Seventy Years of Management Engineering and Consulting: Integrating Health Care Delivery for an Enduring Mission

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On July 21, 2017, the Department of Management Engineering & Internal Consulting (ME&IC) celebrated its 70th anniversary. Over the years, this unique department has partnered with Mayo Clinic colleagues to achieve the best patient experience through objective, innovative, and integrative engineering and business consulting. The Department of Management Engineering & Internal Consulting collaborates with internal groups and external institutions to bring diverse expertise and collective excellence and to develop approaches and methods for the future. This collaboration has helped Mayo Clinic in its mission to provide the most trusted and affordable care. Mayo Clinic’s commitment to engineering and consulting enables the organization to leverage these disciplines in support of integrated clinical, education, and research services, leading to substantial patient care benefits and financial savings. This article briefly reviews the history, progressive journey, and major contributions of the department over the past 70 years. It will conclude with an overview of current ME&IC services and methods, as well as the department’s progress to advance Mayo Clinic’s strategic priorities.

INSPIRING LEGACY INTERTWINED WITH MAYO CLINIC

Mayo Clinic, the first and largest integrated, not-for-profit medical group practice in the world, celebrated its sesquicentennial in 2014.1 For more than 150 years, people from all walks of life have found answers at Mayo Clinic. U.S. News & World Report ranked Mayo Clinic #1 on its Honor Roll of leading medical institutions in 2016 and 2017.2 The past decade has seen a growing national and global recognition of the need for a greater partnership among multiple disciplines to optimize quality, safety, and efficiency in health care. Mayo Clinic has a long history and vibrant culture of using business consulting, analytics, engineering, and operations research to enhance patient care. More than 100 years ago, Henry Plummer, MD, one of the first physicians hired by Mayo Clinic, applied systems engineering principles to medical practice. He developed the unified patient medical record, conveyors, and pneumatic tubes to transport clinical documents within the campus, a color-coded light system to indicate the occupancy status of a patient examination room, a system of underground walkways connecting campus buildings, and many policies, templates, and forms.3,4 Dr. Plummer’s engineering innovations continue to serve the patients and staff of Mayo Clinic today. A key lesson from his work is that efficiency and best practices need to be designed and engineered systematically rather than left to individual initiative to achieve sustainable outcomes and excellent patient experience.

THE EARLY YEARS

Immediately after World War II, it became clear that “systemized” innovations would be vital for Mayo Clinic’s success.3,4 To explore this concept, Mayo Clinic leaders benchmarked with other institutions. According to Richard W. Cleeremans, former Section Head of Systems and Procedures, Mayo Clinic leaders visited the “Methods and Procedures” section of the Prudential Life Insurance Company and the Metropolitan Life Insurance Company in New York City (oral

communication, Janine R. Kamath, MA, MBA, 2007). They were impressed with the “methods men,” whose backgrounds in industrial engineering and accounting provided the skills to develop procedures and design systems in a timely way.

Mayo Clinic leaders decided to replicate this practice and establish a team of industrial engineers at the clinic. This decision was aligned with Mayo Clinic’s commitment to the patient, the physician-patient relationship, and Dr Plummer’s conviction that the system and organization of the clinical practice was important and worthy of management attention. Postwar conditions had presented many new problems, and the procedures used at Mayo Clinic and its primary hospital, Saint Marys Hospital, were in need of restudy, especially those relating to the requesting, reporting, and recording of laboratory tests. Patient admission and registration procedures, x-ray film storage, and medical records also needed to be reviewed.5

Mayo Clinic leaders presented a proposal for the creation of a new section within the Department of Administration. The minutes of the Board of Governors record the formation of the Section of Procedures and Records (now known as the Department of Management Engineering & Internal Consulting):

As recorded in the written minutes of the Mayo Clinic Board of Governors on July 16, 1947:

The Board approved the recommendation of the Executive and Coordinating Committees that a section be established in the Administrative Department to be concerned with procedures and records. It further concurs in the recommendation of the committees that Mr. E. H. Schlitgus be appointed head of this section… Mr. Schlitgus will devote full time to an analysis of all present methods of record-keeping and storage, ordering and reporting tests, and Clinic-Hospital functions, with the ultimate purpose of simplification of procedures and more efficient operation of the routines employed.6

