

ASCC: The Impact of a Silver Bullet

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The AT&T Network Systems Silver Bullet Project, launched in August 1990, represents a major breakthrough in software engineering. It optimizes and accelerates the software development process by incrementally improving business, organizational, and technical processes used by the Operations Systems (OS) Business Unit. In July 1991 OS opened the Advanced Software Construction Center (ASCC) to define and implement an organizational and business model based on the Silver Bullet processes and to expose the model to the stresses of developing products for OS. Since then, the ASCC has developed more than 14 products, achieved International Organization for Standardization (ISO) 9001 certification, and reduced its average product interval from 25 to 15 weeks. It has also been evaluated as one of the top three software organizations in AT&T, based on software process assessments. All this was achieved while keeping its costs one-third lower than the rest of the business unit. The application of the Silver Bullet processes to the OneOS Change Program—an AT&T initiative to create an integrated set of OS assets that can be delivered as an integrated product offering—illustrates the applicability of these processes to larger, more complex systems and organizations. This paper traces the evolution of the ASCC, describes how it operates today, and provides current measures of the interval and quality of ASCC software development.

The Silver Bullet Concept

The Silver Bullet Project was launched in August 1990 by the Operations Systems (OS) Business Unit of AT&T Network Systems to optimize and accelerate the software development process. The vision of Silver Bullet became the mission of the Advanced Software Construction Center (ASCC): to significantly reduce the development interval, improve the quality, and reduce the cost of a new product. The method chosen to achieve this vision uses processes that can be baselined, measured, and then improved. To ensure proper focus, two organizations were chartered—one to develop the process and the other to execute it. The desired outcome was a reduction in

the cost of producing competitive products.

Students of software will recognize one of the influences on the ASCC philosophy, Frederick P. Brooks, Jr., who used the term Silver Bullet in his now famous article "No Silver Bullet Essence and Accidents of Software Engineering." Brooks said:

There are no silver bullets for slaying the werewolves that plague efforts to build software which is, by its nature, abstract, complex and infinitely malleable. Look instead, for incremental gains in strategies for reuse, requirement definition, accelerated prototyping, more organic approaches to "growing" software, and—always—nurturing creative talent.¹

Although this was one starting point for the evolution of project Silver Bullet, other models were also used to put the Silver Bullet vision into practice. The Software Engineering Institute (SEI) provided a model for measuring successive levels of maturity in a development organization,² and Peter M. Senge defined a model for the learning organization.³

The Silver Bullet project team at the Network Systems OS were not looking for a single "silver bullet" with a short-term solution to the problem. Rather, they were seeking an evolutionary, perhaps even revolutionary, solution that could change, adapt, and improve with the maturity and capability of an organization, and with rapid technological changes in the marketplace.

A Brief History. The blueprint for initiating the Silver Bullet project within the corporate culture of Network Systems was the work of Dan Stanzione, then president of OS. David Stone, who succeeded him as president, also saw the value of the Silver Bullet program. To further this work, he created the OneOS Change Program in the OS to introduce high-level engineering rules to integrated product offerings and to implement a software development process. The ASCC plays a key role in this process by continually providing its insights and results to OneOS and to other AT&T organizations.

The Process Engineering Group of the Software Technology Center (STC) was chartered in August 1990 to:

- Select a set of best current practices,
- Define a software development environment,
- Choose a platform for software reuse,
- Establish measurement benchmarks, and
- Define templates for ongoing process engineering.

At the same time, the ASCC was established in Cary, North Carolina—in partnership with the STC—to use the delivered processes to build OS products and provide "real-world" feedback on the process adaptability and performance necessary for continuous process refinement. As the ASCC evolved from a test facility of the processes to a process-focused software development organization, the STC continued to refine the process. ASCC developers and STC process engineers also recognized that one key development needed in this evolution was a set of process tools (or a platform) to help manage and continue to develop the data represented in the process information. The STC now uses its process platform technology to help numerous other organizations define and improve their processes.

