

Putting Continuous Auditing Theory into Practice: Lessons from Two Pilot Implementations

Michael G. Alles

Rutgers, The State University of New Jersey

Alexander Kogan

Rutgers, The State University of New Jersey

Miklos A. Vasarhelyi

Rutgers, The State University of New Jersey

ABSTRACT: In the almost twenty years since Vasarhelyi and Halper (1991) reported on their pioneering implementation of what has come to be known as Continuous Auditing (CA), the concept has increasingly moved from theory into practice. A 2006 survey by PricewaterhouseCoopers shows that half of all responding firms use some sort of CA techniques, and the majority of the rest plan to do so in the near future. CA not only has an increasing impact on auditing practice, but is also one of the rare instances in which such a significant change was led by the researchers. In this paper we survey the state of CA after two decades of research into continuous auditing theory and practice, and draw out the lessons learned by us in recent pilot CA projects at two major firms, to examine where this unique partnership between academics and auditors will take CA in the future.

Keywords: continuous auditing; internal audit; audit systems.

I. INTRODUCTION

Two decades have now passed since the work started on the first large-scale commercial continuous auditing project reported in the original paper by Vasarhelyi and Halper (1991). That project at Bell Laboratories relied on the groundbreaking information technology of the day (PCs, databases, corporate networks, but not yet the Internet) to assure the reliability of the AT&T large billing systems through the automated acquisition and analysis of data and the electronic communication of alarms. Already that first project clearly demonstrated that the ultimate point of continuous auditing (CA) is to bring auditing closer to the operational process, and away from the traditional backward-looking once-a-year examination of financial statements.

This paper draws on the lessons obtained from work on CA at major Fortune 100 firms, led by the authors working in close collaboration with the internal audit departments of the clients. While case studies of some of these implementations have been published elsewhere (Alles et al. 2006, 2007), this paper steps back to draw the broader insights they offer about the emerging conceptual model of continuous assurance. These studies were particularly

insightful about the unique issues that CA poses, which are fundamentally different from those encountered in standard auditing. Importantly, these are not technological concerns, but arise from the basic nature of continuous assurance, with its potentially unconstrained access to the universe of corporate data and the decreased latency between transaction and assurance.

A June 2006 PricewaterhouseCoopers survey finds that 50 percent of U.S. companies now use continuous auditing techniques and 31 percent of the rest have already made plans to follow suit.¹ A similar survey jointly undertaken by ACL and the Institute of Internal Auditors also shows that interest in CA is increasing rapidly, with 36 percent of responding firms stating that they have adopted a continuous auditing approach across all of their business processes or within select areas, and with another 39 percent planning to do so in the near future.² As the latter survey concludes: “Whatever the reasons organizations may have had for neglecting continuous auditing in the past, regulatory demands, the push for real time financial reporting, and the drive to automate resource draining manual audits are nudging them to adopt it now.”

In this paper we review the lessons learned over these last 20 years of attempting to move CA from a concept to practice. Some of the early predictions about how greatly and how rapidly CA would transform auditing have proven overly optimistic. Indeed, while the underlying technology is more advanced than anything envisaged in 1991, the real constraints and drivers of CA have proven to be economic and regulatory, as one might have expected given that auditing is a business practice and not a piece of software.

We highlight in this paper that CA is one of the rare instances in which a significant innovation in accounting practice has been developed and driven by the academic community, as opposed to the usual model in which researchers use archival data to investigate practices originating in industry. While software vendors and business practitioners may increasingly drive the development of CA technology, a critical role continues to be played by researchers. Their task is twofold. First, it is the academic researchers who have to create a conceptual model of continuous auditing so that it becomes a true audit methodology, as opposed to a collection of disparate technologies. Second, only they are in a position to conduct innovative implementations unconstrained by the need to show an immediate ROI that will illuminate the challenges practitioners will face as they turn to CA—in particular, in the process of reengineering audit practice to adapt it to CA.

This paper is organized as follows. The next section of the paper discusses the development of CA in both practice and research literature. Section III examines the debate over the definition and scope of CA. We then turn to the lessons drawn from the two decades of experience with the interaction between CA theory and practice.

II. THE DEVELOPMENT OF CONTINUOUS AUDITING

Vasarhelyi and Halper (1991) was not a conceptual piece, but a report on an actual implementation of a monitoring and control process used on billing data at AT&T. The tools they had available at the time would be considered primitive today, and yet the system they created, known internally as the *Continuous Process Auditing System*, or CPAS, and its successors were in use even as late as a few years ago to detect anomalies in billing and possibly fraudulent use of long distance calling.

¹ Available at: CFO.com, June 26, 2006.

² *Business Finance Magazine*, August 2006. Available at: <http://www.businessfinancemag.com/magazine/archives/article.html?articleID=14670&highlight=acl>.

Despite this working example of CA, it took until 1999 before the accounting profession, in the form of joint committee of the American Institute of Certified Public Accountants (AICPA) and the Canadian Institute of Chartered Accountants (CICA), took up the issue of CA and issued the “red book” on CA.³ Since then, however, change has come at an accelerating pace, with firms increasingly implementing systems that are recognizably CA in their characteristics, as the PricewaterhouseCoopers survey, among others, indicates. Given the technological basis of CA, perhaps the best metric of the “mainstreaming” of continuous auditing is the 46,600 hits that the term generates on Google.⁴ Practitioners and software vendors (such as SAP, ACL, Caseware, Approva, and Oversight Systems) now outnumber academic researchers as attendees at the biannual global CA conferences. Among those practitioners are representatives of the major audit firms, several of whom have ongoing CA initiatives.

As befits a concept developed by academics, there is a large and dynamic research program into CA. A program of academic research in continuous auditing was originally proposed by Kogan et al. (1999). Brown et al. (2006) reviewed the extant continuous auditing literature and classified over 60 papers discussing a wide range of topics and approaches into six major categories: (1) demand factors, (2) theory and guidance, (3) enabling technologies, (4) applications, (5) cost benefit factors, and (6) case studies.

The issues discussed relative to demand factors included: the increasing complexity and data-intensiveness of the business environment, the growing prevalence of electronic transactions (EDI, etc.), the ever-increasing usage of outsourcing, value chain integration, web-based reporting, and the users’ desire for reliable information to be disclosed more frequently, more timely, and in more detail, XBRL-based reporting, and the fact that under Sarbanes-Oxley (Section 409) companies must disclose certain information on a current basis.