The Section of Procedures and Records was created on July 21, 1947.5 In a classic blend of leadership and early adoption, Mayo Clinic became one of the first medical institutions to create a dedicated team of staff to specialize in “methods” and “systems.” These pioneers of engineering, integration, and innovation were open to learning from all spheres of work and life. They were risk takers with a passion for developing and implementing creative solutions focused on the needs of the patient. They reported the benefits of synthesizing the fields of medical science and engineering to serve patients and to provide colleagues with tools and methods to do their work most effectively. Based on an interview with Richard W. Cleeremans in 2007, early projects of the Section of Procedures and Records included developing a patient registration process for hospital patients, managing forms to support clinical workflows, developing procedure guides for physicians, and conducting space studies to accommodate storage needs for medical histories and x-ray films (oral communication, Janine R. Kamath, MA, MBA, 2007). The section was also integral to the planning, design, and occupancy of the 10-story Mayo Building, the largest construction project at Mayo Clinic in a generation. Completed in 1953, the building contained several unique facility design elements to support novel processes and systems, including a pneumatic tube system, medical history drop chutes, bucket lifts, and card conveyor belts.3,4 In 1957, to recognize its changing and growing responsibilities, the section’s name was changed to Systems and Procedures (S&P).

New projects continued to stream in for S&P. For example, S&P was asked to lead the development of the Mayo Clinic paper form specifications (size, paper weight, type of ink, etc) along with the Mayo Clinic Forms Manual, resulting in a centralized method of forms control in 1964. In conjunction with the Coordinating Committee, S&P was responsible for the design, printing, and procedures for the 1100 forms that were part of the forms control program. The cost of printing these forms on an annual basis was estimated to be in excess of $250,000.7
THE EXPANSION YEARS

The mid-1980s through the early 2000s was a time of major capital investment, construction, and expansion for Mayo Clinic. While the Rochester campus was expanding, Mayo Clinic was also growing its physical presence with the opening of the Mayo Clinic campuses in Florida in 1986 and in Arizona in 1987 (Figure 1). On the basis of its contributions to the Rochester campus, S&P was established on-site in Florida and Arizona. Initial efforts focused on facilities development, supply distribution processes, staffing, nursing and surgery workflows, and information technology implementation. In the early 1990s, Mayo Clinic further expanded its operations with the establishment of the Mayo Clinic Health System in Minnesota, Wisconsin, and Iowa. An S&P unit was created to support the health system (Figure 1).

The turn of the 21st century witnessed the largest capital construction and infrastructure development initiative for patient care in the history of Mayo Clinic. Known as the Practice Integration Projects, this Rochester initiative connected new and existing buildings with a patient-centric focus. The Gonda Building, for example, was designed with the concept of providers coming to the patient rather than patients going to multiple provider locations. The S&P division was involved in the design, space and equipment planning, workflow, electronic systems assessment, and flow of patient medical information.

Kerry Olsen, MD, physician leader of the Practice Integration Projects, recalled in February 2017:

In the 1990s and early 2000s, S&P played a major role in practice analysis concerning patient flow, physician time with patients, and other factors. Their studies and recommendations were used to assess needs for staff and space, and to develop practice efficiency options. We used this model in planning the Gonda Building. It was incredibly helpful (written communication, Janine R. Kamath, MA, MBA, 2017).

Complementing the physical expansion, Mayo Clinic embarked on a virtual outreach in 1994 with the establishment of the Ask Mayo Clinic nurse triage telephone line, which provided patients with 24-hour/7-day access to a nurse for clinical guidance. Five years later, a United Arab Emirates telemedicine pilot using store-and-forward technology was conducted. The pilot evaluated the transmission of patient clinical information from around the world to Mayo Clinic specialists for timely review. Systems and Procedures partnered with Mayo Clinic colleagues to develop processes that integrated the software and telecommunications technology with the clinical practice, ultimately allowing Mayo Clinic to serve patients in distant areas. Today, the engineering and consulting staff supports innovative initiatives in the areas of connected and digital health, which use technology to engage Mayo Clinic patients and their caregivers in new ways. For example, staff supports implementation of video telemedicine to reach patients outside the walls of Mayo Clinic, assuring care coordination and documentation. Another key engagement is remote monitoring of patients in their own homes to collect and analyze physiological and medical data.

