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LOGISTICS 4.0 – SOLUTIONS AND TRENDS

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Abstract: Logistics 4.0 means the application of Industry 4.0 in the logistics area. Therefore, many new practical and scientific solutions are created and published giving a huge amount of individual examples for realizing different logistics tasks. To find solutions in a systematic way, it is necessary to create and use meta-knowledge. The paper gives an overview about typical solution fields, the level of knowledge and application. It makes a difference between objects, processes, systems and the relevant infrastructure of logistics according the model "Smart Logistics Zone". The "Smart Logistics Zone" is defined as a scalable examination and action area for the analysis, evaluation, planning, control, regulation and (re-) configuration of logistics solutions. Basis of the research formed many years of scientific work and practical experiences in the area of logistics. This is connected with an evaluation of current scientific publications and own scientific projects on the area of Logistics 4.0. The starting points are changed requirements and conditions according to Logistics 4.0. Solutions of Logistics 4.0 are identified, systemized and described. One solution group are e.g. the possibilities of autonomously driving. They have the same idea to move, to handle and to transport without a driver or pilot realized by different means of transport. The majority of solutions of autonomous driving are on the level of prototypes and pilot projects. The new developed model "Smart Logistics Zone" is recommended to solve all tasks of logistics engineering according to Logistics 4.0 A new model is developed to systemize process knowledge. Logistics 4.0 is integrated. Important trends of Logistics 4.0 are characterized to sign the future. The theory of logistics must be further developed. Therefore, some new and improved systematics are presented in this paper: solutions of Logistics 4.0, strategies to improve logistical processes and trends of Logistics 4.0.
Keywords: Logistics 4.0; Smart objects; Logistics processes; Cyber-physical system; Logistical infrastructure

1. INTRODUCTION

The term Logistics 4.0 brands the specific application of Industry 4.0 in the area of logistics. Industry 4.0 and Logistics 4.0 create a lot of new possibilities and new solutions by digitalization and networking (compare [1]). This is why there is also a growing need for an expanded theory of logistics that helps characterize existing solutions, systematically develop new ones, and bring them together effectively and efficiently. The objectives for science are to develop a new conceptual model, a framework model and a procedure model for current and future logistics solutions including Logistics 4.0. This is a big task. Models help to systemize logistical knowledge. The relevant knowledge areas are e.g. technologies and basics of Logistics 4.0, strategies and methods to improve processes and trends for the future.

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2. METHODOLOGY

Years of scientific work and practical experiences in the area of logistics form the basis of the scientific work. This is extended by an evaluation of current scientific publications and own scientific projects on the area of Logistics 4.0. To enrich the theory of Logistics 4.0 the model “Smart Logistics Zone" is developed. It differs into logistical objects, logistical processes, logistical systems and the relevant logistical infrastructure. The “Smart Logistics Zone” is defined as a scalable examination and action area for the analysis, evaluation, planning, control, regulation and (re-) configuration of logistics solutions [2]. With this methodology a knowledge basis about Logistics 4.0 solutions will be created and systematically applied.

3. RESULTS AND DISCUSSION

3.1. Solutions of Logistics 4.0

Figure 1 gives an overview of some typical solutions of Logistics 4.0. Therefore, figure 1 is differed into the components of a “Smart Logistics Zone”: objects, processes, systems and infrastructure (O, P, S, I).

