How Transport and Logistics Operators Can Implement the Solutions of "Industry 4.0"

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Abstract The idea of Industry 4.0 was presented for the first time in 2011 by Henning Kagermann, former top manager of the SAP company. He suggested that different processes in production of goods can be coordinated in large-sized networks. One of the most important tools becomes the Internet of things (IoT). The implementation of IoT takes place not only in the production but also in the procedures which are used in the supply chains on the global market. Transport and logistics operators have started the development and implementation of IoT within their companies as well as outside of them. An important part of new solutions involves the data exchange between the transport vehicles and objects in their environment—particularly in public transport infrastructure which this paper addresses. Firstly, an overview is provided on multiple reports published by research institutes and market players. Secondly, this paper presents solutions that were implemented before 2016. The analysis provides a description of the challenge in modern transport systems and a discussion of possible actions for transport and logistics operators who aim to keep or improve their market position. Additionally, another part of the paper analyzes the impact on the market of transport and value-added services by the implementation of autonomous vehicles and the new generation of robots by transport and logistics operators. The main conclusion is the recommendation to promote closer cooperation between research institutes and market players as well as public authorities. It will be the best way to increase the efficiency of the development process of new technologies, which can be implemented by transport and logistics operators in the medium-term future.

Keyword Industry 4.0 · Logistics operators

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Introduction

Since 2011, Industry 4.0 has been a subject of discussion regarding the new direction of economic development worldwide. As H. Kagermann used this notion [1], there were only a few people outside the IT industry who understood the importance of a new standard emerging in virtual networks. Four years later, K. Schwab decided to position the Fourth Industrial Revolution as a topic for the World Economy Forum 20 [1] 6 [2]. It seems that the most intensive discussions about the new solutions, which have been already implemented or are in process of development, are taking place in the German industry and academia. The reason for this is that German managers fight to improve competitive advantages of their automotive industry and aim to maintain leadership in the world market. They threaten the development and implementation of new information and communication technologies (ICT), which have been developed in recent years in the USA as a chance to increase the efficiency of the production of cars, vans, busses, and heavy trucks. One has to consider that the level of complexity in the supply chains which serves the automotive industry acting globally has 10^{25} combinations of actions in the process of final product assembly [3]. The German managers are not alone. They are involved in competition with American and European peers as well as with Asian partners. They work together in the supply chains that are managed simultaneously by the shippers on the one side and by the transport and logistics operators on the other side. The service providers face the challenge of developing their procedures in the supply chain management according to the new rules, which are used as the most modern solutions of material planning, manufacturing, marketing and sales as well as distribution, in the era of Industry 4.0. Both the producers and logistics service providers have to learn new methods to capture the market when cloud technology allows the integration of goods and services producers with their customers in real time [4].

It is of main importance to remember that the symbol "4.0" should not be used unfoundedly. The way of thinking and doing in the new era can be considered "4.0" only in cases where the manner is radically changed in comparison with theory and praxis that made standards a few years ago [5]. Market research from 2015 confirmed that the top management of only half of German mid-sized companies has yet realized the importance of examining the way their leadership addresses this new era [6]. Further, it seems that only about 20% of German companies treat digital technologies as a key factor of successful market strategy [7]. As such, an overview of the German economy suggests that the digitalization of the industry, both in production and service sectors, is still a future direction for development and that now, in the middle of the second decade of the twenty-first century, one can observe only the first successful implementation cases of Industry 4.0.

The development and introduction of new business models and technological solutions which are labelled as Industry 4.0 becomes more and more popular in the contemporary economy. The transport and logistics operators develop and

implement new solutions in the supply chain management and in the transport systems. Therefore, the main objective of this paper was to present and analyze the patterns of the new solutions, in particular those based on ICT development.

Logistics 4.0 as Reaction to Industry 4.0

Changes across the world are easier to understand if we define the global megatrends that are having a far-reaching impact on many industries. One of these megatrends is Industry 4.0, as part of complex new technologies [8]. The main goal of Industry 4.0 is to radically transform traditional procedures into smart procedures. In the past, standard solutions were prepared by people, and their task was to control all operations during the entire procedure. Nowadays, new solutions are prepared by people, as it was before, but the operations are carried out partly by self-controlling mechanisms. The key issue is the creation of disruptive technologies. The goal is to build up total connectivity inside of new open networks created in clouds where data exchange take places not only among the people but also among things without action of people. This new solution is called Machine to Machine—M2M—or wider Internet of things—IoT.

