Wearable solutions for efficient manual logistics processes – RFID Wristband and Smart-Glasses

Olaf Poenicke[1], Martin Kirch[1], Klaus Richter[1], Falko Schmid[2] and Péter Telek[3]

1. Fraunhofer IFF, Magdeburg, Germany
2. Ubimax GmbH, Bremen, Germany
3. University of Miskolc Institute of Logistics, Miskolc, Hungary

Corresponding author: olaf.poenicke@iff.fraunhofer.de

Abstract: *In logistics processes with increasing complexity and flexibility the use of wearable solutions can help to increase the efficiency and reliability of manual operation like order picking. With the proof of improving such processes by using wearables like Smart Glasses or a RFID Wristband at hand, the project AR-LEAN focusses on integrating these devices in a flexible wearable assistance solution. Supporting manual processes with such solutions will still be relevant in Physical Internet based environments, as manual handling will remain crucial in processes handling small PI containers. Besides describing the wearable solutions and their development, the paper discusses the relevance of such technologies in relation to smart PI containers.*

Keywords: *RFID Wristband, Smart Glasses, Wearables, Augmented Reality, Picking and Placing, Process Reliability, Process Efficiency, Assistance Solutions for Physical Internet*

1 Introduction

Within current global supply chains warehousing operation make up about 20 percent of the overall logistics costs (De Koster et al., 2017). Manual handling processes like picking and placing cause the major share of these costs they make up roughly 60 percent of the (Baumann, 2013). Even with ongoing steps towards standardization of load carrier units like PI containers of the Physical Internet Initiative and further developments in the field of logistics automation, operations like picking and placing will remain as manual processes when it comes to handling actual single items.

To enable error-free order picking, assistance solutions for the manual processes are of growing importance. Within this paper, applications for Head-Mounted Displays (HMDs) or Head-Up Displays (HUD), assisting manual order picking processes are describes and discussed in section 2. These Wearable based applications on Smart Glasses are used to display job orders and other process relevant information for the worker within the process environment. The Ubimax GmbH as a leading developer and provider for HMD based assistance solutions, carried out studies with different industry partners to measure the increase of productivity using the Smart Glasses in productive processes.

Most of the picking assistance solutions mainly guide the manual operation. Other technical solutions are required to control and confirm the actual manual processes such as barcode or RFID scanning. For the process-integrated RFID scanning of tagged objects (like e.g. load carriers), the Fraunhofer IFF developed a mobile RFID Reader as a wearable device as it was described by Kirch et al., 2014. With this so-called RFID Wristband RFID-tagged objects are automatically identified within manual processes like picking or placing. This enables a process-integrated control and verification of job orders saving process time as also increasing the process reliability. This solution is described and discussed in section 3.

In the ongoing R&D project AR-LEAN both wearable solutions are integrated into a completely mobile assistance solution for information (processing and visualization by Smart Glasses) and control (identification by RFID Wristband). The paper describes the current state of the project developments in section 4.

Section 5 examines the relation between the approaches of the Physical Internet and the requirements for manual processes like order picking. Furthermore the described Wearable solutions can be seen in other assistance solutions based on using smart PI containers. In this context, current approaches as also productive use cases of smart load carriers and the integrated wearable assistance solution are discussed in relation to the Physical Internet.

The paper concludes with a short summary and an outlook on further relevant research and development, for a seamless use of smart containers and process integrated assistance with wearable devices.

2 Wearable assistance using Head-Up Displays

As a developer for industrial assistance applications using wearable devices the Ubimax GmbH in Bremen has taken a leading role in the use of HMDs. Using market available HMDs like Google Glass or devices from Vuzix, Ubimax focusses on developing and rolling out mobile applications for user guidance. This includes typical order picking processes but also applications for assembly or inspection tasks.

2.1 System overview

The Ubimax Enterprise Wearable Computing Suite (UEWCS) is a solution platform for industrial wearable assistance systems. Although it has a focus on HMDs as primary devices, it is designed to develop implementations consisting of many different wearables, such as smart glasses, mobile barcode scanners, smartwatches, or RFID readers. The platform is designed in a device-agnostic manner, thus most available wearable devices can be integrated for specific solutions.

