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Increasing Need for Healthcare Systems Engineering

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Opinion

Simon "Si" Ramo, the "R" in the then-premiere aerospace company TRW, invented Systems Engineering (SE) as a new body of knowledge needed to deal with vastly increasing complexity of ballistic missiles. Ramo understood that complex systems comprise of thousands of complicated subsystems and components, each designed by a specialist who lacks any common language or understanding of other specialties. Ramo also understood that complex systems almost always fail at the interfaces of subsystems, because interfaces of components are created by specialists in totally distinct domains of knowledge, and nobody can be the expert on the entire complex system. Each subsystem tends to work fine in isolation, but when combined together, the intended system fails. So, Ramo invented SE as a new rigorous process to assure perfect performance of the integrated system. It integrates management and engineering of complex multidisciplinary systems. Over the last 50 years, this knowledge permitted engineers to design increasingly complex systems, some comprising of hundreds of thousands of parts. SE has evolved to a well-structured body of knowledge applicable to any domain: engineering, sciences, social sciences, administration, and lately healthcare.

Modern healthcare has reached the level of complexity far exceeding that, of ballistic missiles. The number of "parts" is orders of magnitude larger, and their complexity far exceeds that of mechanical and electrical parts in a missile. Healthcare is an intersection of many complexities: medical and biomedical, economic and political, technological, and human, most growing at exponential rates. Increasing complexity leads to increasingly frequent failures in the system, preventable deaths and harm, brutal pressures applied onto providers and administrators, and uncontrollable system costs. That the system still somehow operates is a testimony more to the extraordinary dedication of the people working in healthcare rather than their expertise in managing complexity.

Traditional management of healthcare relies on the knowledge of "healthcare administration", public health, biomedicine, and device engineering. Modern challenges in healthcare need vastly more than that. The 2014 President's Council on Science and Technology Report recognized that and called for widespread applications of Systems Engineering in healthcare. But the responses of both academia and healthcare industry have been slow.

Consider how SE can aid in some modern challenges in healthcare:

I. Fragmentation in all dimensions is recognized as one of the chief evils of healthcare, killing and harming patients, increasing costs and causing providers' burnout. Increasingly, there is a need to integrate the patient, providers, IT, devices, and health administrators. This integrated system involves human, social, economic, medical, IT, device engineering, and administrative subsystems. SE provides the tools and expertise to integrate such disparate elements.

II. Lean has established itself in all healthcare environments (clinics, hospitals, operating suites (ORs), emergency departments (EDs), clinical and imaging laboratories, pharmacies, as well as the supply chain and administration), providing significant reductions of cycle times; cost reductions; and quality, patient safety, patient experience, and staff morale improvements. Yet, most Lean improvements are confined to a given local process and lack the system-wide benefits. Healthcare SE augments Lean with "systems thinking on steroids".

III. Cost and competitive pressures motivate clinics to offload appropriate portions of medical care onto the patient, to reduce clinic workload and increase patient involvement. This involves human systems (patient), medical (providers), IT and video-tele-medicine, device engineers who design remote and automated monitoring of patients, pharmacy experts, and population health experts. Multidisciplinary integration is the key to success. SE provides user-friendly visual tools for designing integrated architectures of such new systems.

IV. Advanced population health relies on evidence provided from "data mining" from huge databases of healthcare records. This calls for advanced statistics and data extraction and

management which are subject to rigorous HIPAA regulations. Interfaces between electronic health records, IT tools, medical researchers, and statisticians are complex and benefit from systems thinking.

V. New medical devices, some carried on or implanted into the patient, now can transmit their radio signals to Electronic Health Records (EHR). For this system to work, tight integration is needed among device engineering, medicine, radio communications and cybersecurity, EHR/IT, and clinical management. Again, SE is a powerful tool for integration.

VI. Increasingly complex diagnostics (Dx) is already reaching cognitive limits of physicians. There is a desperate need for truly user-friendly computer-aided Dx tool. It would be a folly to design such tools without SE. Also, diagnosis of many conditions benefits from real-time consultations of specialists, which requires re-architecting of clinics to enable easy videoconferencing with specialists and real-time teaming. SE provides powerful system architecting tools.

VII. The significant shortage of both nurses and general practitioners in the U.S., and the myopic medical-only education of providers call for tighter integration of medical and nursing education, educational funding mechanisms, healthcare institutions, and systems engineers. The solution would benefit from well-integrated cooperation of the above parties for the benefit of all. Leading healthcare institutions now ask medical students to take some education in SE. Some large institutions, such as Kaiser Permanente, design their own medical schools accordingly.

Clearly the scope of these challenges far exceeds the traditional skillset of healthcare administrators, public health, and medical professionals. Without SE such projects risk unnecessary iterations, delays, busted budgets, frustrations of stakeholders, and often failure or diminished performance. In contrast, SE provides a rigorous process of identifying stakeholders, goals and interface management, systems thinking, design thinking, risk management, project management, excellent coordination, and, most importantly, integration of subsystems into a verified and validated working system.

The increasing need for SE in healthcare recently gave rise to a new sub-discipline of SE called Healthcare Systems Engineering (HSE). Besides SE and project management, it includes knowledge of specific applications in healthcare, such as patient safety systems, healthcare IT and EHR, healthcare integration, medical device systems, healthcare delivery systems, systems thinking in healthcare, healthcare systems architecting, healthcare system modelling and simulations, and population health systems. Most of the healthcare industry still lacks the appreciation of the immense potential of HSE in addressing healthcare challenges, but the situation is improving. The International Council on Systems Engineering, the professional society of SE, has created a new Healthcare Working Group. The Society of Healthcare Systems Improvement has adopted SE approaches. And at the time of this writing, five U.S. universities have opened graduate programs in HSE. Let us hope in a few years HSE will be a "household term" in healthcare industry.

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