Transdisciplinary Engineering: Crossing Boundaries
M. Borsato et al. (Eds.)

doi:10.3233/978-1-61499-703-0-642

Systems Integration in the Lean Manufacturing Systems Value Chain to Meet Industry 4.0 Requirements

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Abstract. In the last two decades, technological and managerial changes are helping industrial organizations address the growing need to become more competitive, reducing production costs and delivering products that meet quality standards with higher performance. Two factors play a major role in this scenario. The first factor is the widespread application of automation technologies that make extensive use of intelligent information processing techniques, a paradigm that has been called Industry 4.0. The second factor is the adoption of the lean philosophy, with its focus on efficiency, effectiveness and waste reduction by emphasizing the core value that must be delivered to customers. Making decisions related to changes in a production environment usually involves considering aspects related to these factors and their relationships, which in most cases are non-trivial. This work is a historical review of the literature of the industrial revolution to the new industry 4.0, added the needs of automation use in lean production systems and supply chain characterization to develop a framework for integration of information systems and technologies in the stages of the chain value manufacturing.

Keywords. Lean, industry 4.0, systems, integration.

Introduction

Companies constantly undergo changes, whether related to habits, cultures or systems. Besides being a matter of survival, evolution is part of the human nature, being the primary factor on globalization. After the mechanization of production, which marks the first industrial revolution in the late 18th century, the industry continues to go through transformations in production and operations management systems. The increasing developments in technology come from the race of competitiveness and resulting need to reduce manufacturing costs in order to reduce the rates of non-value added and eliminating waste. The challenge in meeting the customer with quality, speed and cost/benefit brings up the advent of intelligent industry that emerges in this

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century, yet not intimidating way, as a new industrial revolution, causing managers to seek new production systems whose words synchronization and industrial control are the key to success. Has a few reasons why they believe have led to the new industrial revolution, they are: an increase in developing countries, leading to a greater number of markets that companies need to provide goods; and reduced product life cycles and consequently greater flexibility in the production network has to deal with [1].

This article aims to conduct a literature review about the industrial revolution issues, industry 4.0, industrial automation in lean systems to understand the integration of these issues and develop a framework with systems and candidates technologies composing the manufacturing value chain in order to meet the new industrial demands contemplated in the so called 4th industrial revolution.

1. Literature Review

1.1. Revolutions in Industry

The constant need of companies become increasingly competitive, induces the fact that inclusion of more technologies. This can be observed with the advent of the industrial revolution, which brought with it several benefits such as the main significant productivity increases.

According to the first industrial revolution began with the introduction of mechanical production equipment with the invention of the steam engine at the end of the 18 century [2]. The second, since the beginning of the 20 century, has as main characteristic the mass production, through the lines of production developed by Frederick Taylor, whose source was electricity-powered energy.

The third, in 1969, introduced the programmable logic controller that enabled digital automation systems programming. The programming paradigm still governs the modern automation engineering system of today and leads to highly flexible automation systems and efficient [3]. Based on advanced scanning within the factories, the combination of 2 types of technologies, Internet and domain-oriented of the smart objects (and products), appears to result in a fundamental change of industrial paradigm, which is being called the fourth Industrial Revolution or 4.0 Industry [4].

1.2 Industry 4.0

Since the late eighteenth century industries have undergone three technological developments. The first industrial revolution occurred in the transition from manual labor to machines powered steam, resulting in new opportunities and facilities for industrial production. The second revolution that occurred in the mid-nineteenth century was characterized by the use of electricity, introduction of mass production and the division of labor. In the third revolution, which took place in the 70s and remains today, it is characterized by the use of electronics and information technology for increased automation systems. As shown in the literature review on the application of automation Integrated Manufacturing Computer in the 80s, it is one of the systems that control and automate a production process using information and communication technology.