Panel 1. Abbreviations, Acronyms, and Terms

ASCC—Advanced Software Construction Center
ASOS—Advanced Services Operations System
DARE—Data Analysis and Representation Engine
FIT—focused improvement team
MATES—Management of Training and Expertise System
OA&M—operations, analysis, and maintenance
OS—Operations Systems
QUEST—Quality, Engineering, Software, and Technology
SEI—Software Engineering Institute
SPA—software process assessment
STC—Software Technology Center

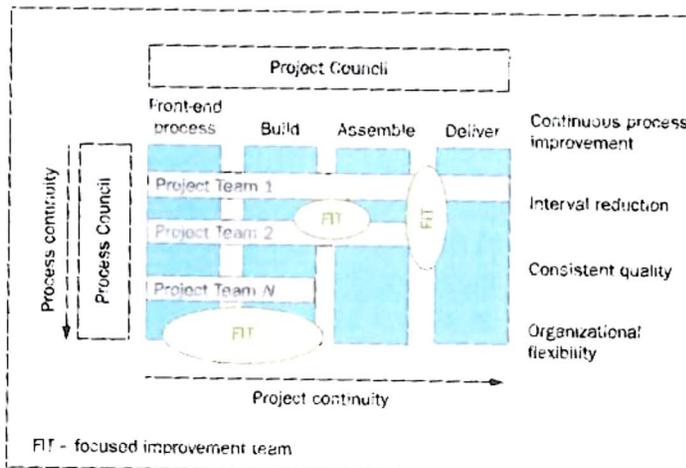
The ASCC Today

Today, the ASCC is a process-focused software development organization whose strategic objective is to continue to reduce software development cycle time, increase productivity, and deliver high-quality software services on schedule. This requires a business focused on meeting and constantly seeking to improve itself as a best-in-class supplier of development services. To demonstrate these abilities, the ASCC must produce high-quality software on schedule and within budget. Process remains the unifying focus for all the products that the ASCC produces.

From the beginning, Silver Bullet required a cultural mindset focused on process execution and improvement. To be revolutionary in its mindset, the ASCC needed to be isolated from the existing culture. The ASCC leadership team and its staff redesigned their organization to focus on the process and the customer by concentrating on how they produced products and services, rather than on the technologies and tools used to produce them. Creating a high-performance organization requires organizational alignment and congruence of all systems, from technical processes, to hiring practices, to reward systems.

The ASCC is organized around self-directed teams. Every year, the leadership team develops center objectives that are aligned with the center's strategic mission. The teams, in turn, develop objectives that sup-

Figure 1. Focused improvement teams (FITs) drive process and project continuity to shorten the interval, reduce the cost, and increase the quality of a product. Members of the ASCC staff make up the project and process teams. Lessons learned during a process are shared across projects, and lessons learned from projects become process improvements.



port the center's objectives, and individuals develop personal objectives that support both team and center objectives. The leadership team and team leaders then review all objectives to ensure total alignment. These objectives are measurable and encompass both process and product development. Team performance is evaluated against team objectives; within each team, individuals are rewarded uniformly based on the measured results. Rewards are budgeted independently for product and process results. There is continuous focus on maintaining the vision and mission of the organization, and significant effort is put into communication throughout the ASCC. For example, the leadership team and all staff members hold a monthly dialogue meeting to discuss the state of the center and its direction.

Every individual in the center is expected to spend at least 10 percent of his or her time on process improvement activities. A process council, consisting of members of staff, is charged with coordinating process improvement and evaluating the process platform. A project council, which includes the leadership team and project leaders, is charged with project management and product quality issues. It acts as the customer of the process council and maintains the tension of reality on the process activities. Lessons learned by process teams are shared across projects, and lessons learned from projects become process improvements. Focused improvement teams (FITs), which drive process improve-

ments across both process and project teams, are formed and dissolved during the year to drive and bring to closure process improvements that reduce the product interval or cost and improve the quality. Figure 1 shows some of the FITs, which comprise ASCC staff on both process and project teams.

The Role of Process

At the ASCC, process has become a rich infrastructure that supports communication and learning. It encompasses the Silver Bullet processes and process platform discussed earlier, and much more. The ASCC has developed online systems that provide information and decision-making capabilities to everyone in the center. These systems are maintained as a World Wide Web site and can be made accessible to internal organizations:

- Silver Bullet processes and process platform;
- Document control and retrieval;
- The Management of Training and Expertise System (MATES) database;
- Budget, staff, and cost management by project;
- Data analysis and representation (DARE);
- Project management reports;
- Process activity reports; and
- The reusable asset repository.