The age of the electronic medical record was on the horizon and promised to considerably disrupt health care. Mayo Clinic worked systematically to move from paper to computerized medical records starting in the early 1990s. Together with clinical informatics and information technology, S&P co-led the

FIGURE 1. Composite view of Mayo Clinic campuses, including (clockwise) Rochester, Minnesota; Jacksonville, Florida; Scottsdale, Arizona; and Eau Claire, Wisconsin.
automation of critical care and hospital charting, outpatient documentation, patient orders and scheduling, patient-provided information, and laboratory results.

Moving toward an electronic medical record was tremendously beneficial for Mayo Clinic. However, the dual paper and electronic medical record created inefficiencies. In 2002, Mayo Clinic leaders decided to replace the paper medical record (Figure 2). A multidisciplinary, physician-led team was formed to enable this important endeavor. Systems and Procedures was responsible for the process and workload analysis, systems reengineering, standardization of procedures, training, implementation, and impact assessment. As more data became electronic, operational infrastructure and processes were developed to enable data-driven and evidence-based decisions. By 2005, Mayo Clinic had one of the largest integrated electronic medical record systems in the world, positively affecting the work of approximately 25,000 employees directly involved in patient care.10

The “systems” philosophy of S&P helped deliver best practices across multiple initiatives and ensure that insights gained from one project would be available to help other projects, including:

• Developing the first record retention policy
• Designing and implementing a system to computerize Mayo Clinic registration procedures and the central appointment desk system
• Conducting environmental and benchmarking studies and developing the first formal strategic planning process and framework for Mayo Clinic

It is important to note that S&P’s focus on innovation and transformation was, and continues to be, reflective in the projects done with Mayo Clinic research and education. The comprehensive research management system was implemented to enhance the management of key research priorities. The goals of this integrated system included optimizing clinical trial management and implementing scalable shared support services for research. The expertise of S&P was used in the design, development, change management, and implementation of the comprehensive research management system. The redesign reduced the time from idea to translation through translation of clinical trials from 125 to 65 days (written communication, Dorothy A. Larsen, MA, 2014). In addition, S&P facilitated the reengineering of Mayo Clinic’s Institutional Review Board process by applying Lean methodology to redesign the process, creating procedures and checklists, and coordinating the associated pilot studies, personnel training, and implementation of recommendations. The new Institutional Review Board model improved employee satisfaction, reduced approval cycle times and study expenses, and ensured more efficient adherence to federal and institutional regulations. In the education arena, Mayo Clinic approved a proposal to expand the Mayo Clinic College of Medicine and Science to Arizona and Florida. A 4-year medical school was opened in Scottsdale, Arizona, in 2016. Systems and Procedures played an important role in making the Mayo Clinic School of Medicine—Arizona Campus—a reality. A heartening accomplishment was the recognition by medical school leaders that including systems engineering and the science of health care delivery in the curriculum for future physicians is critical to their understanding of the potential of these disciplines to transform health care.

As the needs of the health care industry continued to change rapidly, it was imperative that new models of collaboration be explored. Systems and Procedures partnered with Health Care Policy and Research, the Center for Innovation, Quality Management
to form a Systems Engineering/Operations Research Collaborative in 2005. Its mission was to study, share, and encourage the use of Systems Engineering/Operations Research tools in operations, clinical practice, administration, research, and education at Mayo Clinic.\(^{11}\) The collaborative sponsored educational opportunities for Mayo Clinic staff, including a monthly seminar with national experts, discussion forums, a conference on health care systems engineering and operations research, computer-based simulation workshops, and a master’s level Mayo Graduate School course.

On another front, S&P partnered with the Department of Laboratory Medicine and Pathology, Planning Services, Quality Management Services, and clinical practice leaders to create the Mayo Clinic Quality Academy. An immersive 10-day quality improvement course for multidisciplinary teams was designed to teach process improvement methodology. Systems and Procedures provided engineering and project management support for projects such as:

- **Clinical:** acute myocardial infarction, heart failure, pneumonia, surgical infection, ventilator-associated pneumonia, and the use of the anticoagulant drug warfarin
- **Administrative:** wait time, abandoned calls, accounts receivable, patient access, business services, and referring-physician communications

### RECENT EVOLUTION

In 2016, S&P was renamed the Department of Management Engineering & Internal Consulting (ME&IC) to better reflect the breadth and depth of the work and engagement across the organization.\(^ {12}\)

Today, ME&IC has more than 200 members, including administrative leadership, health system engineers, project managers, and support staff. The team serves all Mayo Clinic sites and regions. The Department of Management Engineering & Internal Consulting also supports the Mayo Clinic Care Network comprising more than 45 health care organizations in the United States and abroad as well as other business development entities of Mayo Clinic.

