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Digitalization of logistics processes and the human perspective

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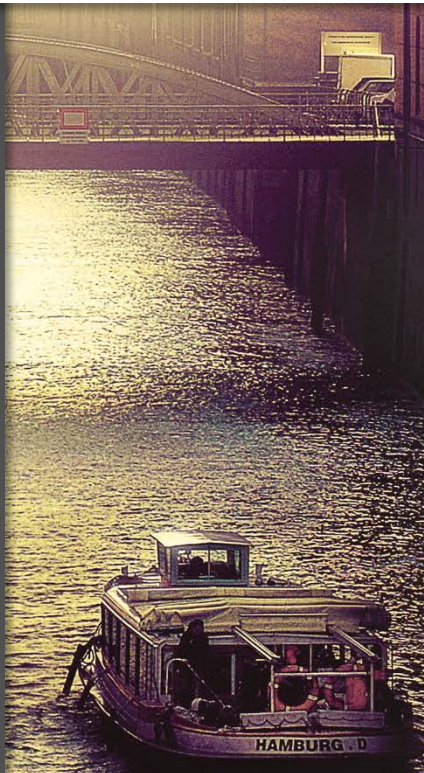


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Digitalization of Logistics Processes and the Human Perspective

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This contribution presents an analysis of the increasing consequences of digitalization with a focus on self-monitoring of personnel in logistics and production processes. This is of interest as digitalization requires large-scale innovative implementation and change management approaches in logistics and production processes. Based on standard DIN ISO 10.075 ('risk assessment') an application-oriented instrument is developed to evaluate and test new job systems, which are impacted by digitalization. This enables the development of digitalization strategies and an option analysis for further digitalization investments based on human workforce orientation. Furthermore, individual concepts for recruiting and selecting qualified personnel for digital job systems could be derived. Such an application-oriented risk assessment tool has the goal of analyzing the increasing digitalization concerning the self-monitoring of personnel and delivers options for the organization and formation of job systems in production and logistics. Afterwards, additional measures for innovative digital job systems for SCM processes and tasks can be derived. These additional measures can also be transferred to other industries in the service sector. This contribution presents first results concerning an in-depth document analysis based on DIN ISO 10.075 in comparison with existing logistics research literature and business practice knowledge.

Keywords: digitalization; risk assessment; change management; mental stress

1 Introduction

Digitalization and automation developments are an important trend in logistics and transportation processes, usually connected to many expectations regarding cost reduction as well as environmental and social (e.g. work conditions, safety) improvements (Caballini et al., 2016; Zijm and Klumpp, 2016; Abdallah et al., 2015; Nossack and Pesch, 2013; Wang and Yun, 2013). For example, in road transportation as one of the major processes in global supply chains as well as a huge employment sector, autonomous driving is foreseen to bring about a revolution in effectiveness in economic as well as environmental and social terms (Bazilinskyy and de Winter, 2017; Brown et al., 2017; Meyer et al., 2017; Ni and Hu, 2017; Pham and Jeon, 2017; Kalra and Paddick, 2016; Levin and Boyles, 2016; Rodriguez-Castano et al., 2016; Talebpour and Mahmassani, 2016; Wietholt and Harding, 2016). Though obviously the persons involved – e.g. truck drivers – are affected greatly, research and business development does largely neglect the “human factor” within such developments, mostly technical and economic aspects are addressed in publications as well as projects (Klumpp, 2017a; Königs and Gijssels, 2015; Koo et al., 2015; Weyer et al., 2015). This is connected to the concept of a balanced triple bottom line approach for forwarders and logistics service providers (Klumpp, 2017b) as well as a future importance of especially social and security dimensions in road transport (Anund et al., 2017; Nowakowski et al., 2015; Ohlson and Asvalder, 2015; Nuzzolo and Comi, 2014; Wu and Huang, 2013; Meech and Parreira, 2011), also labelled the “human factor”. This again is linked to the questions of e.g. further logistics management and driver training (e.g. Todorova et al., 2016) as well as a further calculation of sustainability improvements compared to the current situation (emission and reduction simulations based on existing models, Zhang et al., 2016; Valverde et al., 2016). This also adheres to the core mission of logistics regarding competitive advantages of supply chain actors (Kasarda, 2017). The research question regarding digitalization applications therefore is: RQ: How can an economic, environmental and social viable integration and preparation of human workers within the expected digitalization of logistics processes be attained in the future?