In addition, the STC has provided a rich set of development tools that cover documentation, code analysis and debugging, project management, product configu-

ration, and testing. Every staff member in this modern, up-to-date development environment has either a Sun or a Hewlett-Packard workstation. The leadership team and project leaders use Windows* NT workstations.

This environment has many advantages. It provides the basis for a learning organization. As project teams execute the process, they gain and capture new insights through the process platform. Because all projects use the same platform, this information becomes available immediately to other project teams. As new projects are planned, the most current online process becomes the basis for this planning. To facilitate learning and to broaden the process, the ASCC leadership team has made it a practice to search for and execute projects with characteristics not covered by the process. Recent projects, for instance, have required the use of object-oriented technology.

Another advantage of this environment is the degree to which it simplifies project planning and management. Based on project specifics, project plans need only be customized from the standard process. Initial PERT and Gantt charts can be produced automatically from the process database. Management reports for projects are standardized and can be easily understood across projects.

The process structure and online nature of the system enable developers, project leaders, and management to verify the use and effectiveness of the process. At the beginning of each project, the team produces a Process Execution Checklist, which is then signed by the coach, as a contract for the work products that will be produced during the course of the project. The checklist can be cross-referenced in real time against the library of online documentation that is being produced by the project, including not only the documents, but also the quality records documenting reviews and inspections.

With review and inspection data, project plans, and defect reports all on line, it became feasible to build a measurement and analysis system to measure process application and results. The ASCC's Data Analysis and Representation Engine (DARE) tool has been designed to collect in-process and project management data automatically. The tool evaluates the progress of a project in real time. Metrics include function point counts, defect discovery and repair rates, test progress, interval, and cost. These metrics, tied directly to center objectives, are available for review by both staff and management.

Results

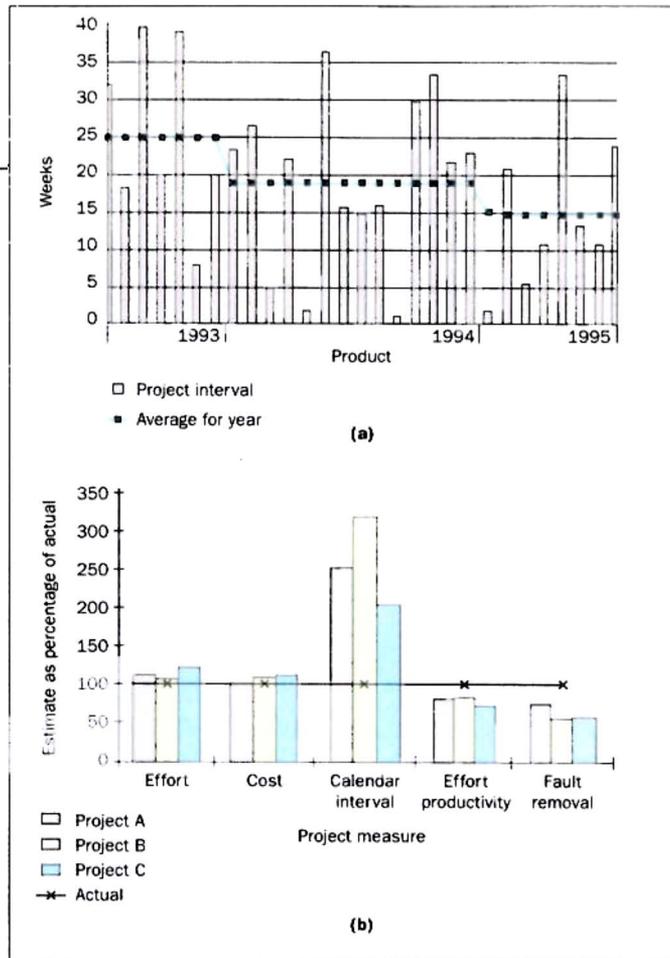
Data is an integral part of the Silver Bullet process. It is used to evaluate the process, provide a basis for improvement, and manage projects in the most streamlined, cost-effective way. Data also enables an organization to benchmark itself against other organizations and to validate its progress towards the objectives of reduced interval, improved quality, and lower cost. Results of the ASCC for each of these perspectives are presented below.

