Preliminary Observations on Information Technology Needs and Priorities for the Centers for Medicare and Medicaid Services: An Interim Report

Committee on Future Information Architectures, Processes, and Strategies for the Centers for Medicare and Medicaid Services; National Research Council

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Preliminary Observations on Information Technology Needs and Priorities at the Centers for Medicare and Medicaid Services

An Interim Report

Committee on Future Information Architectures, Processes, and Strategies
for the Centers for Medicare and Medicaid Services
Computer Science and Telecommunications Board
Division on Engineering and Physical Sciences

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Preface

Increasingly, the core mission of the Centers for Medicare and Medicaid Services (CMS), an agency of the Department of Health and Human Services, is expanding from one of focusing on prompt claims payment to one of becoming more broadly involved in improving health care quality and efficiency. The requirements for the information technology (IT) systems of CMS are changing as its mission changes, and the efforts to evolve its systems from those designed to support the agency's historical mission come in the midst of a push to modernize the nation's health care IT more broadly. These new challenges arise even as CMS must meet challenging day-to-day operational requirements and make frequent adjustments to its business processes, code, databases, and systems in response to changing statutory, regulatory, and policy requirements.

In light of these and other emerging challenges, CMS asked the National Research Council (NRC) to conduct a study that would lay out a forward-looking vision for the Centers for Medicare and Medicaid Services, taking account of CMS's mission, business processes, and information technology requirements. The statement of task for the project is presented in Appendix A.

The study is being conducted by the NRC Committee on Future Information Architectures, Processes, and Strategies for the Centers for Medicare and Medicaid Services. The committee's 16 members possess a broad range of expertise and backgrounds, including specific knowledge of CMS itself, large-scale enterprise computing, health care policy, health care quality, health care outcomes, large-scale data use and database operations, and health IT. Biosketches of the committee members are given in Appendix B.

The study is being conducted in two phases. The first, which resulted in this interim report, draws on a series of teleconferences, briefings, and an information-gathering workshop held in Washington, D.C., on September 27-28, 2010. The second phase, drawing on that workshop and on additional briefings, site visits, and committee deliberations, will result in a final report with recommendations, to be issued at the end of the project in 2011.

It is challenging for an external committee to learn about the complex environment and challenges that characterize an agency with the breadth of responsibilities and scope of CMS. The committee has benefited from the written materials provided by CMS staff and from their presentations and engagement both on telephone conference calls and at the workshop. The committee is accordingly grateful to the CMS staff who have contributed their time and insights to the study, and also thanks all of those individuals who participated in the September workshop and contributed their insights and experiences to the discussion. The committee thanks the reviewers of this report for their constructive feedback. And finally, the committee appreciates the work of the NRC staff members who have contributed to the process to date.

Lynette Millett and Emily Ann Meyer, in particular, have demonstrated an intellectual engagement, a commitment to the task, and an ability to capture and integrate the wide-ranging discussions of a heterogeneous committee. We are indebted to them for their contributions to documenting the committee's deliberations and to the writing of this report.

Edward H. Shortliffe, *Chair*
Committee on Future Information Architectures, Processes, and Strategies
for the Centers for Medicare and Medicaid Services

Acknowledgment of Reviewers

This report has been reviewed in draft form by individuals chosen for their diverse perspectives and technical expertise, in accordance with procedures approved by the National Research Council's (NRC's) Report Review Committee. The purpose of this independent review is to provide candid and critical comments that will assist the institution in making its published report as sound as possible and to ensure that the report meets institutional standards for objectivity, evidence, and responsiveness to the study charge. The review comments and draft manuscript remain confidential to protect the integrity of the deliberative process. We wish to thank the following individuals for their review of this report:

Michael Carey, University of California at Irvine,
Christine Cassel, American Board of Internal Medicine,
Renato A. DiPentima, Independent Consultant, Fort Lauderdale, Florida,
Stephen Holden, SRA Touchstone Consulting Group,
Ashish K. Jha, Harvard School of Public Health,
Joseph Newhouse, Harvard University,
Harry Reynolds, IBM Global Healthcare and Life Sciences, and
Walker Royce, IBM Software Group.

Although the reviewers listed above have provided many constructive comments and suggestions, they were not asked to endorse the conclusions or recommendations, nor did they see the final draft of the report before its release. The review of this report was coordinated by Susan Graham, University of California at Berkeley Appointed by the NRC, she was responsible for making certain that an independent examination of this report was carried out in accordance with institutional procedures and that all review comments were carefully considered. Responsibility for the final content of this report rests entirely with the authoring committee and the institution.

Contents

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Context

The Centers for Medicare and Medicaid Services (CMS), an agency in the Department of Health and Human Services (HHS), is responsible for providing health coverage for seniors and people with disabilities (Medicare), for limited-income individuals and families (Medicaid), and for children (Children's Health Insurance Program, CHIP)—totaling almost 100 million beneficiaries. Collectively, these programs make CMS the largest purchaser of health care in the United States, and it interacts with thousands of health care providers across the country ranging from individual physicians to hospitals large and small, as well as with other providers such as ambulance services and rural health centers. The agency's core mission was established more than four decades ago, with a mandate to focus on the prompt payment of claims which now totally more than 1.2 billion annually.[1]

More recently, CMS has been mandated to undertake new and expanded responsibilities for driving national improvements in such areas as the adoption of health information technology (IT), the collection and analysis of information to promote health and wellness, the support of health care quality, the elimination of health disparities, and improvement in the efficiency of health care services. Recent legislation affecting CMS includes the Patient Protection and Affordable Care Act of 2010 (Public Law [P.L.] 111-148), the American Recovery and Reinvestment Act of 2009 (ARRA, P.L. 111-5; specifically the portion of ARRA known as the Health Information Technology for Economic and Clinical Health [HITECH] Act of 2009), and the Children's Health Insurance Program Reauthorization Act of 2009 (Public Law 111-3).[2] The HITECH Act, for example, calls for improvements in health care nationwide through the

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[1] Julie C. Boughn, Chief Information Officer, Centers for Medicare and Medicaid Services, "CMS Systems Briefing," presentation to the committee, July, 23, 2010. Via teleconference.

[2] Numerous other pieces of legislation affect CMS on a continual operational and policy basis, including the following: the Clinical Laboratory Improvement Act (P.L. 90-174), Conditions for Coverage and Conditions of Participation (42 CFR 482), the Deficit Reduction Act (P.L. 109-171), the EHR Incentive Program (42 CFR 412, 413, 422, and 495), the Emergency Medical Treatment and Labor Act (P.L. 99-272), the Tax Relief and Healthcare Act (P.L. 109-43), the Medicare Prescription Drug and Modernization Act (P.L. 108-173), the Privacy Act of 1974 (P.L. 93-579), the Paperwork Reduction Act (P.L. 104-13), the Economic Recovery Act (P.L. 111-5), and the Health Insurance Portability and Accountability Act (P.L. 104-191).

promotion of the meaningful use of electronic health records (EHRs), and it charges CMS with monitoring and auditing the implementation of associated meaningful-use criteria.[3]

Meeting historical, emerging, and future requirements will depend heavily on the ability of CMS to evolve its information systems and software to provide the needed functionality, fraud prevention, assurance of information security and confidentiality, and interoperability—internally as well as with current and future external IT systems. In working to meet historical, emerging, and future requirements, CMS faces a clear tension between its continuing mission to be an efficient claims-payment organization and its newly mandated mission to be a significant driver in transforming the U.S. health care system. This challenge and tension play out at multiple levels—from the policy level to the levels of management structure and business process and system architecture.

In terms of ongoing operational requirements, CMS must continue to handle a very large volume of claims and other activities in a timely and secure manner even as regular changes to statutes and regulations mean that business processes, software code, databases, and systems must be adjusted frequently, and sometimes substantially. These ongoing operational requirements are currently being met with a very large and complex information technology infrastructure that incorporates hardware, software, and communications systems that vary considerably in age, capability, and sophistication. The ability of this infrastructure to continue to keep up with the ongoing changes demanded of it—particularly as the agency takes on its newly mandated leading role in modernizing the nation's health care system and underlying health information technology—is an understandable source of concern.

