
1.4

THE EVOLUTION OF A SYSTEMS ENGINEER

One of the major expressions of systems engineering still coming into being as a profession is the fact that the main specialization in the field is based on *the accumulation of experience*. There are *graduate programs* in the field, but the training they offer strengthens and deepens the knowledge base of those who have gained experience in the systems fields. In most cases, companies recruit engineers who trained in the basic engineering fields. These engineers advance through the organization's career and job rotation paths. They are assigned to various professional and managerial positions, and some of them, those, whose fields of interests have moved beyond their basic professional area, become systems engineers.

All the systems engineers we have conversed with have experienced this type of development process¹.

Below are a number of examples, based on their own testimonies:

Sharon Shoshany Tavory: "At the Department of Digital Systems, where I worked, the prevalent perception was that real-time software development should be done by electronics engineers, because software people could not see the entire picture. They only saw their own 'bits'.

¹Except for the special case of Eric Honour, who joined the US Navy, which has its own unique needs and qualities, and acquired an undergraduate degree in systems engineering within the framework of his service, as part of a combined training program for officers and system analysts.

At the time, the term ‘systems engineering’ was already in existence, but it did not bear the meaning it does today. It was usually used to refer to someone who got promoted to Assistant Project Manager. In those days, I had begun doing systems engineering work. For example I, managed interfaces and analyzed processes, but I was not called a ‘systems engineer.’

Every engineer starts his professional career as a ‘screw’. He can choose to remain a screw, and focus on the field of engineering he specialized in, or he can choose to look around him. I chose to look around me.”

Bud Lawson – a computer engineer by training: “As I look back and examine my work, I see that I have always practiced systems engineering. But that conceptual shift began, for me, in the mid 1970s, when I stopped focusing upon the computers themselves and started looking deeply into applications for computers. I felt that I was doing something different, but I did not use the word ‘systems engineer.’ I had worked at computer engineering previously, as well. But after I had started working on the applications, I told myself that I needed to learn much more about other areas, such as power distribution. If I wanted to design a suitable solution, then I could not focus just upon understanding the computerization part, I needed to understand the area that the computer was supposed to serve.”

Mimi Timnat – a software engineer by training: “I joined meetings with clients, and was required to understand their expectations and look for solutions. I was exposed to engineering fields I had never dealt with, and terms I had never learned. At first, it was strange and unclear, but along the way, I asked questions, learned and began to understand many engineering subjects – far beyond mere software. I was naturally attracted to the need to understand the whole picture.”

Henry Broodney – an electronics engineer by training: “In the beginning, I did not see myself as a systems engineer. Later, when I was integrated into more projects, I began to understand that I was not dealing with the electronics alone, but with the entire system.”

1.4.1 THE MAIN PATHS OF DEVELOPMENT OF SYSTEMS ENGINEERS

There is, of course, no rigid pattern to systems engineering, and the discipline’s work patterns are affected not only by the differences between organizations, but also by the differences between the personalities, personal preferences, and professional backgrounds of the field’s practitioners themselves.

Nonetheless, it is possible to distinguish between two types of systems engineers. The first, we shall refer to as “Lateral, Management-Oriented Systems Engineers,” and the second, we shall call “Professional-Disciplinary Systems Engineer.” One of the marked differences between the two is in the answer to the question of whether systems engineering is a position or a profession.

“Management-oriented systems engineers” see it as a position. This means that as far as they are concerned, their function as systems engineers is part of their professional development. For instance, an electronics engineer, who becomes a systems engineer at a certain point, will stop being a systems engineer when he advances to the next step in his career and becomes, for example, a development or technological manager.

For example, Alon Gazit, who has never been called a systems engineer, agrees that at a certain point in his professional life, he had, in effect, been a systems engineer, while today, as a Senior Technology Manager, he does not see himself as one: “I am a development manager, who encounters many systemic dilemmas in his day-to-day work. Today, I no longer deal with specifications that need to meet client requirements.”

We chose the example of a project systems engineer, because a substantial part of all systems engineers operate within project frameworks. There are, of course, also, systems engineers in what is referred to as “the engineering groups of the matrix” – the professional support groups that serve projects by dealing with technological developments.

