Chapter 10
Systems and Modeling

A system is a set of variables sufficiently isolated to stay discussable while we discuss it. W. R. Ashby (1956)

Each one of us is a system. We live within systems and are surrounded by them. Systems exist in nature as well as in virtually any conceivable area of human activity. Systems are the focus of research and development in any field of human endeavor. In Chapter 4 we have elaborated on objects and processes as the fundamental building blocks of the universe. In the chapters that followed, we have learned how these building blocks can be combined in a variety of ways to model ever more complex things, which are still objects and processes. Having studied structure and dynamics, we are now ready to discuss systems.

All systems exhibit a common feature: they carry out some function. A system consists of a collection of related objects, represented by the system’s structure, that interact with each other via processes in a coordinated way, accounting for the system’s behavior. The combination of structure and behavior is the system’s architecture. An artificial system is the outcome of a human intent, a goal or objective, translated to function, for which the system has been designed and built. System analysis is a process of increasing human knowledge about the structure and behavior of existing systems. For artificial systems, design typically follows the analysis, yielding an orderly specification of an architecture for attaining the system’s desired function. In this chapter we apply our knowledge of OPM to define, study and model systems and related concepts, such as function, product and project.

10.1 Defining Systems

A system can be natural or artificial. It can be physical or informatical, biological, social or symbolic, or comprise more than one of these. Winograd and Flores (1978) noted that “an entity can be explained when its behavior can be described in terms of parts that play functionally defined roles in its operation.” This sentence contains many concepts that require crisp definitions. In this section we examine several definitions of the term “system” and then try to formulate our own definition.

10.1.1 Some Existing Definitions

The rich literature on systems contains many definitions of the term “system.” Let us examine a few definitions before proposing one that fits our frame of reference.
The definition of a system according to Ashby (1956), provided at the beginning of this chapter, is somewhat cynical and probably too viewer-centered to be useful. In UML (Object Management Group, 2000), a system is defined as a collection of connected units that are organized to accomplish a specific purpose. The US Defense Systems Management College (1999) defines a system as an “integrated composite of people, products, and processes that provide a capability to satisfy a stated need or objective.” The purpose, need, or objective is important as a basis for defining the system’s function, and function is an essential element in our definition of system.

Chen and Stroup (1993) have defined a system as “an ensemble of interacting parts, the sum of which exhibits behavior not localized in its constituent parts.” This definition introduces the Aristotelian principle of synergy, which proclaims that the whole is more than the sum of its parts. It also implies that the behavior of the system is emergent, i.e., it cannot be attributed to any one of the system’s parts. However, this definition also assumes that a system must consist of more than one part. While this is true for any practical non-trivial system and is therefore an academic issue, it should not be a mandatory condition.

Kerzner (1995) has defined a system as a group of elements, either human or non-human, that is organized and arranged in such a way that the elements can act as a whole toward achieving some common goal, objective or end. While this definition refers to non-human as well as human systems, it is oriented towards artificial systems in the sense that it includes the element of intent, goal, objective or end, which is unique to man-made systems. We would like the definition of system to encompass natural systems as well as artificial ones.

Wand and Weber (1989) define a system as “a set of things [which, in our nomenclature, are objects], for any partitioning of which, interactions exist among things in any two subsets.” This definition emphasizes internal interactions among the system’s components. Referring to a possible mathematical model of a system, they note that “if we view such a set of things as a graph, where every thing is a node, and every interaction is represented as a link, then a system is a connected graph.” This definition captures the fact that any two things in a system must be related, either directly or indirectly. Assuming that a system comprises at least two things, this connectivity requirement is indeed important. If two OPM things are not related through at least one structural or procedural link, it is not possible to say anything about a relationship between these things. Being unrelated, they cannot be considered parts of the same system.

Systems are frequently complex, but since complexity is a relative term, it should not be part of the definition of a system. To see why, we note that simple, mundane objects, like a chair or a knife, are systems. It may be odd to refer to a Chair or a Knife as systems, because they are so simple, yet it is acceptable to view a more complex object, such as a Vehicle, as a system. Contemplating the chair example for a moment, a Chair can be more just the classical wooden four-legged object. It can be a sophisticated, orthopedically designed object with many adjustment options and degrees of freedom, in which case we would have no problem calling it a Sitting System. A knife could be an elaborate electric cutting machine.