For strategic advice on addressing these and future challenges, CMS requested that the National Research Council (NRC) conduct a study that would lay out a long-term, forward-looking vision for the Centers for Medicare and Medicaid Services, taking account of CMS's mission, business processes, and IT requirements. This interim report, presented at the conclusion of the first of the study's two phases, presents the very preliminary observations of the study committee—the NRC's Committee on Future Information Architectures, Processes, and Strategies for the Centers for Medicare and Medicaid Services—with respect to the new demands on CMS and areas in which changes will be needed. These observations are organized in three broad categories: (1) emerging requirements for information; (2) challenges involving the transformation of enterprise data and technology management; and (3) organizational, administrative, and cultural challenges.

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[3] The HITECH Act of 2009 promotes the adoption and "meaningful use" of EHRs by eligible professionals and hospitals. Professionals and hospitals receive incentive payments if they adopt the use of electronic health records and carry out a series of measurable objectives intended to ensure that the systems are used to improve the quality and efficiency of care. The meaningful-use objectives are framed as being relevant to quality, safety, efficiency, and the reduction of disparities; patient and family engagement; care coordination; population and public health; and privacy and security. Examples of these objectives include using computerized provider order entries, reporting on specific clinical quality metrics, and providing clinical information to patients. Professionals and hospitals can request incentive payments in 2011 by attesting to achieving the objectives, and they must submit their measures to CMS electronically by 2012. Starting in 2015, penalties are to be assessed against those not meeting the objectives.

In this first brief phase of its study, the committee has had limited opportunity to gather data and conduct its deliberations. Thus this report is necessarily preliminary in nature, is not comprehensive, and does not provide findings or recommendations. The committee received a series of briefings by teleconference from CMS staff, and it convened an information-gathering workshop on September 27 and 28, 2010, to hear a range of perspectives internal and external to CMS. In addition to those sources of background and related information, this report draws on the committee members' individual expertise and experience with health IT specifically and with IT systems in general (see Appendix B for biosketches of the members of the study committee). The committee has not yet completed its fact-finding activities. For example, it has yet to receive much formal input on Medicaid or CHIP.

In its final report, to be issued in 2011 at the completion of the second phase of its study, the committee will review the current state of and plans for the evolution of CMS's IT infrastructure. That report will provide a framework for analyzing and guiding decision making on how to evolve business processes, practices, and information systems to meet today's continuing needs and tomorrow's new demands.

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Emerging Requirements Driving
Multilayered Transformation

Like other sectors of society,[1] health care today is data-driven and will become more so, especially if quality and safety are to be assured. As the provider of health care coverage to more than one-third of the U.S. population,[2] CMS already maintains a huge repository of clinical, administrative, and claims data as well as information both on providers and on individual patients. To improve health care significantly and as mandated in the legislation referred to in Chapter 1, CMS is required to move beyond processing claims—it must also collect, manage, analyze, and make available information extracted from its data repositories. To date, the capabilities of CMS for improving health care quality have been limited because it cannot identify poor-quality performers and intervene in a timely fashion. Clinical data will likely play a much more central role in meeting the new requirements for information placed on the agency. A focus on clinical data[3] will have significant repercussions—some positive, such as the accrual of additional information to help combat and detect fraud and abuse; and some challenging, such as the need to deal with massive increases in the volume of data and the requirement for new procedures for handling and analyzing new kinds of information. And, of course, another challenge will be that of developing and implementing appropriate policies and technical capabilities to ensure the confidentiality and security of data. To manage this shift, CMS will likely need to evolve both its information systems and its business processes, reassess the roles that it plays, and develop and implement a public communications strategy.

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[1] Earlier this year, *The Economist* (February 25, 2010, available at http://www.economist.com/node/15557443) produced an accessible overview—"Data, Data Everywhere"—on the abundance of data and the challenges of managing information. See also Rakesh Agrawal, Anastasia Ailamaki, Philip A. Bernstein, Eric A. Brewer, Michael J. Carey, Surajit Chaudhuri, AnHai Doan, et al., "Claremont Report on Database Research," May 2008; available at http://db.cs.berkeley.edu/claremont/claremontreport08.pdf.

[2] July 2010 numbers from the Secretary of the Department of Health and Human Services indicate that 98 million Americans are enrolled in either Medicare or Medicaid/CHIP or both. See http://answers.hhs.gov/questions/3640.

[3] The term "clinical data" refers to individual data elements related to patient care rather than to summary data or administrative claims data. Traditionally CMS has had to know, for instance, what tests and procedures were performed (in order to reimburse for those items), but now increasingly it will also have to know the results of those tests and procedures in order to do, for example, quality assessments.

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The following are just some of the types of information that emerging demands will likely require CMS to provide:

- *Information to support consumers and patients in health maintenance and improvement.* CMS is experiencing increasing expectations and demands for making data and information tools available to support consumer empowerment and patient-centered medical care. Examples of such expectations and demands include the following: interfacing more proactively with program beneficiaries and patients through consumer-friendly user interfaces (making secondary non-electronic channels available as needed), offering access to personal health information, and providing users with decision-support tools to help them make better-informed decisions about health choices.
- *Information to support a "learning health care system."* [4] CMS must identify those areas in which timely access to accurate information will best contribute to objectives for health care improvement just as other large enterprises are using information to meet analogous business objectives. Examples of such areas include the following: (1) collecting and disseminating meaningful data on quality (especially data that can be generated from and incorporated readily into provider workflows), (2) promoting population health (which also has specific implications for data needs and data structures),[5] and (3) generating claims data in a timely fashion (e.g., to support the effective functioning of accountable care organizations[6]). CMS may well need to be able to partner with patient-centered medical homes to provide the necessary data.
- *Information needed to implement the meaningful-use program for electronic health records.* Pursuant to the provisions of the HITECH Act described in Chapter 1, CMS must determine whether an eligible health care provider meets the prescribed meaningful-use criteria in order to determine when it is appropriate for incentives to be paid or for penalties to be applied. CMS is the final arbiter with respect to meaningful-use outcome measures, which will ultimately need to be generated from EHR data. This responsibility demands new levels of IT sophistication from the agency and its partners. Not only will CMS have to be able to share data and extract information related to meaningful-use criteria from clinical health information, but it will also be playing an integral role in defining how such data are collected. This new role raises a host of issues related to standards, data modeling, terminology, best practices, accuracy, completeness, security, and confidentiality, and it will need to be factored in to the design of CMS's process and planning for its future IT infrastructure.
- *Consumable data about health provision and outcomes.* CMS will need to support the provision of data and information, often of new types, to a wide variety of users. This is largely

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[4] See the Institute of Medicine's Roundtable on Value and Science-Driven Healthcare and its associated reports (available at http://www.iom.edu/Activities/Quality/VSRT.aspx) for more on the topic of a learning health care system.

[5] See D.J. Friedman and R. Gibson Parrish II, "The Population Health Record: Concepts, Definition, Design, and Implementation," *Journal of the American Medical Informatics Association* 17:359-366, 2010.

[6] The term "accountable care organization" refers to a health system model that organizes care providers into entities responsible for managing patients and delivering a continuum of care across different institutional settings, such as hospitals, outpatient clinics, and so on.

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a new activity that CMS and its IT systems do not appear to be designed, resourced, or organized to support. For example, the agency is mandated by the HITECH Act to work to reduce racial and ethnic disparities in health care, and pursuant to the Patient Protection and Affordable Care Act it is mandated to collect and report data reflecting key demographic variables required to meet this obligation.[7] Researchers also seek clinical data that are captured during the patient-care encounter rather than as a by-product of the claims-submission process. Managers of clinical services need these data as well, and their needs tend to be more time-critical, often regarding ongoing patient care or institutional performance, making timely access to accurate information important.

- *Timely information to support the preemptive detection of fraud.* Despite considerable attention to this very significant issue, such as the formation of cross-agency initiatives with the Department of Justice, much of the focus is on investigation, prosecution, and the recouping of dispensed funds. The preemptive detection of fraud—that is, before payment is made—generally has significantly higher payback than does detection after payment is made, but preemptive detection requires very timely data as a foundational capability. CMS may need to further develop, or partner to improve, its ability to access, process, and analyze data in a timely fashion as a first step, and then to implement appropriate systems and business processes to enhance this vital function.

The multitude of potential stakeholders in CMS's efforts is suggested by the range of CMS's responsibilities today. Those responsibilities include the following:

- *As a purchaser of health care services,* CMS is responsible for provider contracting, quality improvement, and so on.
- *As an administrator of health plan services,* it is responsible for eligibility determination, enrollment, payment, referrals, and monitoring for fraud and abuse.
- *As a provider of health education and health promotion,* CMS is responsible for the delivery of personalized health information to enrollees and patients, among other tasks.