UEWCS consists of two layers: the solution layer and wearable computing layer (see Figure 1). The wearable computing layer defines device agnostic implementations of wearables and their sensors to ensure that many wearables can be integrated in specific solutions. The available solutions of the solution layer are organized along segments of the industrial value chain where manual processes are predominant: logistics, production, service and maintenance, and remote support.

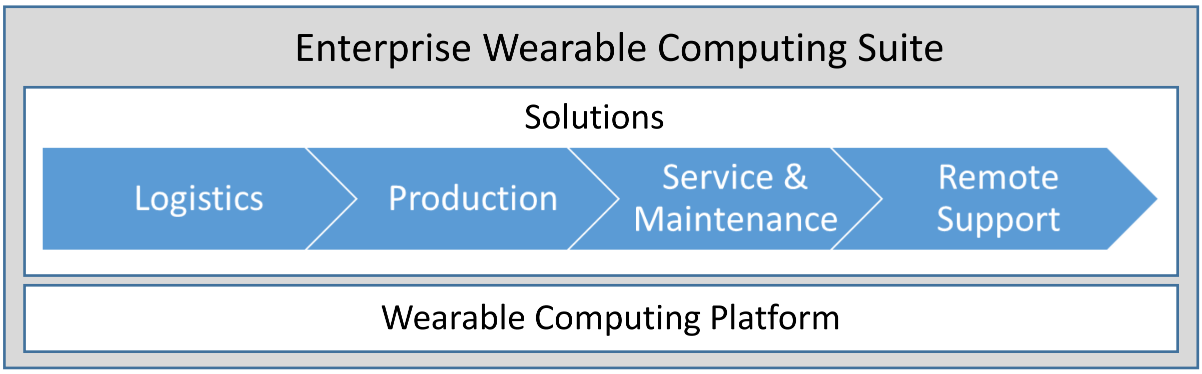

Figure 1: Architecture of the Ubimax Enterprise Wearable Computing Suite (source: Ubimax)

A typical implementation is based on a client-server deployment consisting of a wearable worker assistance system involving one or more wearables (see Figure 2). The wearable ecosystem is communicating to and fed by a server managing all aspects of the application at hand: user and device management, process and workflow management, and implements all communication with and transactions from/to the involved backend landscape.

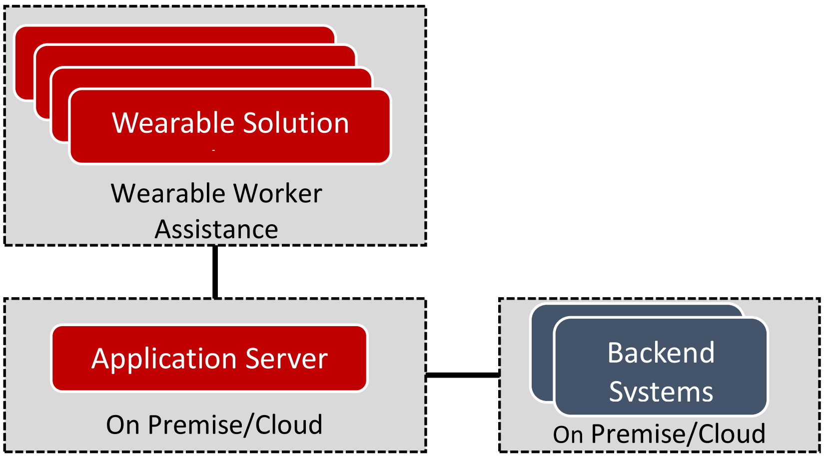

Figure 1: Typical implementation of a UEWCS deployment (source: Ubimax)

In a picking case, a client usually consists of a Smart Glass HMD which can be connected to other wearable devices. The HMD serves as the local process and ecosystem integrator and displays process information to the picker. The visual information supports context-specific information, thus only the information required to complete the (sub-)task at hand.

2.2 Use Cases

A White Paper by Intel, 2017 describes a typical use case of the HMD assisted order picking in a warehouse. In comparison with the current use of barcode handhelds for guiding the workers and scanning the storage locations, the use of HMDs together with a barcode ring scanner showed an improvement of 29 percent time savings. In another use case study, carried out by Ubimax with DHL, the use of HMDs showed a gain in process efficiency of 25 percent (Logistik Heute, 2015).

