Digital Six Sigma

Integrating continuous improvement with continuous change and continuous learning

Howard Smith and Peter Fingar

Abstract

Six Sigma is a widely practiced leadership framework and management methodology that drives business improvement. As a quality method, Six Sigma has always undergone development in the marketplace, first with Design For Six Sigma, now with New Six Sigma, and soon with *Digital Six Sigma*. Six Sigma is in fact an umbrella term—a trusted brand—under which various management disciplines are being integrated by leading companies such as Motorola and linked to powerful change management programs. But the introduction of a Six Sigma program, getting focused on key priorities and scaling up to achieve meaningful results, has proved challenging for many organizations, as challenging as the process improvement Six Sigma seeks to provide. Training is to date the cornerstone for implementing Six Sigma, with those who excel becoming Black Belts. But training alone won't suffice as a foundation for living the life of Six Sigma, for tools commensurate to the task are needed, leading to the emergence of *Digital Six Sigma,* an approach built on the foundations of new Business Process Management Systems (BPMS), together with process portals and integrated Six Sigma workbench tools.

The drive for quality

The need for ever more powerful business process analysis tools has grown in step with the growth of the quality movement in the 1980s. To wit, consider Christopher Koch's story of Sue Unger, the former finance executive turned CIO who presides over one of the world's largest IT groups at one of the world's largest companies, $157 billion DaimlerChrysler.[1] "Perhaps the toughest assignment for Unger was in the mid-1980s when Lee Iacocca trumped the other Big Three during the "warranty wars" by upping the coverage to seven years or 70,000 miles. Unger was the finance manager who had to figure out whether Chrysler would lose what was left of its tattered shirt on warranty repairs. This was an assignment Unger didn't choose herself. Warranty and quality were chaotic backwaters. Engineers used dollies to deliver the stacks of paper that quality analysts needed to pore through to generate their monthly quality reports. 'The paper was stacked so high you couldn't even see the analysts at their desks,' Unger recalls."

"By law, Chrysler has to keep warranty and quality information on every part and every vehicle going back 15 years. But getting at the information about a part that

[1] Koch, Christopher, "Sue Unger's Driving Lessons," CIO Magazine, June 15, 2003.

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failed last week was as difficult as finding one that blew up 10 years ago. Unger realized that if warranty and quality data went online, the engineers would be able to fix the quality problems much quicker. Naïveté about technology may have been a blessing in disguise. 'IT said it was impossible to put this much information in a database, much less analyze it,' Unger recalls. Persistence won, and Unger finally got the database technology she needed."

Considering that Unger's warrantee problem was but one specific instance, multiply her requirements across DaimlerChrysler today, and then again across a supply chain extended across the globe. The papers stacked on analyst's desks to accomplish these tasks would so high as to rival Mt. Everest! While the need for quality programs, has never been more pressing, the need for commensurate tools is clear. While Six Sigma represents the latest evolution in quality methods, the silos of information systems scattered across entire value chains create an immense challenge. IT is, once again, in the unenviable position of having to say that the challenge is impossible. Yet, solutions indeed must be found. While data-oriented analytical systems are a commodity available to Six Sigma practitioners, process management systems are now emerging as powerful foundations for digitizing Six Sigma and applying it in ever more complex business situations and environments—the coming *Digital Six Sigma.*

A retrospective for those new to Six Sigma

The cornerstone of the traditional Six Sigma method is the DMAIC process improvement lifecycle—Define, Measure, Analyze, Improve and Control. Statistical methods are used to identify, root out and eradicate deviations, defects and other types of deficiencies in processes. Practitioners identify the most promising pressure points that can be applied to processes in order to drive their improvement. It relies upon a small number of key best practices that can be taught and practiced in any business context:

- Critical to quality: Attributes the customer values most.
- Defect: Failure to deliver what the customer expects.
- Process capability: What a process can deliver.
- Variation: What the customer sees and feels.
- Stable operations: Ensuring consistent, predictable processes to improve what the customer sees and feels.
- Design for Six Sigma: Designing to meet customer needs and process capability.

Here is an example of DMAIC processes from GE Capital:

- *Define* the customer, what their Critical to Quality (CTQ) issues are, and the Core Business Process involved. Define who customers are, what their

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requirements are for products and services, and what their expectations are. Define project boundaries—the stop and start of the process. Define the process to be improved by mapping the process flow.