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[7] With respect to Medicare, CMS depends primarily on the Social Security Administration for demographic data, but indications are that these data are incomplete and insufficient. For Medicaid, indications are that state-level data collection and reporting are inconsistent and not always either systematic or reflective of the minimum standards promulgated by the Office of Management and Budget (OMB) and addressed by recent studies from the Institute of Medicine (IOM) and related studies on subpopulation data needs. The minimum standards established by OMB in 1997 require reporting of the following groups: American Indian/Alaskan Native, Asian, Black/African-American, Native Hawaiian/Other Pacific Islander, and White. OMB also provides for the reporting of ethnicity with the two broad categories Hispanic or Latino, and Not Hispanic or Latino. (See *Federal Register*, Vol. 62, No. 210, October 30, 1997. In addition, see Institute of Medicine, *Race, Ethnicity, and Language Data: Standardization for Health Care Quality Improvement*, Cheryl Ulmer, Bernadette McFadden, and David R. Nerenz, eds., The National Academies Press, Washington, D.C., 2009; and Institute of Medicine, *Future Directions for the National Healthcare Quality and Disparities Reports*, Cheryl Ulmer, Michelle Bruno, and Sheila Burke, eds., The National Academies Press, Washington, D.C., 2010.)

- *As a regulator,* CMS is responsible for Medicare, Medicaid, CHIP, some aspects of health reform, and some aspects of health IT.
- *And, of course, as an employer itself,* CMS has responsibilities related to that role.

Managing expectations for CMS's wide range of constituencies will be ever more important, along with developing and maintaining methods to learn from and communicate with stakeholders.

As the health care industry continues to evolve, the requirements for data from multiple constituencies will continue to increase rapidly. These requirements will include the need to provide access to clinical information, the generation of improved administrative and claims data, and the incorporation of new information and the aggregation of multiple data sources. Demand will increase from a number of sectors, including researchers who require increased access to clinical-level information for diverse populations as well as improved administrative and claims information to support comparative-effectiveness research and the evaluation of new care-delivery models. Policy makers will demand more timely information (e.g., a lag of 2 to 3 months rather than the current lag of 18 months or more) so that they can better evaluate the impact of new policies on program performance and cost. Additional potential requirements include demands for increasingly well integrated patient-level information at the point of care; the implementation of new care-delivery models such as accountable care organizations, including medical homes; increased dependency on EHRs and evidence-based decision-support systems; and the identification of methods to improve public health.[8]

It is not yet clear to what extent CMS will be required to play a role in meeting the requirements described above and what will be asked of it. But CMS should expect, sooner or later, to become a principal participant in all of these areas.[9] To the extent that CMS itself will be responsible for developing or procuring solutions, it will need to provide support and direction to entities (e.g., subcontractors) regarding solutions and systems that will address indicated needs; CMS will need to ensure that such entities have appropriate levels of understanding of enterprise-wide architectural considerations. An understanding of the existing IT infrastructure capabilities of CMS will be a critical starting point in this consideration. An objective understanding of the existing capabilities, strengths, and weaknesses is a huge asset in such an undertaking. Developing a vision of the future requires a thorough picture of the current situation and the technical marketplace. This understanding allows more credible planning and more potential for optimizing the vision with less uncertainty. It will also be important for attention to be focused on developing both an appropriate infrastructure and an organizational alignment to meet these needs. In particular, it

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[8] With regard to improving public health, IT systems transformation could offer the opportunity to do more sophisticated sharing and exchange of data with other agencies (for example, with the Food and Drug Administration and the Centers for Disease Control and Prevention)—to the extent that policy decisions or user demands urge such exchanges.

[9] Complicating matters still further, a clear trend in data-driven domains (for example, business intelligence) is that as benefits accrue from improved or additional data, the demand for data rises. Thus, it can be expected that demand will increase, fueled by the value derived from access to data. Anticipating data demands far in excess of currently projected uses will likely be important.

seems likely that in many cases it will not be sufficient for new data and information products to be viewed as just add-on features to, say, an existing claims-processing system.

To start to address the sorts of demands described above, CMS might begin to consider information that it provides as a new set of "products." More generally, the current and prospective roles of CMS and the consequent needs for data and information raise the following kinds of fundamental questions for the agency:

- What kinds of information can and should CMS provide?
- What is the market for such information, and what does that market expect in terms of data and information products?
- How can CMS processes and systems be restructured or replaced to support easier generation of such information and data?
- How should CMS track and manage provenance information associated with the data that it is using?
- What protections will be in place for assuring compliance with legally mandated and emerging confidentiality and security requirements for patient data while also ensuring sufficient access for legitimate biomedical and health research?
- What is the role of CMS relative to other stakeholders—for example, in setting standards and in data collection, data management, and data and information extraction and distribution?
- How should CMS design, manage, make available, and recover the costs of its information products?

In short, CMS is faced with significant growth in the complexity of requirements, some of which may conflict with one another when quality constraints are applied. In such circumstances, evolving the scope of change incrementally to control complexity is important. Furthermore, the requirements and demands on the infrastructure (hardware, middleware, software architecture) need to be understood and specified. In particular, the future growth and change scenarios ought to be explicitly characterized as part of the process of gathering requirements. Modern IT solutions such as data warehousing, identity management, business process management, and business intelligence—and associated new architectural approaches—all have the potential to play important roles in meeting CMS's future data and information requirements. Chapter 3 briefly discusses enterprise transformation—in terms of both business process and information systems.

3

Challenges in Transforming Enterprise Technology and Data Management

To the extent that upgrades and enhancements are needed to the existing IT systems of CMS, the goal is to incorporate IT solutions that are superior to the existing systems in cost, performance, and flexibility. In terms of meeting new requirements, CMS may need to develop or implement IT solutions that enable not just technical changes but business transformation as well. The simultaneous pursuit of these goals will be complicated, particularly given the pragmatic complexities of instituting change in a system that must continue to function at scale.[1] Moreover, CMS's present business processes and systems were developed largely on a program-by-program basis rather than on an enterprise-wide basis. Nonetheless, good IT solutions can provide a basis for both IT enhancement and IT transformation.[2]

The demands for transformation will be ongoing. The complex constellation of legislation and regulation to which CMS must be responsive will present continuing challenges; new rules and legislation prompt frequent updates to systems and processes, and major changes and whole new programs have been called for in recent legislation. Health care reform has accelerated the pace of change, and ongoing legislative activity and the development of regulations suggest that the business requirements for CMS are unlikely to stabilize. Furthermore, a broad trend toward integrated health care will exert further pressure, pushing the entire system toward more integration and affecting the mission, products, and service delivery of CMS. As the agency's mission and service model evolve, business processes will need to change with them. A thorough understanding of future-state business processes and a disciplined way to document those processes are prerequisites to designing systems that successfully meet the multiple challenges ahead for CMS.

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[1] See Michael L. Brodie and Michael R. Stonebraker, *Legacy Information Systems Migration: The Incremental Strategy*, Morgan Kauffman Publishers, San Francisco, Calif., 1995; A. Bianchi, D. Caivano, V. Marengo, and G. Visaggio, "Iterative Reengineering of Legacy Systems," *IEEE Transactions on Software Engineering* 29:225-241, 2003; and B.M.R.S. Borges, A.F. Vincent, C. Penads, and R.M. Araujo, "Introducing Business Process into Legacy Information Systems," in *LNCS—Business Process Management 2005* 3649:452-457, 2005.

[2] See, for example, Kate Leggett, William Band, Connie Moore, and Andrew Magarie, *Extend Business Process Management to the Front Office to Transform Customer Service,* Forrester Research, Cambridge, Mass., October 5, 2010.