The IoT cannot be created as an island network inside of one organization. In the new era, as presented in Fig. 1, each producer can and has to be connected with an unlimited number of suppliers on one the side and with an unlimited number of customers on the other side [9]. In the new generation of the supply chains, the IoT connects users and devices representing at least three groups of market players. The first group contains shippers and consignees of goods. They are at the beginning or

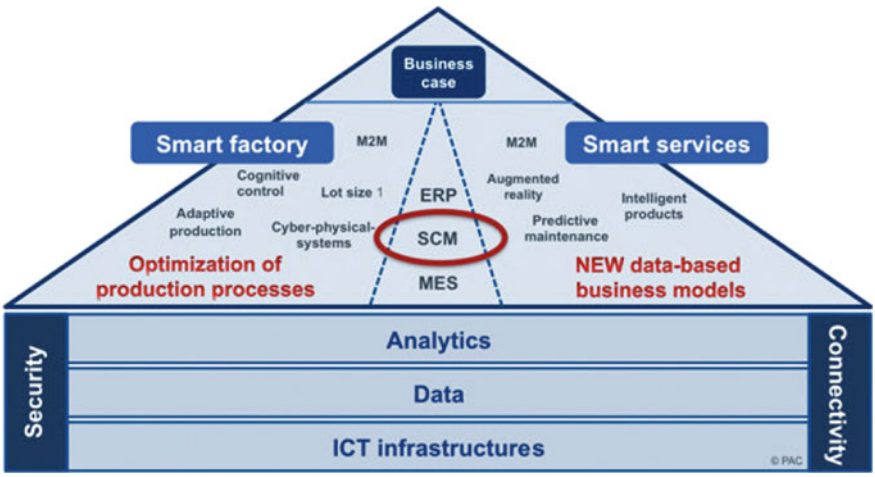

Fig. 1 Supply chain management (SCM) in the era of the Fourth Industrial Revolution. *Source* https://www.pac-online.com/scm-im-zeitalter-von-industrie-40 (7.02.2016)

at the end of each supply chain. On both ends of the entire supply chain, there are active people who use their hardware and software. The second group comprises people, hardware, and software that are employed or used by transport and logistics operators. The third group includes owners and/or infrastructure managers (e.g., IM of the public railway network in particular states) with their technical infrastructure: railroads with electric traction network and systems of traffic management, roads, takeoff runways in the airports, or warehouses. All of them manage their staff, technical equipment, and operations as well as the administration support using universal or dedicated software. Some of them have started to manage robots, which are *semi*-autonomous devices.

The new solution of Logistics 4.0 integrates these three groups of market players and additionally those public bodies which play the role of market regulator. The original improvement concerns the extension of the existing systems with implementation of the robots and the data exchange that runs autonomously among devices. The smart factory, as consignee, can create an order to the supplier of raw materials or spare parts, which are the subject of manufacturing or assembling. The order can be created by the smart factory's IT system without action of an employee, simply as a result of the automatic procedure [10]. In the supplier facility, incoming orders can be manually managed by automatic procedure. The IT system can send an order to a robot in the warehouse. Then, the robot carries out the picking order and packaging procedure and addresses the shipment to the loading ramp. The next step in Logistics 4.0 will be actions of the autonomous vehicle, which arrives to the ramp and picks up the shipment. In the following steps, the shipment will be transported to the place of delivery. In the smart factory, the shipment will be reloaded and transferred to the place where delivered goods will be used in the process of manufacturing or assembling. An alternative scenario utilizes the 3D-printer. It is a kind of robot which can be installed in the receiver's facility, yet it is controlled remotely by the suppliers. In this scenario, there is a significant difference in what becomes a subject of the physical movement. According to the traditional scheme, the good that is ordered for delivery is produced in the supplier's location, and the final product is shipped to the consignee. In the modern scheme, the subjects of the physical movement are raw materials which will be handled by the 3D printer. The transport of raw materials over any distance is easier than the transport of the final product. As a consequence, the implementation of a 3D printer can cause a significant reduction in the operating costs in the supply chains.

Every year there are new innovative solutions that can be implemented in the logistics industry. Each improvement brings new advantages. Since competition on the global market requests unending reduction of costs, it becomes more and more important to install new equipment which allows reductions in operating costs and investment of capital. The new generation of the reach trucks launched by Jungheinrich during the Hannover Fairs in 2016 provides a new opportunity to skip the installation of the cable network inside a warehouse. The new reach truck does not communicate anymore with devices located in the corridors among the racks

and is able to observe its way using 3D cameras. This new generation of warehouse *semi*-autonomous equipment causes significant spending cuts [11].

