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Research Article

SUSTAINABLE CITIES NEED SMART TRANSPORTATION: THE INDUSTRY 4.0 TRANSPORTATION MATRIX

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ABSTRACT

Governments are facing challenges regarding transportation systems, such as understanding and responding to changes and future demand, long-term funding for transportation systems, investing in supporting economic growth, embracing technology challenges and opportunities, and responding to environmental externalities. This study focuses on the technology related difficulties and opportunities and analyzes the impact of Industry 4.0 (I4.0) on the transportation sector. After introducing key elements of Industry 4.0, it is explained how Industry 4.0 related concepts, originally used in the manufacturing industry, might be applied to the transportation sector and how a transportation scenario of the future might look like. It is developed a matrix where I4.0 related technologies and concepts are categorized in how to benefit pre-defined areas of the transportation industry. The model is enriched with selected showcases from different countries, showing I4.0 integration in transportation. The results of this study revealed that the developed matrix might be used by (local) governments to plan their Industry 4.0 related activities strategically and by private sector companies to plan and estimate the demand for their products, tailored for transportation stakeholders.
Keywords: Industry 4.0, matrix, technology, transportatation sector.

1. INTRODUCTION

Transport is an essential part of the globalized world economy. The industry is challenged by environmental impact, market conditions and the investment in infrastructure. Governments and businesses are facing continually legal, regulatory, security and technological challenges, all of them driving continuous innovation into the transportation sector. Intelligent transport systems are revolutionizing the transportation industry, offering excellent prospects for improvements in safety, environmental outcomes and effectiveness, and efficiency. Governments are challenged to keep up with the pace of technological changes and have to make sure that new technologies might be used and new business models adopted. Governments are key players in realizing benefits from emerging technologies, serving as well as an investor, regulator as well as a facilitator. Globally, transport is undergoing substantial changes in technology and user behavior. The transport sector in Turkey is expanding rapidly, in parallel with the country's high economic and population growth; with a significant amount of the total annual government budget dedicated to transporting infrastructure. Turkey, especially Istanbul, has to focus on a variety of

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transportation types, which are air transport, rail transport, road transport, inland waterway transport and maritime transport. Each organization in the transportation sector has to consider security and safety of its passengers, employees, physical assets and facilities. The following challenges have to be considered: increasing variety of threats (such as hostage situations, terrorism and hijacking, and weather-related emergencies), outdated (sub) systems (some of them stand alone (security) systems, like access control and video surveillance, which are not able to communicate with each other or security employees), reactive response (without a cohesive command and control platform officials are forced to react to incidents rather than reaching an awareness level, where officials can provide proactive response to environmental changes instead of reactive incident management). How might these obstacles be overcome? On the one hand technology platforms such as situation management systems, video management and analytics might help to overcome some of these barriers; on the contrary, there is a need for a comprehensive framework to address all areas of interest for the transportation sector (types of transport and transport infrastructure). This framework might be Industry 4.0; which could, with its concepts, technologies, and strategies, support the sustainable development of the transportation sector.

2. LITERATURE REVIEW

Industry 4.0, the fourth industrial (r)evolution, focuses on interconnected systems for smart production and service provision to develop smart and connected systems with the Internet of Things concept and cyber-physical systems as a technological foundation [1]-[2]. Industry 4.0 depends on some technological developments. One of them is information and communication technologies, which are used to digitize information and integrate systems at all stages of service provision. They have an organization internal and a cross-organizational approach, to monitor and control the physical processes and systems as well as support human workers by using robots, intelligent tools, and augmented reality [1]-[3]-[4]-[5]. Industry 4.0 depends on several design principles: decentralization (cyber-physical systems can make decisions on their own), virtualization (linking sensor data with plant models and simulation ones), interoperability (the ability of cyber-physical systems, smart factories, and humans to connect and communicate with each other via the Internet of Things), real-time capability, modularity (flexible adaptation to changing requirements), and service orientation [6]-[7]-[8]-[9]-[10]. The term ‘cyber-physical system’ stands for the integration of computation, networking, and physical processes. According to the Industry 4.0 paradigm, all objects of the services provision world are equipped with integrated processing and communication capabilities [11]. These objects are machines, robots, devices, applications, services, tools, systems, products, people, etc. The next generation of the internet is named as ‘The Internet of Things (IoT)’. It is referred to as a global system (interconnected computer networks, sensors, actuators, and devices) potentially connecting all physical objects via the internet [12]. Thus, Industry 4.0 and IoT describe a paradigm shift in production and service provision technology [13]. However, these concepts are not only boosting productivity. They are turning economics, creating big investments, fostering industrial growth and also revenue growth, modifying the profile of the workforce by increasing employment with competencies in software development and IT technologies [14]. Furthermore, they are changing supply chains, business models and business processes and innovation opportunities significantly [15]. One buzzword of Industry 4.0 is ‘Digitization’, the continuing convergence of the real and the virtual world is one of the primary drivers of innovation and change in all sectors. The new wave of innovation is driven by the Internet of Things, Data, and Services, which is an ‘Internet of everything’, where subjects and objects alike can communicate in real time with each other [3].