Like the IT systems of many other federal agencies, those of CMS are based on legacy technologies. Systems based on such technologies and architectures can be notoriously difficult to maintain and update, may not be well positioned for interoperability, and can depend increasingly on specialized knowledge that is ever more difficult to obtain in the commercial marketplace. Although CMS's IT systems have been remarkably effective in meeting changing requirements over the past 40 years, they were not designed for the kinds of flexibility and ease of evolution likely to be needed to support the emerging set of requirements being mandated to be carried out by CMS. More specifically, past changes to CMS systems seem typically to have been made on a project-by-project basis, as needed in response to specific new requirements and as new funds were appropriated and allocated for the implementation of particular programs. Architectures that facilitate such narrowly focused modifications to IT systems tend not to allow for re-envisioning in the face of change or the implementation of major system-wide changes. Such significant changes typically require reconceived and redesigned hardware, software, and system architectures and will encompass all aspects of system performance, including processing, storage, communication, interface, and flexibility.

A major challenge that CMS faces is how to manage the combination of continually new and broadening requirements, an increasingly broad and diverse user population (including providers, beneficiaries, and other information consumers), and a correspondingly ever-more-challenging environment in which security and confidentiality must be assured. Assuming that new architectures will be needed to meet the new challenges that CMS faces, the transition to such new architectures will itself pose a formidable challenge. Specifically, there will be a need for system and software architectures that are sufficient to support existing CMS requirements, flexible enough to support an expected range of future requirements, and robust enough to support the complex transition from the current IT infrastructure to CMS's future IT infrastructure. In short, new requirements and demands will likely mean that CMS systems need to be modernized in various areas because CMS currently does not use at scale modern IT solutions that are available and that are likely critical to meeting its new requirements (or even to meeting current requirements at new scales).

In the committee's view, reengineering and evolution of this kind are difficult. Although it entails considerable risk, reengineering can be approached in ways that reduce risk. This reengineering might mean that certain hardware and/or software systems would need to be replaced, although mere replacement or "upgrade" is not the goal per se.

Because emerging requirements place a premium on flexible approaches to collecting and assembling data across the enterprise, improvements in data management appear to be critical. CMS IT systems have historically been developed to support plan-administration and claims-processing functions and have been implemented program by program, resulting in multiple data stores. In part because of their coarse granularity and location in multiple data stores, the data available today are likely not well suited for tracking health outcomes or conducting comparative-effectiveness research, and significant effort is required to produce needed data sets.

Indeed, the most successful private-sector users of IT at comparable scales reengineered their approaches to data more than a decade ago. This reengineering has made it easier for them to modify and change systems to keep up with evolutionary IT changes and new demands, and

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to create separate data warehouses that have been effective in managing large and diverse data sets and in supporting broad needs for information that are of a range and scale comparable to what is projected to be needed by CMS for decision support and business intelligence.[3]

Another factor that will need to be incorporated into CMS's transformational efforts is the need for experimentation and pilots. Given the mandates of the Patient Protection and Affordable Care Act of 2010 and the pressing need to "bend the cost curve," significant experimentation with various approaches to developing an efficient, integrated health care ecosystem will be needed. CMS will play a central role here, and it will need to balance its efforts in this area with the need to keep existing programs running smoothly. In general, incorporating flexibility into system and software architectures in the face of change will be critical, as any system developed now is likely to face even more changes in the future. Learning from other large-scale enterprises that have transitioned to new business models will be critical. The rapid change in the political and policy dialogues means that requirements for future CMS systems are not yet known or stable. And yet system and transformation efforts will have to be undertaken despite that uncertainty. Proceeding in such a way inevitably increases risks with regard to meeting requirements, or risks of outright failure as in the case of past procurements by a number of federal agencies as well as by organizations in the private sector. In short, CMS needs to leverage proven IT approaches and solutions that are most likely to be able to cope with ongoing significant advances in IT generally and with rapid evolution in health care IT and policy.

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[3] Many large e-commerce providers, such as Amazon.com and Hewlett Packard, among others, use this model. (See, for example, Stavros Harizopoulos, Daniel J. Abadi, Samuel Madden, and Michael Stonebraker, "OLTP Through the Looking Glass, and What We Found There," *Proceedings of the 2008 ACM SIGMOD International Conference on Management of Data,* Association for Computing Machinery, New York, 2008; and Surajit Chaudhuri and Umeshwar Dayal, "An Overview of Data Warehousing and OLAP Technology," *SIGMOD Record* 26(1):65-74, March 1997.)

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Organizational, Administrative, and Cultural Challenges

In the general case, organizational and cultural change—encompassing people and process dynamics—is a significant factor in the effectiveness of new technology as well as in its adoption by the relevant stakeholders. Technology management—the strategic planning, design, development, and deployment of IT solutions, including new technologies—is a critical factor in successful transformation efforts.[1] Indeed, the number of failures (based on metrics such as cost, schedule, and function) of large-scale projects of the sort being discussed in this report exceeds the number of successes. Both technical implementations and business process challenges have contributed to many expensive failed efforts in industry. Successful efforts depend a great deal on understanding and addressing the requirements of all of the relevant stakeholders and depend critically on acceptance or adoption of the new processes. Depending on the significance of the changes, a cultural change in the supported enterprise is likely to be an integral part of a successful effort.

CMS will need to grapple with these challenges, and studying what has tended to be most successful in the past would be instructive. The need for information systems to accommodate changing business requirements is matched if not surpassed by the need for these systems to meet increasing technical requirements—not only those relating to the scope and scale of transactions and data volumes, but also those relating to performance, efficiency, and cost. Advances in all areas of IT over the four decades of the life of CMS have been profound, with improvements in architecture, capacity, performance, and cost-effectiveness. Most IT solutions that are critical to CMS, including databases, data warehouses, transaction processing, and distributed computing, have matured through several generations. To accommodate significant business change and to take advantage of modern IT solutions, it is common for all

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[1] Pure technology challenges arise when new technologies are emerging (current examples include service-oriented architectures and social computing) and the computational and operational models are technically incomplete and immature. Vendors typically overpromise what the new technologies can provide—and how quickly they can do so—but enterprises often must still grapple with how to integrate new technologies into their architectures and processes. An 80/20 rule as a generalization is often applicable: roughly 80 percent of the challenges related to technology enablement are anchored around organizational and process dynamics, and only roughly 20 percent of the challenges are related to technology itself. (See, for example, Thomas H. Davenport and James E. Short, "The New Industrial Engineering: Information Technology and Business Process Redesign," *Sloan Management Review*, Summer, pp. 11-27, 1990.)

decades-old systems to be considered for modernization. This modernization could involve re-architecting or re-implementing the existing information system and might involve migrating information system components—for example, databases, business rules, and other contents that must be incorporated in the modernized information system.

Reforming infrastructure in the face not only of demanding new requirements, but also of potentially significant changes to those requirements in the short term and medium term, will be difficult, and the process will be further complicated by the ever-changing policy environment in which CMS must operate. Moreover, cultural change to address new demands and requirements means a change in the way that the agency and its stakeholders operate and do business day to day. Such change will require an array of new skills and new ways of managing the development of needed functionality. In particular, architecting a sophisticated, complex, and constantly evolving system is a challenge when individual components of it are implemented and maintained by different entities (whether internal or on a contractual basis). A coordinated and direct management approach to ensure appropriate integration and adherence to well-articulated architectural requirements will likely be needed.

But CMS's efforts are further complicated by federal budgeting—which does not easily allow for sustained long-term agency budgets or flexibility in resource allocation—the oversight context within which CMS must operate, and the complexity of the overall U.S. health care system. Resource constraints pose a significant challenge to successful transformation. The year-by-year, project-by-project approach to federal IT demanded by the budgeting process makes it difficult for CMS to prepare, plan, or implement a long-term, multiyear, multiprogram IT project. Moreover, past experience has been that funds for the development of new or refined systems are often obtained only by the removal of funds from other equally critical areas. However, the transformations and reengineering suggested above will likely require a substantial net investment made over an extended period of time. As noted previously, CMS has accommodated significant adjustments to its mission (and consequently its systems) over time, most recently the implementation of the Medicare Part D program for subsidizing the costs of prescription drugs. However, the scope and scale of upcoming changes associated with the recent legislative mandates described earlier seem, in the committee's view, to present even greater challenges than any that CMS has thus far encountered.

