality Analytics

SAS® Qualitative Assessment Manager

SAS® Quality Analytic Suite

SAS® Quality Knowledge Base for Customer Information

SAS® Quality Knowledge Base for Product Data

SAS® Real-Time Decision Manager

SAS® Risk Analytics Builder

SAS® Risk and Finance Workbench

SAS® Risk Dimensions®

SAS® Risk Engine

SAS® Risk Modeling Workbench

SAS® Risk Reporting Repository

SAS® Scalable Performance Data Engine

SAS® Scalable Performance Data Server

SAS® Scoring Accelerators

SAS® Simulation Studio

SAS® Social Network Analysis

SAS® Solution for CECL

SAS® Solution for IFRS 17

SAS® Solution for IFRS 9

SAS® Solution for LDTI

SAS® Solution for Regulatory Capital

SAS® Solution for Solvency II

SAS® Solution for Stress Testing

SAS® SpeedyStore

SAS® Studio

SAS® Studio Analyst

SAS® Studio Engineer

SAS® Text Analytics

SAS® Text Miner

SAS® Text Miner for Desktop

SAS® Underwriting Risk Management for P&C Insurance

SAS® Visual Analytics

^ CONTENTS

SAS® Visual Data Mining and Machine Learning

SAS® Visual Forecasting

SAS® Visual Investigator

SAS® Visual Scenario Designer

SAS® Visual Statistics

SAS® Visual Text Analytics

SAS® Viya®

SAS® Viya® Advanced

SAS® Viya® Enterprise

SAS® Viya® on Microsoft Azure

SAS® Viya® Programming

SAS® Web Report Studio

SAS® Web Report Viewer

SAS® Workflow Manager

^ CONTENTS

Glossary

- **Accessibility:** The degree to which a product, service or environment is usable and available to people with disabilities, including those with visual, auditory, motor or cognitive impairments. Accessibility ensures that products and services can be accessed and used by the widest possible audience. The SAS Disability Support Center contains various resources for SAS users with disabilities.
- **Advanced Analytics:** A set of techniques and methods used to analyze and interpret complex data sets to uncover insights and gain deeper understanding of business operations and customer behavior. Predictive modeling, data mining, machine learning and statistical analysis are used to identify patterns, trends and anomalies in the data. Advanced analytics is used to support decision-making, optimize processes and drive business growth.
- **Artificial Intelligence (AI):** The theory and development of computer systems able to perform tasks that normally require human intelligence, such as visual perception, speech recognition, decision-making and translation between languages.
- **Business Continuity Management:** A holistic management process including advanced planning and preparation of an organization to maintaining business functions or quickly resuming after a disaster has occurred.
- **Computer Vision:** A field of AI that enables computers and systems to derive meaningful information from digital images, videos and other visual inputs and then take actions or make recommendations based on that information.
- **Continuous Integration/Continuous Delivery or Continuous Deployment (CI/CD):** A software development practice that involves automating the building, testing and deployment of software applications. CI/CD is used to improve the efficiency, quality and reliability of software development by enabling faster feedback, reducing the risk of errors and increasing the speed of delivery. It involves the use of various tools and practices, such as version control systems, automated testing frameworks and deployment pipelines to automate the software development process and accelerate the time to market for new features and improvements.
- **Continuous Delivery (CD):** A software development practice where code changes are automatically built, tested and deployed to production or other environments after passing a series of automated tests and manual reviews. The goal of continuous delivery is to deliver software faster and more reliably, while reducing the risk of errors and minimizing the time to market for new features and improvements.
- **Continuous Deployment:** A software development practice where code changes are automatically built, tested and deployed to production or other environments without any human intervention or review. The goal of continuous deployment is to automate the entire software delivery process, from code changes to production deployment, enabling organizations to release software faster and more frequently while maintaining high quality and reliability.
- **Continuous Integration (CI):** A software development practice where developers frequently integrate their code changes into a shared repository, triggering an automated build and test process to detect integration issues early in the development cycle. The goal of continuous integration is to improve code quality, reduce integration risks and accelerate the software development process.
- **Data Lineage:** The process of understanding, recording and visualizing data as it flows from data sources to consumption. This includes all transformations the data underwent along the way, such as how the data was transformed, what changed and why changes were made.