Figure 3: User view of a HMD assisted Ubimax application (source: DPDHL)

As shown in Figure 3 the HMD information are permanently visualized in the visual field of the user. In that specific example of the DHL use case, the picking tasks are displayed on the left side (aisle number, location, quantity and next pick location) and the information where to put the picked item on the trolley are shown on the right side with a schematic representation of the trolley.

These industrial use cases only can give rough measures on time savings or reduced error rates, as the different assistance solutions are not compared in a controlled environment. Still these measures are almost similar to measures of scientific studies.

2.3 Improvement potential

Such studies are showing that solutions like Pick-by-Light, Pick-by-Vision or Pick-by-CMD (Car-Mounted Display) are able to reduce the operation time and the error rate in order picking processes significantly compared to the basic pick-by-paper list. In such comparative studies, the use of HMDs showed the highest potential to ensure efficient and reliable picks (Guo et al., 2015; Baumann, 2013).

Nevertheless, there is several potential for further improvements. One field for improvements can be seen in combining the HMDs as a guidance solution with other devices for controlling and verifying the actual manual processes. As barcode scanning of the actual picking location is often cumbersome, RFID scanning is a promising approach. Also integrating other wearable device for picking quantity verification is an important point for improving the assistance solutions, as these wrong number errors are still significant for pick-by-vision solutions (compare Figure 4 sourced from Guo et al., 2015).

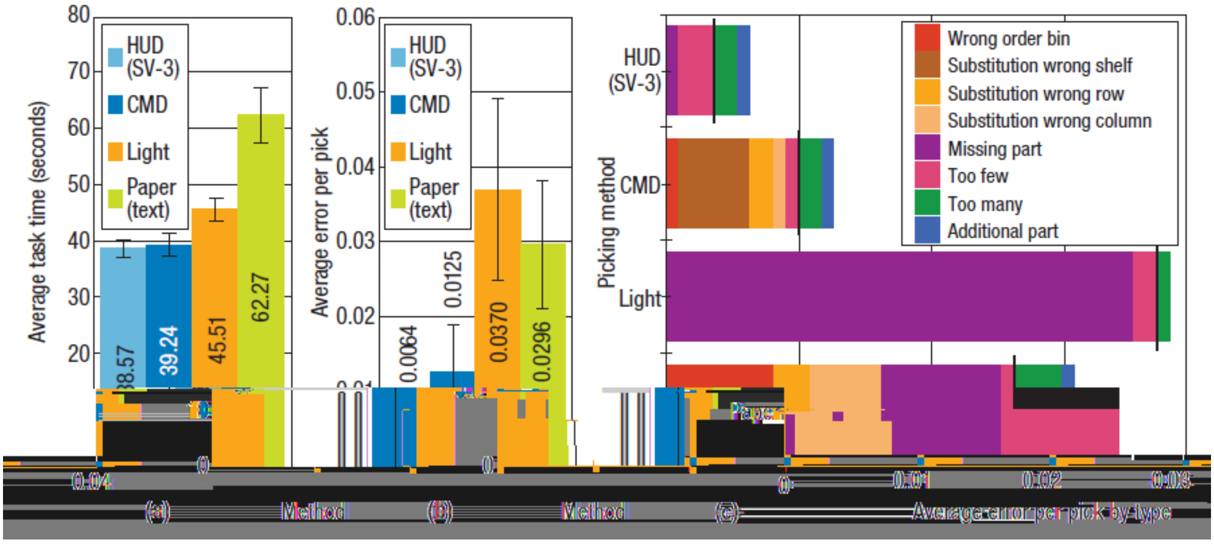

Figure 4: Comparative performance of different assistance solutions. (a) average task time, (b) average error per pick, (c) average error per pick by type (source Guo et al., 2015)

3 Process integrated work step confirmation using the RFID Wristband

Kirch et al., 2014, have described the initial development of the RFID Wristband by the Fraunhofer IFF with the focus on verifying picking processes in automotive assembly processes. This paper already included a comparison of the RFID based solution with barcode based picking verification solutions. Starting from a first application in assembly processes, the RFID Wristband has been evaluated in further applications in logistics operations.

