In Chapter 1, the need for improving the evolution of systems thinking has been identified using Joe's case as one of various examples where an individual needs to act and develop within a professional environment. A central concept in the context of this research project is the system. This concept directs the structure of this chapter. First, systems engineering and related concepts are described (Section 2.1). The definitions of systems engineering involve the application of systems thinking, which is the focus of Section 2.2. Section 2.2 starts with an introduction to knowledge and thinking in engineering. How is systems thinking performed? Who is involved and what are the ingredients? Section 2.3 provides a discussion on the evolution of knowledge. The evolution of knowledge is regarded as learning. Learning in the workplace is discussed, in particular in the area of engineering. Section 2.4 introduces the characteristics of space industry as the area in which the empirical studies described in this book have been executed. Finally, Section 2.5 concludes the chapter and proposes three detailed research questions based on a refinement of the first part of the main research question introduced in Chapter 1.2.

2.1 Systems Engineering

This section starts with a definition of this research project's central concept, the system (Section 2.1.1). Section 2.1.2 introduces basic characteristics of systems engineering. Section 2.1.3 presents systems engineering as an activity performed in multi-disciplinary teams. Finally, Section 2.1.4 concludes the section.

2.1.1 System

Systems engineering is considered to have started with the seminal work of Hall (1962). He defined 'system' as follows.

"A system is a set of objects with relationships between the objects and between their attributes. Objects are simply the parts or components of a system, and these parts are unlimited in variety. Systems may consist of atoms, stars, switches, springs, wires, bones,
neurons, genes, gases, mathematical variables, equations, laws, and processes. Attributes are properties of objects. For example, in the preceding cases objects listed have (among others) the following attributes: stars – temperature, distance from other stars; switches – speed of operation, state; springs – spring tension, displacement; wires – tensile strength, electrical resistance. Relationships tie the system together. In fact, the many kinds of relationships (causal, logical, random, etc.) make the notion of 'system' useful" (Hall, 1962, p. 60).

Haskins et al. (2010, p. 5) from the International Council on Systems Engineering (INCOSE) define system as a "combination of interacting elements organised to achieve one more stated purposes." Similarly, Blanchard (2004, p. 8) defines system as "a set of interrelated components working together with the common objective of fulfilling some designated need." These definitions underline the viewpoint that a system is defined by its elements and their relationships. Haskins et al. (2010) and Blanchard (2004) highlight another system feature in their definitions, namely that it has a purpose: it has to achieve a stated purpose or fulfil a designated need. Not all systems have this second feature: it differentiates human-made systems from natural systems such as the solar system. Hence, the two main aspects of human-made systems (Daenzer, 1977; ECSS-E-ST-10C; Rechtin, 2000) are: a) the relationship of a number of elements that constitutes the system and b) the motivation by a purpose or objective that needs to be fulfilled.

The observer determines which objects are to be parts of the system (Hall, 1962). Haskins et al. (2010, p.9) introduce the notion of "system-of-interest" which highlights the selection and definition of a particular system depending on an observer's interest and purpose. "One person's system-of-interest can be viewed as a system element in another person's system-of-interest. Furthermore, a system-of-interest can be viewed as being part of the environment of operation for another person's system-of-interest." This hierarchy of subsystem, system (of interest), and hypersystem ('System-of-systems') has been already described by Daenzer (1977). Objects that are determined to be outside of the system are considered as environment, outside of the system boundary; hence, the system-of-interest determines the system boundary.

There are various definitions of complexity (Young, Farr, & Valerdi, 2010). Within this research project, the complexity of a system is defined by two factors, namely the number of disciplines and organisations involved in the creation and use of the system (Elliott & Deasley, 2007). The lowest level of system complexity is a system on which mainly one engineering discipline in one organisation is working. Examples are a PC motherboard, a car gearbox, and an antenna for an aircraft. The second level of system complexity concerns a system that involves two or more engineering disciplines or requires two or more organisations to design, build, operate, and maintain it. Examples are an electricity