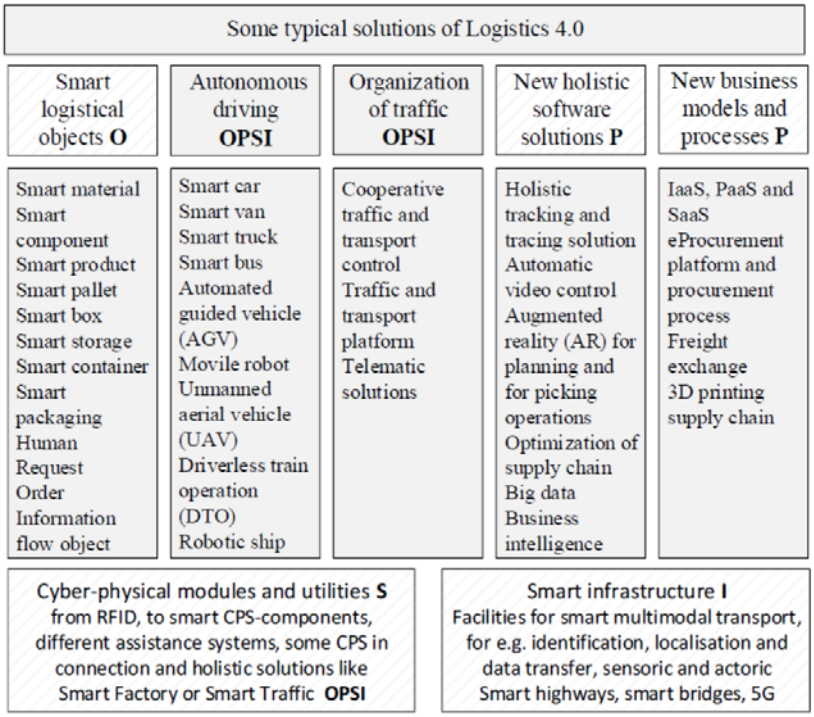

Figure 1. Some typical solutions of Logistics 4.0 (Compare [1] [3])

The first group are smart, logistical objects. They include the use of embedded systems to collect data, communicate and make networking. They use identification (e.g. RFID) and

sensor technologies. They create transparency about the identified logistical products or load carriers and their behavior. This information builds the basis for holistic tracking and tracing solutions and for process control. Processes are changed, where the logistic objects are involved.

The second group contains possibilities of autonomous driving and will be realized in combination of (O, P, S, I). They have different technical solutions, but realize the same task to move, to handle and to transport without a driver or a pilot. There is a great potential to improve the energy efficiency and to increase the capacity of the transport mode and space. Smart vans, trucks and busses have sensors for direction, speed and safety distances. Driving mirrors are replaced by cameras. GPS and WLAN give information about topological characteristics. New models of Automated Guided Vehicles (AGVs) and mobile robots use more sensors to get more information, drive autonomously and communicate with each other. They navigate by themselves to places where they are needed. They support e.g. transportation and delivery processes, handling of tools and parts, assembly, quality control and maintenance. The newest solutions of Unmanned Aerial Vehicles (UAV) and the self-positioning of trains are also part of Logistics 4.0. (Compare [4]) Robotic ships will have robots, cameras, sensors, radar, sonar and GPS onboard. The navigation is autonomous, but could also be centrally controlled.

The third group of solutions (O, P, S, I) deals with the organization of traffic and transport by cooperative traffic and transport control. This is based on the recording of the current traffic situation and the adaption of traffic signs and signals, while the traffic platform interconnects the intermodal transport and the intermodal movement. Telematics solutions use technical data to optimize fleet management, vehicle management, driver management and cargo management.

The fourth group of solutions contains new holistic software solutions (with Cyber physical System (CPS) characteristic) allowing new processes. Tracking is useful for position fixing and for the delivery status of the objects. Tracing gives a holistic view on the value added chain. Video control is used for documentation, for security tasks and for control of logistics processes. The video sequences are automatically checked and give signals and/or actor activities as reaction to abnormal situations. Augmented Reality (AR) helps to increase the process quality by avoidance of logistical failures and by increasing the efficiency of staff by avoidance of unnecessary searching processes. Supply Chain Management (SCM) allows the identification of possible savings and the avoidance of effectivity losses in the framework of a holistic consideration. Big data are based on data analysis methods to discover patterns and other useful information. Business intelligence (BI) are “the processes, technologies, and tools needed to turn data into information, information into knowledge, and knowledge into plans that drive profitable business action. Business intelligence encompasses data warehousing, business analytic tools, and content/knowledge management.” [5]