This analysis is affiliated with developments regarding digitalization and the physical internet and industry 4.0 concepts with e.g. big data applications at the core of those developments (Handfield, 2017; Montreuil et al., 2012; Montreuil, 2011).

The contribution is structured as follows: After this introduction, the second section outlines trend developments in logistics. Section three describes the crucial significance of the human factor in logistics and transportation processes. Section four provides a detailed outline of the relevant international standards regarding mental health of workers connected to digitalization. Section five finally outlines implications for specific logistics fields.

2 Trends in Logistics Processes

Digitalization is driven by technological progress in three different areas. First, there is the part 'IT and software', which includes cloud technologies, mobile applications, big data technologies and artificial intelligence. The second part is 'robotic and sensor technology' and the third part contains 'networking', which means cyber physical systems for internet of things and industry 4.0 (BMW et al., 2017, p. 5; Zijm and Klumpp, 2016, p. 2). This builds the foundation for current trends in logistics processes.

In a current study, which analyzes trends in the field of logistic and SCM, the authors structured trends in the categories 'business process management', 'competitive advantage', 'strategic management' and 'network structure' (Zijm and Klumpp, 2017, p. 367). The first category business process management means management of activities with the aim of output supply for customer requirements, e.g. reverse logistics, tracking & tracing and inventory/warehouse. Competitive advantage contains all the innovations, which helps companies to reach advantages, e.g. information technology/industry 4.0, sustainability or demographic change. Strategic management describes the ambition to reach efficiency resource allocation, e.g. human resources, organizational learning and skills/competences. Network structure contains information and material flows as well as potentials, which originate in vertical or horizontal cooperation, e.g. collaboration, cooperation and supply chain integration (Zijm and Klumpp, 2017, p. 367).

Logistics trends could be further distinguished in 'global trends', 'basal trends', 'customer trends' and 'economic cycle trends'. Global trends are for example the increasing integration of world trade (globalization) or corporate social responsibility (CSR). Basal trends, which mean technological and organizational developments, are for example physical internet and Auto-ID technologies as

for example RFID. Customer trends could be special services, flexibility of individualization, for example mass customization. Economic cycle trends as GDP or autonomous trends as workload of international competitors or demand cycles are also factors, which influence logistic activities (Klumpp et al., 2016, pp. 4-11).

The logistic trend radar published by DHL distinguishes between 'social & business trends' on the one hand and 'technology trends' on the other hand. A typical example for social & business trends is 'fair & responsible logistics', therefore logistic players combine the economic aim of generating revenues with the social aim of increasing sustainability. Another example is 'on-demand delivery', which should satisfy the customer requirements concerning delivery time and locations, which means delivering their purchase at any time and any place. Typical examples for technology trends, which are in the focus of this publication, are 'augmented reality', 'bionic enhancement', 'robotic & automation' and 'self-driving vehicles'. Augmented reality provides with help of heads-up displays, e.g. smart glasses, contextual information to workers at the right time and in the right place. Bionic enhancement, for example wearable technologies and exoskeletons, helps the workers expand physical boundaries and reduce health and safety risks. Robotics and automation offer a wide range of support concerning manual handling activities. Self-driving vehicles, e.g. autonomous forklifts or driverless trucks, create new logistics aspects regarding safety, efficiency and quality (DHL, 2016, p. 13-17; Zijm and Klumpp, 2016, p. 2).