3. INDUSTRY 4.0 AND THE TRANSPORTATION SECTOR

Smart City: For the transportation sector, to benefit from technological and business-related innovations, the concepts of Industry 4.0 and the smart city might be considered together.

According to [17], a Smart City brings together technology, government, and society under six dimensions, which are smart economy, smart environment, smart mobility, smart people, smart living, and smart governance. Technologies associated with Smart Cities are numerous, such as Intelligent lighting, smart building control, facial recognition, transportation sensors, intelligent buildings and integrated transportation. The primary purpose of the smart city concept is ensuring the sustainability of cities, improving a quality of life and safety of citizens. Furthermore, it is an objective to provide maximum energy efficiency, in the critical areas economy, environment, mobility, people, living, and governance, with the contribution of the latest technologies [18]. The transformation of cities into smart cities is a series of change processes. There is a need for rethinking how cities, citizens, and businesses work together.

The Industry 4.0 framework underlying concepts are nonmotorized systems, smart city, and Internet of Things. Core capabilities of such a framework are data and analytics, focusing on digitization and integration of horizontal and vertical value chains, digitization of product and service offerings, as well as digital business models and customer access. Contributing digital technologies within such a framework are mobile devices, Internet of Things (IoT) platforms, location detection technologies, advanced human-machine interfaces, authentication and fraud detection, smart sensors, big data analytics and advanced algorithms, multilevel customer interaction and customer profiling, cloud computing and augmented reality [16]. Mobile devices are tablets, smartphones, e-Readers, personal digital assistants (PDAs) or portable music players with smart functions. An IoT platform is a mediator between hardware and application layers and is capable of being integrated with connected devices and blend in with the applications used by the devices. This independence from underlying hardware and overhanging software allows a single IoT platform to implement IoT features into any connected device in the same straightforward way. Location detection technologies, such as the global positioning system (GPS), are included as a standard feature in many new mobile telephones. These technologies can provide real-time information about the location of devices, and hence the location of users of the devices. The types of devices that can be located include mobile telephones, laptop computers, PDAs, and gaming consoles [19]. Some integrated systems have been designed for situations where a human needs to be considered as a relevant part of the system. In such cases, the human-machine interface is a critical component of the system. Such systems produce much more data than a human can digest in a time-critical situation. The interface has to present data in a form easily understandable by the human and to provide an easy means of interacting with the system [21]-[22]. Authentication is the process of determining whether someone or something is, who or what it is declared to be; credentials provided are compared to those on file in a database of authorized users' information on a local operating system or to an authentication server. Fraud detection is a topic applicable to many industries including government agencies, law enforcement, financial sector, and banking. Data mining helps to anticipate and quickly detect fraud and take immediate action to minimize costs [24]. Smart sensors are devices that takes input from a physical environment, use built-in compute resources to perform predefined functions upon detection of particular input, and process data before passing it on. They record data, control system operations, and communicate over networks. Big data analytics is the process of examining large data sets to uncover hidden patterns, preferences, trends, unknown correlations, and other information that might help organizations to make improved business decisions [23]. Interlinking of real (physical) and virtual world will lead to cyber-physical systems that determine Industry 4.0 solutions. Robotics, automation equipment combined with advanced algorithms and machine learning, result in self-learning robots. RFID and automation equipment, coupled with advanced data analytics and cloud computing, resulting in self-reconfiguring machines. Camera and imaging systems, traditional sensors and virtual ones, combined with real-time image processing, advanced data analytics, and advanced algorithms, result in smart environment recognition. Augmented reality (AR) is a technology in which the view of the elements in a physical, real-world environment is augmented by computer-generated sensory input. AR is technology which combines virtual reality with real world [27]-[28]-[29]