3.1 System overview

The RFID Wristband is a mobile RFID reader (UHF at 865.6 to 867.6 MHz) which is worn at wrist level to enable the identification of RFID tagged items within manual handling processes. By that the RFID Wristband allows hands-free operation. The complete electronics, consisting of the RFID reader, a microcontroller, the ZIGBee based communications interface, the RF antenna and an exchangeable battery, is integrated in the RFID Reader Module. The Reader Module is attached to user individual Strap via magnet. With an overall weight of approx. 120g, the RFID Wristband can be worn throughout complete shifts without causing fatigue.

As shown in Figure 5 the RFID Wristband is used to scan RFID tags (1), which are identifying e.g. picking areas or boxes. The RFID read data are then transmitted to an external device (e.g. a workplace computer) where the read tag ID is further processed (3). Based on the result of the logical operation (e.g. comparison target against actual) feedback signals can be send back to the RFID Wristband via the ZIGBee interface (4).

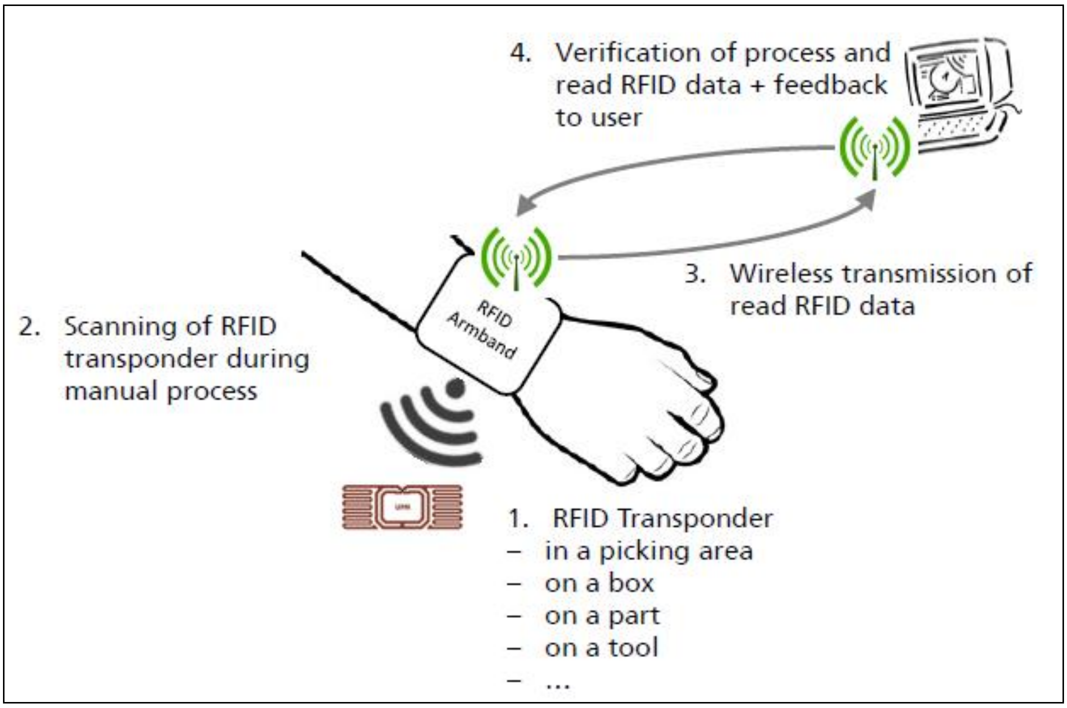

Figure 5: Application principle of the RFID Wristband (source: Fraunhofer IFF)

Optimized for near field identification of RFID tagged objects, the read range of the RF field, which is located below the arm wrist, can vary from 1 to approx. 40cm (depending on reader output power setting and on RFID tag sensitivity). The RFID Wristband is not designed for far field RF reading, as higher reading distances will cause false-positive reads in most of the picking and placing environments.