Part of grappling with the kind of transformation described in this report involves developing ways to ascertain the needed skill sets and key gaps in those skill sets as well as devising and implementing a plan to address those gaps. High-level strategy setters, not the IT managers, should drive the development of business processes and definitions. However, the IT leadership at the agency must "sit at the executive table" as the high-level strategic directions of CMS, including the evolving business model, processes, and requirements, are addressed. Such participation by the IT leadership ensures that decisions made are cognizant of IT best practices in such areas as systems integration and standardization of processes and data, among others. In addition, in large-scale transformations, it is typically the program managers, architects, and transformation managers at the middle levels of the organization who have the most difficult job—that of transforming the technical results of the practitioners into the business results demanded by the executives and external stakeholders. Thus, building

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organizational trust in this middle level—and nurturing and hiring champions of the needed transformation efforts within it—is as essential as ensuring clear leadership at the top.

The role and impact of modern information systems can be seen in terms of the ecosystems in which the systems exist. Along with user and process ecosystems that make up the operational ecosystem that is its reason for being, an information system exists in several other ecosystems, including those defined by its organizational, management, development, and operational contexts. As with a user or process ecosystem, the success of a modernized information system depends critically on understanding and addressing those contexts (which are ecosystems in themselves), each of which must participate in and support the modernization effort and adopt the resulting system. For example, the information system must align with organizational missions and goals; modernization requires management support and leadership to address significant challenges; and it requires the development and operational life cycles to have the means to support the transformation.

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Concluding Observations

Following are the preliminary observations of the committee at the conclusion of the first phase of its study on information technology needs and priorities at the Centers for Medicare and Medicaid Services. The observations address three broad categories: (1) emerging requirements for information, (2) challenges involving the transformation of enterprise data and technology management, and (3) organization, administrative, and cultural changes.

- The collection, management, dissemination, and analysis of data and information products on clinical care and health care outcomes are fundamentally different from CMS's historical claims-processing and claims-payment activities. Neither the current business process of CMS nor its information technology systems appear to have been architected to support these new activities effectively.
- In particular, the IT systems of CMS do not appear to have been designed to provide the flexibility or evolvability that are likely to be necessary for CMS to meet its significant new and characteristically different obligations even as it maintains and improves service levels for its traditional functions.
- Large-scale transformations of the sort that CMS is expected to undertake require both substantial organizational commitment and the full integration of the IT leadership of the transformation process into the highest levels of strategic planning.
- Organizations that successfully transform themselves tend to focus on reengineering their processes at least as much as on re-architecting their systems.
- Even the best-managed and best-resourced transformation of large-scale IT systems is well known to be risky.[1] The risk grows only if the resources available to support the transformation are insufficient or if the requirements for the transformation are poorly understood or unstable.

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[1] An example of a government program of similar scope that has experienced significant cost overruns and failure to meet any objectives on deadline is the Federal Aviation Administration's systems modernization program, which began in 1981 and has yet to be completed. Although this program has recently been moved from the Government Accountability Office's "high risk" list, it has a long way to go to meet its goals. Among the shortcomings of this program were a lack of an institutionalized architecture, incomplete investment management processes, and an organizational culture that impaired modernization efforts. (See, Government Accountability Office, *High Risk Series: An Update,* GAO-09-271, Washington, D.C., January 2009.)

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Appendixes

A

Statement of Task

The Centers for Medicare and Medicaid Services (CMS) face enormous challenges related to their information systems. They must meet challenging day-to-day operational requirements and make frequent adjustments to their business processes, code, databases, and systems in response to changing statutory, regulatory, and policy requirements. Increasingly, their core mission is expanding from one focused on prompt claims payment to one that is more broadly involved in improving health care quality and efficiency. And all of this is being done with old, and arguably antiquated, information technology even as CMS is increasingly engaged in efforts to modernize the nation's health care information technology.

An ad hoc committee will conduct a study that will, in the foregoing context, lay out a forward-looking vision for the Centers for Medicare and Medicaid Services, taking account of CMS's mission, business processes, and information technology requirements. It will review the current state of CMS's technical infrastructure and systems architecture and current plans for its evolution, and make recommendations to CMS on modernizing its business processes, practices, and information systems to meet today's and tomorrow's demands, including how to build in the flexibility to cope with changing requirements. The study will anticipate ever-broadening mandates for CMS to deal with data on outcomes, performance, and clinical procedures—perhaps even extending to electronic health records themselves—and requirements for interacting directly with beneficiaries, both to manage claims and to manage health.   It will also consider the financial and human resources necessary to implement this modernization.

The study will take place in 2 phases. The first phase, drawing largely on a workshop (centered on the current CMS landscape and emerging strategy to match its information technology to changing mission requirements), will result in an interim report to be issued 6-9 months after the project start. The second phase, drawing on the workshop and additional briefings, site visits, and committee deliberations, will result in a final report to be issued by the end of the project.

B

Biosketches of Committee Members and Staff

Edward H. Shortliffe, *Chair,* is the president and chief executive officer (CEO) of the American Medical Informatics Association, the informatics professional association based in Bethesda, Maryland. He is also a professor of biomedical informatics at the University of Texas Health Science Center in Houston, Texas. Previously he was a professor of biomedical informatics at Arizona State University and a professor of basic medical sciences and professor of medicine at the University of Arizona College of Medicine. From March 2007 to May 2008, Dr. Shortliffe served as the founding dean of the Phoenix campus of the University of Arizona's College of Medicine. Before that he had been the Rolf A. Scholdager Professor and chair of the Department of Biomedical Informatics at Columbia College of Physicians and Surgeons in New York City (2000-2007) and professor of medicine and of computer science at Stanford University (1979-2000). After receiving an A.B. in applied mathematics from Harvard College in 1970, he moved to Stanford University, where he was awarded a Ph.D. in medical information sciences in 1975 and an M.D. in 1976. During the early 1970s, Dr. Shortliffe was the principal developer of the medical expert system known as MYCIN. After internal medicine house-staff training at Massachusetts General Hospital and Stanford Hospital between 1976 and 1979, he joined the Stanford internal medicine faculty where he served as chief of general internal medicine and associate chair of medicine for primary care and was the director of an active research program in clinical information systems and decision support. Dr. Shortliffe is an elected member of the Institute of Medicine of the National Academies and the American Society for Clinical Investigation. An elected fellow of the American College of Medical Informatics and the American Association for Artificial Intelligence, he is also a Master of the American College of Physicians. He is the editor in chief of the *Journal of Biomedical Informatics* and serves on the editorial boards for several other biomedical informatics publications. In addition, he received the Grace Murray Hopper Award of the Association for Computing Machinery in 1976 and the Morris F. Collen Award of the American College of Medical Informatics in 2006, and he has been a Henry J. Kaiser Family Foundation Faculty Scholar in General Internal Medicine. Dr. Shortliffe has authored more than 300 articles and books in the field of biomedical computing and artificial intelligence.

Michael L. Brodie is chief scientist of Verizon Services Operations at Verizon Communications, one of the world's leading providers of communications services. Dr. Brodie works on strategic information technology opportunities and challenges to deliver business value from emerging

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technologies and practices in large-scale, distributed operational environments. He is concerned with the "big picture," including business, economic, application, and technical aspects of information ecosystems, core technologies, and integration, with an active involvement in the Semantic Web and the holistic view of Web Sciences. Dr. Brodie holds a Ph.D. in databases from the University of Toronto; has authored more than 160 books, chapters, and articles; and has presented more than 150 keynote addresses and invited lectures in more than 30 countries. He is an adjunct professor, National University of Ireland, Galway; an adjunct research fellow, Digital Ecosystems and Business Intelligence Institute at Curtin University of Technology, Perth, Australia; and the chair of advisory boards for three institutions—Semantic Technology Institutes International, Vienna, Austria; the Digital Enterprise Research Institute, National University of Ireland; and the Semantic Technology Institute, Innsbrück, Austria. He is also a member of several advisory boards—for the European Research Consortium for Informatics and Mathematics; the School of Computer and Communication Sciences, École Polytechnique Fédérale de Lausanne, Switzerland; Web Science Champion for the Web Science Trust; and the European Union's Information Society Technologies 5th, 6th, and 7th Framework Programmes. Dr. Brodie is a reviewer for the European Research Council and is on the editorial board of several research journals. He has served on the National Research Council's Committee on Technical and Privacy Dimensions of Information for Terrorism Prevention and Other National Goals, the VLDB (Very Large Databases) Endowment, and the Client Advisory Board, Forrester Research, Inc.