Thus, we must emphasize that today we are in the middle of where the fourth technological revolution and the birth of a new technology and digital industry known as Industry 4.0. According to the transformation must be intensified by nine grounds of advanced technology [5]: autonomous robots, simulation, horizontal and vertical systems integration, the industrial Internet of things, cybersecurity, cloud computing, additive manufacturing, augmented reality and bi data and analytics. For the development of an Industry 4.0 environment, Deloitte developed a framework with the concepts that form the fourth industrial revolution interface, shown in Figure 1.

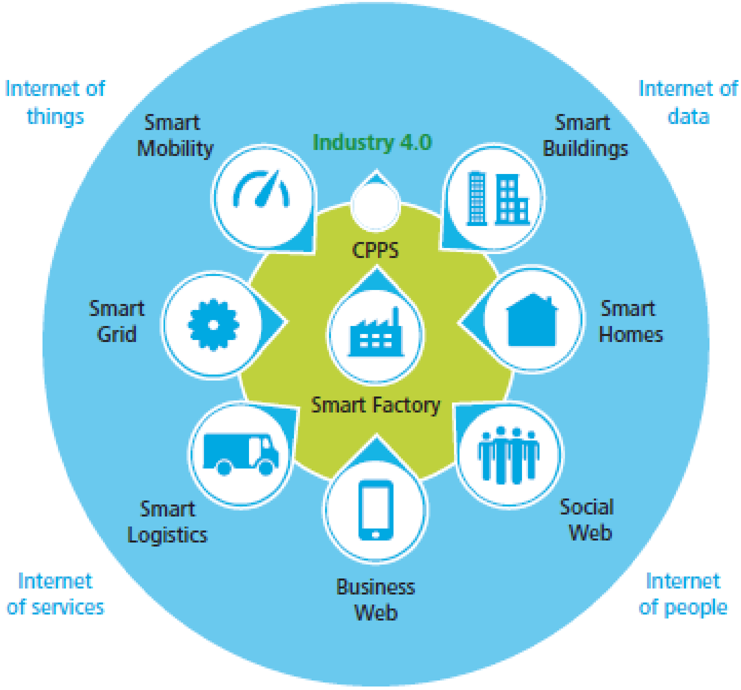

Figure 1. Nine technologies that transform the industrial production.

The central importance of I4.0 is the interface between other intelligent infrastructure such as smart mobility, grid, logistics and intelligent buildings. As the links between business and social networks provide an important role in digital transformation.

1.3 Automation and Lean Manufacturing

With the advent of industrial technology and lean manufacturing needs, automation systems have become increasingly sophisticated seeking higher quality of products and processes and lower cost for customer demand service.

An automated assembly has a system of automated machinery material handling and assembly automatizadode a system to be successful, it takes major product design modifications. The appropriate product design for assembly by no human hands can not be applied directly to an automated assembly, because the capacity of human beings can not be played by machines [6]. For automated production systems are divided in three basic types as shown in Table 1 [7].

Table 1. Types of automation.

Types of automation	Characteristics
Rigid automation	High initial investment in equipment; Higher production rates; Flexibility on the equipment in the room variety of production.
Programmable automation	High investment in equipment; Low production rates; Flexibility to deal with the variations and changes in the product; Highly adaptable for batch production.
Flexible automation	High investment in custom engineering system; Continuous production of a wide range of products; Flexibility to cope with changes in product design.

Second we consider nine reasons to automate a production system [7], they are: i) increase productivity; ii) Increasing productivity; iii) reducing production costs; iv) minimize the effects of the shortage of workers; v) Reducing or eliminating manual and administrative tasks routines; vi) To increase worker safety; vii) improve the quality of the product; viii) Decrease production time; ix) perform processes that can not be performed manually; x) Avoid the high cost of no maintenance.

In the present scenario many industrial automation projects are intertwined with information technology. The link between these technologies provides important data on the shop floor to the management level. The World Wide Web and the new information technologies allow greater integration of software and hardware systems beyond the borders of the company [8]. But the Web can be an inhibitor because it can pose security risks of the automated system, such as hackers and viruses. For the standardization and development of integration models of this system will need to expend much effort.

