A Brief History of Systems Engineering

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While many will attribute systems thinking to great accomplishments such as the Egyptian pyramids, Incan ziggurats, and the Roman aqueduct system, this article will pick up with the early mentions of systems engineering as a discipline. One only has to look to find a healthy body of works on the history of systems engineering. Many of those articles are cited in the References section below. The purpose of this article is to highlight the evolution of both the practice and definition of systems engineering as it emerged in the 20th century.

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The Forties and Fifties

(1940-1959)

During World War II, systems engineering began to emerge to deal with the myriad new technologies developed in support of the war effort. For example, an analysis of the RAF Fighter Command C2 System, which was crucial to the United Kingdom's prevailing in the 1940 Battle of Britain, performed by Derek Hitchens in 2005, concluded that its design represented "systems engineering of the highest caliber, even though that term had not yet been invented". (Hitchins 2005)

The first known use of the term "systems engineering" was in a March 1950 presentation to the Royal Society of London by Mervin J. Kelly, then Executive Vice President of Bell Telephone Laboratories. The transcript of Kelly's presentation entitled, "The Bell Telephone Laboratories - An Example of an Institute of Creative Technology", was published in the Proceedings of the Royal Society later that year. (Kelly 1950) In it, Kelly discussed the progress of Bell Labs over the first half of the twentieth century. He stated that the organization "grew in size and matured in the scope and character of its work during the period of rapid expansion in research in the physical sciences". From there, he went on to describe the organization of their work. The first organizational heading was Research and Fundamental Development. The second was 'Systems Engineering,' at the same level of importance as the research and development departments. Kelly described the responsibility of the systems engineering organization as "… the determination of new specific systems and facilities development projects – their operational and economic objectives and the broad technical plan to be followed. 'Systems engineering' controls and guides the use of the new knowledge obtained from the research and fundamental development programs in the creation of new telephone services and the improvement and lowering of cost of services already established…it attempts to ensure that the technical objectives of the development projects undertaken can be realized within the framework of the new knowledge available in the reservoir and present engineering practice."

The first published paper specifically about systems engineering appeared in 1956. In it, Kenneth Schlager of General Motors wrote, "Increased complexity in the fields of communications, instruments, computation, and control has led to an emphasis on the field of systems engineering." He went on to say, "Though engineers with system functions can be found in almost all phases of the modern electronics and aircraft industries, there seems to be no commonly agreed upon definition of the term “systems engineering.” Nevertheless, he said, “the rise of systems engineering as a separate field has resulted in some organizational changes in the engineering departments of many companies… “typical instance is that of a systems engineering group which has established itself on an equal level with other electrical and mechanical design groups in the engineering department.” (Schlager 1956)

E.W. Engstrom grew up in the Radio Corporation of America (RCA) Laboratories. He became the president and CEO of RCA in 1961 and 1966 respectively. However, in 1957 he published another early paper on systems engineering in Electrical Engineering. Engstrom explained the concept of systems engineering in terms of its evolution and characteristics and described the engineering of a color television system and of a specific weapons system to illustrate its application. He stated [that “the task of adapting our increasingly complex devices and techniques to the requirements and limitations of the people who must use them has presented modern engineering with its greatest challenge. To meet this challenge, we have come to rely increasingly during recent years upon the comprehensive and logical concept known as systems engineering. He defined only two requirements for successful systems engineering. “First, a determination of the objective that is to be reached; and second, a thorough consideration of all the factors that bear upon the possibility of reaching the objective and the relationships among these factors.” (Engstrom 1957)

The first textbook on the subject of systems engineering was Systems Engineering: An Introduction to the Design of Large-Scale Systems written by Goode and Mahol. It sold for $10 when published in 1957. In it, the authors stated, “this book develops no general theory. It presents experience, the parts and the pieces, and the relationships among them; occasionally, in a small area, it attempts to tie several parts together with a general observation”. (Goode and Machol 1957)

The Sixties and Seventies (1960-1979)

Arthur Hall, who also worked for Bell Telephone Laboratories, taught one of the earliest Systems Engineering courses at MIT. In his book “A Methodology for Systems Engineering”, Hall identified five traits of the ideal systems engineer (1962):

1. an affinity for the systems
2. faculty of judgment
3. Creativity
4. facility in human relations, and
5. facility for expression

He also wrote: “Systems engineering is most effectively conceived of as a process that starts with the detection of a problem and continues through problem definition, planning and designing of a system, manufacturing or other implementing section, its use, and finally on to its obsolescence. Further, systems engineering is not a matter of tools alone; it is a careful coordination of process, tools, and people.”