Internet of X: The primary objective in developing applications for the Internet of Things is to integrate technology into everyday lives. The Internet of Things (IoT) is a network of physical products embedded with sensors, software, electronics, and network connectivity, enabling a data collection and data exchange for objects. The Internet of Things concept offers advanced connectivity of devices; each device is connecting to the internet is expected to have a set of smart services, which are called Internet of Services (IoS). IoT technologies enabled with IoS can be used to create the Internet of People (IoP). This could be seen as a CPS, with enhanced people-centered applications. Services and processes are going to be created and optimized according to people feedback. Internet of Energy (IoE) is an integrated dynamic network infrastructure, which connects energy networks with the internet. It can help to achieve energy savings via remote monitoring, and actual energy demand can be estimated collecting data from IoT, IoS and IoP [16]-[30].

Smart Transportation and Internet of People (IoP): The transportation sector changes rapidly since it can no longer be seen as only 'moving individuals and goods from one place to the other.' Transportation has to be understood as a sum of services offered to citizens, companies, organizations and transportation network objects. The smart city concept focuses on minimizing travel times. Smart urban planning and other aspects of smart cities shall focus on accessibility instead of only mobility. When looking at transportation, attention has to be paid to sharing vehicles and infrastructures, minimizing resource storage, service orientation and a focus on accessibility instead of only mobility. Internet of Things technologies needs people-centered enhancements. IoP should be based on the following principles [16]: Interactions where people, things, and devices are interacting have to be SOCIAL. IoP should support heterogeneity by supporting different types of devices people might use and let them interact. Devices need to be context-aware and have to adapt automatically to social behavior of other devices. Interactions between people have to be PERSONALIZED to sociological contexts and profiles. The triggering of interactions must be PROACTIVE, not manually commanded by users. And finally, interactions must be PREDICTABLE; they should be triggered according to a predictable context, predefined by users matching predefined behavior patterns.

IoP Transportation Scenarios: Figure 1 shows a possible transportation scenario of the future, with the Internet of People (IoP) approach as a key idea. Nowadays, it is not enough to sell personal transportation, and people want a driving experience which is personalized and keeps them connected to everything which is important for them, such as information, friends, maps, music, schedules. Toyota, e.g., has joined forces with salesforce.com to allow electric devices and plug-in hybrids to communicate with the driver through social networking tools. How to get to the level of 'automated driving'? Vehicle communication has to be combined into a single platform, connectivity standards have to progress, security topics have to be addressed and privacy issues solved.

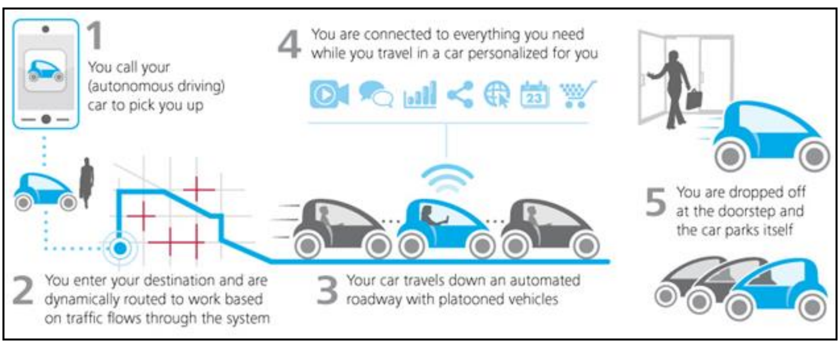

Figure 1. IoP Scenario I [31]

Table 1. IoP Scenario II [16]