The most widely used AT and IT integration models are: Computer Integrated Manufacturing (CIM) or Computer Integrated Manufacturing and ISA-95 of the International Society of Automation or International Automation Society. The following is a summary of each model.

For computer integrated manufacturing activities involving the processing of information that provide data and knowledge necessary to the successful manufacture of the product [7]. They are designed to perform four basic functions of production: i) business functions; ii) product design; iii) Production Planning; iv) Production control.
There is a hierarchical model of automation represented by a pyramid [9]. On the first, lower level are the active output devices of the system from the controller commands. In the second level are the systems of individual drivers of industrial plant equipment. Level 3 consists of the computers, with supervision order. At level 4 is done the total production control, production and programming. Finally, level 5 runs strategic planning.

The ISA-95 model is a standard for Control and Business Systems Integration which is applicable in continuous processes, batch and discrete. According to the ISA-95 2009 model and ISA-95 terminology manual can be used to generate information which will be exchanged between systems to production systems, finance and logistics, sales, maintenance and quality. The ISA-95 model consists of four levels [9]: i) Level 1: composed of the sensors of the plant; ii)Level 2 consists of the automation functions for monitoring and control equipment; iii) Level 3: This level consists of the functions of Manufacturing Execution System (MES) - scheduling, allocation, resources, etc.; iv)

Level 4: This level consists of the functions of the Enterprise Resouce Planning (ERP) - scheduling, quality management, etc.

1.4 Logistics and supply chain

The logistics alone has a fundamental role in all organizations, since it is through it that makes it possible to supply the production with the raw materials needed, as well as supporting tools and other inputs to the processing phase. It is also responsible for controlling all the information flow of materials and information, including those that are received and/or sent to stakeholders.

According to Logistics is that part of the supply chain process that plans, implements and controls the efficient, effective flow and storage of products, services and related information from the point of origin to the point of consumption in order to meet the needs of customers [10].

Already the supply chain is concerned mainly with the production, distribution and sales of physical products [11]. She is managed by means of information systems that facilitate the integration and sharing of information between the company and the chain itself. Such integration is built on four levels of functionality [12], are: 1) transaction systems; 2) managerial control; 3) analysis of decisions and 4) strategic planning, along with some major components as:

- Enterprise resource planning (ERP-Enterprise Resource Planning) or legacy systems;
- Communication systems;
- Execution systems;
- Planning systems.

The need for flexibility and changeability found in production, from the desire for individual products (customized products) and the growing influence in buying behavior by global trade and logistics, causes the I4.0 has a significant impact on logistics, mainly for being related to supply chain management considering the flow of information and materials [13]. In addition to this fact, it is directly related to evolution of identification of disturbance processes, both internally and outside, covering the entire value chain.

2. Development

To facilitate the application of the implementation I4.0 in a particular organization, it has a model that assists in the identification of the implementation of this new industry in an organization [14].

2.1. Application of an identification model of Industry 4.0

The model prepared [14], shown in Figure 2, consists of five horizontal levels that are grouped by: technology, benefits and applications. This model is used to illustrate what the possible scenarios of Industry 4.0 application, ie, the implementation can only exist as the criteria levels are met.