Interval. Figure 2 shows the project interval results for the ASCC. Organized by time, this figure shows that the interval to produce a product has continually decreased, on average, from the beginning of 1993 through the end of 1995. The project interval is defined as architecture through the start of beta. Averages are shown for product deliveries in 1993, 1994, and 1995, respectively. This is one of the most difficult metrics to control fully. It is affected by dependencies on other product teams during joint development; the complexity of the product, its feature content, and technology; and the number of experienced staff. The variation in Figure 2 shows the results of these influences. Accurate estimates of project size help to normalize the variance. One approach that can be taken is to improve the level of control and predictability of the development interval.

The ASCC has started to use function points as a standard estimation technique. R. A. Brownlie of AT&T Bell Laboratories and D. Faulkner of the ASCC analyzed three ASCC projects using function points and the Capers Jones tool called CheckPoint.* They discovered two things: ASCC projects required slightly less effort and from one-half to one-third the interval predicted by the average project in the CheckPoint database.

Quality. Early in 1993, the ASCC decided to make International Organization for Standardization (ISO) 9001 registration and compliance a major component of quality planning at the ASCC. ISO 9000 consists of a set of guidelines and contractual standards that define a basic quality assurance system. It contains 20 elements that must be measured and met to qualify for ISO 9001 certification,⁴ which is a validation of the consistent use of process across an organization. It implies the ability to meet business and quality objectives, but it does not guarantee it. The execution results of the Silver Bullet process were subjected to an external

Figure 2. Interval results for the ASCC. (a) Project interval results for the ASCC over time. The interval to produce a product has decreased, on average, from the beginning of 1993 through the end of 1995. (b) ASCC projects require slightly less effort and from one-half to one-third the interval predicted by the average project in the CheckPoint database.



audit using the ISO 9001 international standards.

The initial results were encouraging. The processes did provide an adaptable framework for the rapid development of an ISO process control quality policy. Other issues, however, such as document control, process training, and the availability of online tasks, templates, and role descriptions also proved vitally important. Becoming ISO certified was key to scaling the process across an organization growing in size, capability, and complexity. It helped instill a sense of discipline about process execution that continues to bear fruit.

The ASCC received ISO certification in November 1993. It was a challenge to prepare for the certification process because the entire ASCC staff had to be trained to understand the ISO process. All this occurred during a period of high growth, as the staff continued to meet its project commitments. Remarkably,

the center grew 78 percent during this nine-month interval and delivered seven software tests, or betas, as shown in Figure 3.

In 1994 and 1995, the ASCC was subjected to an independent software process assessment (SPA). These external assessments, conducted by the AT&T Quality, Engineering, Software, and Technology (QUEST) organization, use assessment techniques developed by Capers Jones and the Carnegie-Mellon Software Engineering Institute (SEI). The ASCC requested these to assess the current benchmarks of the organization's process execution and the organizational maturity of its software engineering. These assessments measure the strengths and weaknesses of the organization, compare the organization with "best in class," and assign both SEI and SPA ratings.

In 1994 the ASCC was rated as one of the top five development organizations within AT&T. Output from this assessment was used to drive a year-long effort to

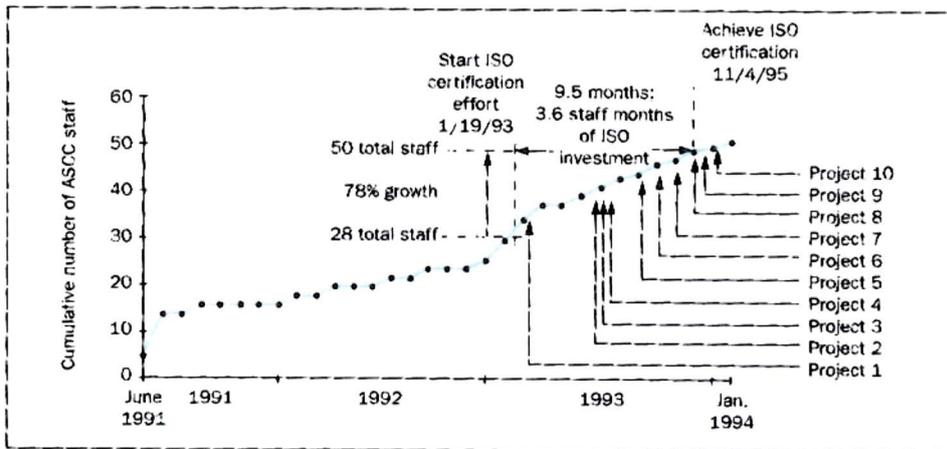


Figure 3. The challenge of ISO 9001 certification at the ASCC, showing the increase in staff from June 1991 through January 1994.