3 Significance of the Human Factor

Concerning the aforementioned trends in logistics processes, it is necessary that organizations rethink their educational systems, so that staff can handle new technologies and can work in the context of future concepts like the physical internet or cyber-physical-systems (Zijm and Klumpp, 2017, p. 367). Despite the proceeding digitalization in all logistics and production processes, the human factor still plays an important role (Becker, 2015, p. 25). In comparison to machines, human beings are clearly superior with their cognitive and sensorimotor skills as well as their creativity, experience and ability of solving problems - and so will still be needed in cyber-physical-systems (Günthner et al., 2014, p. 309). Furthermore, human beings are clearly superior compared to machines because of their ability of association, so they can be easy reskilled to other tasks und can react rapidly

on modifications - a machine can just do for what it is constructed, but in a very rapid way with high accuracy of repetition (Schließmann, 2014, p. 454).

However, for future production and logistics systems, it has to be developed in which ways the human-machine-interaction takes place. However, human beings will still be in charge of the planning, controlling, managing and scheduling activities. For sure the work contents, work tasks, work processes and the environmental conditions will change. Furthermore, the requirements concerning the functional, regional and timely conditions will change for workers. Especially the aspects complexity, abstraction, problem solving, self-directed actions, communication and self-organization will be modified regarding their requirements for workers (Becker, 2015, p. 25-27). On the one hand, there will be work contents with high technical, technological, economical and IT-specific requirements and on the other hand, there will be work for low qualified workers (Becker, 2015, p. 27; Tödter et al., 2015, p. 73). The main tasks will change from manual, physical work to monitoring activities. The problem is that most of the low qualified worker will not understand what to do in case of interferences (Hirsch-Kreinsen, 2015, p. 90). To solve this problem it is necessary, that workers have a qualification profile which combines theoretical knowledge with practical experience (Hirsch-Kreinsen, 2015, pp. 90-91). It can be assumed that working places with low qualification requirements and easy, repetitive work will be substituted by machines; furthermore, tasks for high-qualified workers could not be needed in this form anymore, because of the automation of easy machine handling activities, material adjustments as well as some kinds of controlling and monitoring functions (Hirsch-Kreinsen, 2015, p. 91). These new tasks could be done by lower qualified and cheaper workers instead of high-qualified workers. Nevertheless, there can also be expected a requirement for higher qualified workers, because of the increased complexity and IT-based decentralization of decision, control and coordination activities (Hirsch-Kreinsen, 2015, pp. 91-92). The operative workers have to plan and coordinate the processes self-contained (Hirsch-Kreinsen, 2015, p. 92). A wide knowledge of the total processes as well as social competences with a high integration of different working groups and functional areas will be needed. Manual tasks will be less important, while particular programming knowledge as well as coordinating, managing and adjusting of complex systems will be more and more important. It seems that there will be a polarization of qualification: on the one hand, there will be needed high-qualified 'managers' for planning, controlling and coordination activities and on the other hand, there will be needed low qualified workers for easy tasks. The middle qualified workers will be substituted by automated cyber physical systems und will not be needed

anymore, because these tasks are well structured and could be algorithmatized very easily (Hirsch-Kreinsen, 2015, pp. 92-95). Therefore, it is important that staff have the necessary education and qualification for new workplaces requirements, which has to be implemented into educational systems and advanced training systems.

4 International Standard for Mental Work-Load

4.1 Ergonomic Principles related to Mental Work-Load (DIN ISO 10075)

The basis for the risk assessment tool is the standard DIN ISO 10075 ('risk assessment'). Because of digitalization, job specifications and the qualification requirements for workers will change und causes new aspects concerning mental workload.