A DAY IN THE LIFE OF PETER		
1	**Who is Peter?**	Peter is manager in a telecommunication company
2	**Where does Peter live?**	Peter lives in a residential suburb of Brussels
3	**What does Peter do today?**	Like every day he is driving his daughther to kindergarten before he goes to work
4	**Does he have a smartphone?**	Yes
5	**What did his smartphone 'learn' so far?**	It learned where Peter lives significant learned where he works It knows the route he usually takes in the morning It knows when he normally leaves home in the morning
6	**What does the smartphone regularly do?**	It reports information routinely from (5) to the local transportation control systems
7	**Why does Peter allow the smartphone to share frequently information?**	Peter decided to contribute anonymously to a project of his home city focusing on the simulation and prevision of potential traffic problems
8	**Does Peter always have to interact with his smartphone?**	No, he doesn't. His smartphone already learned where he is going in the morning.
9	**How can the , check if he is going to work or not?**	The be divided checks that route and speed are as usual.
10	*Today, a traffic accident occurred. Peter is stuck in a jam.*	
11	**Any reaction by his smart phone?**	Yes, the smart phone detects an abnormally low speed at a certain point.
12	**What does his smart phone do?**	It asks the daughter of people nearby whether they're stuck, too
13	**What comes then?**	If confirmed by the other phones as well, Peter's smart phone sends an alert of a possible incident to the transportation control system.
14	**What are other smartphones do?**	They are reporting the same possible incident
15	**The reaction of the transportation control system?**	Since several smart phone reported the same, a traffic alert is raised, and vehicle-based of people usually taking the same route are informed, and alternative routes suggested.
16	**Peter?**	His smart phone receives the information on the alternative route and on the expected arrival time.
17	**What comes then?**	The smart phone reports to a new route to the car's navigation system, which immediately informs Peter how to get out of the jam.
18	**Anything to do with the smart phone?**	It knows Peter is late, so it notifies his office on the delay and the expected arrival time.
19	*On a whole, Peter arrives only 10 minutes late at work*	
20	*Peter is happy that he could contribute to the transportation control alert system and remembers the days were smart phones were only used to talk, reading emails or surfing the internet while waiting in a jam.*	

4. INDUSTRY 4.0 TRANSPORTATION MATRIX

From the six dimensions of the Smart city concept, smart mobility is the one, mainly relevant for the transportation sector. Smart mobility counts on connectivity and the availability of information and communication technologies (ICT). Indicators for smart mobility are efficient road accessibility, efficient public transportation, nonmotorized accessibility and the availability of an ICT infrastructure. Industrial Control Systems (ICSs) are computer-based facilities, systems, and equipment used to monitor and/ remotely or control critical/sensitive processes and physical functions. These systems collect operational data from field locations, they process and display information, and then relay control commands to local or remote equipment or human-machine interfaces (operators) [25]-[26]. The I4.0 matrix, introduced in Table 2 focuses on a categorization of the transportation sector, transportation modes, as well as on types of control systems used in the transportation landscape. Then essential Industry 4.0 related concepts and systems, explained in the previous sections, are categorized, followed by a summary of intelligent transportation systems (ITS), including technologies, taxonomy, components and in-vehicle system solutions.

Table 2. Industry 4.0 Transportation Matrix

TRANSPORTATION SYSTEMS SECTOR			
SUB-SECTORS			
Aviation	Highway and Motor Carrier	Pipeline Systems	Maritime Transportation System
Mass Transit and Passenger Rail		Freight Rail	Postal and Shipping
TRANSPORTATION MODES			
Aviation Mode	The Aviation Mode is composed of aircraft, air traffic control systems, Commercial airports, and public airfields. Included in this mode are civil and joint use military airports, heliports, short takeoff and landing airports, and seaplane bases.		
Highway Mode	Highways, roadways, intermodal connectors and associated infrastructure. This network of roadways provides access to various vehicles, including automobiles, school buses, motorcycles, and all types of trucks, and trailers.		
Maritime Mode	The Maritime Mode includes a range of watercraft and vessels and can be divided into two sectors: vessels and ports.		
Pipeline Mode	The Pipeline Mode includes pipeline networks. This mode includes city gate stations, distribution networks, and terminals that transport and distribute natural gas and about hazardous liquids, in addition to other chemicals.		
Surface Transportation Mode	The Surface Transportation Mode consists of freight rail and passenger rail (also referred to as public or mass transit).		
CONTROL SYSTEMS IN THE TRANSPORTATION LANDSCAPE			
supervisory control and data acquisition (SCADA) systems	SCADA systems are distributed systems used to control geographically dispersed assets, where centralized data acquisition and monitoring are critical to system operation.		
Distributed control systems (DCSs)	DCSs are integrated as a control architecture containing a supervisory level of control overseeing multiple, integrated sub-systems that are responsible for managing the details of a localized process.		
Programmable logic controllers (PLCs)	PLCs are computer processor-based solid-state devices that control industrial equipment and processes. PLCs are used in transportation to control operational activities associated with systems and equipment such as airport baggage systems; air conditioning, heating, and ventilation		
general purpose controllers (GPCs)	GPCs are industrial computers that control and meter vehicular flow in freeways and arterials. They typically operate in standalone, direct, and distributed mode.		
Key ICS components	Control Loop	Human-Machine Interface (HMI)	Remote Diagnostics and Maintenance Utilities
INDUSTRY 4.0 RELATED CONCEPTS AND SYSTEMS			
Industry 4.0 underlying concepts	Cyber-Physical Systems	Smart City	Internet of Things (IoT)
Digital Technologies	Location Detection Technologies	IoT platform	Advanced Human-Machine Interfaces
	Authentication and Fraud Detection	Smart Sensors	Big Data Analytics