In addition new business models and business processes are created. Examples are the realization of business-to-business or business-to-consumer or business-to-government purchase or the new 3D-printing process. New solutions of Logistics 4.0 realize the full process in the kind of a sensor triggered, software integrated, autonomously realized and optimized process. One more example is the freight exchange to conclude sub-contracts and to reduce empty runs. Integrated software helps to realize process mining, e.g. Business Activity Monitoring (BAM), Business Operations Management (BOM) and Business Process Intelligence (BPI).

Some typical Cyber-physical modules and utilities are smart shelf, shelfs with robots, modular cross-linked conveying systems, robot assistance, smart clothes, data glasses, data gloves. CPS should have the following functions: identification, object information and –storage (by CPS or by cloud), ability to communicate, localization, control/monitoring, to recognize and report problems, to make a decision and to realize actions.

Smart infrastructure gives the frame for smart processes and systems. Examples are e.g. smart docks, smart gates, smart ramps or urban test-fields for mobility. They allow different logistics processes and systems. As a result it is to sum up that the majority of solution in fig. 1 will only change the fulfilment of existing processes, but some of them will also create new business processes.

3.2. Processes of Logistics and Logistics 4.0

Logistics is a service fulfilling customer requirements and protecting the existence of companies. That means to do the right things in an efficient way. Logisticians are the masters of flows and processes. So process knowledge is very important for logisticians. The following Table I shows a new schema for systematization of the strategical process knowledge in the Logistics area.

Table I.

Schema for systematization of strategical process knowledge to improve logistical processes

Aspect	*Examples*
General process models:	SCOR-model, material flow operations, information flow operations, financial flow operations, energy flow operations
General possibilities to improve processes:	
(a) Use typical processes (Application, adaptation/modification and combination)	JIT, JIS, KANBAN, CONWIP, Milkrun, Consignment warehouse processes, sourcing processes, VMI, Pick by vision
(b) Best practices, conveyance of solutions	Benchmarking, Analogy technique
(c) Total new processes	Business Process Reengineering, Process Reengineering, **Logistics 4.0 processes**
(d) Improvement of existing processes	KAIZEN
Tool set with special focus on:	
Define targets and trends	TOWS, SWOT, Scenario technique
Environmentally responsible behaviour	Green Supply Chains, Sustainability
Value	Value stream mapping
Eliminate waste	Lean production, Lean techniques
Accept no failures	Six Sigma, TQM, FMEA
Classic automation	Logistics 3.0
Digitalization and networking	**Logistics 4.0, Smart Logistics Zone**
Identify potential	Potential analysis
Identify weaknesses in SC	Material flow analysis
Identify key aspects	ABC-, XYZ-, HML-, GMK-, FSN-, SDE-, SOS-, VED-, SKFO-, GOLF-Analysis (Compare [6] and [7])
Controlling	Balanced Scorecard, Key factors

Basics for the schema are process models for different types of flows. This can be business processes in supply chains as well as material, information, financial or energy flow operations. They can be used to define and describe elementary, complex or integrated logistics processes.

In general, there are four possibilities to improve processes: (a) use of typical, well known, empirical strategies and processes (also modified and combined), (b) use of best practices, (c) define totally new processes, e.g. Logistics 4.0 processes or (d) optimize existing processes.

