1.5

SYSTEMS ENGINEERING IN VARIOUS ORGANIZATIONS

It is apparent that systems engineering wishes to provide solutions, mostly in innovative, complex systems that require orderly work processes, to minimize the systems' development and implementation risks, reduce the risk of possible failures, and have ways of handling them successfully, if they do happen. In addition, systems engineering deals with changes in the demands of the market and the needs of the clients, as well as the technological changes that affect systemic solutions. These are the underlying reasons for some of the differences in the extent to which systems engineering is implemented in various industries.

Systems engineering is particularly evolved in the aeronautics, space, and defense industries, because the engineers of these industries have been tackling complex projects as early as the 1940s (the Manhattan Project) and 1960s (the Apollo Program). These projects required extremely high system reliability and safety levels. Furthermore, these projects faced very tight, challenging schedules. Compared to them, other branches of industry are still in the process of carefully examining systems engineering, weighing cost/efficiency considerations, and gradually adopting it into their work.

Naturally, much of the defense industry (and of the aeronautics and space industry as well) is government funded and operates as part of the public sector. Prof. Olivier De Weck finds substantial differences between the business and public sectors, in terms of their willingness to adopt systems engineering work patterns: "Systems engineering in the public sector, in government or defense projects (which usually

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are also government projects – the authors), is integrated into the system, an inseparable part of the requirements specification. The business sector, on the other hand, is focused on immediate or short-term benefits, and so, only uses systems engineering methodologies if it has added value, namely, financial profitability."

Below are a number of examples that demonstrate the difference in the implementation of systems engineering by various industries:

Boaz Dovrin, a systems engineer who transitioned from a company in the defense industry (Elbit), where systems engineering had been deeply rooted, into a company in the field of medical equipment (Phillips Medical Systems Israel), at a time when it had just begin to incorporate systems engineering work methods among its employees: "I understood from the questions they had asked me (in the job interview) that they did not know what systems engineering was. They were basic questions, completely out of place for someone who had arrived from Elbit … The gaps between Phillips and Elbit were so large that I could not understand how their projects worked, how they were able to manage multiple projects without synchronizing their resources."

A similar testimony, by Benjie Rom, who also transitioned from The Elbit Group (namely, its subsidiary, Elop) into digital printing equipment company, Indigo: "At Elop, the systems engineer is responsible for designing a part of the system, while at Indigo, he has no part in the design. Here, a systems engineer can share his experience with the designers, or take the group in a certain direction, but the planning itself is done by the matrix bodies. The main reason for this is the complexity of Indigo's products, which necessitates the placement of a systems engineer in each technological group, thus reducing the need for the systems engineers to deal with the project's more technological components."

Further explanation is offered by one, who transitioned from the defense industry to the chemical industry – Gillie Fortuna – appointed to the position of CEO of ICL-group's TAMI Institute for Research and Development: "Systems engineering is important in a system with numerous components that require trade-offs to be made. In the chemicals industry, most of the systemic view stems from the need for optimization between several products, some of which are beneficial, while others are attached as part of the process. There are not as many alternatives as there are in aeronautical systems. It is possible to examine alternatives, considering the purity of the material and the cost of the product, but it does not compare to the complexity and high level of the alternative examination process required to launch complex airborne systems into the air. In the chemicals industry, the final test is the application of the development to competitive, economic production. In the end, this necessitates a systemic view of all the development and economic production capabilities, but at a lower level of complexity."

In comparison, the oil and gas industry is characterized by significant safety-related constraints and complex systems, and still, it has yet to successfully integrate the discipline into its work patterns.

Prof. Olivier De Weck demonstrates: "A lot of offshore oil drilling takes place in shallows, but major incidents happen in deep waters. These drilling projects are complex systems that have to handle extreme conditions, not unlike those of space exploration, namely, working with robots under high pressure, at high temperatures, and at distant locations. In spite of all that, when asked about systems engineering, the people of this industry usually respond by asking what that is. The first signs of the implementation of systems engineering are beginning to emerge in refineries founded today, but things are still done sloppily, and the dangers are many. When the system operates at low temperatures and there is a leak, the leak is repaired and the problem is resolved. But when the pressure and temperatures are high, the same leak becomes a serious problem."

Dr. Cecilia Haskins also mentions this industry: "For products located in extreme environmental conditions there are many challenges, both technological and physical. The heads of the oil and gas industry have only recently begun to recognize the fact that systems engineering can help them find solutions to some of those problems."

In this context, Prof. Olivier De Weck says: "The problem with systems engineering in the business world is that its short-term benefits are somewhat hidden. Even if great efforts were invested into systems engineering, the benefits will only emerge after a period of time, which could be several months or years. When a complex system lasts many years, people will talk about what an impressive job the systems engineers had done on it, and how they should be thanked and appreciated for it. But after so many years, those systems engineers will not receive the recognition they deserve, because by then they will have retired or moved away. The gap between cause and effect here is very wide."

The differences in "systemic" work patterns are not limited to those between different industries. Each company has its own, unique organizational culture, and it affects the systems engineering work patterns of that company. The basic work methods may not vary greatly, but the ways they are implemented and the placement of the emphases, change from company to company, even within the same branch of industry.

For example, Dr. Kobi Reiner distinguishes between companies within the defense industry that began as defense R&D units and companies that began as production and maintenance arrays. Companies of the former category emphasize the first stages of a project, using numerous systems engineers during the development phase, while companies of the latter type emphasize the more advanced stages – the ones that deal with integration. Naturally, these differences influence the types of systems engineers working at both kinds of organizations, the manner of their work, and the methodologies they employ.

1.5.1 WHO IS A SYSTEMS ENGINEER? – A QUESTION OF TERMINOLOGY

Another way, in which organizations differ from one another, is terminology. A systems engineer can be known by different names. In Elbit Systems, for instance, a project's lead systems engineer is called a "technical manager." Yossi Ackerman, who, until recently presided over Elbit, says that there is no exact definition for a good systems engineer, and that is a good thing: "The position needs to be given space, and then defined in accordance with the given situation. A manager, who is an engineer by profession, and who looks at the whole technical and technological picture, can be called a systems engineer."

The opposite is also true: in some organizations, those referred to as "systems engineers" do not actually practice systems engineering. An example of this is computing giant IBM, which, according to Henry Broodney, employs thousands of so-called "systems engineers," the vast majority of whom do not fall under the commonly accepted definition of a systems engineer at all. Rather, *they are Information Technology engineers, who use systems engineering methodologies in their work* – systems engineers within the IT field.

Moreover, unlike most industries where the systems engineering discipline is well rooted, most of the systems engineers at IBM are not in the company's research and development bodies, but *in the sales, marketing, and service divisions*. This way, they speak the same language as the systems engineers employed by potential clients.