As impediments, Brown et al. (2006) drew attention to Alles et al. (2002) who discussed independence issues such as who will pay for the large start-up costs and who owns work product. Under theory and guidance, Brown et al. (2006) cited articles describing CA concepts, proposing a framework and research agenda for the topic, and providing implementation guidance and discussing implementation challenges.

Vasarhelyi et al. (2004) discuss the enabling technologies, including statistical methodologies such as belief functions, neural networks, as well as technologies from computer science such as database and expert systems, intelligent agents, and especially technologies for tagging data to facilitate transmission and comparison, most notably XBRL and XBRL-GL. In the applications domain, case studies now exist of CA implementations, such as the pilot implementation of the monitoring and control layers for continuous monitoring of business process controls (Alles et al. 2006), the formerly mentioned CPAS system developed at AT&T Bell Laboratories (Vasarhelyi and Halper 1991), the FRAANK—Financial Reporting and Auditing Agent with Net Knowledge—agent for finding accounting numbers in EDGAR filings (Bovee et al. 2005), and advanced analytics at a major health services provider, referred to as HSP hereafter (Alles et al. 2007).

There is also an emerging literature of product descriptions in the application domain driven by the emergence of packaged commercial CA software solutions. Such solutions are now actively developed both by established CAAT vendors such as ACL and CaseWare IDEA, and by new software vendors that are quickly establishing themselves in this emerging market, such as Approva and Oversight Systems.

³ CICA/AICPA Research Study on Continuous Auditing, 1999.

⁴ June 25, 2007.

The final category of cost benefit issues deals with possible paths along which continuous assurance will evolve, long-run operating cost of running database audit, benefits of timely discovery of errors, omissions, defalcations, cost-effectiveness of automated, software-driven audit procedures, discussion of economic feasibility of continuous audit, an experimental market and laboratory experiment for Continuous Online Audit (COA), and nine benefits of continuous business assurance analytics.

While not yet an established technology, it is clear that CA is maturing both in practice and in the research arena, as lessons learned in implementations are used in refining the underlying conceptual model. The very definition of CA has seen this ongoing process of evolution, as we discuss next.

III. WHAT IS CONTINUOUS AUDITING AND WHO SHOULD USE IT?

Continuous auditing is most commonly defined as proposed by the 1999 CICA/AICPA committee:

A continuous audit is a methodology that enables independent auditors to provide written assurance on a subject matter, for which an entity's management is responsible, using a series of auditors' reports issued virtually simultaneously with, or a short period of time after, the occurrence of events underlying the subject matter.

The difficulty of delineating the area of continuous auditing is manifested by the significant efforts spent in the academic literature (Vasarhelyi and Halper 1991; Vasarhelyi et al. 2004; Rezaee et al. 2002) on defining the distinction between continuous assurance and continuous auditing and how both differ from traditional audit. Alles et al. (2002) define continuous auditing as the application of modern information technologies to the standard audit products, be they the mandated annual audit opinion or internal IT audit. By this view, continuous auditing is another step on the path of the evolution of financial audit from manual to systems-based methods. The literature on continuous auditing can restrict itself to technical matters, working under the assumptions that the demand for the mandated audit is a given and that the emerging technologies will be adopted because they are cheaper and more effective than the current audit methods.

By contrast, continuous assurance sees continuous auditing as only a subset of a much wider range of new, nonstatutory products and services that will be made possible by these technologies. Elliott (1997, 2002) has been the most forceful proponent of this wide view of CA, stating as long ago as 1997 that "Online reporting based on databases updated in real time will be less wedded to current protocols for periodicity, creating a parallel evolution toward continuous auditing. Continuous auditing may lead to continuous reporting that supplements and eventually replaces the annual audit report." Subsequently, with the scope of such services expanded by the AICPA from auditing to assurance, Elliott (2002, 7) went on to say that "The advantages of electronic business reporting will provide a market for—indeed, the necessity of—continuous assurance."

Alles et al. (2002) subjected this view to an economic analysis and recognizing that assurance is driven by business necessity rather than being an inevitable outcome of technology. They postulated that CA is more accurately described as "auditing on demand" and questioned whether that demand existed. Shortly afterwards, the passage of the Sarbanes-Oxley Act, especially its Section 404 requirements for assurance over financial reporting controls, validated the view that demand would be the driver of CA.

However, what was not anticipated by Alles et al. (2002) and other writers prior to the passage of the Sarbanes-Oxley Act was that it would be internal rather than external auditors who would be the main champions of CA. The reasons were twofold. First, external auditors

were overwhelmed with doing Section 404 work and so had no time to spare for developing new CA methodologies, while internal auditors, who also had to find resources to take on new Section 404 responsibilities, saw in CA the means of reducing the headcount demands of their existing tasks. Second, Sarbanes-Oxley Section 201 strengthened the independence standards on external auditors and there was great concern that CA would violate those constraints, while internal auditors obviously faced no such restrictions.

In particular, an important component of continuous assurance is what Alles et al. (2006) call "Continuous Control Monitoring," which is the application of technology to the continuous monitoring of internal controls of business processes. This is often driven by management needs, as opposed to the requirements of external auditors, and so typically can only be carried out by internal auditors.

In contrast to the academic literature, practitioners seem to attach less significance to what "CA" means, with definitions mattering less than the application of CA techniques and the value they create. The roles of internal and external auditors in implementing CA have been determined in practice depending upon the particular circumstances of each individual firm, and without the use of any overarching framework defining responsibilities and boundaries. Academic research will help that process, which will ultimately be shaped by market forces and regulatory action, by both developing a conceptual model of CA and by drawing together the unifying lessons from independent implementations of CA.

In the early days of CA, the ultimate ideal was the eventual development of the "push button audit," in which auditing functions somewhat analogously to the way in which virus protection software automatically protects a PC today with little intervention from the user. This overly optimistic vision of the potential of CA is due to the focus on the extraordinary possibilities of modern information technology and its rapid rate of change. But business practices, let alone the mindsets of the people involved, change far more slowly, and only in response to proven value added. That makes pilot implementations and the role of academics in creating and disseminating the lessons learned essential to the development of CA.

IV. LESSONS FROM PILOT PROJECTS

Our theoretical research has been driven by the perspective that the uniqueness of CA is in a fundamental rethinking of auditing for a modern information technology-based economy, in which auditors have access to business process data at a *far finer granularity in time and detail* than ever before (Vasarhelyi et al. 2004; Vasarhelyi and Greenstein 2003). Everything else, including the ability for more frequent reporting, is a byproduct of this fundamental change in the basis of auditing. At the same time, in our field studies we have generally followed the approach of grounded theory (Glaser and Strauss 1967), as lessons learned from practice are incorporated into our theoretical understanding of CA.