The first part of this standard (DIN ISO 10075-1:2015) determines general concepts, terms and definitions for ergonomic principles related to mental workload (DIN, 2015, p. 1). Mental stress can result from any activity, even a mostly physical activity, and is described as a result from any external influences, which concern human beings in a mentally way. It is possible, that mental stress results in positive and negative effects on human beings (DIN, 2015, p. 6). The term "mental stress" means all external influences, which concern human beings or workers mentally (DIN, 2015, p. 6). Mental stress comprises generally several external stress factors, which influence in their combination, not isolated, human beings and leads to cognitive, informational und emotional processes (DIN, 2015, p. 6). These stress factors can be categorized in four different parts (DIN, 2015, p. 13):

The first category 'task requirements' contains sustained attention (e.g. supervising a monitor for a very long time), information processing (e.g. to deal with a very high number of information or to deal with incomplete information), responsibility (e.g. to be responsible for co-workers health and safety), duration, temporal pattern and temporal position of action (e.g. distribution of working hours, rest periods and shift work), task content (e.g. the calculating, planning, executing and evaluating parts of work) and danger (e.g. underground working, handling explosive or dangerous goods, working directly beside highways).

The second category 'physical conditions' contains lighting (e.g. very bright or dark lights, glare), climatic conditions (e.g. extreme heat or cold, air moisture), noise (e.g. very loud working areas), weather (e.g. working outside with extreme rain, storm, snow or extreme insolation) and odors (e.g. intense or disgusting fragrances).

The third category 'social and organizational factors' contains type of organization (e.g. organizational structure, hierarchy, communicational politics), organization climate (e.g. interpersonal relationships, meaning of human factor), group factors (e.g. size of working groups, cohesion), leadership (e.g. high or less controlling leadership), conflicts (e.g. between workers or between leader and workers) and social contacts (e.g. much teamwork and contacts to others or isolated workplaces).

The fourth category 'societal factors' contains social demands (e.g. social corporate responsibility), cultural standards (e.g. good working conditions) and economic situation (e.g. labor market).

Mental stress, which will exceed human ability of information processing, will lead straight to errors in human performance. In this case the mental stress reaches a level in which accomplishing tasks is generally impossible. So it is necessary that human-machine-interfaces will be modeled in an adequately way to avoid such mental stress situations (DIN, 2015, p. 7).

The term mental strain means the immediate effect of mental stress for every human being, which depends on individual preconditions (DIN, 2015, p. 9). Examples for individual preconditions can be grouped into four categories (DIN, 2015, p. 13):

Examples for the first category are level of aspiration, confidence in one's own capabilities, motivation, attitude and coping style of each human being. The second category includes for example abilities, skills, knowledge and experience of human beings. General condition, health, age, gender, physical constitution and nutrition of human beings are examples for the third category. The last one, the fourth category describes for example actual condition and initial activation level of human beings.

4.2 Short- and long-term Effects

Mental strain can have different effects on human beings. On the one hand, it can have facilitating effects with short-term or long-term potential and on the other hand, it can have impairing effects with short-term or long-term potential (DIN, 2015, pp. 9-11).

There are four different examples for facilitating effects with short-term potential. The first one is the warming-up effect, which is a frequent effect of mental strain and results soon after the task begins in a reduction of effort compared to the effort at the beginning of this task. The next one is the activation effect, which is an internal state with increased mental and physical functional competence. Learning is another facilitating effect with short-term potential and is a process based on work experiences which results in changes concerning behavior or behavioral potential, for example for plans, attitudes and values. The last one of this category is the practice effect and means a permanent change in individual performances which results from the repeatedly reaction to mental strain (DIN, 2015, p. 9-10).

A facilitating effect with long-term potential is competence development, which comes from an intense discussion with a certain tasks. Impairing effects with long-term potential could be described by six different examples: mental fatigue, fatigue-like states of human beings, monotony, reduced vigilance, mental satiation and stress response (DIN, 2015, p. 11).

An impairing effect with long-term potential is burnout, which is a state of sensed mental, emotional and/or physical exhaustion. It is a distant attitude concerning own tasks and a perceived reduced performance as a result from prolonging exposure against mental stress, which results in impairing short-term effects (DIN, 2015, p. 11).