Alon Gazit expands the distinction between the two types of systems engineers: “Management-oriented systems engineers are potential managers. They have leadership abilities and communication skills, and they are more willing to compromise. Suppose there is a multidisciplinary problem that needs solving, and it is not yet possible to even define where it originates, and, consequently, who should be handling it. This is the type of problem a good systems engineer needs to be able to solve, by combining leadership and analytical skills. In a case like this, a professional systems engineer would find the problem more difficult, because, although he has the necessary analytical skills, he will be limited by his lacking leadership ability. Professional systems engineers are more solid, more perfectionists. They enjoy dealing with technology, but not the small, technological details – technology in a wider sense.”

Erez Heisdorf and Benjie Rom (respectively) further add: “Some systems engineers want to manage other people, to organize; they have the personalities of leaders. In contrast, there are those who wish to delve deeper into their fields and mature as professionals. They are not interested in managing people; they wish to focus on the technology.

Management-oriented systems engineers have the ability to take a broad view of the situation. They look at the product from the client’s perspective as well. Compared to them, professional systems engineers certainly possess a broad perspective, as they must, but they focus more on the technical side, and less on the business aspects.”

In technological companies, the importance of systems engineers is rising, and with it, raises the numbers of those who believe the systems engineer to be a critical position in the career of anyone who wishes to manage multidisciplinary systems.

Thus, for instance, at the conference of the Israeli Association for Systems Engineering, INCOSE_IL, which took place in Israel in 2013, The CEO of IAI declared that in his view, the company's systems engineers are a group of professionals, which, by its very nature, constitutes the company's executive reserve.

Because the systems engineer position is still amorphous, many organizations have yet to devise designated promotion paths for it. Systems engineers advance in an organization by being assigned jobs that entail responsibilities over systems with ever-widening scopes; they can be promoted to the position of chief systems engineer, or to project management positions, which require an in-depth understanding of systems and a well-established technical background.

In many cases, a separation between the career paths of project managers and those of systems engineers does exist, but it is not absolute separation. In technological organizations, such as those engaged in defense systems, aviation, or space, many projects managers grow out of the chief systems engineer discipline. Contrastingly, in business organizations, project managers may evolve out of marketing specialists and business managers.

1.4.2 THE EVOLUTION OF SOFTWARE ENGINEERS INTO SYSTEMS ENGINEERS

Over the years, an ambivalent connection has existed between software engineering and systems engineering. On the one hand, systems engineering is a methodological tool meant to support the design of engineering systems and integrate between them; a systems engineer needs to understand and show interest in the engineering fields that comprise the system he is in charge of. Software engineers, however, have often been perceived as those who concern themselves only with software and have no real knowledge or understanding of the world of classical, physical engineering. On the other hand, there are many similarities between systems engineering and software engineering, because both deal with abstract systems. Both systems and software engineering require virtual models in order to perform at least one of their common, overarching missions, namely: the integration of technological systems.

In the words of Sharon Shoshany Tavory: "In systems engineering, there is a lot of abstract discussion that needs to take place before moving on to the 'physical' stages. It is different from classical engineering fields. In many cases, engineers who focus on the physical aspect and attach little importance to the abstract aspect are criticized. Software engineering, however, is abstract in its very essence. Software specialists do not produce a physical product. The blueprint of the product – the code – is the product. And so, in time, the work methods of systems engineers have become more and more similar to those of software specialists."

Conversations we held in this context have raised, on the one hand, arguments, according to which software specialists tend to concern themselves with software and are less willing to deal with the other engineering disciplines. On the other hand, some argued that, because of the increasing importance of software in the creation of

systems and supersystems, more and more systems engineers rise from the ranks of software engineers.

Mimi Timnat: “Alongside those who prefer to specialize in software, there are software people with a tendency towards working with systems, who enjoy working in large projects, in systems of systems, and being able to understand the whole picture. These people choose to evolve into systems engineers, and thus, become familiar with other disciplines. Furthermore, it is important for the chief systems engineer to have a good grasp of the dominant area in the project he is developing. In software-heavy systems, software engineers have a natural advantage.”