- *Measure* the performance of the Core Business Process involved. Develop a data collection plan for the process. Collect adequate data from many sources to determine types of defects and metrics. Compare with customer survey results to determine shortfall.

- *Analyze* the data collected and the process map to determine the root causes of defects and identify opportunities for improvement. Identify gaps between current performance and goal performance. Prioritize opportunities to improve. Identify sources of variation.

- *Improve* the target process by designing creative solutions for fixing and preventing defects. Create innovative solutions using technology and discipline. Develop and deploy an implementation plan.

- *Control* the improvements to keep the process on its new course. Prevent reverting back to the "old way." Require the development, documentation and implementation of an ongoing monitoring plan. Institutionalize the improvements through the modification of systems and structures (staffing, training and incentives).

The Evolution of Six Sigma

While Six Sigma's roots lie in statistical deviation analysis applied to variations in manufacturing process performance, the same statistical techniques are now being applied more broadly within the business—and across a much wider variety of business processes than its roots in manufacturing quality might indicate. Today, Six Sigma is applied even in areas of the business traditionally thought to be devoid of process, such as creative design, marketing and business development. To meet that need, Six Sigma now embraces a portfolio of various "best practices" including Voice of the Customer (VOC), Balanced Scorecard, High-Performance Teams, Black Belt Teams, TRIZ and Dashboards. These methods and tools help Six Sigma practitioners focus on the most effective metrics that can be analyzed using Six Sigma's traditional statistical methods.

Six Sigma *black belts* are skilled in precisely defining DMAIC processes and then developing effective ways to apply them so that they work in practice across the organization. They work with Six Sigma team members, many of which are the employees involved in the processes to be improved. They develop approaches that accommodate process change in situations where those impacted don't have the time, or inclination, to think or act in terms of processes. Indeed, for many in business the very word "process" is an anathema—overloaded with negative connotations from the era of disruptive reengineering and prescriptive workflows.

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These new Six Sigma methods stress organizational alignment on goals, objectives, priorities, targets, actions and the orthogonal alignment between needs, skills, competencies and assets. *New Six Sigma* is Motorola's umbrella under which updated Six Sigma techniques are applied more broadly (end-to-end) within the corporation. Modern Six Sigma practitioners, such as Motorola's Matt Barney, aim to integrate key disciplines from Finance, Engineering, Strategy, Statistics, Tangible and Intangible Asset Management, IT and Industrial-Organizational Psychology. His work and that of his colleagues in the Six Sigma community will radically re-define Six Sigma over the coming years. The focus of the New Six Sigma method is away from simply reducing defects and towards reducing variation around accomplishing business goals. At Motorola, Six Sigma has evolved from a metric process to a culture.

Figure 1 – The Evolution of Six Sigma

Tools for Six Sigma

Traditionally, Six Sigma practitioners have used only discrete productivity tools, such as drawing packages, spreadsheets, statistics packages and personal or workgroup databases—they have built their own Six Sigma processes around these tools. They use techniques such as FMEA, C&E Matrix, SIPOC and associated diagrams, including CT-Trees, Fishbone diagrams and Process maps. Six Sigma practitioners also rely upon templates for project selection, prioritization and charter definition as well as the application of project planning tools to create plans for process control, audit and data collection. Bringing all of these methods together, and integrating the Six Sigma information across them, can be daunting. For this reason, new Six Sigma tools are emerging in the marketplace.

Microsoft supplies a Six Sigma solution, but it hardly represents a major innovation. Microsoft has integrated existing tools such as Project, Excel and Access using Visual Basic scripts to provide a basic Six Sigma working toolset. The perceived weakness in such an approach has led others to go further. For example, SigmaFlow provides a dedicated, integrated, purpose-built environment in which to conduct Six Sigma projects. But such productivity tools, even though they are a major advance, do not close the loop to process execution. What Six Sigma practitioners want to do is insert new quality processes directly into live operations and use them to control the lifecycle of process improvement. For this reason some companies are experimenting with the integration of Six Sigma tools with various kinds of business process management (BPM) solutions.

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One example is SigmaFlow's announcement of an alliance with workflow/BPM vendor Metastorm. In addition, BPM vendors are also adapting their own solutions toward Six Sigma. For example, Action Technologies uses coordination and negotiation processes to measure the effectiveness of teamwork as a Six Sigma metric.