Rather than repeat, however, the trial and error methods by which our research agenda proceeded, extending over several years and across multiple industry interactions, in this review we will use the power of hindsight to put that research into a broader perspective. In particular, we will focus on two major pilot CA projects that we led, one at Siemens USA and the other at HSP. While small in scale, both projects aimed not just to help out these particular firms, but to develop broader lessons that would apply to CA in general. These projects examine two essential facets of the CA conceptual model:

- (1) **Siemens:** Since the minimum requirement for continuous auditing is the automation of assurance, but practicality requires beginning with how auditing is done today, as opposed to starting from scratch with a clean sheet approach, *what are the*

challenges and possibilities in transforming manual audit procedures for use in a CA environment?

- (2) **HSP:** If the underlying basis of CA is giving auditors access to data at an unprecedented level of disaggregation, *what audit procedures become feasible, efficient, and effective when data availability is no longer a constraint?*

This is only a subset of the projects undertaken on CA by us and by others, but they get at the central issues in the area: how will CA transform auditing practice and how will we get there from here?

The two studies reviewed in this paper were chosen to investigate two very different environments for continuous auditing: one with highly automated business processes heavily reliant on modern integrated ERP systems, and the other with a fairly low level of automation and mostly legacy system landscape. Because of the underlying difference in the environments, the projects focused on different aspects of continuous auditing. By analogy with conventional auditing, continuous audit procedures can be designed either to test internal controls (Alles et al. 2006) (continuous control monitoring) or to execute substantive testing (including analytical procedures) (continuous data assurance) (Alles et al. 2007). Therefore, from the procedural point of view, we divide continuous auditing into two distinct, but complementary aspects:

$$\begin{aligned} \text{Continuous Auditing} &= \text{Continuous Control Monitoring} \\ &+ \text{Continuous Data Assurance} \end{aligned}$$

The remainder of the paper examines these two components of CA in detail, which together help answer the question: how will CA transform auditing practice and how will we get there from here?

V. THE SIEMENS PROJECT: CONTINUOUS CONTROL MONITORING

Siemens has over 460,000 employees and total global revenues exceeding USD95 billion in 2005.⁵ In the United States Siemens employs some 70,000 people in divisions spread throughout the country, generating in excess of USD20 billion in sales. We have been working with the U.S. IT internal audit group to:

- (1) Investigate the extent to which CA techniques can be applied to their existing audit process.
- (2) Help implement an automated CA system that frees up internal audit workforce.
- (3) “CA-enable” established manual audit procedures by reengineering them.

Alles et al. (2006) provides a detailed overview of the progress made on the first two of these objectives while work continues on the third goal. Siemens is one of the most SAP-enabled firms in the world. A downside as far as internal audit is concerned is that with over 60 SAP installations spread throughout the United States alone, each site can be audited no more often than once every two years. The SAP IT audit process has to cover all the major SAP modules and is highly labor intensive. Each audit takes nearly 70 person days and requires a large audit team to travel to the site at great expense, both financial and personal.

Apart from the obvious desire to increase the efficiency of this process, another key driver of interest in CA by Siemens was the anticipated demands of implementing Section

⁵ Available at: www.Siemens.com.

404 of the then-recently passed Sarbanes-Oxley Act. The challenge IT Internal Audit was presented with by senior management was to cope with the additional burden of Section 404 while not adding to headcount. CA was seen as a promising tool for at least reducing the workload of the audit team when carrying out the existing tasks, which could then be redeployed to Section 404 work. Ideally, the CA methodology would itself be considered Section 404-compliant, thus leveraging the value added.

Working with Siemens presented an excellent opportunity to test how CA would move from concept to implementation. Vasarhelyi et al. (2004) predicted both that ERP-enabled firms are the environments most suited to first deploy CA, and that the course of the implementation would begin with automation of existing audit procedures and then, once the feasibility and value added had been demonstrated, move on to the reengineering of the audit to make it more CA-ready:

The experience with the evolution of new technologies and business processes suggest that CA will initially be used to do no more than automate existing audit procedures, and thereby take full advantage of the capabilities that it has in the new ERP-based environment ... [The] second stage of its evolution [will be reached] when audit processes are reengineered to exploit the underlying technological capabilities to the fullest ... However, to reach that stage will require more than technology implementation. For one thing, it will necessitate auditors actually examining their processes to see if they are susceptible to process mapping and reengineering. (Vasarhelyi et al. 2004, 19–20)

This is hardly an independent test of these predictions since the authors were actively involved in planning for the implementation. Nonetheless, the project had an internal logic of its own, largely driven by the fact that the audit of each SAP instance is based upon an audit manual consisting of predetermined procedures. These procedures consist of several hundred *Audit Action Sheets* (AASs) which describe in considerable detail what the internal auditor is supposed to test for in each SAP site. These are prescribed for each SAP module and guide their grading. The pilot CA system aimed at automating the existing AASs, as opposed to a clean sheet re-imagining of how the SAP audit should be undertaken using CA.

In order to illustrate what automating an AAS procedure involves, consider the following example, which requires the auditor to check the proper settings of access controls.

Rating Criterion:

The RSPFPAR report lists all basic system parameters for password creation:

- (1) login/min_password_lng (minimum password length has to be eight characters)
- (2) login/password_expiration_time (password has to expire after a maximum of 90 days)
- (3) login/fails_to_sessions_end (is the number of illegal login attempts before the session is aborted set to three?)
- (4) login/fails_to_user_lock (the number of failed login attempts before system lock-out should be set to a maximum of five)
- (5) login/failed_user_auto_unlock (is a system lockout automatically cancelled overnight? recommended setting = 0)

Rating Notes:

Inadequate protection for SAP access (authentication problem) may be provided internally by company staff or by external parties to whom network access has previously been granted. If the IS Guide is not followed, the rating should be 0 = very significant

noncompliance. If the respective parameters (see above) have the recommended settings, the rating should be 4 = no noncompliance. In the case of partial compliance, depending on the settings made, rate the audit action sheet 2 = noncompliance.

The Rating Criterion section of the AAS outlines five specific criteria for the SAP access protection. The Rating Notes specify how the internal auditor is to grade the SAP instance on this particular test.