This also explains the increase in the number of software engineers who become systems engineers:

Mini Timnat: “In the past, hardware components had much more dominance in systems than software components, and so a considerable part of the systems engineers rose from disciplines of relatively high technological complexity, such as electronics. Today, software takes up much more weight, causing more systems engineers evolve from that area.”

Prof. Aviv Rosen is of the opinion that the major share of software engineers still prefer to focus on software, and only a minority is willing to tackle other fields. He believes the reason for the growing number of systems engineers who rise from among the ranks of this group of engineers is that software engineers have greatly increased in numbers in recent years (in many projects, they constitute the largest group of engineers). He claims that if we look at the percentages, we will see that the relative share of systems engineers who started out as software engineers is still fairly small.

1.4.3 THE TRAINING OF SYSTEMS ENGINEERS

It is commonly assumed that *systems engineering is meant, first and foremost, to serve the needs of the industry*, being a profession that emerged and evolved, mainly as a result of needs in the field. The head of the systems engineering program at the Technion, Prof. Aviv Rosen, says that this need stemmed from the fact that more and more large systems were failing. They were either technologically or economically unsuccessful, or simply failed to meet their deadlines. Organizations, mostly in the technologically and systemically complex fields of aviation and defense, recognized the problem and began to develop their own training programs, some of which were very extensive and numbered hundreds of hours of study.

Prof. Aviv Rosen: “In Israel, this trend picked up speed during the nineties, mainly in the defense and aviation industries, which felt that systems engineers who acted as such on their own accord were not enough; they needed to be given tools and methodologies to help them bring order to their applications of systems engineering.”

At a later stage, the industries approached educational institutions that taught engineering and asked them to develop training programs that granted academic degrees in systems engineering. Run in collaboration with industry officials who even take

part in the academic steering committees, these programs are mostly intended for engineers, and their graduates receive Master's degrees.

This brings us to a question: why would an institution that mostly concerns itself with research want to provide professional training that largely deals with practical applications? To this, Prof. Aviv Rosen replies: "The ultimate goal of engineering schools is to train engineers. An institution that performs research can train engineers better than one that occupies itself only with training." Also, in the context of Israel and the Technion, he adds: "The founding fathers of the Technion had established that one of its goals was to contribute to the needs of the State of Israel; training a systems engineer, who would benefit Israeli industry, is one way of realizing this vision."

As the CEO of one such industry, Yossi Ackerman from Elbit relates his angle: "A good systems engineer can manage without furthering his studies. This is true for every field: there are exceptional teachers who have never studied pedagogy, and there are, of course, those who have. There are excellent systems engineers who never attended formal training frameworks. They possess the right qualities and are self-taught.

Nonetheless, continuing education programs have an added value. They have put things in order. They poured meaning into what systems engineers were doing. These programs also create a common denominator among Elbit's systems engineers, each of whom had arrived from a different unit. As time passed, because of the growing importance of the systems engineer's role in each project, we wanted to institutionalize the field and asked the Technion to create better-founded educational frameworks that awarded Master's degrees."

Not everyone believes systems engineering training can only take place in academic, Masters' degree programs, meant for experienced students. One such contender is Eric Honour, who, based on his unique experience, does not dismiss the viability of basic systems engineering studies: "There are undergraduate programs available in the US, and I believe it is entirely possible to study this field without prior experience. After graduation, one can gradually be integrated into the practical field. It is not very different from an electronics engineer who studies for 4 years and then starts working at an organization, having no prior experience. At first, he is first attached to a mentor and charged with a relatively simple task. Similarly, a newly graduated systems engineer can first be assigned less complex tasks and aided by a mentor."

Being also the owner of a company that offers systems engineering training courses, Eric Honour presents the differences between companies like his and academic institutions: "Many of the lecturers in these programs are academics with no hands-on field experience. There is no competition between these studies and the ones provided by training companies; the two complement each other. However, in recent years, in order to generate more income, universities have begun to offer on client-site short term courses. For this purpose, they also offer instructors with field experience. This particular activity indeed competes with private training companies."