While valuable, these point solutions only hint at the potential of the coming *Digital Six Sigma.* Will individual vendors such as SigmaFlow be required to create alliances with, and technical interfaces to, each of the numerous execution environments within the typical enterprise, including different workflow solutions, ERP, SCM, CRM EAI and application server? Can what Action Technologies has achieved be applied outside of the specific human-human collaboration processes it supports so well? Neither of these approaches is yet based on the principles of business process *digitization* and they will not deliver the potential of *systemic Digital Six Sigma.*

Digital Six Sigma

Digital Six Sigma is the systemic use of information technology (beyond separate statistics packages, spreadsheets and knowledge tools) to close the loop between end-to-end business process design, and execution and optimization. The foundation for *Digital Six Sigma* implementation is the Business Process Management System (BPMS)—the process engine linking tangible and intangible assets (people, processes, systems, knowledge) horizontally across all participants in a value chain, and vertically from business strategy to IT implementation.

BPMS vendors provide a process lifecycle orthogonal to today's software engineering lifecycle. They support business process modeling languages (such as BPML[2], an extension of BPEL) and provide the *lingua-franca* across disparate processes, process improvement methodologies, tools and notations. Such an approach goes far beyond the import/export capabilities for processes currently provided in some process modeling tools. The BPMS provides a process platform on which process modeling and analysis tools, including those for Six Sigma, can be integrated.

The BPMS provides process projection and consolidation of numerous technologies and tools already in the enterprise. Each technology and the processes it provides can participate in end-to-end *Digital Six Sigma* processes modelled using the design-driven-architecture (DDA) principles inherent in the BPMS. The emphasis is on the modeling of end-to-end process behavior, providing a complete process lifecycle.

In addition to the business processes brought under the purview of the BPMS platform, Six Sigma, itself a process, can be *built-in. Digital Six Sigma* takes change off the critical path to performance and innovation by integrating continuous improvement, with continuous change, with continuous learning—and goes far

[2] www.bpmi.org

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beyond discrete Six Sigma productivity tools. Discrete tools such as SigmaFlow can nevertheless be integrated with the BPMS. And process collaboration tools provided by companies such as Action Technologies and Metastorm can play a role in the end-to-end processes created. For example, each can be the vehicle for exposing the new processes directly to end-users.