For (a) there is a big group of generic strategies and typical processes to realize Logistics. They all have a main idea of solving logistics tasks. This is the group of proved and tested empirical knowledge. However, there is the danger that only basic technologies are used. These basic processes can be adapted, modified or combined. For (b) it is necessary to identify best practices if not known. This requires time for examination and evaluation. For (c) creativity is required. A new reference solution should be designed and realized. The Smart Logistics Zone supports this in a systematic way. For (d) the focus is on the improvement of existing processes. Typical aspects can be the aspects which the logistician wants and needs (compare Table 1) e. g. cost, time, quality and value. Material and information flows are as important as financial flows in Logistics. Financial key factors are to record in the logistics network and to be controlled. Important targets are profitability and liquidity of enterprises with logistics services. It is necessary to record cost and revenues as well as cash flows. Examples for energy operations are e.g. energetic conversion, to increase, to reduce, to modify the direction, to conduct, to isolate, to collect, to share, to mix and to separate energy [8].

Typical for Logistics is the procedure to create variants of the processes and choose the best one. Therefore, the use of e.g. the Value benefit analysis and the evaluation with key factors are to be recommended. The evaluation by intelligence factors and levels is new in this field.

3.3. Trends and research areas of Logistics 4.0

The solutions of Logistics 4.0 will be enhanced in the next few years. New technologies and solutions will occur. There are common trends: progressive dispersion of modern information and communication technologies, rising globalization of the economic system, short life cycle of innovations and technologies, increasing individualization of customer requirements, demographic change, increasing importance of the efficiency of resources and energy, increasing requirements according reliability and safety. (Compare [9]) These trends have impacts on Logistics: globalization and individualization induce growing material flows with more and more single objects. There is also mentioned an increasing cost pressure, an increasing networking and faster processes along the Supply chain. Modular systems will be more and more typical, fulfilling individual customer requirements. In addition, there are some trends, changing Logistics 4.0. Table II gives an overview about some of these trends. A short description characterized each identified trend. The trends are also scientific areas of operation and research for the future.

Table II.

Some trends and research areas of Logistics 4.0

Trends	**Short description**
Cloud software [10]	New offered services include infrastructure (IaaS), platforms (PaaS) and software (SaaS). Memory capacity, processing power and applications were provided by internet and do not installed local.
Edge Computing	Data streams were processed and compacting local. Resources are preserved and the data volume is reduced.
Artificial Intelligence [10][11][12]	Three group of methods are used and developed: Artificial neural networks, Fuzzy Logic and Evolutionary algorithm. It is possible to optimize f. e. logistical processes and systems (prescriptive analytics), prediction of failurs and disturbances (predictive maintenance).
Pattern matching [13] and Big Data Analysis	Increasing data volume requires efficient methods of processing. It is necessary to evaluate situations and do forecast.
Blockchain technology	The accounting of logistics activities can be realized automatically by using block Chain technology (Smart contracts).
Decentral organization and self-organization (Compare [13])	Allows multiple interactions in the logistical zone between OPSI, have often a strong dynamical non-linearity.
Networking (Compare [14])	Internet of things (IoT) connects physical and virtual things by using information and communication technologies. The task is now to develop the Internet of services (IoS)
Autonomous driving	Solutions realize the same task to move, to handle and to transport without a driver or a pilot. Objectives are to improve the energy efficiency and to increase the capacity of the transport mode and space. They support e.g. transportation and delivery processes, handling of tools and parts, assembly, quality control and maintenance.
New professions and activities in logistics	E.g. data specialist, drone pilot, robot coordinator, digital transport manager, global supply chain manager
Infrastructure and smart infrastructure	Mobility infrastructure e.g. charging infrastructure for e-mobility and cargo bikes; 5G projects e.g. communication for mobility and communication for factories

4. CONCLUSION

The theory of logistics has to be further developed. Therefore, some new and improved systematics are presented in this paper: (1) solutions of Logistics 4.0, (2) strategies to improve logistical processes implementing Logistics 4.0 and (3) trends (as well as research fields) of Logistics 4.0. These systematics offer meta-knowledge in this field.

The use of the new theory of the Magdeburg Logistics Model ("Smart Logistics Zone")

promises significant effects in the targeted, systematic, cross-functional, efficient, engineering-technical work as well as in the solution quality of Logistics 4.0 tasks that can be achieved in this way.

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