Don E. Detmer is a professor emeritus and professor of medical education in the Department of Public Health Sciences at the University of Virginia, senior adviser to the American Medical Informatics Association (AMIA), and visiting professor at the College of Healthcare Information Management Executives, University College of London. He is the founder and co-chair of the Blue Ridge Academic Health Group, chair of the Institute of Medicine's (IOM's) membership committee, chair of the board of MedBiquitous, associate editor of AMIA's *Standards Standard*, and a director of the Corporation for National Research Initiatives. He is a member of the Institute of Medicine, a lifetime Associate of the National Academies, a recipient of the IOM's Walsh McDermott Medal for lifetime contributions, and a fellow of the American Association for the Advancement of Science, American College of Medical Informatics, American College of Surgeons, and American College of Sports Medicine (emeritus). Dr. Detmer is the immediate past president and CEO of AMIA and a past chair of the IOM Board on Health Care Services, National Library of Medicine Board of Regents, and National Committee on Vital and Health Statistics. He sat on the Strategic Plan Work Group of the Policy Advisory Committee to the Office of the National Coordinator for Health Information Technology. He chairs the Steering Committee of the AMIA Global Partnership Program. Dr. Detmer's M.D. degree is from the University of Kansas, and his M.A. is from Cambridge University, United Kingdom. His education and training included work at the University of Kansas, Johns Hopkins University, the National Institutes of Health, Duke University, the Institute of Medicine (IOM), and Harvard Business School. He has held faculty appointments at the University of Wisconsin-Madison, the University of Utah, the University of Virginia, and Cambridge University. He served as vice president for health sciences at the University of Utah and the University of

Virginia. He chaired the IOM committee that produced the computer-based patient record reports of 1991 and 1997 and was a member of the committees that produced the IOM reports *To Err is Human: Building a Safer Health System* and *Crossing the Quality Chasm: A New Health System for the 21st Century*. Dr. Detmer's research interests include national and international health information and communications policy, quality improvement, administrative medicine, vascular surgery, the education of clinician-executives, and leadership of academic health sciences centers.

John R. Dyer is currently dividing his time between health care consulting to information management companies and a family business based in Central America involved in coffee, real estate, and cemetery and investment portfolio management. He is president and a consultant at Jarrett Associates, Inc. From January 2007 to August 2009, Mr. Dyer was the deputy commissioner for operations and chief operating officer (COO) of the Food and Drug Administration (FDA) in the U.S. Department of Health and Human Services (HHS). Mr. Dyer managed the overall day-to-day operations of the agency. Mr. Dyer served as the COO at the Centers for Medicare and Medicaid Services (CMS) within HHS from 2004 to 2006. He led the implementation of the Medicare Modernization Act, which provided a new Medicare prescription drug benefit to 43 million eligible Medicare beneficiaries. Mr. Dyer held executive positions with the Social Security Administration as the senior advisor to the commissioner (2000), principal deputy commissioner and chief information officer (1995-2001), and chief financial officer (1988-1994). Mr. Dyer is a graduate of the University of Notre Dame and holds a master's degree in public health from the University of Michigan. He is the recipient of four Presidential Rank Awards and numerous other awards from both government and the private sector.

John Glaser is the CEO of Siemens Healthcare. Before joining Siemens he was the vice president and chief information officer of Partners HealthCare System, Inc. Previously, he was vice president, Information Systems at Brigham and Women's Hospital. Prior to serving at Brigham and Women's Hospital, Dr. Glaser managed the Healthcare Information Systems consulting practice at Arthur D. Little, Inc. Dr. Glaser was the founding chair of the College of Healthcare Information Management Executives (CHIME) and is past president of the Healthcare Information and Management Systems Society (HIMSS). He has been a member of the board of the American Medical Informatics Association and is the former president of the eHealth Initiative Board and a fellow of HIMSS, CHIME, and the American College of Medical Informatics. He was awarded the John Gall Award for Healthcare CIO of the Year. CHIME established a scholarship in his name, and he was elected to the Healthcare CIO Hall of Fame. Partners HealthCare has received several industry awards for its effective and innovative use of information technology. Dr. Glaser has published three books on the strategic application of information technology in health care. He holds a Ph.D. in health care information systems from the University of Minnesota.

Laura M. Haas is an IBM Fellow and has been the director of computer science at IBM Almaden Research Center since 2005; she also serves as a "catalyst" for ambitious research across IBM's

worldwide research laboratories. Previously, Dr. Haas was responsible for Information Integration Solutions (IIS) architecture in IBM's Software Group after leading the IIS development team through its first 2 years. She joined the development team in 2001 as manager of DB2 UDB Query Compiler development. Before that, Dr. Haas was a research staff member and manager at the Almaden laboratory for nearly 20 years. At IBM Research, she worked on and managed a number of exploratory projects in distributed database systems. Dr. Haas is best known for her work on the Starburst query processor (from which DB2 UDB was developed); on Garlic, a system that allowed federation of heterogeneous data sources; and on Clio, the first semiautomatic tool for heterogeneous schema mapping. Garlic technology, married with DB2 UDB query processing, is the basis for the IBM WebSphere Information Server's federation capabilities, while Clio capabilities are a core differentiator in IBM's Rational Data Architect. Dr. Haas is an active member of the database community. She served as vice president of the VLDB Endowment Board of Trustees from 2004 to 2009 and was vice chair of the Association for Computing Machinery's (ACM's) Special Interest Group on Management of Data (SIGMOD) from 1989 to 1997. Dr. Haas has received several IBM Awards for Outstanding Technical Achievement and Outstanding Innovation and an IBM Corporate Award for her work on federated database technology. In 2010 she was recognized with the Anita Borg Institute Technical Leadership Award. She is a member of the National Academy of Engineering and the IBM Academy of Technology, an ACM Fellow, and vice chair of the board of the Computing Research Association. Dr. Haas received her Ph.D. from the University of Texas at Austin and her bachelor's degree from Harvard University.

Blaise Heltai is the principal at genus2 Technology and a general partner at NewVantage Partners, LLC. His focus is on the practical applications of technology to business transformation and product innovation. Dr. Heltai was previously an executive at the FleetBoston Financial Group, where, as the managing director for eBusiness and Corporate eCatalyst, he led the company through a fundamental transformation across all lines of business, in the United States and internationally. Dr. Heltai has also been the customer intelligence executive for Bank of America; was the CEO of fileTRUST, which produced secure online document storage and sharing service; and has held multiple positions at Bell Laboratories and AT&T Consumer Products. There he started by using behavioral methods to predict the future demand for telecommunications offerings and ended up leading the development and marketing of 1990s' versions of smartphones, intelligent devices, interactive television, and online services. Dr. Heltai has won numerous awards, including Internet Week's Top 100 of 2001, MassEcomm Top 10 Executives, Microsoft Innovation Award, and Best in Show at the Consumer Electronics Show. He has served on the board of directors of MECA Software, Integrion, and several nonprofit organizations. He has been on the advisory boards of S1 Corporation, PostX, and FTVentures and is past president of the Massachusetts Innovation and Technology Exchange (MITX). He has served on the National Research Council's Committee on the Social Security Administration's E-Government Strategy and Planning for the Future and currently serves on the Social Security Administration's Future Systems Technology Advisory Panel, and on the Advisory Committee for the University of Massachusetts College of

Mathematics and Natural Sciences. He received his Ph.D. in mathematics from the Stony Brook University in 1984.

George Hripcsak is the Vivian Beaumont Allen Professor and chair of Columbia University's Department of Biomedical Informatics, director of Medical Informatics Services for New York-Presbyterian Hospital, and senior informatics adviser at the New York City Department of Health and Mental Hygiene. Dr. Hripcsak is a board-certified internist with degrees in chemistry, medicine, and biostatistics. He led the effort to create the Arden Syntax, a language for representing health knowledge that has become a national standard. Dr. Hripcsak's current research focus is on the clinical information stored in electronic health records. Using data-mining techniques such as machine learning and natural language processing, he is developing the methods necessary to support clinical research and patient safety initiatives. As the director of Medical Informatics Services, he oversees a 7,000-user, 2.5-million-patient clinical information system and data repository. He is currently the co-chair of the Meaningful Use Workgroup of the Department of Health and Human Services' (HHS's) Office of the National Coordinator of Health Information Technology; it defines the criteria by which health care providers collect incentives for using electronic health records. Dr. Hripcsak was elected a fellow of the American College of Medical Informatics in 1995 and served on the board of directors of the American Medical Informatics Association (AMIA). As chair of the AMIA Standards Committee, he coordinated the medical-informatics community response to HHS for the health-informatics standards rules under the Health Insurance Portability and Accountability Act of 1996. Dr. Hripcsak chaired the National Library of Medicine's Biomedical Library and Informatics Review Committee, and he is a fellow of the American College of Medical Informatics and the New York Academy of Medicine. He has published more than 200 papers.