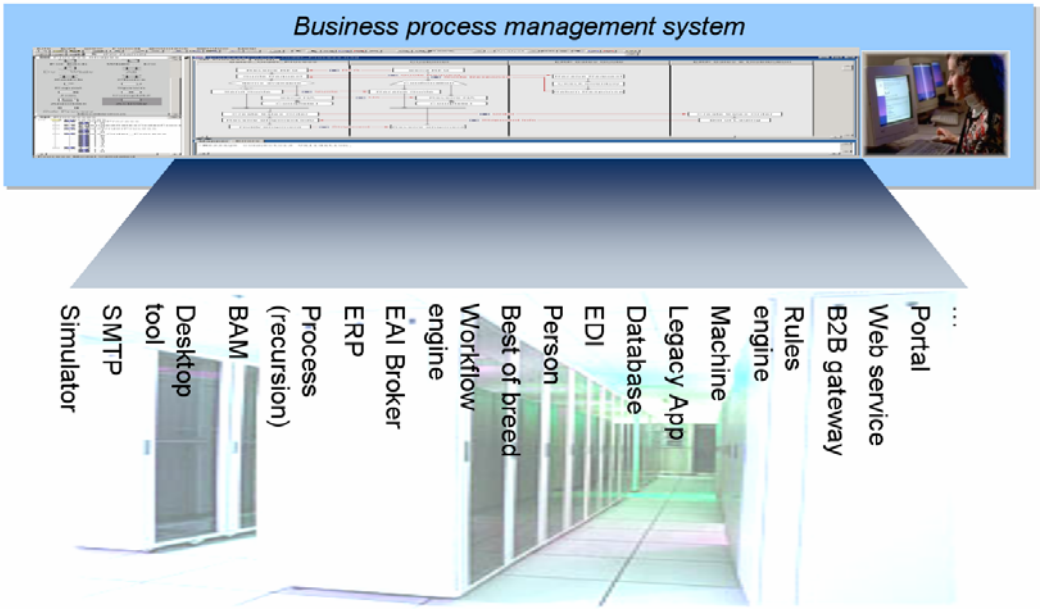

Figure 2 – Process Consolidation Using BPMS

BPM is pervasive but practice and terminology varies

The research firm, Metagroup, reported that Global 2000 organisations are almost universally embarking on multiple process improvement exercises to increase organizational efficiency and effectiveness. These efforts go by many names, including industrial engineering, ISO certification, Six Sigma, enterprise business architecture (EBA), business process improvement (BPI), business process re-engineering (BPR), Rummler-Brache Performance Improvement, Integrated Definition Function Modeling (IDFM) and lean thinking, to name a few. Supporting these process improvement initiatives are a wide variety of process notations and methods, including entity relationship diagrams, ANSI standard flowcharts, process maps of various types, data flow diagrams, Unified Modeling Language (UML) diagrams (activity, class, etc.), Catalyst, LOVEM, network diagrams, CRUD (create, read, update, and delete) matrices, IDEF charts (0 through 9) and EPCs (event chains). When the founders of the Business Process Management Initiative (BPMI.org) first met in 1999, they asked a simple question: could there be something in common to each of these improvement initiatives, notations and methods? The answer surprised all of us.

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BPMI.org found a way to represent all business processes that parallels the significance of the relational data model for business data. The group were also successful in developing a methodology for processes that could accommodate the expression of diverse business improvement methods. They are nothing more than processes participating in other processes. Through this work the door opened towards the era of BPMS, as the development of the relational model opened the door to RDBMS.

Just as enterprise data management depends upon the RDBMS capability, *Digital Six Sigma* depends upon the BPMS capability—a digital process platform that can implement a complete process lifecycle. Six Sigma practitioners already understand the need for this process lifecycle. They have been implementing this lifecycle in their businesses for years, but using manual techniques and piecemeal digital tools. Only now with the emergence of the BPMS are means available to implement the process lifecycle across the existing IT infrastructure and in the design of new processes.

The Digitized Business Process

Business processes are not only about the flow of documents, work items or the technical integration of applications or Web services. They are mainly concerned with coordinating the end-to-end collaborative and transactional activities that bring value to customers. While computational activities are well understood and modelled in computer systems, the communication links between discrete computational elements of information systems have been lacking formal underpinnings. In other words, each computational element can provide a capability, but it is the linking of such discrete capabilities through communication that provides the overall capability of the information system—the whole being greater than the sum of the discrete parts.

The BPMS uses the principles of Pi Calculus[3] to unify our view of communication and computation at all levels into a single paradigm. A BPMS can be thought of as a communication back-plane where plug and play process capabilities (including Six Sigma processes) can be implemented and managed as a unified whole, breaking down the artificial distinctions inherent in stovepipe processes in systems and practices. The end-to-end model of process that BPMS enables is similar to the end-to-end data model that the relational model of data enabled. Pi Calculus is a new foundation for computing that does not distinguish between the computing parts and the communicating parts. Pi Calculus provides a new representation for processes in which all computation can be viewed as communication and all communication can be viewed as computation. Quite literally, in the Pi Calculus, there is no distinction between computation and communication. In implementations of languages such as BPML which are based on the Pi Calculus, this provides the following benefits:

- Distinctions between business logic, software code and data flow vanish, exposing the real process to business people in a way they can understand

[3] www.bpm3.com/picalculus/workflow-is-a-pi-process.pdf

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- Distinctions between processes and what processes process, vanish. Everything is a process and the results of all processes can be considered process data amenable to analysis by other processes (Analogy for networks: Internet Protocol (IP) over everything and everything over IP)

- Workflows are connected into multi-participant processes and visualised using role/activity/swimlane-type diagrams. Distinctions between workflow cases and workflow processes vanish. The case is the process. The process is a new form of digital content. Nested transactions and processes can be implemented across an end-to-end view of process participants. Processes are free to evolve in line with the business as controlled evolutions of their starting design.

Using the principles of Pi Calculus, the BPMS can represent end-to-end processes—past, present and future state—horizontally across the company so that all participants can be involved, and vertically from the highest expression of business strategy to the most intricate details of process execution. The BPMS *digitizes* our view of the enterprise end-to-end, as RDBMS digitizes our view of business data.