	Multilevel Customer Interaction and Customer Profiling	Cloud computing	Augmented Reality (AR)	
Smart City/smart Mobility principles	Connectivity	Availability of Information and Communication Technologies (ICT)		
Indicators for Smart Mobility	Efficient Road Accessibility	Efficient Public Transportation	Non-Motorized Accessibility	
Internet of X	Internet of Things (IoT)	Internet of Services (IoS)	Internet of Energy (IoE)	Internet of People (IoP)
Smart Transportation and IoP	Social	Personalized	Predictive	Proactive
INTELLIGENT TRANSPORTATION SYSTEM (ITS)				
An intelligent transportation system (ITS) is a technology, application or platform, which improves the quality of transportation. ITS is the application of analysing, sensing, control and communications technologies to ground transportation to improve safety, mobility and efficiency. ITS includes a broad range of applications that process and share information to improve traffic management, ease congestion, minimize environmental impact and increase the benefits of transportation to commercial users and the public in general. ITS are part of Internet of Things.				
ITS Technologies	VEHICLE-TO-VEHICLE (V2V)	VEHICLE-TO-INFRASTRUCTURE (V2I)		
ITS POSITIONING				
Vehicle level	Technologies deployed within vehicles, including sensors, information processors, and displays			
Infrastructure level	Sensors on and by the side of roads collecting traffic data (roadside messages, GPS alerts, and signals to traffic flow).			
Cooperative level	Communication between vehicles, and between infrastructure and vehicles.			
ITS TAXONOMY				
Advanced Traffic management System (ATMS)	Integrated several sub-systems, such as vehicle detection, variable message systems, communications) into a single interface that provides real-time data on traffic status and predicts traffic conditions Dynamic traffic control system, freeway operations management system, incident response system			
Advanced Traveler Information System (ATIS)	Provides travel related information used for decision-making on route choices, to avoid congestion and to estimate travel times. Used technologies: GPS enabled in-vehicle navigation systems, dynamic road message signs for real-time communication on bottlenecks, accidents and maintenance issues.			
Advanced Vehicle Control System (AVCS)	Used to enhance driver's control on vehicles. E.g., Vehicle collision warning system			
Commercial Vehicle Operations (CVO)	Used in commercial vehicles such as vans, trucks, and taxis (assembled from navigation system, computer and digital radio) and affords constant monitoring of operations by central units.			
Advanced Public Transportation System (APTS)	Real time passenger information systems, bus arrival notification systems, automatic vehicle location systems, transit signal priority systems.			
Advanced Rural Transportation System (ARTS)	Information about remote road and other transportation systems			
ITS COMPONENTS				
A) Categorized by responsibility	**Components**			
Automated data acquisition	Sensors	Automatic Vehicle Identifier (AVI)	Automatic Vehicle Locators (AVL)	GPS
Communication Tools	Dedicated short range communication (DSRC) provides communication between the vehicle and the roadside. Wireless communication systems provide network connectivity			