This example demonstrates the challenges in taking an AAS designed for an auditor who is able to draw upon experience and guidance and exercise judgment when conducting and evaluating an audit procedure and transforming it into one that can be undertaken automatically by a CA system. For example, while the scoring system described in the rating notes is clear if all or none of the five criteria are met, the auditor would need to make a subjective judgment as to what is the appropriate score if one or two of the variables are not properly set. Moreover, while the sheet mentions only ratings of 4, 2, and 0, depending on the circumstances, the auditor is free to exercise her or his judgment and assign the intermediate ratings of 1 or 3 as well. The incompleteness and ambiguity of these rating notes is symptomatic of almost all the scoring criteria used in the AASs, which arguably are actually better specified than most typical manual audit program scoring models.

The AASs also call upon the auditor to interview the client to gain an understanding of methodology and risk-based strategy behind the emergency authorization of a password. The interview would cover such ground—obvious to a human auditor—as what constitutes an emergency, who in particular should be granted the password, the extent and time frame for the access, and so forth. But again, this critical additional information which puts the AAS ratings into context cannot be readily incorporated into an intelligent software model without adding significant complexity and effectively capturing management's thinking process.

AASs ranged from clearly automatable to those obviously necessitating human judgment. The AAS procedures which required significant subjectivity and such human intervention as management interviews for gathering input were left intact, on the assumption that enough automatable AAS procedures remained that the time saved on them could be redeployed to procedures where people are indispensable.

Vasarhelyi et al. (2004) and Alles et al. (2002) both speculated on what value proposition would justify CA, ranging from better audits to cheaper audits. But the actual argument that Siemens internally used to justify the research effort was the need of labor savings through automation, leaving aside any increase in audit effectiveness through greater frequency of audits or the possibility of eventually expanding the scope of the CA system.

The implementation of the CA pilot proceeded on the basis of the following set of steps based on Vasarhelyi et al. (2004):

S1: Determine the best mode for the continuous monitoring of the chosen controls.

S2: Develop system architecture for this task, whether by using a monitoring and control layer or some sort of embedded audit module.

S3: Determine the interaction and integration between the CA mechanism and the ERP system.

- S4:** Develop guidelines for the formalization of the AASs into a computer-executable format. In particular, determine which AASs are automatable and which require reengineering.
- S5:** Create processes for managing the alarms generated by the automated CA system and put in place the required set of audit trails.
- S6:** Formulate a change-management plan to move the project from the pilot stage to industrial-strength software.

Step S1 concerns the important question of how one determines whether control procedures are being followed, which is essentially the mandate of the internal audit group. There are three possible approaches, each with their strengths and weaknesses:

- (1) *Verifying that data based on observations of a process subject to a control agree with the existence, correctness, and functioning of that control.* The advantage of this approach is that it can be applied even if the controls are not directly accessible by the auditor, but the problem is that the observed behavior may not completely cover the whole range of control functions and so typically cannot give a definitive answer as to whether the control is working.
- (2) *Verifying by executing a prohibited behavior that it either cannot happen or is detected and compensated for.* The problem with this approach is that the auditor typically has read-only access to the firm's production IT systems. Such "penetration testing" is common with IT professionals themselves, but they jealously guard such high-level access in order to protect the integrity of the firm's production data. That is why "penetration testing" of production systems is hardly ever utilized by the auditors.
- (3) *Verifying that retrieved automatic control settings stored in the enterprise system match the benchmark.* The drawback with this approach is that its effectiveness depends entirely on whether the benchmark for what the control setting should look like is correct, and that a system running under those settings implements correctly the automatic control's logic. The advantage is that it can be executed on the basis of read-only access to the production system.

The adopted approach was driven by the high level of control automation at Siemens (in their SAP instances) and on the initial decision to design the CA system around the AASs, given that many of the procedures on the AASs fall into the third category of comparing control settings against a standard. The CA team's approach was to determine which of the control setting tests could be automated, so freeing up the time of the human auditors to focus on the observations of behavior and policies at a particular site.

The adoption of continuous monitoring of automated business process control settings as the mode of continuous control monitoring is a novel contribution of the project. This approach could not be utilized systematically in the past because the extent of automation of business process controls was extremely limited, if any. The current high level of business process automation in leading companies such as Siemens makes this approach both feasible and very attractive at present, while the ongoing broad advances in business process automation across many industries will likely make this approach prevalent in the future.

The approach to the second of the CA steps, S2, was also to mimic the manual audit procedures as much as possible by using the architecture of a monitoring and control layer as opposed to an embedded audit module (EAM). Indeed, in general CA systems have

rarely used the EAM approach, despite the initial excitement over their potential (Groomer and Murthy 1989) as the reality of protecting the integrity of the firm's IT systems from excessive interference sank in. In this case the internal auditors relied on data about SAP control settings extracted in batch mode from the SAP system by a proprietary tool known as E-Audit. Its output was a text file which internal auditors would manually examine when completing the AASs.

The challenge the CA team faced was in parsing the E-Audit output (to convert from being "machine readable" to "machine understandable") and under step S3, in determining protocols for how often extractions would be undertaken, since there is no longer any reason to stick to the multiyear approach necessarily adopted in a manual audit.

The real focus of the project was, however, S4 in the generic set of CA procedures, the development of guidelines for the formalization of the AASs into a computer-executable format. This requires determining which AASs are immediately automatable and which require reengineering. The object of reengineering is to see whether some of the AASs that do not appear at face value to be automatable can be made so by reconfiguring or formalizing them to make them more specific. Only if reengineering fails, it can be concluded that this particular AAS has to remain in the human intervention domain. Thus for example, if the AAS specifies that an interview be conducted, the CA team has to determine whether the object of the dialogue is to obtain a specific piece of machine-readable data, or something more abstract such as determining the "tone at the top."

Part of this process involved shadowing an actual internal audit to see what the distinction is between how the audit is supposed to be conducted based on the AASs and what really happens in the field, taking as given the reality that the latter may somewhat diverge from the former. One particular issue has to do with compensating controls, with the field auditors issuing a passing grade despite the site failing a particular test because they are aware that the subject of that particular test is covered by another test elsewhere. An experienced human auditor can easily incorporate this level of complexity into the audit procedure—taking into account circumstances that are so site-specific that they cannot be written into the generic AASs—but that is a hard challenge for a CA system to factor in without a costly process of customization for each and every site.