Digital Six Sigma requires the capability to manage, in combination, all the characteristics inherent in business processes:

- Automational, eliminating human labor from a process, or reinforcing human processes with automational support
- Informational, capturing process information for purposes of understanding
- Sequential, changing process sequence, or enabling parallelism
- Tracking, closely monitoring process status and participants
- Analytical, improving analysis of information and decision-making across processes
- Geographical, coordinating processes across distances
- Instrumented, measuring, touching and sensing process performance
- Integrative, consolidating and integrating sub-processes and tasks
- Intellectual, the process of capturing and distributing intellectual assets
- Disintermediating, eliminating intermediaries from a process
- Computational, performing calculations as part of a distributed process
- Collaborative, allowing participants to manage sets of shared work processes
- Compositional, building new processes from elementary reusable process patterns

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Digital Six Sigma Infrastructure

We define *Digital Six Sigma* as the implementation of the Six Sigma processes using the BPMS. The BPMS provides the foundation upon which to build a collaborative, consolidated, enterprise-wide environment for the conduct of comprehensive Six Sigma initiatives. The objective is to accelerate results from Six Sigma investments by providing a tangible (executable) Six Sigma Process Lifecycle Model. Such a model supports the key Six Sigma objectives of process alignment, mobilization, acceleration and governance.

Think of the BPMS as the engine we can use to examine the behaviour of all processes, not in terms of how they are implemented in discrete subsystems, but in terms of how they behave, based on observation of the interactions between participants at all levels. The central component of the BPMS that is able to do this is called a process virtual machine, the component that implements the Pi Calculus. The BPMS also contains projectors that allow existing computing elements such as ERP, portals and dashboards to be included in processes.

With Six Sigma built in, the BPMS can be predictive, self-correcting, visible and dynamic. The BPMS provides the end-to-end view of processes—past, present and future—creating the process data as processes execute that make it possible to support the distributed Six Sigma team through a process portal that encourages collaboration through coordination, commitments and negotiation processes.

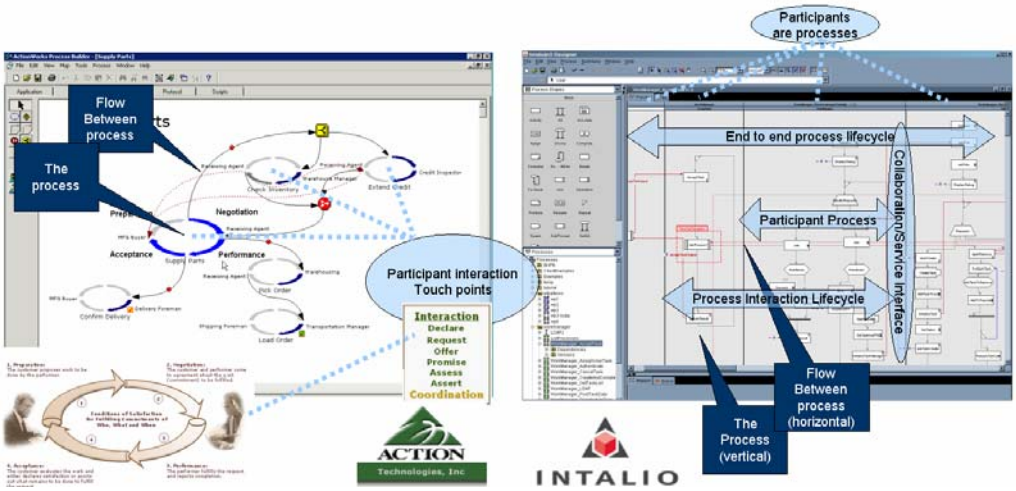

Figure 3 – The Role of Process Portals and BPMS in *Digital Six Sigma*

The BPMS establishes a domain-specific process repository and live process deployment in the distributed enterprise-computing environment. The BPMS consolidates, describes and includes all the key process participants (e.g., people, systems, machines, other processes, Six Sigma processes) across the value chain, end-to-end. Leading organizations such as Motorola, the inventors of Six Sigma, are already at work developing frameworks for various kinds of *Digital Six Sigma*.

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The Digital Six Sigma Process

Six Sigma comprises a set of interlinked processes for Definition, Measurement, Analysis, Improvement and Control. There are also New Six Sigma processes for Alignment, Mobilization, Acceleration and Governance. These processes cannot be packaged in the form of software applications; they must be modeled and executed in the unique circumstances of each company, and that's precisely where the BPMS fit in, because:

- The design of the processes must reflect how the company wishes to compete in the marketplace and how it wishes to improve its operations, products and services, and;
- End-to-end processes must map onto and consolidate the processes supported by the existing IT infrastructure, the hundreds of systems the company relies on, and how these have been deployed and customized, and;
- They must reflect the unique ways in which the firm wishes to pursue Six Sigma quality, taking into account numerous practical factors in the business.