In a dynamic health care environment, ME&IC recognizes the importance of growing its value and transforming its operations to ensure performance excellence. The department has developed a number of best practice approaches, including a standardized business consulting model, a talent-management program, and a balanced scorecard. The Department of Management Engineering & Internal Consulting aligns the use of its professional frameworks and methods to serve the needs of its clients, including:

1. Queuing theory to optimize patient and staff surgical flows,
2. System dynamics models for resource allocation,
3. Simulation modeling to design facilities and spaces,
4. Decision-support methods to manage patient

### FIGURE 3. An overview of the Department of Management Engineering & Internal Consulting (ME&IC).
conditions, and (5) analytics and systems engineering for expense management. The staff of ME&IC strives to bring an objective, big picture perspective to all projects, including an understanding of patient and provider needs, organizational knowledge and relationships, and upstream and downstream implications. To position ME&IC for the next 5 years, the vision, value proposition, and service lines have been refined as outlined in Figure 3.

Continuous professional development, scholarship, and learning are critical to providing the best service. The staff of ME&IC is involved in presenting at national and international conferences, publishing in peer-reviewed journals, serving as faculty in academic institutions, and seeking membership on professional boards and committees.

Although the quantitative value of ME&IC to Mayo Clinic has been reported over many years, the team’s qualitative advantages are also important differentiators, including:

- Providing end-to-end services from project initiation through execution and sustainability
- Building professional relationships that lead to improved client understanding, buy-in, and ownership
- Expediting project deliverables and translating best practices in a contextual and result-oriented manner
- Serving as a talent pipeline for leadership and other positions, thereby extending the “spirit” of engineering and consulting throughout Mayo Clinic

To foster Mayo Clinic’s primary value—“The needs of the patient come first”—ME&IC assesses its impact on patient experience, as highlighted by the patient experience diagram in Figure 4.

The contributions of ME&IC have been recognized in several ways. The Mayo Clinic College of Medicine and Science added academic rank for the field of Health Care Systems Engineering in 2011. In 2014, Mayo Clinic was awarded the Institute for Operations Research and Management Sciences Prize for application and integration of advanced analytics, systems engineering, and operations research. ME&IC was judged the overall winner of the Association of Internal Management Consultants’ 2015-2016 Internal Consulting Excellence Award for its delivery of high-quality consulting processes and sharing of best practice methodologies with the global consulting community.
INTO THE FUTURE

In 2016, ME&IC became a shared service formally integrating the ME&IC teams across all Mayo Clinic sites. This allows the department to provide greater value through consistent and best practice knowledge and skills, a converged and streamlined core internal infrastructure, and a strategic set of service lines. It also supports establishing a national reputation through additional professional relationships and contributions.

The complex and increasingly competitive health care environment will continue to challenge Mayo Clinic. The pressure to accelerate the delivery of quantifiable results as health care providers adapt to payment reform, new models of care, and an ambiguous future will be important to skillfully manage. ME&IC has a rich legacy to lean on as it navigates these challenges and strives to deliver sustainable value at Mayo Clinic. The primary focus of the department will be to enable the priorities of Mayo Clinic by using novel and best practice engineering and consulting approaches and methods. ME&IC’s greatest asset is its diverse workforce with varied educational backgrounds and global professional experience in different industries.

CLOSING THOUGHTS

Mayo Clinic has been a pioneer in blending science with engineering to deliver high-value patient care and experience. The culture of collaboration and continuous improvement traces its roots to the early efforts of Dr Plummer. For 70 years, Mayo Clinic leadership has recognized consulting and engineering as important contributing disciplines for sustained excellence and market differentiation.

As the enduring mission and quest for answers continues, ME&IC is inspired by the spirit of systems thinking and the words of Dr William Worrall Mayo (Figure 5). The past has shown us that there are no final answers. We have to be open and curious as we strive to discover the next steps in our exciting journey.

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