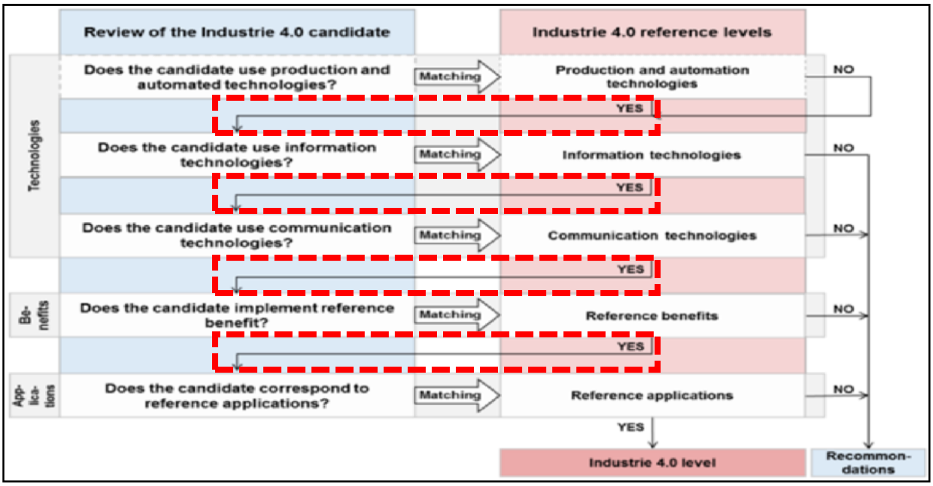

Figure 2. Model of level to identifying applications in Industry 4.0.

Based on the study of the authors, they pose as essential that at least one criterion for each level, except the first, be entertained and there are three groups to be satisfied.The last two require a preliminary table for query, which are represented in Figures 3 and 4.

	High priority		Minor priority
Benefit	▪ Real-time capability ▪ Security ▪ Networking ▪ Scalability ▪ Transparency ▪ Flexibility ▪ Modularity ▪ Decentralisation	▪ Self-organisation ▪ Autonomy ▪ Remote diagnosis ▪ Identifiability ▪ Traceability ▪ Monitoring ▪ Energy efficiency ▪ Assistance	▪ Shortening of development time ▪ Intuitive operability ▪ Flow of information to employees ▪ Automation ▪ High transfer rates ▪ Shapeless workpiece manufacturing

Figure 3. Benefits reference.

	Human	Technology	Organization
Reference application group	Human-machine interaction	Networking	Value added
Reference applications	▪ Enable ageing- and ageappropriate working conditions	▪ Intelligent products are information carriers, adressable and identifiable	▪ Mediation of regional added value
	▪ Expand the scope and the qualifications	▪ Machines load data themselves to expand their capabilities	▪ Using a Suppliers-Cloud to find alternative suppliers in real time

Figure 4. Application reference.

2.2. Proposed framework for systems integration in the value chain

For all levels discussed in Section 1.3, the responses related to the current status of the supply chain were positive, whose explanation is demonstrated in Table 2. To illustrate in which actors the technologies mentioned above are inserted along the chain, as discussed in Figure 5, whose construction was based on data collected in an automotive company of the metropolitan region of Curitiba, PR.

Fit to add that the ERP (Enterprise Resource Planning) is in short a system integration and information management operational procedures, administrative and even an organization management [15]. For this, he was considered to be comprehensive across the supply chain, as the system that could unite all the others. However, this is not yet a reality within the context of I4.0.

Table 2. Explanation of answers.