Indeed, in their onsite observations of Siemens' auditors undertaking engagements throughout North America, the researchers realized that whole subsets of the AASs were not even examined because the experienced auditors knew that these were designed for Siemens applications in China and had no relevance elsewhere. These are the types of domain-specific knowledge that any CA system will have to incorporate, first and foremost, through extensive observation and structured debriefing of those experienced auditors, especially with regard to actions they take that are not defined explicitly in the formal AASs, such as compensating controls and other exceptions to the control set.

The initial pilot focused on the AASs relating to the Basis system of SAP (the application layer operating system for SAP) since controls in this area are applicable to any SAP system. After examination of the 25–30 AASs in this set, 12 were chosen as representative of the challenges in automating and reengineering. A machine-readable form of E-Audit output provided the input data and a pilot was developed in Visual Basic to serve as a test environment for evaluating technical research questions. Producing an industrial-level piece of software was outside the scope of this project, but the research team did develop a prototype in Visual Basic to show what a CA system would look like, building in the capabilities an internal auditor would need it to have in practice. The grading system from the ratings notes of the AASs is a subset of this system's capabilities, but the ability

for more general forms of grading aggregation, including propagation of critical failures and weighted grading, is also built in.

A critical issue in the use of an automated CA system is creating protocols for dealing with detected exceptions as step S5 in the CA implementation methodology. The system is designed to generate alarms that will alert the auditor through emails, instant messages, or automated phone calls that a problem has arisen. The problem is not with communication, however, but in ensuring that “alarm floods” do not overwhelm the attention span of the human auditor, thus undoing the objective of automation in the first place. Unfortunately, even in the best-run firms, there are likely to be a significant number of alarms generated on a regular basis simply because of the complexity of any ERP system and the needs of a dynamic business to adjust the system’s settings to take changes in personnel, products, and markets into account.

Alarms floods will be especially prevalent in the immediate aftermath of the changeover to CA from a manual system, and that will inevitably require a large commitment of human resources to deal with one-time exceptions. Once the CA system settles down to a steady state, the alarms flood is expected to subside, but dealing with alarms also has to be automated to the greatest possible extent if the benefits of automation of assurance are to be sustained. This will require the creation of a parallel alarm classification hierarchy that assesses whether the exception is trivial or material, aggregates and rolls up alarms and determines when the threshold for human intervention is reached. The process for handling alarms is clearly a very complex subject that warrants further research, and the insight into the role of alarms in CA is an important finding from the Siemens project.

Alles et al. (2006) provide much more detailed coverage of the many aspects of the Siemens project up to mid-2005, and work continues on extensions. One initiative that is being planned is to precisely quantify the extent to which CA techniques can be used to transform existing manual audit systems. Once classification is completed of all the AASs for a particular SAP module, the next question that will arise is whether the degree of automation of the AASs is stable or variable across the numerous SAP modules, and then across firms.

This project remains within the IT internal audit domain. A much more challenging task is to extend CA techniques to the standard financial audit, an area where existing audit methodologies go well beyond data extractions from the firms’ ERP systems. A new approach toward CA will undoubtedly have to be developed if this highly manual process is to be successfully CA-enabled. This ambitious project is still in the early stages of feasibility planning, but the fact that Siemens continues to want the research team to help with these new assignments is indicative of their estimation of what has been accomplished thus far.

But our focus in this paper is on the lessons learned. Clearly the automation of 12 AASs and a Visual Basic prototype is not a full-fledged CA system, and nor was its creation the objective of the project. What was accomplished was the proof of concept that existing manual procedures can be the starting point toward the automation of assurance that is the basis of CA. This project provides initial supporting empirical evidence to theoretical predictions in Vasarhelyi et al. (2004) and others that being ERP-enabled helps to implement CA.

What this project also demonstrated, however, was that tools by themselves are insufficient without the audit model being in place to make use of them. The emerging CA commercial software offers far more powerful data-extraction tools, for instance, than the modified E-Audit mechanism the research team developed, but until the AASs are classified

and modified the audit cannot be turned over from the manual auditors to a system like the one presented here. That technological capability has to be preceded by a clear change-management plan that takes into account the various important stakeholders, such as the external auditors and senior management, which in the case of Siemens, meant those at the corporate HQ in Germany. Moreover, CA software, however sophisticated it may be, does not give the firm a CA capability, unless its output is officially accepted as providing the exact assurance that the auditors, both internal and external, require.

The experience with ERP implementations indicates (Vasarhelyi et al. 2004) that the road toward successful large-scale implementations of CA will be a challenging one. Developing the necessary software in-house will not be a viable option in most cases, and the implementations will have to rely on commercial packaged CA software. Over time, as CA software matures and becomes standardized, it will likely follow the trajectory of ERP in incorporating best business practices and industry-specific modifications of their packages. This will create an opportunity for the firms to reexamine their audit programs at the time of CA implementation. While the Siemens project discussed here faithfully automated certain parts of the existing audit program, attempting to accomplish the same on a large scale and using packaged software will in most cases necessitate significant customization of CA packages, which will be costly, time-consuming, and nonmaintainable in the long run. Given the availability of effective industry-specific audit programs in CA packages, it may be more cost efficient to reengineer the audit program to match the software rather than to customize the software to each firm's individual audit process.

The Siemens experience indicates that in environments characterized by highly automated business processes, CA can be defined as a process that continually tests controls based upon criteria prescribed by the auditor and identifies exceptions for the auditor to perform additional procedures. This definition recognizes that while "Continuous Control Monitoring" or CCM is viewed as a management function, auditors may likewise perform a continuous monitoring function of the internal control environment. That is to say, to have a process in place to continually test management's monitoring processes of internal controls.

Bringing continuous monitoring of control settings into the CA conceptual model is the contribution of the Siemens project, an achievement that can be put into perspective when one considers that the monitoring of control settings was not mentioned in earlier work defining CA, such as the AICPA/CICA red book, or Alles et al. (2002). But recognizing that CA encompasses CCM is essential in the wake of Sarbanes-Oxley Section 404. The other leg of the conceptual model is the treatment of transactional-level data, and that was the subject of the parallel HSP project.

VI. THE HSP PROJECT: CONTINUOUS DATA ASSURANCE

HSP is a large national provider of healthcare services, composed of locally managed facilities that include hundreds of hospitals and outpatient surgery centers all over the U.S. and overseas. One of the largest employers in the United States, the company has billions in revenue. A key strategic driver for HSP is the management of their supply chain, which encompasses a large number of warehouses around the country supplying the firm's health providers with everything from paper towels to heart/lung machines.