Yeona Jang is a professor of practice at the Desautels Faculty of Management Information Systems of McGill University. Prior to joining McGill University in 2008, she worked as a senior executive and decision maker in companies in industries as widely varying as telecommunications, financial services, utility, and high-tech and information technology (IT) services. She led various transformational programs and initiatives in IT strategy, IT-enabled business innovation, the strategic use of 6 sigma for business transformation, knowledge management and e-learning, enterprise architecture, software product development, large-scale systems integration, IT productivity transformation, IT governance, and IT outsourcing management. Her current research focus is on advancing the understanding of IT-to-value pathways to help organizations shape the future and drive changes for greater efficiency and innovation in the 21st-century economy: Not "What worked in the past and how do we repeat it?" but "What's necessary for the future and how do we create it?"

Ralph W. Muller is the CEO of the University of Pennsylvania Health System (UPHS), a $3.3 billion enterprise that includes three owned and two joint-venture hospitals, a faculty practice plan, a primary-care provider network, multispecialty satellite facilities, home care, hospice care, and long-term care. His 28-year career in health care administration has set the stage for his extensive knowledge of the multiple and complex challenges faced by today's urban-based

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academic health systems. Prior to joining UPHS, he was, from 1985 to 2001, the president and CEO of the University of Chicago Hospitals and Health System. In 2001 and 2002, he was a visiting fellow at the Kings Fund in London, United Kingdom. In 1985 and 1986, Mr. Muller also served as the deputy dean of the Division of the Biological Sciences at the Pritzker School of Medicine at the University of Chicago. Previously, he had been the budget director at the university. Before joining the University of Chicago, Mr. Muller held senior positions with the Commonwealth of Massachusetts. His career with the Commonwealth included serving as deputy commissioner of the Massachusetts Department of Public Welfare, where he was the operating officer responsible for the state's major welfare programs, including Medicaid. Since the 1990s, Mr. Muller's voice has been at the forefront of the national dialogue and debate on such important health policy issues as the social role of teaching hospitals and medical schools, federal and state payments for patient care and care of the uninsured, and the creation of patient-oriented medical care systems. On the national front, Mr. Muller was a commissioner (2001-2007) of the Medicare Payment Advisory Commission (MedPAC), an independent federal body that advises the U.S. Congress on issues affecting the Medicare program. From 1999 to 2000, Mr. Muller served as chair of the Association of American Medical Colleges (AAMC), the umbrella advocacy organization that represents the interests of the 141 accredited medical schools in the United States and Canada and of the nation's 400 major teaching hospitals. In that role Mr. Muller partnered with the AAMC's leadership to advocate for increased research funding and improvements to medical education, as well as the development of a new coalition of health care providers to improve access to care for the underinsured. Currently, Mr. Muller is chair of the University Healthsystem Consortium, a director of the National Committee for Quality Assurance, and a commissioner of the Joint Commission. A former chair of the board of the National Opinion Research Center at the University of Chicago, he is currently a member of the Institute of Medicine of the National Academies and a fellow of the American Association for the Advancement of Science. Mr. Muller received his bachelor's degree in economics from Syracuse University and a master's degree in government from Harvard University.

Leon J. Osterweil is a professor in the Department of Computer Science, co-director of the Laboratory for Advanced Software Engineering Research (LASER), and founding co-director of the Electronic Enterprise Institute, all at the University of Massachusetts, Amherst, where he also served as the dean of the College of Natural Sciences and Mathematics from 2001 to 2005. Previously he was a professor in and chair of the Computer Science Department at both the University of California, Irvine, and the University of Colorado, Boulder. He was the founding director of the Irvine Research Unit in Software and the Southern California Software Process Improvement Network. Professor Osterweil's research focuses on the definition, analysis, and iterative improvement of processes. He led the project to develop the Little-JIL process definition language. He has also collaborated with colleagues in leading research projects aimed at defining and analyzing processes in domains such as health care, elections, scientific data processing, software development, and negotiation.   His work on processes for the delivery of health care services has resulted in numerous papers demonstrating the ability to identify various kinds of defects and inefficiencies. His work on processes for negotiation has led to the development of the STORM 2 system, which supports interest-based bargaining

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approaches to negotiation. His work has been supported by a variety of sources, most principally by numerous grants from both the National Science Foundation and the Defense Advanced Research Projects Agency. Professor Osterweil was awarded the Association for Computing Machinery's (ACM's) SIGSOFT Outstanding Research Award for Lifetime Excellence in Research in 2003 and the ACM SIGSOFT Most Influential Educator Award in 2010. His Ninth International Conference on Software Engineering (ICSE 9) paper was awarded a prize as the most influential paper of ICSE 9, awarded as a 10-year retrospective. Professor Osterweil is a fellow of the ACM. He is a member of the editorial boards of *IEEE Transactions on Software Engineering, Software Process Improvement and Practice, Automated Software Engineering,* and the *International Journal of Software and Informatics.* Previously he was a member of the editorial boards of the *ACM Transactions on Software Engineering Methods, IEEE Software,* and *Software Process Improvement and Practice.* He chaired the National Research Council committee that studied strategies for improving electronic services provision for the U.S. Social Security Administration. He has presented keynote talks at a variety of meetings, including ICSE 9, where he introduced the concept of process programming. Professor Osterweil has been the program committee chair for such conferences as ICSE 16; the Second International Symposium on Software Testing, Analysis, and Validation; the Fourth International Software Process Workshop; the Second Symposium on Software Development Environments; and both the Second and the Fifth International Conferences on the Software Process. He was also the general chair of the Sixth ACM SIGSOFT Conference on the Foundations of Software Engineering, and of the 28th International Conference on Software Engineering. He has consulted for such organizations as IBM, Bell Laboratories, SAIC, MCC, and TRW, and for the Software Engineering Institute's Process Program Advisory Board.

Ruth Perot is the managing director of the National Health IT Collaborative for the Underserved (NHIT Collaborative), a public-private-community partnership established to help ensure that underserved, vulnerable communities benefit fully from health information technology initiatives and advances. She is also a co-founder and the executive director and CEO of Summit Health Institute for Research and Education, Inc. (SHIRE). Since 1997, SHIRE has served as a resource for the attainment of health parity and optimal health for all Americans, with an emphasis on communities of color and other vulnerable populations. Ms. Perot has championed the collection and reporting of racial, ethnic, and primary language data to monitor progress toward health equity for all Americans. She also has extensive experience in educating and engaging members of vulnerable populations. With respect to health information technology, her relevant assignments include appointment to the National eHealth Collaborative Membership and Communications Committee and its predecessor, AHIC Successor Inc.; appointment to the Health Information Communication and Data Exchange Taskforce of the State Alliance for E-Health, National Governors Association; and service from 2007 to 2010 as a board-appointed member of the HIMSS Public Policy Steering Committee. In 2010, she served as an advisory council member and presenter for the Brookings Institution's conference addressing data-driven strategies for eliminating health disparities. She also reviewed the Institute of Medicine's report *Future Directions for the National Healthcare Quality and Disparities Reports*. In addition to participating as an appointed member of the CMS

Systems Modernization expert panel, she currently advises the Office of the National Coordinator and the Health Resources and Services Administration, Department of Health and Human Services, as an expert panelist addressing the impact of health information technology on underserved communities and those with health disparities. Ms. Perot is a graduate of Oberlin College and received a Master of Arts in Teaching degree from the Harvard Graduate School of Education. Currently a fellow of the National Academy of Social Insurance, she is also a recipient of the Congressional Black Caucus Health Braintrust's Healthcare Hero Award and Families USA's Consumer Advocate of the Year Award.

