Chapter 28
Industry 4.0 From the Systems Engineering Perspective: Alternative Holistic Framework Development

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ABSTRACT

Systems engineering focuses on design, development, and implementation of complex systems. Not only does the Industry 4.0 concept consist of various technical components that need to be properly set and interconnected, but it is also tied to various managerial aspects. Thus, systems engineering approach can be used for its successful deployment. Overemphasis of technological aspects of Industry 4.0 represents the main starting point of this chapter. Then, collocation analysis, word clusters identification, selection and exemplification of selected domain in the business management realm, and frequency analysis are used in order to develop a holistic framework of Industry 4.0. This framework comprises six levels – physical, activity, outcome, content, triggers, and context. Moreover, the information and control level is integrated. The new holistic framework helps to consider Industry 4.0 from the complex systems engineering perspective – design and deployment of a complex system with required parameters and functionality.

INTRODUCTION

Systems engineering represents a discipline that deals with radical improvement or design, modelling and development of complex artificial systems. In the past, there were three main leaps that significantly influenced construction of complex systems. We call them industrial revolutions. We are told that the fourth one has been taken place for several years in the advanced economics. The first industrial revolution was based on mechanical production plants based on water and steam power at the end of the 18th century. The second industrial revolution was tied to mass labour production based on electrical energy

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at the beginning of the 20th century. Automatic production based on electronics and internet technology is a specific feature of the third industrial revolution that we noticed during 1970s. Nowadays, the fourth industrial revolution is the subject of interest any various technological or economic fora, congresses, conferences, or blogs written by experts. This topic can be found in headlines in both professional and research journals. Thus, the buzzword "Industry 4.0" represents a magic formula for both research initiatives, and practical implementations. This term was coined in Germany, the biggest European economy, while comparable initiatives outside Europe are called "Advanced Manufacturing Partnerships" for the USA or "Made in China 2025" for China (Dujin, Geissler & Horstköter, 2014; Kagermann, Wahlster, & Helbig, 2013). Its main principle mechanisms, technologies, tools or methods have already been implemented in various types of organisations ranging from healthcare industry, precision agriculture or retail industry, to transportation, manufacturing, energy, construction or public administration (Attaran, 2017).

Introduction of Industry 4.0 into an enterprise is a complex task. Thus, techniques and methods that originated in the systems engineering field of study can be very helpful. Technological side of systems engineering represents its integral component and is mostly perceived as systems engineering itself. From this perspective, the connection of systems engineering and Industry 4.0 is quite clear and straightforward. However, there is the other side of the coin. All industrial revolutions were associated also with human, process, economic or social facets. Pure technological change would be useless if higher objectives was not achieved. Industry 4.0 is not an exception. Therefore, a higher level of operational efficiency, a higher level of automatization and productivity are considered to be the main objectives of Industry 4.0 (Thames & Schaefer, 2016). Achievement of these objectives is associated with five major features, namely 1) digitisation, optimisation, and customisation of production; 2) automation and adaptation; 3) human machine interaction ; 4) value-added services and businesses; 5) automatic data exchange and communication (Roblek, Meško, & Krapeš, 2016; Posada, J., Toro, C., Barandiaran, I., Oyarzun, D., Stricker, D., Amicis, R. de, … Vallarino, I. Jr., 2015). Furthermore, application of modelling and simulations of economic systems can be added as the sixth feature (Bureš & Tučník, 2014; Tučník & Bureš, 2013).

Industry 4.0 is currently explored from many points of view and is associated with phenomena such as Big Data, Cloud Computing, Internet of Things, Cyber-Physical Systems, or Smart Factory Automation. Although this list is definitely not complete and enumeration could continue with tens of other concepts and terms, it is clear that the concept is grounded in technological progress and application of advanced technological systems. Surprisingly, implementation of Industry 4.0 in practice is not as complicated as it may seem. The reason is that complexity and requirements in the manufacturing industry have steadily increased for last decades. Introduction of the Industry 4.0 concepts has only strengthen this trend. As cited by Hofmann and Rüsh (2017):

the implementation starts with small steps here and there, there won't be a big bang that is going to introduce Industry 4.0. On the contrary, it will come step by step. But if we look back in ten years we will see that the world has changed significantly.

The crucial question here is, whether we can talk about industrial revolution when changes will come slowly, step by step. Should we talk about evolution? Answer to this question can be found in analysis of both underlying ideas and components of Industry 4.0 and managerial approaches and consequences that will be brought by Industry 4.0 introduction in practice.

According to Thuemmler and Bai (2017) there are four main Industry 4.0 components. These can be described in the following way (Hermann, Pentek, & Otto, 2015):