We started to work with HSP internal audit in 2002 on a joint project to improve the assurance they could provide over their supply chain. What they could provide us was extracts from their corporate data warehouse, which, while only a sample limited in time

and geography, still encompassed megabytes of data, much more detailed than anything typically examined in a standard audit.

The datasets include all procurement cycle daily transactions from October 1, 2003, through June 30, 2004, for a portion of their supply chain. The number of transaction records for each activity ranges from 330,000 to 550,000. These transactions are performed by ten facilities of the firm including one regional warehouse and nine hospitals and surgical centers. The data was first collected by the ten facilities and then transferred to the central data warehouse in the firm's headquarters. While not analyzed in real time, the extent of this data mimics what a CA system would have access to, and so it provided an opportunity to examine how an auditor can provide better assurance when she or he has access to highly disaggregate data.

Unlike the Siemens environment, HSP's system landscape was mostly based on legacy systems, which were only loosely interconnected, and having few, if any, automated business process controls. Such enterprise system technology makes the CCM approach (utilized in Siemens) toward implementing CA infeasible. This is the reason why in this case we based our CA approach on continuous data assurance. The main prerequisite for implementing continuous data assurance is unconstrained access to raw business process data, which can be extremely problematic, if at all possible, in a disparate legacy systems environment. What made the implementation of CA possible in this case was HSP's deployment of a modern business data warehouse, where the raw transactional data was uploaded overnight by the source's legacy systems. The internal audit department has full-read access to this data warehouse, and the dataset provided to us was extracted from it. Thus, our automatic audit procedures executed on this dataset represent a simulation of what a continuous data assurance system can do if provided with direct access to this data warehouse.

The classical definition of CA, with its emphasis on the frequency of reporting, is silent on how audit methodology will have to change if it is to take advantage of an unconstrained data environment. It is important to note that much of existing audit methodology is driven precisely by lack of data and the cost of accessing it: hence, auditors do sampling, establish materiality thresholds for investigations, and carry out analytical procedures before substantive testing so that they can focus only on likely trouble spots. Will any of these familiar practices survive in an age of digital firms with close to trivial costs of data storage, access, and communication? The scope of auditing is driven not only by what evidence is available, but also whether there exist benchmarks—the “established criteria”—to compare that audit evidence against. Those benchmarks provide guidance about what the data is supposed to look like when drawn from a firm operating without any anomalies.

The HSP project examined the hypothesis that what access to a much broader data stream makes possible is the testing of audit evidence at a highly disaggregate level by the establishment of audit benchmarks with an unprecedented degree of correspondence to underlying business processes. Business processes (BP), which are defined (Davenport and Short 1990) as “a set of logically related tasks performed to achieve a defined business outcome,” are considered today to be the fundamental atomic elements that make up a company and drive its strategy, as opposed to its fixed assets or employees, as might have been the case in earlier eras (Porter 1996).

Modeling processes requires data at a highly disaggregate level, far below the level of account balances that are used in standard audit analytical procedures. With access to that full richness of the dataset, it is feasible to create the process-based audit models using as benchmarks *Continuity Equations* (CE), which we define as *stable probabilistic models of*

highly disaggregated business processes. Continuity equations are commonly used in physics as mathematical expressions of various conservation laws, such as the law of the conservation of mass.⁶ In the continuity equation metaphor, each business process is analogous to a control volume made up of a variety of transaction flows, or business activities. If transaction flows into and out of each business process are equal, it would be in a steady state, free from anomalies. If spikes occur in the transaction flows, the steady state of the business process cannot be maintained.

Monitoring the content of a firm's data flow against continuity equation-based benchmarks focuses on examining both exceptional transactions and exceptional outcomes of expected transactions. Ideally, CA software will continuously monitor company transactions, comparing their generic characteristics to observed/expected benchmarks, thus identifying anomalous situations. When significant discrepancies occur, alarms are triggered and are routed to the appropriate stakeholders.

Using the HSP data, we demonstrated that CEs can be used to calculate the expected values of business process metrics, as well as the acceptable levels of variance. Any deviation of the observed value beyond the acceptable range derived from the CE represents an anomaly that has to be investigated further by the auditors. Business process metrics used in CEs can be both financial (such as the dollar amounts of daily purchases) of the sort which are commonly used in auditing, and nonfinancial (such as the quantity of items ordered, or the number of purchase orders placed) which are more common in engineering and statistical process quality control.

The HSP project focused on inferring CEs for a subset of the company's business processes, those relating to purchases, which is clearly a key strategic process considering the nature of the firm. By way of example, we construct a workable CE by beginning with the most generic representation of that process.

If a company has a strictly enforced business rule that no deliveries are to be accepted without a cross reference to a purchase order, then one can infer the existence of a deterministic relationship between the counts of purchase orders (P.O.s) sent and of shipments received:

$$\# \text{ of shipments received} = \# \text{ of P.O.s sent}$$

Certainly, for a given transaction, either the shipment received is matched against a P.O. or it is not, but the objective here is to examine whether the relationship holds in a dataset measured over a given time period, and for a specified subset of the firm. These measurement and aggregation aspects significantly affect what the underlying structural relationship looks like as a CE.

It may seem to be defeating the purpose to aggregate data in data-level assurance, for aggregation inevitably leads to a loss of information about individual transactions. One has to keep in mind that our continuous data assurance system includes two stages. In the first stage (which is described in more detail later in this paper), various automatic tests are applied to individual transactions to verify their integrity. These tests can be viewed as CA-analogs of manual tests of details. Then, in the second stage we utilize CEs (based on aggregated business process metrics) to provide additional assurance on the overall behavior of business processes. Aggregation can be thought of as removing idiosyncrasies and irrelevant variation. The debate over how and to what extent to aggregate transactional data

⁶ For a control volume that has a single inlet and a single outlet, the principle of conservation of mass states that, for steady-state flow, the mass flow rate into the volume must equal the mass flow rate out.

is as old as accounting itself and its use of ledger accounts as a means of summarizing data. The difference is that with the technical ability to process very large datasets, the degree and nature of aggregation is now a choice that is open to accountants to make, rather than one forced on them by the constraints of information technology.

In this case the raw transactional data can be aggregated over a range of time periods, including a year, a quarter, a month, a week, a day, an hour, or a minute. Clearly, in most settings, measuring whether the CE holds over a minute, or even over an hour, makes no business sense, while daily counts can be readily available in modern ERP (or even most legacy) environments. Some business processes have a natural time frame: for example, certain billing cycles accumulate for a month, some shipping processes promise to ship the same day, and certain payable processes require daily review to take advantage of discounts.

