2.6.2 Recognizing and Managing Life-Cycle Impacts

In evaluating past experiences regarding the development of technical systems, it is discovered that most of the problems experienced have been the direct result of not applying a *disciplined* top-down "systems approach." The overall requirements for the system were not defined well from the beginning; the perspective in terms of meeting a need has been relatively "short term" in nature; and, in many instances, the approach followed has been to "deliver it now and fix it later," using a bottom-up approach to design. In essence, the systems design and development process has suffered from the lack of good early planning and the subsequent definition and allocation of requirements in a complete and methodical manner. Yet, it is at this early stage in the life cycle when decisions are made that have a large impact on the overall effectiveness and cost of the system. This is illustrated conceptually in Figure 2.12.

Referring to Figure 2.12, experience indicates that there can be a large commitment in terms of technology applications, the establishment of a system configuration and its performance characteristics, the obligation of resources, and potential life-cycle cost at the early stages of a program. It is at this point when system-specific knowledge is limited, but when major decisions are made pertaining to the selection of technologies, the selection of materials and potential sources of supply, equipment packaging schemes and levels of diagnostics, the selection of a manufacturing process, the establishment of a maintenance approach, and so on. It is estimated that from 50% to 75% of the projected life-cycle cost for a given system can be committed (i.e., "locked in") based on engineering design and management decisions made during the early stages of conceptual and preliminary design. Thus, it is at this stage where the implementation of systems engineering concepts and principles is critical. It is essential that one start off with a good understanding of the customer need and a definition of system requirements.

The systems engineering process is applicable over all phases of the life cycle, with the greatest benefit being derived from its emphasis on the early stages, as illustrated in Figure 2.12. The objective is to influence design early, in an effective and efficient manner, through a comprehensive needs analysis, requirements definition, functional analysis and allocation, and then to address the follow-on activities in a logical and progressive manner with the provision of appropriate feedback. As conveyed in Figure 2.13, the overall objective is to influence design in the early phases of system acquisition, leading to the identification of individual discipline-based design needs. These should be applied in a

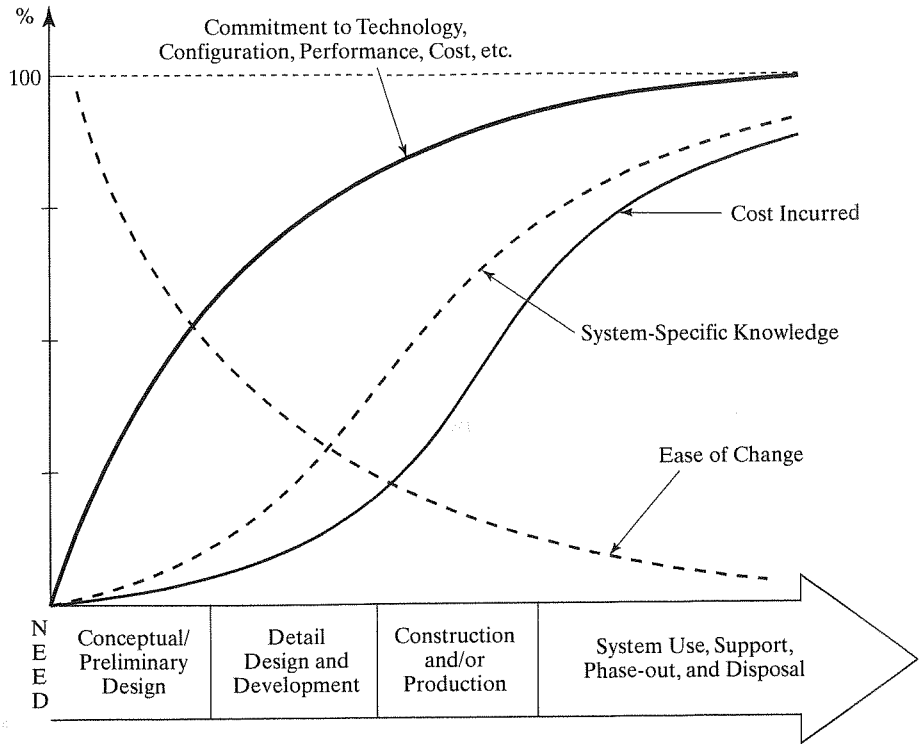

Figure 2.12 Life-cycle commitment, system-specific knowledge, and incurred cost.

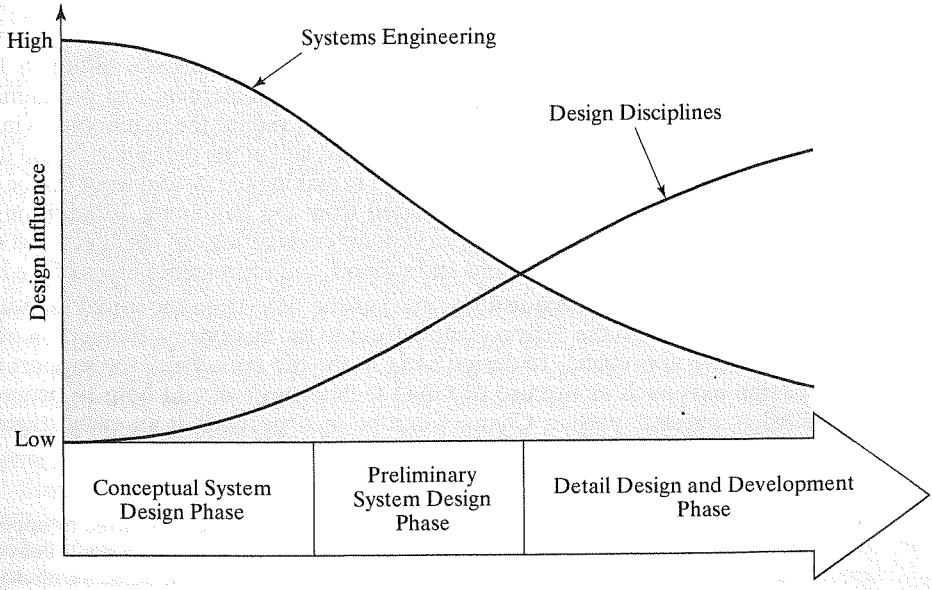

Figure 2.13 Systems engineering versus engineering discipline influence on design.

timely manner as one evolves from system-level requirements to the design of various subsystems and components thereof.[8]

[8]In Figure 2.13, the intent is to convey the degree of "design influence" imparted by application of the systems engineering process, and not to imply levels of human effort or cost. A single individual with the appropriate experience and technical expertise can exert a great deal of influence on design, whereas the establishment of a new organization and the assignment of many people to a project may have little beneficial effect.