Helen L. Smits is an independent consultant. She was the deputy administrator and chief medical officer of the Health Care Financing Administration (HCFA; now CMS) during President Clinton's first term. She is a former member of the Board of Regents of the American College of Physicians and the Board of Commissioners of the Joint Commission on Accreditation of Healthcare Organizations, serving as its first woman chair from 1991 to 1993. She has been a member of the faculties of the Yale School of Public Health and the School of Medicine at the University of Connecticut, a visiting professor at the Wagner School in New York, and a member of the faculty of medicine at the Medical School of the Eduardo Mondlane University in Maputo, Mozambique. Dr. Smits was the director of the John Dempsey Hospital at the University of Connecticut for 7 years. She is the author of a number of publications, with particular emphasis on the policy issues associated with the quality of health care. Her recent work has focused chiefly on Africa; she served as a volunteer for the Clinton Foundation HIV/AIDS Initiative in Mozambique and as a senior consultant to the Doris Duke Foundation's African Health Initiative.

Walter Suarez is a physician and a public health and medical information systems specialist and the director of health information technology (IT) strategy for Kaiser Permanente. Before joining Kaiser, Dr. Suarez was the president and CEO of the Institute for HIPAA/HIT [Health Insurance Portability and Accountability Act/Health Information Technology] Education and Research. Earlier he was the CEO of the Midwest Center for HIPAA Education, and before that he was the executive director and CEO of the Minnesota Health Data Institute. He also worked for the Minnesota Department of Health in various senior policy positions. Dr. Suarez has provided project management, technical and policy consulting services, and project and program evaluation services to health care provider organizations, health plans, Medicaid and Medicare programs, public health agencies, and vendors in the areas of health information technology/health information exchange, public health data standards, health disparities, quality measurement, health information privacy and security standards, and HIPAA standards, including Transactions and Code Sets and the National Provider Identifier. More recently, Dr. Suarez was a lead consultant to national and regional projects such as the Health Information Security and Privacy Collaboration—HISPC (Office of the National Coordinator—Agency for Healthcare Research and Quality), Technical Assistance to Medicaid and CHIP [Children's Health Insurance Program] agencies on health information technology and health information exchange (AHRQ), and Development of Statewide Uniform Companion Guides for HIPAA Transactions (Minnesota). Dr. Suarez was appointed in 2008 by the secretary of Health

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and Human Services (HHS) to the National Committee on Vital and Health Statistics (NCVHS), where he now co-chairs the Sub-Committee on Standards. In 2009 the secretary of HHS also appointed him to the Health Information Technology Standards Committee of the Office of the National Coordinator for Health Information Technology. He has also served actively in several national organizations, including as a member of the board of directors of the former Health Information Technology Standards Panel (HITSP), where he co-chaired the Security, Privacy and Infrastructure Technical Committee, the Clinical Research Tiger Team, and the HITSP Education, Communications and Outreach Committee; co-chair of the Privacy and Compliance Workgroup of the Certification Commission for Health Information Technology; founding president of the Public Health Data Standards Consortium; member of the executive board of the Joint Public Health Informatics Task Force; and member of the National Uniform Claims Committee.

John A. Swainson is a senior adviser at Silver Lake and an independent consultant. Formerly, he served as the CEO and director of CA Inc., a Fortune 500 enterprise software company, from early 2005 to the end of 2009. While at CA Inc., Mr. Swainson led the company through an extensive transformation of its internal processes and corporate image. During his tenure, the company successfully completed the Deferred Prosecution Agreement, raised customer satisfaction by 20 percentage points, doubled operating margins, restored cash flows to a sustainable growing level of more than $1.2 billion, and added almost $1 billion of revenue. In a period of profound economic uncertainty, the company was upgraded to investment grade by all three major debt-rating agencies, and CA's stock was upgraded to "buy" by the majority of firms providing coverage. He hired a new management team and with them reengineered the sales, marketing, finance, tax, development, and support processes, successfully installing a single worldwide instance of SAP to support the new business processes. Having repositioned the company with a strategy for growth, he stepped down from CA at the completion of his employment agreement. Prior to working at CA, Mr. Swainson worked for IBM Corporation for more than 26 years; there he held various management positions in the United States and Canada, including, for 7 years, the role of general manager of the Web Sphere Middleware Division, a business that he founded in 1997 and that grew to more than $1 billion. He also ran the IBM worldwide software sales organization and held a number of senior engineering, marketing, and sales management positions. He has attended numerous executive education programs over the past 30 years, including the Wharton International Fellows Programs and various programs at Harvard Business School (New CEO, Building Better Boards, etc). He sits on the boards of Visa, Inc., where he is the lead director, and of Cadence Design Systems. He lives with his wife of 32 years, Linda, on a small farm in Ridgefield, Connecticut, where they raise horses and dogs, fruits, and vegetables. In addition to the farm, his hobbies include aviation (commercial/multi-instrument rated pilot), boating, and golf. Before he joined IBM, Mr. Swainson worked for the Utah Mines Division of General Electric Corporation, where he was a process metallurgist. He has a bachelor's degree in engineering from the University of British Columbia, Canada.

Peter Szolovits is a professor of computer science and engineering in the Massachusetts Institute of Technology (MIT) Department of Electrical Engineering and Computer Science (EECS), a professor of health sciences and technology in the Harvard/MIT Division of Health Sciences and Technology (HST), and head of the Clinical Decision-Making Group within the MIT Computer Science and Artificial Intelligence Laboratory (CSAIL). His research centers on the application of artificial intelligence (AI) methods to problems of medical decision making and the design of information systems for health care institutions and patients. He has worked on problems of diagnosis, therapy planning, execution and monitoring for various medical conditions, computational aspects of genetic counseling, controlled sharing of health information, and privacy and confidentiality issues in medical record systems. His interests in AI include knowledge representation, qualitative reasoning, and probabilistic inference. His interests in medical computing include Web-based heterogeneous medical record systems, lifelong personal health information systems, and the design of cryptographic schemes for health identifiers. He teaches classes in AI, programming languages, medical computing, medical decision making, knowledge-based systems, and probabilistic inference. Professor Szolovits has been on the editorial board of several journals, has served as program chair and on the program committees of national conferences, and has been a founder of and consultant for several companies that apply AI to problems of commercial interest. Professor Szolovits was elected to the Institute of Medicine of the National Academies and is a fellow of the American Association for Artificial Intelligence, the American College of Medical Informatics, and the American Institute for Medical and Biological Engineering. He serves as a member of the National Research Council's Computer Science and Telecommunications Board.

Staff

Lynette I. Millett is a senior program officer and study director at the Computer Science and Telecommunications Board (CSTB), National Research Council of the National Academies. She currently directs several CSTB projects, including a comprehensive exploration of sustaining growth in computing performance and an examination of opportunities for computing research to help meet sustainability challenges. She served as the study director for the CSTB report *Social Security Administration Electronic Service Provision: A Strategic Assessment*. Ms. Millett's portfolio includes significant portions of CSTB's recent work on software, identity systems, and privacy. She directed, among other projects, those that produced *Software for Dependable Systems: Sufficient Evidence?*, an exploration of fundamental approaches to developing dependable mission-critical systems; *Biometric Recognition: Challenges and Opportunities*, a comprehensive assessment of biometric technology; *Who Goes There? Authentication Through the Lens of Privacy*, a discussion of authentication technologies and their privacy implications; and *IDs—Not That Easy: Questions About Nationwide Identity Systems*, a post-9/11 analysis of the challenges presented by large-scale identity systems. She has an M.Sc. in computer science from Cornell University, where her work was supported by graduate fellowships from the National Science Foundation and the Intel Corporation; and a B.A. with honors in mathematics and computer science from Colby College, where she was elected to Phi Beta Kappa.

Emily Ann Meyer is a program officer and study director at CSTB. She came to CSTB from the National Materials Advisory Board and the Board on Manufacturing and Engineering Design. While at the NMAB she completed two studies on Aviation Security (*Fusion of Security System Data to Improve Airport Security* and *Assessment of Millimeter-Wave and Terahertz Technology for Detection and Identification of Concealed Explosives and Weapons*), directed the roundtable on biomedical engineering materials and applications, and oversaw a workshop on nondestructive evaluation for materials state awareness, among other activities. She holds a J.D. from Hamline University School of Law and a B.A. (magna cum laude) in political science from Virginia Wesleyan College, where she also minored in German.

Eric Whitaker is a senior program assistant at CSTB. Prior to joining the CSTB, he was a realtor with Long and Foster Real Estate, Inc., in the Washington, D.C., metropolitan area. Before that, he spent several years with the Public Broadcasting Service in Alexandria, Virginia, as an associate in the corporate support department. He has a B.A. in communication and theater arts from Hampton University.