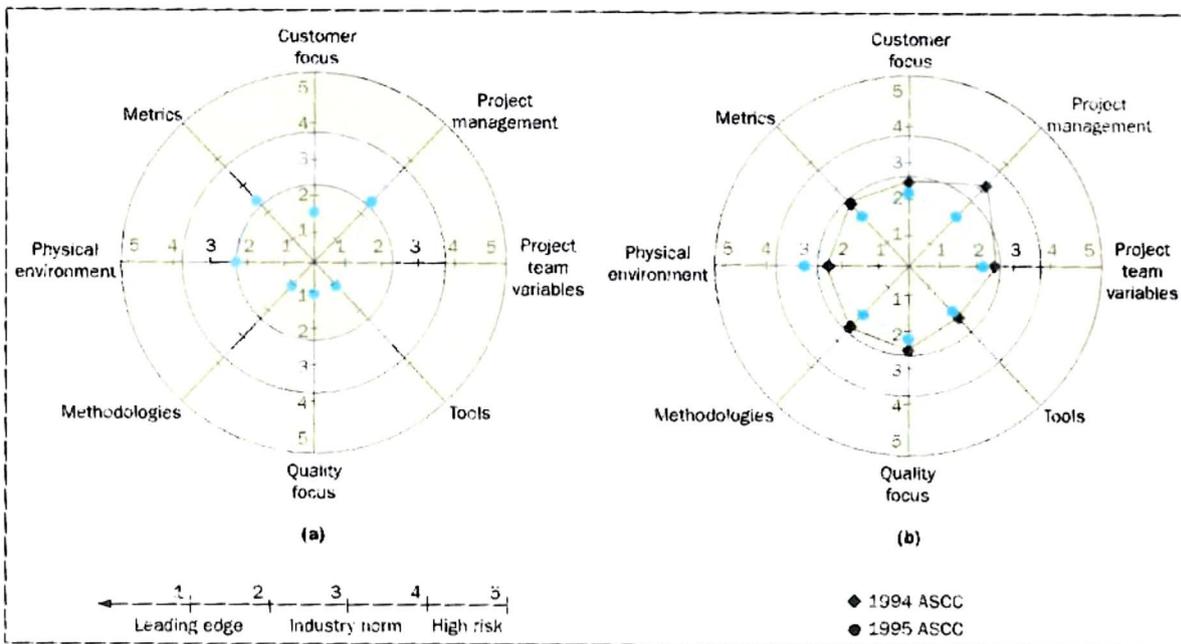
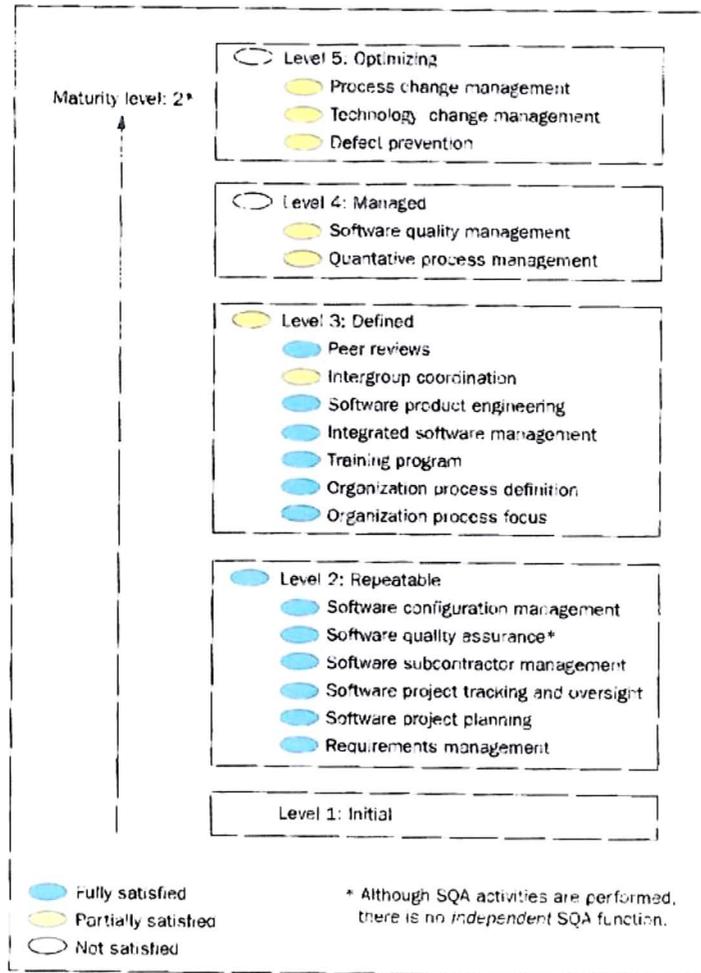