The reduction in costs across the entire supply chain creates the biggest challenge in the global market. There are two topics to discuss. Firstly, the automatization is nothing new but in past decades it was implemented only inside of a factory or warehouse. The data exchange among the infrastructure (e.g., roads) on the one side and vehicles on the other side allows establishing automatic control of processes which also take place outside. An autonomous truck can be advised during its movement that the environment has just changed and the road in front of it has just been blocked. This difference is very significant. A human driver can react only when he observes something unexpected as the rule is "respond to what you have noticed in the visual line of sight." The autonomous vehicle [12] is able to run beyond of the visual line of sight because its behavior can incorporate what is not in sight. It acts according to numerous signals, and most of them are provided as a data exchange among the devices without human control. Secondly, there is a question of quantity and quality of failure cases. The standard procedure in the supply chain is human-controlled to keep the time sequence of particular actions. The rule "just in time" means that each action has to be finished exactly on time, neither too early nor too late. This rule is violated by human mistakes which can be deliberate or accidental. The new solution eliminates both kinds of mistakes and allows a large number of actions at the same time, which cannot be controlled by a single person or even by a team [13].

The presented idea of automatic cooperation of robots and autonomous vehicles should be treated as a goal of development. Currently, the implementation of this idea has limitations due to low satisfaction of the job provided by technical devices. One of the biggest failures of the technical development in the last two decades is the still very limited capability of the FRID-technology. The printed barcodes continue to be used in the production and retail industries as well as in the logistics industry, while the implementation of chips has not become popular yet. The reason is that this technology has not brought the expected results in the supply chain. The managers of supply chains claim that the content of the shipments still has to be re-controlled by humans because the robots cannot do it properly. In some of the controlling procedures (e.g., on the ramp of retail shops), human sense organs are still viewed as sufficiently precise and reliable. The implementation of technical equipment and software there seems to be not efficient and effective enough yet.

Where and When Will the Autonomous Vehicle Replace the Truck Driver?

Heavy commercial vehicles are used to fulfill several kinds of transport tasks. Table 1 presents the description of particular services and conditions of work of these vehicles and their drivers.

Table 1 Transport services, characteristics of work of vehicles, and nature of driver's job

Type of service	Characteristics of work of vehicles	Nature of driver's job
Local transport in the loop inside of limited territory (e.g., transport of soil inside of a construction site)	Movement inside of the defined territory, partly off-road	Mostly routine actions
Local transport inside or outside of urban territory	Movement on streets and local roads that are used by different users: cars, busses, light and heavy commercial trucks, motors and bicycles as well as adult and child pedestrians; in some countries, this includes movements off-road	Complex actions in particular windows of time (peak hours) as well as partly routine actions
Medium- and long-range transport on the network of low-category roads	Movement on local and country roads that are used by different users: cars, busses, light and heavy commercial trucks, motors and bicycles as well as pedestrians; in some countries, this includes movements off-road	Complex actions in particular windows of time (peak hours) as well as partly routine actions
Medium- and long-range transport on the network of high-category roads	Movement on high-category roads; this activity is mostly extended on "first mile" and "last mile" distances where movement takes place on local and country roads of low category	Mostly routine actions including particular windows of time without any actions; fully passive presence of driver when only driving straight ahead on the highway

Transport operators are very interested in the implementation of autonomous vehicles in two of the above-defined cases: (i) local transport in the loop and (ii) medium- and long-range transport on the network of high-category roads. In these cases, the nature of the driver's job allows for its replacement by control systems that can manage vehicle movements. It means that the vehicles can be developed as *quasi*-autonomous vehicles that are able to control a part of their activities and are subject to interaction with the remote control system full time [14]. In both of these cases, it is possible to install some devices necessary to establish systems of communication between vehicle and infrastructure. There is experience in two cases. Inside of the construction site, there are temporarily installed mobile devices that exchange data with vehicles running there. On the highways in the USA, Germany, and some other countries, certain areas have already been equipped with devices that create the IoT and integrate it into the common network both for the vehicles and the infrastructure. In such cases, the infrastructure becomes intelligent and is described as a self-aware infrastructure [15]. The implementation of *quasi*-autonomous vehicles is possible if they work as

a part of the complex transport system integrating both the vehicles and the territorially defined infrastructure. Such transport system will run under the permanent control of humans. The operator of such a system and its management will personally take responsibility in case of any failures. This type of transport system is very important due to the fact that common law regulation worldwide still requests that a human is responsible for any activities [16]. One can expect in the future that *quasi*-autonomous vehicles will replace trucks with drivers in these two cases described above [17].