	to vehicles.				
Data Analysis	Data cleaning, fusion and analysis				
Traveler Information	Variable message signs, SMS, the Internet, Highway Advisory Radio, automated phone messages, other media tools. These systems offer real-time information on travel times, travel speeds, accidents, delays, route closures and others.				
B) Categorized by system type	**System Types**				
	Traffic Signal Control Systems	Freeway Management Systems	Transit Management	Railroad Grade Crossing Safety	Electronic Fare Payment Technologies
	Electronic Toll Payment	Incident Management Systems	Traveler Information Services	Emergency Management Services	
INTELLIGENT INFRASTRUCTURE AND VEHICLES					
Intelligent Infrastructure	Arterial Management	Freeway Management	Transit Management	Incident Management	
	Emergency Management	Electronic Payment and Pricing	Traveler Information	Information Management	
	Crash Prevention and Safety	Intermodal Freight	Roadway Operations and Maintenance	Road Weather Management	Commercial Vehicle Operations
Intelligent Vehicles	Collision Avoidance Systems	Driver Assistance Systems	Collision Notification Systems		
IN-VEHICLE SYSTEM SOLUTIONS					
In-vehicle system solutions	Fleet management: Vehicle localization Technical diagnostics Fuel monitoring Route optimization	Public Bike rental system: Rental services management Repairs and reallocation Data collection and processing	Processing: Engine control Energy optimization Safety monitoring Driver behavior		
	Passenger Information System	Traffic information system (real time)	Video surveillance		

TRANSPORTATION SUB-SECTORS and INDUSTRY 4.0 RELATED TECHNOLOGIES			
	Industry 4.0 underlying concepts		
Sub-Sector	*Cyber-Physical Systems*	*Smart City*	*Internet of Things (IoT)*
Aviation Mode	X	X	X
Highway Mode	X	X	X
Maritime Mode	X	X	X
Pipeline Mode	X	X	X
Surface Transportation Mode	X	X	X
	Industry 4.0 Digital Technologies		
	Location Detection Technologies (1)	IoT platform (2)	Advanced Human-Machine Interfaces (3)

	Authentication and Fraud Detection (4)			Smart Sensors (5)			Big Data Analytics (6)		
	Multilevel Customer Interaction and Customer Profiling (7)			Cloud computing (8)			Augmented Reality (AR) (9)		
Sub-Sector	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Aviation Mode	X	X	X	X	X	X		X	X
Highway Mode	X	X		X	X	X	X	X	
Maritime Mode	X	X	X	X	X	X		X	X
Pipeline Mode		X			X	X		X	X
Surface Transportation Mode	X	X			X	X	X	X	

5. INDUSTRY 4.0 TRANSPORTATION SHOWCASES

In the United States of America, there was initiated the ‘IntelliDrive’ Initiative, which is a multimodal one, leveraging on wireless technology to enable communications among vehicles, the infrastructure, and passengers’ communication devices. Within this initiative the following dilemmas have to be addressed: Fast fleet penetration, vehicle or infrastructure first, and infrastructure deployment. The ‘Next Generation 9-1-1 initiative’ establishes public emergency communications services through all forms of communication media. Metropolitan areas implement four strategies to contribute to the relief of urban congestion: (1) Trolling (reducing congestion through fee payment), (2) Transit (promoting use of train, bus and ferries), (3) Telecommuting (enabling work from alternate locations) and (4) Technology (applying emerging technologies to support congestion reduction efforts.