Using a BPMS to link business processes to Six Sigma quality objectives creates a far more pervasive and symbiotic relationship between the Six Sigma program and the business. Technically, the Six Sigma processes participate one within another and with the business processes they improve. The BPMS supports the "white space" between all processes. It defines the interfaces between and among processes. These process boundaries and the information flows across them create the measurement points where Six Sigma statistical methods can be applied, for *Digital Six Sigma* BPMS provides:

- A shared language for the expression of all processes (Six Sigma processes and other business processes)
- Executable processes, and a live process deployment environment that is able to express end-to-end processes which include all key participants
- Six Sigma data collection that can be automated using processes; the data is the exchange of information between participants in the process
- Executable processes that provide audit trails and a persistent store of process interactions for Six Sigma analysis
- A process query language, providing the foundation for numerous, custom Six Sigma dashboards as participants in the process
- Processes that can encode Six Sigma specific metrics enabling real-time Six Sigma

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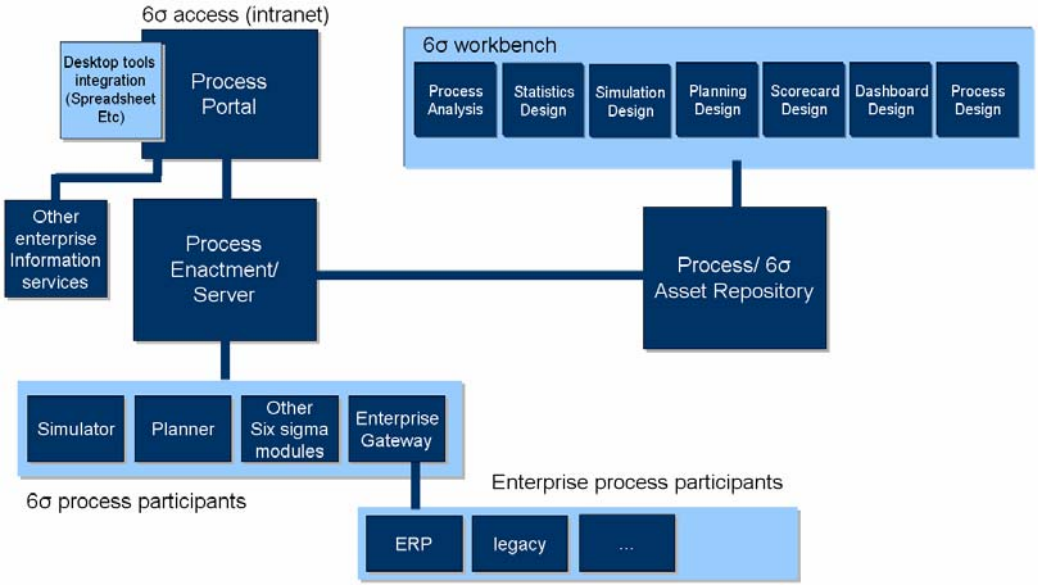
- Process portals that automatically adjust to new Six Sigma process designs, mobilizing employees to use such new processes

- Autonomous Six Sigma processes that can be directly executed, streamlining the Six Sigma effort, enabling efficient knowledge transfer between Six Sigma practitioners and business leaders

- Simulation that can be an active component, simulating new process design or providing simulation-enhanced processes (simulation as a process participant)



Source: Computer Sciences Corporation

Figure 4 – Conceptual Design for a *Digital Six Sigma* Infrastructure

Applying Digital Six Sigma

Instances of Digital Six Sigma processes proceed from design to execution with no requirement for traditional software development. The BPMS provides a process engineering environment that puts process at the heart of the architecture, opening process manipulation for business improvement just as CAD/CAM put 3-D models at the center of product design, opening the possibility for computer-integrated manufacturing. Digital Six Sigma is CAD/CAM for business processes. It creates a shared environment for process design and a path to execution, closing the loop from strategy to operations. Actions required for process improvement are made visible to everyone in the extended enterprise, accelerating adoption across business units and business partners. Here are examples:

BPMS facilitates the DMAIC process in at least the following ways:

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- *Define activity.* BPM languages help express the process under study. The process can be described in as much or as little detail as required—from the finest details of implementation to the highest-level abstract expression of a business model design. It is directly executable with no further steps.