Another important dimension of measurement is the business subdivision for which the relationship is examined. Should the data for the CE pertain to the whole company, or to its major subdivisions, or only individual facilities? Similarly, the CE's domain can be restricted by vendors and/or products, any of these representing the advantages to the auditor of having the choice of aggregation. More generally, data does not have to be aggregated over time, but could be measured on such other dimensions as geography; for example, by warehouse. Alternative modes of aggregation were another important avenue of investigation in this study.

The more disaggregate are the metrics which are related by the continuity equations, the more accurately likely problems can be pinpointed; for example, to breakdowns in the supply chain process at a given facility, or over a particular period of time. On the other hand, highly granular metrics tend to have less stability as opposed to their more aggregate counterparts. The constraints of the traditional audit technology typically limit substantive testing either to analytical procedures performed at the highest level of aggregation (corresponding to the general ledger accounts) or to a very cumbersome random manual verification of transactions at an individual level. A major innovation of CA consists in enabling the application of analytical procedures to the intermediate levels of aggregation. In our example, the counts of P.O.s and shipments can be daily aggregates corresponding to a warehouse serving a defined geographic region.

Another important factor that differentiates a real world CE model from a theoretical business relationship is the lag between the time periods of the aggregates. Most business processes have nonzero latency. For example, it usually takes at least several days before a shipment is delivered on a P.O. Since the auditor measures whether the relationship holds in aggregate over a given time period, it is important to allow for an appropriate lag between the dispatch of the P.O. and the arrival of the shipment. This has to be reflected in the CE by the explicit introduction of the time lag δ , so that if we index the daily aggregates by t , then the resulting equation looks like:

$$\# \text{ of shipments received } [t + \delta] = \# \text{ of P.O.s sent } [t]$$

What is the value of δ ? This is an empirical question, and in some analytical modeling methods before a CE can be set up the time lags have to be determined from the past data. However, a closer look at the past experience will typically reveal that not all the received shipments had exactly the same time lag. Therefore, when considering aggregated transactions, the only possibility is to estimate the time lags statistically; for example, as the average latency of the corresponding business processes. The variations in the process latency imply that the CE does not hold deterministically since some shipments are delivered earlier while some others are delivered later than the average value of δ used in the

equation. Moreover, if the business accepts partial deliveries on purchase orders, the total number of shipments usually exceeds the total number of purchase orders. However, on the average, one may still expect to find a statistically stable relationship between the number of shipments and the number of purchase orders:

$$\# \text{ of shipments received } [t + \delta] = \alpha \{ \# \text{ of P.O.s sent } [t] \} + \varepsilon$$

Here ε is a random residual and α is a model parameter.

In the reality of interrelated business processes, purchasing does not exist in isolation, but eventually leads to paying vendors on their invoices. Therefore, purchasing metrics should be related to payment metrics. More specifically, one can expect a stable statistical relationship between the number of shipments received and the number of payment vouchers processed, which, after taking aggregation and time lags into account, can be combined with the purchasing CE to yield a system of simultaneous equations:

$$\# \text{ of shipments received } [t + \delta_1] = \alpha_1 \{ \# \text{ of P.O.s sent } [t] \} + \varepsilon_1$$

$$\# \text{ of vouchers processed } [t + \delta_1 + \delta_2] = \alpha_2 \{ \# \text{ of shipments received } [t + \delta_1] \} + \varepsilon_2$$

Taking into account such situations as partial deliveries and vendor's aggregation of multiple purchase orders into a given delivery, one cannot have any prior expectation about whether the coefficients α should be greater than or less than 1, nor what the range of lags one will observe in the delivery and ordering pattern. Hence, both the coefficients α and the lags δ should be estimated from the past data. Note that the choice of the value of the time lags will critically affect the estimate of the coefficients and the stability of the relationship. While the average latency may be a good starting point as the value of δ , some experimentation may be needed to determine the statistic for δ which results in the most stable relationship.

Estimating CE systems of this level of complexity requires powerful statistical techniques which allow for dynamic sets of CEs with multiple time lags and feedback loops. Thus the theoretical model of the purchasing system is transformed into an audit benchmark through the estimation of its parameters and the subsequent generation of estimates to compare against the audit evidence. While the development of such models and the choice of proper statistical methods for their estimation require very significant expertise and effort, these issues will not become the burden of regular audit team members, since they will be solved at the implementation stage of the CA engagement by the subject matter experts. This initial implementation can also incorporate special techniques to adapt the constructed analytical benchmarks to the future changes in the business process. To achieve this, the system can be designed to re-estimate automatically the model parameters using the sliding window of past business process data. The data used in this re-estimation should have already passed the verification stage to make sure that possible errors do not contaminate the audit benchmark. Such automatic model adaptation is absolutely critical given the dynamic nature of the modern business environment.

In the HSP case we examined three different estimation methodologies for the purchasing model: Simultaneous Equation Modeling (SEM), Vector Autoregressive Models (VAR), and linear regression. The SEM can model the interrelationships between different business processes simultaneously while the linear regression model can only model one

relationship at a time, but the latter is obviously less computationally demanding. Alles et al. (2007) discuss these estimation models and how the comparison was made between them in great detail. The results confirm that joint analysis of business processes gives the auditor an analytical procedure with a robust capability to detect anomalies in a real-time continuous auditing environment with highly disaggregated data. While the preliminary conclusions of the project are that more complex CE models, such as VAR, provide benefits of greater prediction accuracy and error detection ability, it is the nature of the data that serves as audit evidence that is the primary driver of audit effectiveness, with the selection of the specific analytical procedure a second-order concern—not because the audit benchmark is not important, but because auditing at the process level makes errors stand out much more obviously in the data.

Another important takeaway from the project concerned the need to develop new audit methodologies to deal with data of this scale. The issues concerning the choice of aggregation and the selection of time lags have already been mentioned. Even with access to the universe of data, it should not be used only in its most disaggregate form because the usual imperatives for aggregation, such as reducing idiosyncratic variation, still remain. But the point of not being constrained to use data that is already at a high level of aggregation, such as account balances, is that the auditor can make the tradeoff between improving data quality by appropriate aggregation versus the resulting loss of information content, as opposed to being forced to accept the limitation of the data imposed by outside circumstances.

The CE techniques fail to fall neatly into the classification of audit techniques in current use, such as tests of detail or analytical procedures. They are similar to the former in that they provide data-level assurance based on disaggregate data, but operate more like the latter in that the CE is an analytical benchmark used to compare against the audit evidence.