5 Implications for Logistics Processes

5.1 Implications for Augmented Reality

Generally, it can be determined that all digitalization processes have to be accepted by workers, so they work in efficiency ways and do their very best (BMW i et al., 2017, p. 21). Furthermore there has to be considered the privacy for each

worker, because it can be necessary to use sensible data from workers for controlling such technical systems (Günthner et al., 2014, p. 318). The fear against the possibility of 'glassy staff' will influence the acceptance of digitalization processes (Hirsch-Kreinsen, 2015, pp. 92).

Augmented reality integrates background information for users into the field of view through smart glasses (DHL, 2016, p. 35; Günthner et al., 2014, p. 315). It can be used in several processes in warehouse operations, e.g. for picking processes; it is called in this context 'pick-by-vision-system' (DHL, 2016, p. 35; Günthner et al., 2014, p. 316; Schraven, 2017, p. 25). For workers this means an increase in process efficiency as well as an efficiency in quality and a reduction of strain in labor-intensive activities (DHL, 2016, p. 35; Günthner et al., 2014, p. 316). Furthermore smart glasses can be used to scan barcodes on the one hand and to navigate through warehouses on the other hand (DHL, 2016, p. 35). These information, for example for warehouse workers could be parking positions, article numbers, final destination of goods and are displayed at the edge of the visual field (Schraven, 2017, p. 25). Therefore, the user can see his working area in reality and the needed information virtually at the same time (Schraven, 2017, p. 25). Furthermore, augmented reality can be used to visualize danger areas at roads for drivers as a next generation of navigation and driver-assistance systems (DHL, 2016, p. 35). At least it can be used for intelligent loading in the way that the user sees through the smart glasses the optimal loading sequence of each shipment (DHL, 2016, p. 35).

The opportunities of this technology are hand-free operations, shorter handling-times in warehouses and a fast training because of very easy interface and the flexibility of language settings (DHL, 2016, p. 35). This technology is actually limited concerning deep frozen areas, because in these areas only very short working time is possible. It is necessary that these smart glasses have a high wearing comfort and the rack must take part in the several courses of movements of the user (Schraven, 2017, p. 25). Therefore, the weight has to be relatively low and the balance has to be well-adjusted (Schraven, 2017, p. 25). Smart glasses can be also used in driving processes as driving a forklift (Günthner et al., 2014, p. 316). The challenge for drivers is that their visual field is limited because of the mast and the loading units and additional information through smart glasses will limit the visual field additionally (Günthner et al., 2014, p. 317).

DIN ISO 10075-1 has the following implications for augmented reality as the first example for digitalization in logistics processes. From the first category of standard DIN ISO 10075-1 'task requirement' the aspects 'information processing' and

'task content' is relevant. Users get the information needed through the smart glasses. The aspect 'information processing' means that users get too much information through these glasses, more than they need and too much so handle. So they feel overstrained and overloaded because of too much information and too high complexity. Furthermore, the aspect 'task content' means that the users are not able to plan, control or evaluate the data shown by smart glasses. The users just execute what the smart glasses told them. A consequence could be that these users feel externally controlled by a virtual machine.

From the second category 'physical conditions' the aspect 'lightening' is relevant, because the smart glasses could have a gleaming effect. Furthermore, the weight of the glasses can affect the user as well as the wearing comfort.

The third category 'social and organizational factors' is relevant concerning two aspects. The first is 'leadership', which means in this context that users of smart glasses feel very controlled by their supervisors. This is because smart glasses should be connected directly into an information system. So, the supervisors can control for example at picking systems when which worker picks which item. As well the times needed for each pick and the times of non-work will be monitored. The second is 'social contacts' which can result in isolated workplaces and less interactions between co-workers, because the smart glasses 'show' the user everything what he has to know and no communications between human beings are necessary in extreme cases.