Figure 4. (a) Software process results "Top 10" data. The spokes of the diagram represent key areas of process focus. Points closest to the bull's-eye are best. (b) The results of the 1995 software process assessment (SPA) of the ASCC.

Figure 5. Key process area profile of the ASCC software process assessment.



improve the project management process. In 1995 the ASCC was rated as one of the top three software development organizations within AT&T.

Figure 4 shows the process assessment results for the Capers Jones top ten list.⁵ The spokes of the diagram represent key areas of process focus. Outward scores (moving towards 5) reflect weakness. Inward scores (moving towards 1) indicate strength and lower risk. An optimal score would be closely centered around the "bull's-eye." The Capers Jones chart,

Figure 4a, represents the best of the best, not one of an existing organization. The process assessment results of the ASCC, shown in Figure 4b, reflect a close alignment towards the center.

As part of the SPA, the ASCC was also assessed against the SEI Maturity Model. Figure 5 shows the SEI categories that must be satisfied to move upward in the ratings (in this case, 5 is best). A higher rating implies a more "mature" software development organization. The ASCC received an SEI level 1 in 1994 and improved to a

Table I. Employee satisfaction scores, 1993 versus 1994

	ASCC		High-performance norm		Delta	
	1993	1994	1993	1994	1993	1994
Company satisfaction	80	82	68	68	-12	-14
Competitive position	78	67	65	70	+13	-3
Teamwork	78	75	73	68	-5	+7
Empowerment	77	76	59	59	+18	+17
Job satisfaction	77	81	69	71	+8	+10
Management leadership	78	59	62	55	16	+4
Quality process	69	82	N/A	N/A	N/A	N/A
Operating efficiency	69	62	64	68	+5	-6
Integrity	68	71	75	63	-7	+8
Employment security	68	74	69	64	-7	+10
Respect	62	56	56	N/A	+6	N/A
Recognition	62	73	N/A	N/A	N/A	N/A
Performance management	60	72	63	62	-3	-10
Dedication to customer	58	64	N/A	75	N/A	-11
Pay and benefits	58	49	N/A	57	+2	-8
Supervision	57	64	65	65	-8	-1

level 2 in 1995. As in the case of the ISO, the ASCC uses these assessments to benchmark the organizational objective of process focus and continuous improvement in quality and cycle time. The scores are also strong predictors of the capability to produce higher quality products and shorter interval.⁶

Part of the quality system is the quality of the environment for workers. One concern about becoming process focused is that it stifles the creativity of the staff and is too tedious to follow. Table I shows that this view is not supported by the AT&T Opinion Survey. This survey is conducted yearly for AT&T by an external consulting firm, with results provided for each organization. The ASCC uses it to plan the work efforts of the leadership team and the culture support team. Although it is not surprising that the scores were high the first year, it is noteworthy that the scores for the last four years have been sustained, and even increased, by the continued focus on

process improvement. This strongly supports the value of process to the people in the organization.