In two other cases described in Table 1, the implementation of the *quasi*-autonomous vehicles seems to be much more difficult. Nobody has yet forecasted that IoT will cover the full territory of the Earth or even the full territory of particular countries, even into the third or fourth decade of the twenty-first century. It can happen in some regions, including very large metropolitan areas and the territory of small countries (e.g., Luxemburg). So long as there are technical barriers in the infrastructure, these are the only locations that could implement *fully* autonomous vehicles. Having vehicles equipped with self-managing systems supported by artificial intelligence, a human as a driver in a car or truck would be not be necessary anymore.

Producers of Cars and Trucks Become Competitors to the Logistics Service Providers

A big challenge for the existing transport operators (2PL) and logistics services operators (3PL) is the new strategy of the automotive industry that recognized that their final products are going to radically change their character. Traditionally, cars and trucks were treated as industrial final products that are used as transport means by commercial service providers. Nowadays, these products become connected cars and trucks. It is no longer their main functionality that they move people and goods. They are recorders, senders, and receivers of big data which has a value much higher than the value of traditional transport services. The automotive producers have understood that they can diversify and increase their revenue if they extend the offer. They have already realized that the data connectivity as a service can bring them new recurring revenues. Some of the producers have decided that a part of their output will be kept as the own fleet of producers who will start to use it as a tool of their own activity as a service provider on the multifunction service market. One of the advantages of this new offer will be that it becomes a transport solution for each different specific purpose. Conventionally, private consumers and the majority of the transport operators used to purchase vehicles which were able to carry out every transport order. Only a part of trucking companies followed another business policy and purchased specialized equipment, e.g., trucks or semitrailers with a tank for transport of liquid commodities. One of the advantages of this new offer will be a solution for each different, specific purpose.

An example of a new project is *CAR2SHARE cargo* prepared by Daimler Business Innovation [18]. The Courier Assist schema includes five services as follows:

- Smart Van,
- Smart Fleet Management,
- Smart Driver Management,
- Smart Administration, and
- Smart Tour Management.

Usually, there are three groups of partners who can take part in such a project. The first group is made of shippers who have to move their shipments. Due to the fact that each shipment can contain a different commodity, in particular cases different vans can be requested to match the specific patterns of a commodity. The second group comprises the classic service providers who carry out their transport services having their own drivers and using vehicles. Daimler or other automotive producers who traditionally offered cars, vans, or trucks as their products now belong to the project as new partners who offer transport capacity—and not any more transport means—only as their final products. The data exchange among all partners is the key factor. Each van can change the user every time, even several times during one day. Entrance to the van takes place using a code, which an employee receives from Daimler's *CAR2SHARE* management system and receives via Internet from his mobile device to the van. In this moment, he takes over the van that was used a few minutes ago by another driver from another company. The code is valid only during a fixed time window which was defined in the contract between the classic service provider and Daimler as the new service provider. During the working day, the same driver can use another van which is longer or higher than the first one, according to the new requirements described in the new order from the same or other shipper. In this project, the fleet used by the classic service provider becomes a virtual one. Every time such vehicle is available on request of the shipper. There are no more technical limits to carry out different orders. In this project, it is also possible to create a virtual team of drivers. The open question is how to recruit drivers who would carry out particular transport orders. All of them who are registered on the list of the "cloud staff" can and have to be continuously ready to get a new order and get into a van. Due to remote control of the permanent technical status of each van, it is possible to state without any doubt by whom and when any damages were made. The total process in this project is arranged by Daimler, including the full calculation and invoicing procedure that is automatically executed and booked into the accounting systems, for both the classic service provider and Daimler as the new service provider. In the *CAR2SHARE* project, it is also possible to optimize the utilization of the entire fleet. It happens in planning of tours which concern the movements both of the loaded and unloaded vans.

The Forecast for a Mixed System: Chances and Risks

The contemporary transport system contains both the very old technical solutions and the very modern virtual solutions. On the one side, in some countries, there are very old locomotives and (passenger or cargo) cars produced 50 years or more ago in operation in the railway industry. On the other side, the metropolitan traffic in several regions of the world is managed by the Uber company, which has nothing more to offer to millions of customers than a software and data exchange in the cloud. What will happen in the next 10–15 years?