Statement on Auditing Standards (SAS) No. 56 requires that analytical procedures be performed during the planning and review stages of an audit, and recommends their use in substantive tests in order to minimize the subsequent testing of details to areas of detected concern. That sequence is logical in the manual audit because of infeasibility of applying tests of detail to all the firm's transactions. By contrast, if certain tests of detail are automated in CA, there is no reason to limit their application only to a sample of firm's transactions. Moreover, if a CE is inferred using the data that is in error or has anomalies, then the benchmark builds them in and becomes contaminated. Hence, in the HSP project an important step was the formalization of certain transaction integrity requirements as automatic tests of details of transactions, and filtering through these tests the stream of transactions to clean up the dataset before its use to estimate the CE. A particular problem is that at HSP, unlike at Siemens, the data is uploaded to the data warehouse from numerous underlying legacy systems which lack many of the automated controls present in modern ERP systems. Not surprisingly, then, there are numerous transaction integrity issues.

Two categories of records fail our transaction verification tests and are removed from our datasets: those that violate data integrity and those that violate referential integrity. Data integrity violations include purchase quantities, receiving quantities, and check numbers. Referential integrity violations are largely caused by many unmatched records among different business processes. In a sense, our approach of applying formalized transaction verification tests to clean up data before estimating the CEs reverses the recommended procedure in SAS No. 56, because we effectively conduct automated tests of detail before undertaking analytical procedures (though in reality, auditors also examine data before proceeding to do analytical procedures). This is but one indication of the potential modifications to established audit procedures that data-level CA will likely necessitate.

Another important distinction between CA techniques and standard auditing that was explored in this project is what we call “Real Time Error Correction.” In a CA environment, when an anomaly is detected, the auditor will be notified immediately and a detailed investigation will be initiated. In theory, the auditor will then have the ability to correct the error before the next round of audit starts.

Whether this technical possibility can or will be carried out in practice depends both upon the speed at which error correction can be made and the more serious issue of the potential threat to auditor independence of using data in subsequent tests that the auditor has had a role in correcting. These issues clearly require detailed consideration, but what we focused on at this stage was quantifying the benefits of real-time error correction in a CA environment. For comparison purposes, we examined how well our CE models worked with and without the error correction. The conclusion was that real-time error correction improved the ability of the benchmarks to detect anomalies in the audit evidence across all three CE models, which means that it is now time to begin examining the practical and regulatory feasibility of adding that tool to the CA audit toolkit.

Another issue that arises only in data-rich settings is the ability to increase model accuracy by continually expanding the sample data used for estimating the CEs as more data comes in. The alternative is to keep the data window constant but keep shifting it forward in time to accommodate new data, in a way analogous to the calculation of a moving average. Which of these methods is most appropriate is a function of how stable or dynamic the underlying business processes are, and this is an important topic for future research.

An important issue yet to be addressed is the feasibility of using these CE models in practice. For CEs to become an essential component in future CA systems, they will have to be sufficiently easy to implement, which means that generic CE models developed in the laboratory must be generally applicable to different firms and processes. Testing the robustness of the CE models created using HSP data on other datasets is on our research agenda, beginning with supply chain data from Siemens and then extending to processes from other business areas.

Dealing with more data rather than less, in real time as opposed to archival, will become a necessity once stakeholders recognize that traditional audit methodologies are essentially throwing away the richness of the data that the firm’s IT systems are now making available to the auditor—and that the time frame for the audit is increasingly at odds with the decision cycles of the real-time business. But there are still a great many unresolved issues as to how auditing will have to change to correspond to this new environment of universal, real-time data availability.

VII. DISCUSSION

If a new definition for CA was being prepared today, taking into account the multiple aspects of assurance at the control and data levels would just be the starting point. A new definition would also have to place more emphasis on the role of internal auditors—the drivers of both projects discussed here—as the champions of CA, though as Section 404 work—and perhaps, as concerns about independence—wind down, the role of the external auditor will become prominent again.

But the biggest issue we have learned in this research project is the way in which continuous auditing tends to overlap with operational monitoring by management. When presenting both the Siemens and HSP projects, the immediate question raised by the audience—inevitably, perhaps, given the reduced latency between transaction and assurance

that is the essence of CA—is whether what is being proposed is a tool for internal auditors or for management. Or as another observer asked, is the “only difference between auditing and managing who is doing it”? In other words, perhaps it is better to say that continuous auditing is only a subset of what we might call Continuous Management Monitoring (CMM).

The overlap of assurance with the needs of management is both the greatest challenge and opportunity facing CA. Equating CA with CMM is an opportunity in the sense that it makes it possible to sell CA as a profit driver, with the same information used for both providing assurance and running the firm on a timelier basis. If CMM is a necessary tool for managing a real-time, digital firm, then its creation is a certainty, which means that CA can be “piggybacked” onto that monitoring layer in much the same way as both systems are built upon the firm’s ERP system. Of course that does not mean that there is no need for research into CA, because the needs of auditors cannot be left as a residual from a management control system, but must be built into the system from the ground up if CA is to be fully effective.

On the other hand, the clear danger of CMM dominating CA is the potential to compromise auditor independence. Error correction in the HSP case is but one small, leading indicator of the fundamental problems CA will pose for standard auditing as reduced latency makes it possible for the auditor to intervene in the system and then necessarily audit results affected by his own work. It will certainly be important to take into account other issues raised in these studies, such as the distinction between automation of existing audit procedures and their reengineering, the issues posed by the choice of aggregation and universal data availability, and the importance of electronic communication, as well as such tagging technologies as XBRL.

Surveys such as those conducted by PricewaterhouseCoopers or that jointly undertaken by ACL and the IIA show interest in CA increasing rapidly. Note, however, that while the two surveys present broadly similar findings, the latter survey also presents the very important statistic that 91 percent of audit executives believe that management and business process owners should have responsibility for monitoring internal controls over their business processes—a leading indicator of the prospects for CA in the future. However, only 33 percent of firms already possess the technology to achieve that goal or are planning to implement it in the coming year.

The increasing attention to CA in practice attests that continuous auditing has become an important field of scholarly inquiry. Notably, the Honorable David Walker, comptroller general of the United States, head of the Government Accountability Office (GAO)—and chair of the United States Center for Continuous Auditing, in the plenary speech given at the 9th World Continuous Auditing Conference held at Newark in November 2003, proclaimed his belief that CA is essential to the future of U.S. business and government and that it is vital that business schools focus on it as a matter of priority.

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