Cost. From its inception, cost management has been a major initiative of the ASCC. The cost of software developed by the ASCC has been consistently one-third lower than other AT&T organizations. Some of the reasons for lower costs in the ASCC are the diverse skills of its staff, lower rents in its geographical area, the minimization of staff idle time, control of depreciation from capital expenditures, and careful management of training expenditures by suitcasing training. Each year, the ASCC spends approximately \$4K on employee training, an average of 80 to 100 hours per employee. Costs are tracked as part of the information system. Line item expenses are budgeted, and each project team knows its budget and its current expenditure rate against that budget. All members of the staff are empowered to participate in the cost management process.

A Case Study of Interval Reduction

The evolution of the ASCC's operations, analysis, and maintenance (OA&M) platform is an example of the organization's ability to use process improvement as a method of reducing interval. The OA&M portion of a product is what supports the product's delivery, installation, and configuration. It is the first thing a customer sees in a product and often can be the difference between a well-integrated product and a poor, unreliable product. Because it is not application software, traditionally the OA&M software often can be an afterthought in product development, created late in the development cycle as the product is rushed to delivery.

OA&M software should be the framework on which an entire software product is built. When viewed as the platform of the early product, the OA&M design will significantly reduce the development interval by reusing interfaces between software subsystems and significantly reducing the chaos generally experienced during the initial integration of the final product. An OA&M platform encourages reuse and eliminates the development efforts and the associated project cycle encountered on each new project.

The first project undertaken by the ASCC encountered a classic initial integration problem whose chaotic nature was attributed to a lack of early OA&M design work. Concluding that seven weeks was too long a timeframe for integration, the project team responded by designing the first OA&M platform. This process improvement was immediately applied to the next project (BNS-2000 UMAT), in which the OA&M was one of the first pieces of code written.

From these early lessons came the idea of a standard reusable OA&M platform. In fact, the ASCC's next project was to build the OA&M software specifically for a product being developed in Columbus, Ohio. The Columbus development team used the OA&M platform to rapidly develop a series of releases for the product. At this point, the ASCC had begun to formalize its OA&M process into a series of design questionnaires and templates that could be shared and reused by all the project's developers. As a result of this first application of the OA&M platform, the Columbus team integrated the application code in fewer than five days.

By mid-1994 the OA&M had become an official platform being reused on all projects in the ASCC. Its use

on the loop surveillance module, an AT&T Network Systems integrated product offering, enabled Network Systems to establish the platform environment in two days. Today, the OA&M platform is being used in Network Systems' largest integrated product offering, the Advanced Services Operations System (ASOS). The incremental improvements—learned in more than four years of work and captured as part of the OneOS process—are being reused by 15 development teams in at least four locations.

Overall, the ASCC product integration interval is averaging 10 percent of the total development interval, an impressive accomplishment when industry data indicates that product integration can average 38 percent of the total development interval.⁵

A Case Study in Quality Improvement

This final example demonstrates an ASCC project team's use of process and process improvement to measure, improve, and control the quality of its product. The ASCC began developing a network mediation product in mid-1992, followed by several later releases. The project team's quality objectives for the first release were on-time delivery and zero severity 1 and 2 trouble reports from the customer. Substantial monetary penalties existed for late deliveries and poor quality.

The team met all of its quality objectives for the first release of the product. Unfortunately, the second release of the product underwent requirements' changes during the beta phase of the development cycle. Figure 6a shows the modification request distribution for Release 1.1. A substantial number of problems were discovered after system test, reflecting the requirements change late in the development cycle. The team used the process tools, and the data supplied by these tools, to improve its process and the quality of the product. Figure 6b shows the results. Close to 95 percent of the problems were found prior to system test. This improvement in quality was accomplished while the product interval was being reduced from 28 weeks for Release 1.0 to 14 weeks for Release 2.0. In addition, the cost to develop a new switch interface was reduced by 35 percent.

This case exemplifies the value of having a team that can focus on process improvements from a business perspective and then accomplish these improvements through planning and execution. Self-initiated efforts such as these are a key element in the success of the ASCC.