5.2 Implications for Bionic Enhancement

Bionic arms or smart contact lenses as examples for bionic enhancement can assist logistics work concerning communication and process implementation on the one hand and can reduce risks for workers health and safety on the other hand (DHL, 2016, p. 37). The idea is to reduce stress and strain which result from cyclical actions in all kind of manual handling activities (DHL, 2016, p. 37). In the future with help of smart wearable and ergonomically bionics work-related injuries should be purged (DHL, 2016, p. 37). Exoskeletons as one example of bionic enhancement can increase the user's strength and staying power, so older workers can execute longer their tasks (DHL, 2016, p. 37). Robo-Mate exoskeletons for example allow holding of things that are normally too heavy for a worker's hand (DHL, 2016, p. 37). Another advantage beside the decrease in work-related injuries is an increase in productivity and efficiency (DHL, 2016, p. 37).

DIN ISO 10075-1 has the following implications for bionic enhancement as the second example for digitalization in logistics processes. From the first category of standard DIN ISO 10075-1 'task requirement' the aspect 'danger' is relevant. Wearing bionic arms or smart contact lenses for example can lead to negative influences to the health of human bodies. There are no long-term studies concerning wearing exoskeletons all day long and use them in working activities.

The third category 'social and organizational factors' is relevant concerning two aspects. The first is 'group factors', which means in this context that the co-worker is a technical thing as a Robo-mate exoskeleton for example. It is not possible to have group factors like cohesion with a technical thing. The second is 'social contacts', which can result in isolated workplaces and less interactions between co-workers, because the exoskeletons take the role of a co-worker, but without human communication interaction.

5.3 Implications for Robotic & Automation

Robotics & Automation offers new opportunities in logistics processes and maintain a zero-defect process and increase in efficiency (DHL, 2016, p. 42; Hülsbömer, 2017, p. 48). One application for robots and automation is in warehousing and fulfillment processes by using them as assist workers for item picking, packing and sorting (DHL, 2016, p. 42; Hülsbömer, 2017, p. 49; Tödter et al., 2015, p. 71). These robots are prepared with high-definition cameras, pressure transducer and self-learning skills (DHL, 2016, p. 42; Hülsbömer, 2017, p. 49). Another example is using robots to load and unload trailer and container to benefit from robots strength (DHL, 2016, p. 42). The third example is robots, which are used for local delivery processes (DHL, 2016, p. 42). They can be used as assistant to delivery workers in the way that they go after the workers by transporting heavy items to the customers (DHL, 2016, p. 42). Furthermore, they can re-sort packages in the delivery vehicle or can transport autonomously letters or packages to fixed gathering places (DHL, 2016, p. 42). Beside more efficiency, another advantage is that robots help with physically and stressfully tasks, so workers can concentrate on more complex and planning activities (DHL, 2016, p. 42; Tödter et al., 2015, p. 74-75).

DIN ISO 10075-1 has the following implications for robotics & automation as the second example for digitalization in logistics processes. From the first category of standard DIN ISO 10075-1 'task requirement' two aspects are relevant. The

first aspect is 'task content'. The workers have not programmed the robots and normally are not able to reprogram them in situations where the robots should do something else. So workers feel losing control over their assistants. Because the robots are machines, workers can't talk to them, ask them anything or discuss anything with them in situation where this could be necessary. The second relevant aspect is 'danger'. Working together very close with robots could be dangerous for human beings. Actual there exist legal restrictions on the use of robots near human workers (DHL, 2016, p. 42).

The third category 'social and organizational factors' is relevant concerning two aspects. The first is 'group factors', which means in this context that the assistant of a worker is a robot. It is not possible to have group factors like cohesion with a technical thing, in this case a robot. The second is 'social contacts' which can result in isolated workplaces and less interactions between workers, because the robot assistant can't talk, interact, discuss or have any human abilities which define human interactions or interpersonal relationships.