Japan is a pioneer in vehicle-based navigation systems, implementing first systems of Honda and Toyota in the 1980s. Digital road maps are available since 1990, Vehicle Information and Communication Systems (VICS) since 1996 and Electronic Toll Collection Systems (ETC) since 1997. In 2011 the country launched nationwide ITS Spot Services, which supports dynamic road guidance, the save driving support initiative and the realization of ETC. Japan focuses on the present on the development of a fully functional ITS. Canada has been at the forefront of intelligent transportation for half a century, installing the world first computer-controlled traffic signal system in the late 1950s; and implementing the COMBO smartcard in the 1990s. The user services of the Canadian ITS focuses on traveler information systems, traffic management services, electronic payment services, public transport services, commercial vehicle operations, emergency management services, vehicle safety and control systems, and information warehouse services. Current projects in Canada focus among others on ITS for school bus drivers (using ITS to detect children around school buses and warn drivers), traffic signal priority (allowing buses to receive priority at traffic signals when running behind schedule, reducing the number of stops at intersections, improving trip time reliability, and contributing to reducing operations costs. Automated vehicle tracking systems are used to collect and analyze data for validating and adjusting transit schedules. The City of Montreal hosts in 2017 the World Congress on Intelligent Transportation Systems. In the United Kingdom, several ITS approaches have been implemented successfully. Transport Direct (TD) combines all forms of public transport and enables users to compare with road journeys, and offers pricing information for driving and public transport. The Traffic Scotland Information Service (TSIS) provides real-time information about the Scottish road network to the traveling public. TSIS disseminates information across a variety of platforms, including, Variable Message Signs, desktop and mobile websites, smart phone applications, Really Simple Syndication (RSS) feeds, Twitter, a dedicated call center, national, local and commercial media and via a streaming internet radio service. The National Traffic Information Service (NTIS) provides accurate real-time traffic information to the public using some different method, Minimize the congestion caused by incidents, road works and events taking place near the motorway and trunk road network, and Provide information on diversions to help motorists avoid the queues. The UK has a mixture of free to air and private traffic information services that can be received in the vehicle, and information is delivered to vehicles by radio using the Traffic Message Channel (TMC). The Hands-Free Traffic Talker England App gives motorists access to real-time, personalized traffic and roadway travel information on the main highways in England. The term 'Managed Motorways' covers a number of interventions the UK is making on the strategic road network which utilize data collection and traffic management technologies to make better use of existing road space and add capacity where it is most urgently needed (smoothing the flow of traffic using variable speed limits, Traffic loop detectors, and CCTV cameras to monitor traffic flow and set mandatory speed limits accordingly, either by an automated system or by control centre operators).

6. CONCLUSIONS

Digitisation and the integration of companies' horizontal and vertical value chains is a key focus, with digitization being used to improve transparency and to integrate planning and processes. In the logistics field, companies are using big data analytics for demand forecasting improving inventory planning, warehousing fulfilment, and distribution. The term Industry 4.0 refers to the combination of several innovations in digital technology. These technologies include advanced robotics and artificial intelligence, the Internet of Things, sophisticated sensors, cloud computing, data capture and analytics, platforms that use algorithms to direct motor vehicles. Industry 4.0 takes shape, and transport logistics will also play an even more important role alongside data logistics. It can be seen that for all different transportation modes, such as aviation, maritime, highway or pipeline mode, Industry 4.0 related concepts, technologies and developed systems might be applied.

REFERENCES

[1] Davis, R. (2015): Industry 4.0. Digitalisation for productivity and growth, European Parliamentary Research Service, PE 568.337, September 2015.

[2] Fraunhofer IOSB (2013): Industry 4.0 - information technology is the key element in the factory of the future. Fraunhofer Institute of Optronics, System Technologies and Image Exploitation, PR, 31.01.2013, 1-5.

[3] Kagermann, H. (2015): Change through Digitization - Value Creation in the Age of Industry 4.0, in: Albach et al. (eds.): Management of Permanent Change, Springer Fachmedien, 23-45.

[4] Xia, F./Yang, L./Wang, L./Vinel, A. (2012): Internet of Things. Editorial, International Journal of Communication Systems, 25, 1101-1102.

[5] Schaffers, H./Komninos, N./Pallot, M./Trousse, B./Nilsson, M. & Oliveira, A. (2011): Smart cities and the future internet: Towards cooperation frameworks for open innovation, The Future Internet, Lect. Notes Comput. Sci., vol. 6656, 431–446.

[6] Belden (2015): The Smart Factory of the Future-Part 1, Retrieved from http://www.belden.com/blog/industrialethernet/The-Smart-Factory-of-the-Future-Part-1.cfm

[7] Steinmetz, K. (2014): Advancing the smart factory through technology innovation, Texas Instruments, SSZY013. Retrieved from http://www.ti.com/lit/wp/sszy013/sszy013.pdf

[8] Drath, R. /Horch, A. (2014): Industrie 4.0: hit or hype?, IEEE Industrial Electronics Magazine, 8(2), 56-58.

[9] Mulligan, C./Olsson, M. (2013): Architectural implications of smart city business models: An evolutionary perspective, IEEE Commun. Mag., 51(6), 80-85.

[10] Hernández-Muñoz, J./Vercher, J./Muñoz, L./Galache, J./Presser, M./Hernández Gómez, L./Pettersson, J. (2011): Smart Cities at the forefront of the future Internet, The Future Internet, Lect. Notes Comput. Sci., vol. 6656, 447–462.