^ CONTENTS

- **Deep Learning:** A subfield of machine learning that involves training artificial neural networks to learn and recognize patterns in data. It involves multiple layers of interconnected nodes that process information in a hierarchical manner to extract features and make predictions. Deep learning is used in various applications, such as computer vision, speech recognition, natural language processing and robotics.
- **DevOps:** A software development methodology that emphasizes collaboration and communication between development teams and IT operations teams, with the goal of delivering high-quality software products more rapidly and efficiently. DevOps (development + operations) involves integrating software development, testing, deployment and operations into a single, continuous process to streamline the development and deployment of software.
- **Forecasting:** A field of AI used to make scientific predictions about the future without requiring oversight.
- **IDeaS:** A wholly owned subsidiary of SAS Institute that produces a suite of revenue management software and services for the hospitality industry.
- **JMP Statistical Discovery LLC:** A wholly owned subsidiary of SAS Institute that produces the JMP® suite of software used for interactive, visual statistical data analysis.
- **Machine Learning:** A subfield of AI that involves the use of algorithms and statistical models to enable computers to learn from data without being explicitly programmed. It involves building models that can make predictions or decisions based on patterns in the data. Machine learning is used in various applications, such as image recognition, natural language processing, recommender systems and fraud detection.
- **Model Governance:** The process for how an organization controls access, implements policy and tracks activity for models, and helps accountability and traceability to machine learning models.
- **Multivendor Architecture (MVA):** The underlying design of SAS Foundation, which enables SAS code to be compiled for, and run on, diverse host platforms without requiring any modifications.
- **Natural Language Processing:** An interdisciplinary subfield of linguistics, computer science and AI concerned with the interactions between computers and human language, in particular, how to program computers to process and analyze large amounts of natural language data.
- **Numerical Accuracy:** The degree to which the numerical results obtained from a computation or measurement are correct and reliable. It is a measure of how closely the calculated or measured values match the true values or expected values.
- **Optimization:** The application of AI technologies, such as machine learning and advanced analytics to automate problem-solving and processes in network and IT operations, and to enhance network design and optimization capabilities.
- **Reliability:** The degree to which a system, product or service consistently performs its intended function over time and under various conditions. It is a measure of the dependability and consistency of a system, and it is often evaluated in terms of factors such as uptime, downtime, mean time between failures and mean time to repair.
- **SAS Component Language (SCL):** A programming language designed to facilitate the development of interactive applications using SAS.
- **Threaded Kernel (TK) Libraries:** Lightweight, threadsafe services upon which concurrent/threaded code may be written, allowing SAS products written in SAS/C® to take advantage of servers with multiple processors.

^ CONTENTS

What's New

July 2025:

- Updated *The Foundation of Quality Development* to include additional information.
- Updated *Appendix 5: Quality in SAS Education* to reflect current processes.
- Various minor editorial and content updates.

June 2025:

- Various minor editorial and content updates.

May 2024:

- Added *API Standard* to include information about SAS' approach to developing secure and robust APIs.
- Added *R&D Engineering Standards* to include information about SAS' R&D engineering requirements.
- Updated *Third-Party Software and Open Source Contributions* to include additional information.
- Updated *Appendix 3: Installation and Operational Qualification for SAS® 9.4 and SAS Viya* with information about SAS Viya Operational Qualification (OQ) tests.
- Various minor editorial and content updates.

November 2023:

- Expanded *Protecting Privacy* to include more information about SAS' approach to individual privacy rights and privacy and data protection laws.
- Added *Environmentally Responsible IT* section to reflect the SAS IT organization's approach to corporate environmental sustainability.
- Expanded *Software Globalization* to reflect current definitions and approaches to SAS' software globalization efforts.
- Updated *Maintenance and Support* to include information about SAS Viya platform hot fixes and maintenance releases.
- Various minor editorial and content updates.

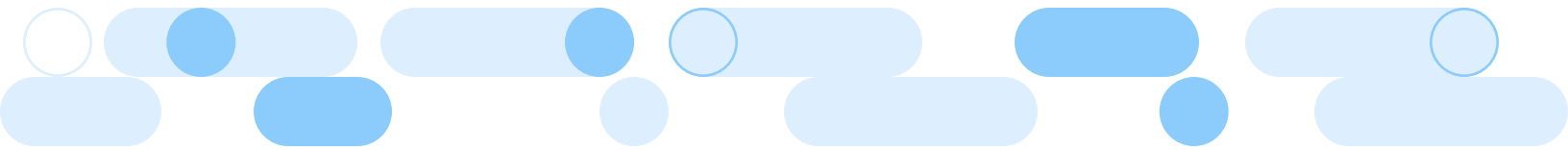
May 2023:

- Added *Glossary* and *What's New* sections.
- Updated *Our Employees: Employee Training and Appendix 4: Employee Training* to reflect updates to training processes.
- Updated *Our Employees: Quality Starts With Communication* to reflect updates to internal communication processes.
- Various minor editorial and content updates.

^ CONTENTS

Release Information
The version of this paper is July 2025.

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



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