It is likely that hybrid systems will find their future in the world. The standard cars and trucks produced using very poor technology are very simple to manage in operation and maintenance. The fleet of such cars and trucks will be kept for a long time in several regions. A tourist arriving in Cuba may observe the older cars and wonder how it is possible to maintain them without original spare parts. The answer is quite easy—in small workshops, they produce copies of the old spare parts or install similar spare parts to the original ones. This is still possible depending on how long the self-made old timers remain as products of the analog industry and they can run without any software. On the same streets of Habana, the newest limousines are used by diplomats. They belong to the most modern generation of connected cars which are able to park without direction of the driver, and in two to three years will be powered by hydrogen fuel cells [19]. In such cars, it is simply impossible to start the engine if the computer on board registers any failure in the operation system or outside of the car in the next environment. One can expect that in the supply chains, the modern digital technologies will become more and more popular. However, in some cases, it will be necessary to synchronize the old analog and new digital technologies.

The economy, which is more and more dominated by disruptive innovations, will evolve from two co-existing worlds where people live and work. In the former, people will try to continue the existence according the old rules. Some years ago one could say that such old world will remain in the South. The social movements which have come to light in the USA, Hong Kong, and Western Europe since the beginning of the current century shows that a significant group in the North does not accept the contemporary development [20]. The medium- and very-rich people belonging to this world are interested in having dinner in restaurants listed in the Michelin Guide because they request and expect the quality proved by professional inspectors using objective criteria. In the second world, people will create new requirements and adapt to them. There are people who are ready and able to change their mindsets and behaviors [21]. They are willing to achieve the level of the development where artificial intelligence will replace human creativity and diligence. They do not like to drive a car, and they expect to be moved by the *fully* autonomous car to a bar and back after consuming alcohol or drugs. They like to be admired in the popular bar confirmed by virtual San Pellegrino global ranking system, published in social media [22].

How Can These Two Worlds Coexist?

Even if one says that people from both of these worlds would like to coexist peacefully, there are some reasons why they will face some conflicts. The first of potential disputes is global climate policy [23]. Is it possible to eliminate the emission of CO_2 caused by human activity? Can such a goal be achieved without Industry 4.0? The second topic is criminal acts. If one wants to protect privacy, one cannot accept the permanent and omnipresent Big Brother practice. It means that individuals and even organized crime will use their (even limited) privacy to carry out criminal acts. In Industry 4.0, it is likely to see increased attacks on the networks, data bases, and applications. Hackers have already had success in blocking the software installed in advanced cars [24]. Open access to the method of storage in clouds creates an additional temptation for digital piracy [25].

Academics have a challenge to create the educational offerings for students who will soon enter school and expect successful careers. Regardless of the field of study, youth should learn the most modern digital technologies and the traditional humanities to be able to understand what is important to continue economic development and what is necessary to keep it sustainable. It is clear that the future of supply chains remain in their mixed character, but the question is how to manage the coexistence of the analog and digital worlds and not lose control of the balance of them.

Social movements have impact on the players who determinate the formal economic plans and manage public institutions. The public sector composes the infrastructure in each country. The open access to the network of roads, railways, waterways, etc. on the one side and to the network of electric energy lines and to the communication networks on the other side is a precondition to develop the modern supply chains where the most modern digital solutions can be efficiently implemented. Additionally, the public institutions have to act properly to ensure improvement of regulations that keep the activities of people and technical devices —including robots—on the national and international markets under control.

Conclusions

Transport and logistics operators take up the gauntlet of fundamental transformation of their activity in order to fulfill the challenge of the Fourth Industrial Revolution. The operators are surrounded by producers and entities involved in goods exchanges in the market which develop and introduce new network solutions, including the technology IoT and robots. The participants of the supply chain anticipate that the operators who serve them will use the same technologies and will adjust their business models to the changing demands of their customers.

A special challenge is the entry of new industrial enterprises, including startups of novel business profile which introduce disruptive innovations, on the traditional

market of transport and logistics services. Rolling stock producers, including autonomous vehicles, keep a part of their final production for own uses and use new business models to offer services to the shippers instead of selling the final products to the shippers as well as to the transport operators, whereas before the era of Industry 4.0 the same shippers either made self-service or were served exclusively by transport and logistics operators.

A new way of proceeding of public infrastructure managers is expected in the era of the Fourth Industrial Revolution. Managers must create conditions for the development of integrated road networks, electric power transmission and electronic data exchange. Besides, they must adjust the created network to the autonomic proceeding within IoT.

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