Another interesting historical description of systems engineering appeared in a 1967 report to the Committee on Science and Astronautics of the U.S. House of Representatives. In the report, Hendrik Bode of Bell Laboratories wrote: “…the systems engineer resembles an architect, who must generally have adequate substantive knowledge of building materials, construction methods, and so on, to ply his trade. Like architecture, systems engineering is in some ways an art as well as a branch of engineering. Thus, aesthetic criteria are appropriate for it also. For example, such essentially aesthetic ideas as balance, proportion, proper relation of means to ends, and economy of means are all relevant in a systems-engineering discussion. Many of these ideas develop best through experience.” (Panel on Applied Science and Technological Progress 1967)

Several common themes emerge in the early references to systems engineering as practiced during its first three decades:

- Systems engineers were deeply immersed in, and knowledgeable of, their application domains,
- Their analysis relied on domain-specific science, math, and engineering,
- The systems engineering effort transcended multiple technical and non-technical disciplines (e.g. including economics, psychology, and operations). It was, in fact, “transdisciplinary” from its inception, though that term has only been applied recently and
- As practiced, systems engineering was informal in nature, essentially the application of systems thinking

to the engineering of systems.

Despite the lack of formal structure during these early decades, systems engineering played an essential role in the achievement of perhaps the greatest technical accomplishment of that era, the landing of a man on the moon and his safe return to the earth in July of 1969.

Coincidentally, the same month as the Apollo landing saw the introduction of the first formal systems engineering process. Military Standard (MIL-STD)-499: *System Engineering Management*, was published by the U.S. Air Force. (1969) Later extended to the entire DoD, the intent of this Mil-Std was to provide program managers and contractors with guidance for managing the systems engineering process. Later, in 1974, the DoD updated their guidance with MIL-STD-499A. It too covered the process but added guidelines for the Systems Engineering Management Plan (SEMP) and task statements that could be selectively applied to a DoD acquisition program.

The Eighties and Nineties (1980-1999)

The National Council on Systems Engineering (NCOSE) grew out of the need for formally trained systems engineers. Meetings between industry and academia began in 1989 and continued through 1991. Notable names included Jeffrey Grady (GD), Dr. David Sworder (UCSD), Dr. Brian Mar (U of Washington), Dr. Terry Bahill and Dr. Ron Askin (U of Arizona), and Gerald Chasko (DSMC Regional Director). The group grew to include industry and DoD representatives from the USAF, TRW, Lockheed, Martin Marietta, MacDonnell Douglas, Aerospace Corp, Bechtel, TI, Boeing, Unisys, IBM and many others. In 1989, Dr. Brian Mar took the lead to begin the International Council on Systems Engineering and is recognized as the Father of INCOSE. (Grady, 2013).

Hughes hosted the January 1992 business meeting in Los Angeles with NCOSE, now a formally incorporated organization (Honour, 1998). Later, this organization would change its name and become known as the International Council on Systems Engineering. The first edition "Systems Engineering", the journal for NCOSE was published in July/September 1994.

In 1995, the NASA Systems Engineering Handbook (NASA/SP-6105) was published to bring the fundamental concepts and techniques of systems engineering to the National Aeronautics and Space Administration (NASA) personnel in a way that recognized the nature of NASA systems and the NASA environment.

Finally, version 1 of INCOSE's *Systems Engineering Handbook* first appeared in 1997.

21st Century

In 2005, the International Standards Organization (ISO) published their first standard defining systems engineering application and management. The purpose of this ISO standard was to define the interdisciplinary tasks which are required throughout a system's life cycle to transform customer needs, requirements and constraints into a system solution. In addition, it defines the entire systems engineering lifecycle. A number of related standards followed, to include ISO/IEC TR 24748-1:2010, 15288, and 12207.

There are a many great articles documenting a more thorough history of systems engineering that are found in the References section of this brief article.

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