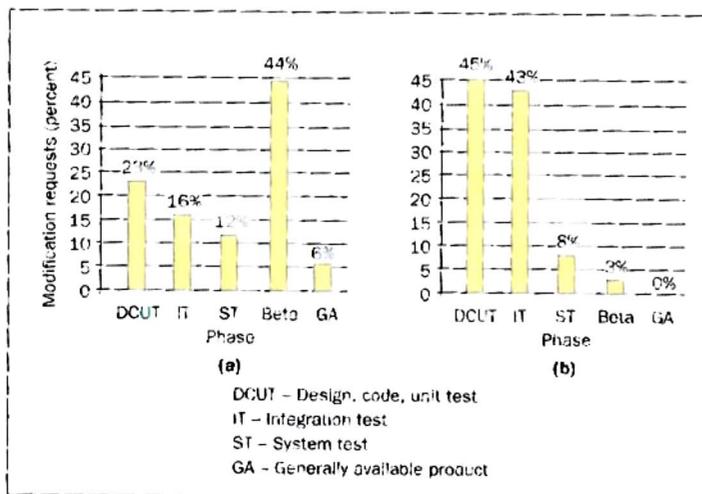


Figure 6. Network mediation project percentage of modification requests by development phase for (a) Release 1.1, in which a substantial number of problems were discovered after system test. The product interval for Release 1.1 was 28 weeks. (b) For Release 2.0, in which the switch interface was reengineered and a set of standardized test cases were implemented. 95 percent of the problems were found prior to system test. This resulted in a product interval of 14 weeks and a significant reduction in modification requests.

Conclusion

The ASCC has found, as Brooks suggested,¹ that gains in accelerating software development can be achieved incrementally on many fronts. These are hard-won gains, the results of submitting to the discipline of meticulously measuring and explicitly defining the layout and execution of each step in a development project. The key factors in achieving these gains were the quality and productivity of the members of the ASCC staff, their commitment, and the organizational design that supports them in their efforts. The cumulative effect of these painstaking gains, while not "silver bullets," have the same impact.

Perhaps the solution for slaying the werewolves of software development alluded to by Brooks will never be found: they are problems yet to be encountered. Indeed, the focus should be to address the problems as they are uncovered, capture what is learned, build on this knowledge, and move forward at increasing speed.

***Trademark**

CheckPoint is a registered trademark of Software Productivity Research.

Windows is a trademark of Microsoft Corporation.

References

1. F. P. Brooks, "No Silver Bullet: Essence and Accidents of Software Engineering," TR80-020, The University of North Carolina, Chapel

Hill, Department of Computer Science, September 1986, pp. 1-18.
 2. Carnegie-Mellon University Software Engineering Institute, *Capability Maturity Model Guidelines for Improving the Software Process*, Addison Wesley, Menlo Park, California, 1985.
 3. P. M. Senge, *The Fifth Discipline—The Art and Practice of the Learning Organization*, Doubleday/Currency, New York, 1990.
 4. *ISO 9001*, International Organization for Standardization (ISO), International Standards, Part 1, Geneva, Switzerland, July 1994.
 5. Capers Jones, *Applied Software Measurement: Assuring Productivity and Quality*, McGraw-Hill, New York, 1991.
 7. P. K. Lawlis, R. M. Flowe, and J. B. Thordahl, "A Correlational Study of the CMM and Software Development Performance," *CrossTalk, The Journal of Defense Software Engineering*, Vol. 8, No. 9, September 1996, pp. 21-25.

Further Reading

- M. Carr, "A Data Analysis and Representation Engine to Support Software Reliability Engineering," *Proceedings of the 6th Annual International Symposium on Software Reliability Engineering (ISSRE)*, October 1995, pp. 368-374.
- T. H. Davenport, "Process Innovation: Re-engineering Work Through Information Technology," *Harvard Business School Press*, Boston, 1993.
- Russell H. Dewey, "Streamlining Software Development," SRI International, Business Intelligence Program, Report No. 833, 1995.
- S. J. Gelman, F. M. Lax, and J. F. Maranzano, "Competing in Large Scale Software Development," *AT&T Technical Journal*, Vol. 72, No. 6, November, December 1992, pp. 2-11.

- S. J. Gelman, "Silver Bullet: An Iterative Model for Process Definition and Improvement," *AT&T Technical Journal*, Vol. 73, No. 4, July/August 1994, pp. 35-45.
- R. G. Grady, *Practical Software Metrics for Project Management and Process Improvement*, Prentice Hall, Englewood Cliffs, New Jersey, 1992.

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