[11] Gorecky, D., Schmitt, M., Loskyll, M., & Zühlke, D. (2014, July). Human-machine-interaction in the industry 4.0 era. In Industrial Informatics (INDIN), 2014 12th IEEE International Conference on pp. 289-294. IEEE.

[12] Fantana, N. K., Riedel, T., Schlick, J., Ferber, S., Hupp, J., Miles, S., & Svensson, S. (2013). IoT applications–value creation for the industry. Internet of Things: Converging Technologies for Smart Environments and Integrated Ecosystems, 153.

[13] Valdeza, A. C., Braunera, P., Schaara, A. K., Holzingerb, A., & Zieflea, M. (2015, August). Reducing complexity with simplicity-usability methods for industry 4.0. In Proceedings 19th Triennial Congress of the IEA, 9(14).

[14] Rüßmann, M., Lorenz, M., Gerbert, P., Waldner, M., Justus, J., Engel, P., & Harnisch, M. (2015). Industry 4.0: The future of productivity and growth in manufacturing industries. Boston Consulting Group, 14.

[15] Schmidt, R., Möhring, M., Härting, R. C., Reichstein, C., Neumaier, P., & Jozinović, P. (2015). Industry 4.0-potentials for creating smart products: empirical research results. In International Conference on Business Information Systems, pp. 16-27, Springer International Publishing.

[16] Carpintero, J. / Mäkitalo, N. / Garcia-Alonso, J. / Murillo, J. (2015): From the Internet of Things to the Internet of People, IEEE Internet Computing, pp.2-9.

[17] IEEE (2017): Smart Cities. Retrieved from http://smartcities.ieee.org/about.html

[18] Lom, M., Pribyl, O. / Zelinka, T. (2016). System Engineering for Smart Cities, WMSCI 2016, Orlando.

[19] Australian Government (2010, August). Location detection technologies. Retrieved from http://www.alrc.gov.au/publications/9.%20Overview%3A%20Impact%20of%20Developing%20Technology%20on%20Privacy/location-detection-technologies

[20] Berkley Sourcing Group (2015, December). An Introduction to IoT Platforms for Makers. Retrieved from http://www.berkeleysg.com/2015/10/an-introduction-to-iot-platforms-for-makers/

[21] University of Central Florida, College of Engineering and Computer Science (2017). Advanced Human Machine Interfaces. Retrieved from

[22] http://istf.ucf.edu/Tools/NCTs/Living_Systems/Advanced_Human_Machine_Interfaces/

[23] Schneider Electric (2016). Human-machine interface. Retrieved from http://www.engineering.schneider-electric.dk/Attachments/ia/guide/asg_8_human_machine_interface.pdf

[24] Rouse, M. (2017, March). Big Data Analytics. Techtarget Network. Retrieved from http://searchbusinessanalytics.techtarget.com/definition/big-data-analytics

[25] StatSoft, Inc. (2013). Electronic Statistics Textbook. Tulsa, OK: StatSoft. Retrieved from http://www.statsoft.com/textbook/.

[26] Albino,V./berardi, U. & Dangelico, R.M. (2015). Smart Cities: Definitions, Dimensions, Performance, and Initiatives. Journal of Urban Technology, 22(1), 3-21.

[27] Lombardi,P./Giordano,S./Farouh,H.,Yousef, W. (2012). Modelling the Smart City Performance, Innovation: The European Journal of Social Science Research, 25(2),137–149.

[28] Van Krevelen, D. W. F., & Poelman, R. (2010). A survey of augmented reality technologies, applications and limitations. International Journal of Virtual Reality, 9(2), 1.

[29] Quigley, M., & Burke, M. (2013). Low-cost Internet of Things digital technology adoption in SMEs. International Journal of Management Practice, 6(2), 153-164.

[30] Alam, M. F., Katsikas, S., Beltramello, O., & Hadjiefthymiades, S. (2017). Augmented and virtual reality based monitoring and safety system: A prototype IoT platform. Journal of Network and Computer Applications, 89, 109-119.

[31] Lom, M., Pribyl, O., Svitek, M. (2016). Industry 4.0 as a Part of Smart Cities, Smart Cities Symposium Prague, pp.1-6.

[32] Fishman, T. (2012).Digital-Age Transportation. The Future of Urban Mobility. Retrieved from https://dupress.deloitte.com/dup-us-en/industry/automotive/digital-age-transportation.html.