5.4 Implications for Self-Driving vehicles

The first step of self-driving vehicles took place in accurately monitored environments such as warehouses or yards for example (DHL, 2016, p. 43; Hülsbömer, 2017, p. 50; Lassau, 2017, p. 15; Tödter et al., 2015, pp. 69-70). The next step is self-driving vehicles in common and open areas, for example highways or streets (DHL, 2016, p. 43). Actually there are very exact laws concerning the usage of such vehicles in open areas, but there will be still worked on the acceptance of fully driverless vehicles (DHL, 2016, p. 43). There are four different applications for self-driving vehicles. The first one is the use of autonomous forklifts, pallet movers and swarm conveyor belt systems in warehouses (DHL, 2016, p. 43; Hülsbömer, 2017, p. 50; Lassau, 2017, p. 15). The second possibility are outdoor logistics operations for automate container handling at terminals, in which self-driving vehicles that are intelligently composed, transport and stack the containers as needed (DHL, 2016, p. 43; Hülsbömer, 2017, p. 50). The third option is line-haul transportation, which often includes very long tours overnight (DHL, 2016, p. 43). One possibility is an autonomous highway, which needs the driver only for entering and leaving the highway (DHL, 2016, p. 43). The last possibility is an autonomous last-mile delivery, where self-driving trolleys go after workers and can support them by transporting the packages (DHL, 2016, p. 43). The problems are that legal restrictions in many countries forbid driverless vehicles (DHL, 2016,

p. 43). Furthermore, there is a risk from hackers and software bugs, affirmation and responsibility aspects must be reconsidered and the social acceptances of such systems by workers on the one hand and by public on the other hand have to be considered (DHL, 2016, p. 43).

DIN ISO 10075-1 has the following implications for self-driving vehicles as the fourth and last example for digitalization in logistics processes. From the first category of standard DIN ISO 10075-1 'task requirement' four aspects are relevant. The first aspect is 'sustained attention'. This means for example watching a screen for prolonged periods. Currently it is not allowed that completely self-driving vehicles operate on public areas, so a human driver has to be inside such vehicle. Because of the self-driving competence of the vehicle a driver is for a long time in a non-working period. Just in case of any problems, the driver has to react and interfere. The problem is that after a long period of non-use human beings fall into some kind of stand by modus and then it is difficult for them to react very fast and with high concentration. The second one is 'duration, temporal pattern and position of action'. The argumentation is nearly the same as for the first aspect 'sustained attention'. Drivers have a long period of non-use, which is very exhausting and unsatisfactory and then they have to react immediately in dangerous situations. The third relevant aspect is 'task content'. Generally the main task of a driver is driving. If self-driving vehicles will take care of this task and the driver has just a monitoring task, the task content will change completely. The fourth relevant aspect is 'danger'. Being in a self-driving vehicle could be dangerous if hackers or software bugs lead to any kind of accidents. Drivers could feel other-directed by the self-driving vehicle and have to trust it concerning his live and health.

6 Conclusions

Digitalization will definitively shape logistics and supply chain processes in the future. However, the core question of future economic and social competitiveness of corporate operations will be how digitalization is implemented and especially how human workers are integrated in and prepared for these developments.

Regarding the propose research question of how an economic, environmental and social viable integration and preparation of human workers within the expected digitalization of logistics processes can be attained in the future, the detailed answer proposed in this contribution is by extensively looking into specific areas

and processes in the logistics sector, e.g. with the structural help of industry standards like the analyzed DIN ISO 10.075. As outlined in section 5, many implication areas for logistics can be identified and therefore further enquiries and research are necessitated.

Viable options for further research are piloting and testing endeavors in real-life business contexts as well as further in-depth analysis of further sections of the DIN ISO 10.075 standard (desk research). In combination, this may shed more light onto the future developments that await us in the logistics domain regarding digitalization and the integration of human workers within this major development of our economies and global value chains.

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