<table>
<tr><th>Level</th><th>Answer</th><th colspan="3">Description</th></tr>
<tr><td>1</td><td>Yes</td><td colspan="3">The automation is increasingly present in the logistics scenario.
Example: there are available on the market use of tele stand-alone carriers in conjunction with information systems for use in stock, apart from self guided vehicles for transport of parts and stands as container handling pickings.</td></tr>
<tr><td>2</td><td>Yes</td><td colspan="3">Due to interface with the system of communication technology by means of devices and tracking system and connection to multisetores agents within the organization.
Example: using RFID (Radio-Frequency IDentification) chips to fellowship with ICT (Information and Communications Technology). Serves both for inventory, how to schedule production and PPC (Production Planning & Control).</td></tr>
<tr><td>3</td><td>Yes</td><td colspan="3">Because communication with the information system of production scheduling, as production sequencing and identification of necessary parts.
Exemple: Use of interns ICT (Information and Communications Technology) in conjunction with AGV (Automatic Guided Vehicle), to transport spare parts in stock for production lines.</td></tr>
<tr><td rowspan="3">4</td><td rowspan="3">Yes</td><td colspan="3">Main benefits granted</td></tr>
<tr><td colspan="2">Group 1 (high priority)</td><td>Group 2 (low priority)</td></tr>
<tr><td colspan="2">1) Flexibility: due to differentiation of the models as requested by client customization and need to reduce inventory to reduce costs.
2) Modularity: due to the supply of parts and components in kits as sequencing models, to gain in agility.
3) Monitoring: due to quality management, process mapping and control indicators (even with statistical reports generated by software).
4) Autonomy: taking into account the perfect shooting of internal communication and information systems at the moment with the interface, when a piece is taken from stock, is automatically updated your quantity and at the right time a new application is requested via as to a supplier.</td><td>1) Intuitive Operability: due to especifico.Alguns training systems require processes require constant updates and consequently new formations should be performed.
2) Flow of Information to Employees: because the information which is passed on to operators through information and communication systems.</td></tr>
<tr><td rowspan="3">5</td><td rowspan="3">Yes</td><td colspan="3">*Main applications met*</td></tr>
<tr><td>Man-machine interaction</td><td>Technology</td><td>Organization</td></tr>
<tr><td>Operations are built only with validation of ergonomics.
Example: using collaborative robots that can work in conjunction with an operator.</td><td>Through the system of Information and Communications Technology (ICT) and connection to the multi sectors.
Example: Investments in automation of stocks, as the vertical automated inventory using teleporters and communication with an information system and/or RFID.</td><td>N/A</td></tr>
</table>

From the results found in the above model, it was possible to draw up the framework for integration of systems and technologies along the supply chain chain of the manufacturing industry. The framework to integrate systems in the chain value of manufacturing is available in Figure 5.

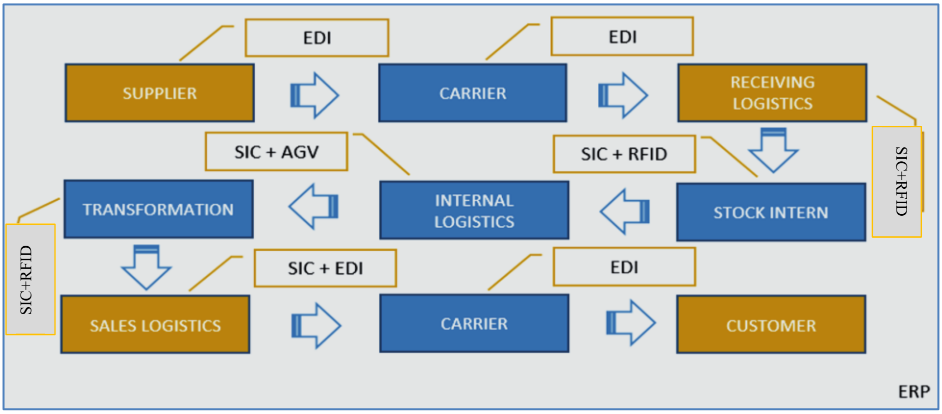

Figure 5. Framework to integrate systems in the chain value of manufacturing.

3. Conclusion

Field devices, machines, plants and factories will be increasingly connected to a network. They will be available as data objects on the network and can store data in real time. Therefore, they become searchable, exploitable, and response on the network [3]. This will lead to an explosion of objects and data available, accessible from anywhere. Despite the many benefits identified in the literature review, it is necessary to consider some points of attention to the implementation of I4.0 along the chain, because the process requires the integration of production, systems and management stakeholders. So that there is effective communication between all users and processes is necessary that the systems work with the same type of communication protocol (language) and this is a big challenge.

Another key factor to be considered is that process data require cloud storage, which imposes requirements like: agility of the transmission of information, storage, connection speed, virtual security in conjunction with confidentiality of information. However, according to scenario in which the Brazil, beyond the need for investment in transport, there's the matter of internet network infrastructure, such points would be a major obstacle to the implementation of successful I4.0, at least until the next developments.

However, according to scenario in which the Brazil, beyond the need for investment in transport, there's the matter of internet network infrastructure, such points would be a major obstacle to the implementation of successful I4.0, at least until the next developments in these fields.

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