- *Measure activity.* An executable process can express the DMAIC data collection plan precisely, whether it involves analysis of a single element or of many elements from across multiple systems. It can immediately collect data from operational systems and work patterns in a fully automated manner and on a regular basis. Metrics data will be complete, accurate and timely. This will provide a true business activity monitoring (BAM) as opposed to the derivation from the "after-the-fact" results of static data analysis, or the indirect results of observing technical messages on an enterprise network.

- *Analyze activity.* An executable process can encode metrics within any process design so that the comparison of variations in current performance against stated goals can be readily derived. The BPMS maintains the lifecycle of the end-to-end state, structure and design of the processes under study, and can be queried by existing tools. Executable processes can encode the calculation of the Six Sigma metric itself in terms meaningful to a particular industry—defects in products, uptime on a power grid, reported telecommunications faults, ability to supply, and so on.

- *Improve activity.* The BPMS can assist Six Sigma practitioners in the generation and exploration of alternate process designs, in conjunction with simulation. Simulation can be added to processes as a participant.

- *Control activity.* The BPM approach helps prevent revised processes reverting to the "old way" by adjusting the human interface of process systems to reflect changing process design. Process portals and a process desktop expedite knowledge transfer related to new processes by keeping employees totally involved in and interacting with the evolving digital process.

Conclusion

To the old adage, "you cannot improve that which you cannot measure," we add, "*you cannot effectively measure that which you cannot digitize."* Bringing organizations to the state of excellence in today's global markets demands unprecedented requirements for speed and customization that only business process management systems can deliver. If organizations adopt an ad-hoc approach to Six Sigma, they will re-invent the wheel in every improvement project. On the other hand, analysts like Gartner and others have shown how workflow, rules and BPM speeds the implementation of business transformation and process improvement projects. These same technologies can be applied to Six Sigma. But to close the loop with operations and execution, Business Process Management Systems with *Digital Six Sigma "built in"* are required. The results are directly executable, end-to-end business processes that amplify the power of Six Sigma by bringing it to all processes. Good Six Sigma processes don't make winners; winners make good Six Sigma processes.

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Resources

[1] SigmaFlow is building an integrated Six Sigma "practitioner's toolset" (http://www.sigmaflow.com) that can be used standalone or integrated with workflow/BPM solutions. For example, they recently announced a partnership with Metastorm (http://www.metastorm.com/news/100903.asp)

[2] Case study of a process collaboration/portal/BPM vendor, Action Technologies applying Six Sigma "digitally" to unstructured people-people processes (http://www.actiontech.com/library/Documents/GetDocs.cfm?ID=WebinarSixSigma)

[3] A Business Process Management System for supporting digital end-to-end processes and implementing a process lifecycle, Intalio n^3 BPMS, the foundation for *Digital Six Sigma* (http://www.intalio.com)

[4] "Workflow is just a Pi process," Howard Smith and Peter Fingar, October 2003 (http://www.bpm3.com/picalculus/) (29 page PDF download)

[5] Sophisticated simulation both *of process,* and *in process,* will be an inherent component of Digital Six Sigma, for example see (http://www.lanner.com/)

[6] The Six Sigma Academy (http://www.6-sigma.com) and the International Society of Six Sigma Professionals (http://www.isssp.com/)

[7] Six Sigma terminology http://www.gpsqtc.com/library/abc.shtml

[8] Motorola University (Matt Barney) FAQ http://mu.motorola.com/faqs.shtml

[9] *The New Six Sigma,* Motorola University, Matt Barney and Tom McCarty, available from Amazon.com

[10] Six Sigma is often conducted with little more than customized spreadsheets (http://www.sigmazone.com/sixsigma_new.htm) or special purpose or general purpose statistics packages (http://www.minitab.com/, http://www.statsoft.nl/sixsigma.html)

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[11] Project Management is a key component of Six Sigma, specialized packages exist (http://www.sigmasoftwaregroup.com/) or practitioners use off the shelf project planning tools (http://www.microsoft.com/office/project/default.asp)

[12] Microsoft's Six Sigma toolset. Little more than loosely integrated desktop productivity tools? (http://www.microsoft.com/solutions/sixsigma/)

About the authors

Smith and Fingar are co-authors of two books about business processes, *Business Process Management—The Third Wave* (December 2002, Hardback 311 pp) and *IT Doesn't Matter—Business Processes Do.* (July 2003, Paperback 128 pp). They can be previewed at www.bpm3.com.

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