3.2 Use Cases

In the current design of the device the RFID Wristband can be used for any manual processes in that RFID tags are scanned below the wrist level. This includes typical order picking handling of objects from picking them out of bins or shelves and putting them into bins or onto shelves as also supplying processes, where the put-away of bins into storage locations needs to be controlled (see Figure 6).

The advantage of the wearable RFID scanner over other mobile devices for process verification like Barcode or RFID handhelds is the process integrated scanning of the picking location. This is saving time and securing a higher process reliability, as picking and scanning are not separated process steps.

Figure 6: Typical use cases. (a) control of storage, (b) control of picking, (c) control of putting (source: Fraunhofer IFF)

Besides the already mentioned use case in the automotive industry (Kirch et al., 2014), a comparative study has been carried out in an order picking process, where the RFID Wristband was compared with barcode scanning and operation without scanning. With using the RFID Wristband more than 3,500 picks have been carried out by different workers. The picking rate in these tests reached an average of 176 picks per hour, which equals the average picking rate without scanning. Compared to that, the barcode scanning only allowed an average of 137 picks per hour with a still significant error rate of 0.25 percent (Schulze, 2016).

3.3 Improvement potential

In its current form the RFID Wristband is giving feedback information (e.g. correct pick / wrong pick) to the user via a signal LED and an acoustic beeper. This is sufficient in relatively fixed work environments, like picking work places or assembly benches providing a screen visualizing all relevant process information.

Especially in applications where the user has to move through a warehouse or has to work within a noisy environment the feedback features of the device are not sufficient. Because of that, it is often a requirement to visualize process related context information on a display. To keep the ergonomic usability of the RFID Wristband (especially low weight, meaning not extending the battery for further power consuming features) the approach for extended visual guidance is to combine the RFID Wristband with a HMD in an integrated system solution.

4 Integrated wearable solution of RFID Wristband + HMD

In the ongoing funded R&D project AR-LEAN both wearable solutions are integrated into a completely mobile assistance solution. Figure 7 shows a first experimental setup of combining HMD provided information (processing and visualization by HMD) and picking verification (identification by RFID Wristband). AR-LEAN is an international EUREKA project with a duration of 19 months (July 2016 to January 2018). The German Federal Ministry for Economic Affairs and Energy funds the German project part of Fraunhofer IFF and Ubimax under the funding reference 16KN045445.

Combining the wearables HMD and RFID Wristband will enable a completely mobile and flexible system solution with the HMD used for processing all necessary logics. The RFID Wristband will be connected to the HMD via Bluetooth Low Energy (BLE). It will transmit the RFID read events and receive feedback signals and process related reader settings. Fraunhofer IFF and Ubimax are developing the process logics for synchronizing the use of both devices based on their long-term experience of integrating the devices in productive environments.

Figure 7: Combined use of HMD and RFID Wristband in a first experimental setup (source: Fraunhofer IFF)

The technical tasks within the project furthermore include hardware developments on the RFID Wristband (interfaces for bi-directional communication with the HMD via BLE), the IT integration of RFID Wristband and HMD (communication protocol, process logics) as also the development of a platform for the flexible generation of process related applications for industry partners. The platform also will enable the integration of further mobile and wearable devices such as tablets or smart watches.

The project aims at the testing and demonstrating the integrated wearable solution in a productive process environment. The target applications are focusing on the use cases described above for HMDs and the RFID Wristband combining the advantages of both solutions for an efficient picking instruction and control. Based on the findings of the aforementioned evaluations of HMDs and the RFID Wristband it is expected that the benefits of the partial solutions will add up in an integrated system solution.

Currently the hardware of the RFID Wristband is extended to offer enhanced connectivity and to include further user interface triggers which will be used to verify picked item quantities. For connecting RFID Wristband and HMD with the limitations of BLE communication, a shared communication protocol is developed.

A first demonstration setup of the integrated system solution shall be available at the end of September 2017. Following these first demonstration the integrated solution will be examined in productive process environments to evaluate the actual benefits of the system compared to other assistance solutions. Based on that evaluation further required steps for the product development will be defined.

5 Relation of the wearable assistance solution to the concept of the Physical Internet

The approach of the Physical Internet aims at enabling further logistics process automation by standardizing the different levels of load carriers (PI containers as described by Montreuil, 2012). But even with a higher level of automation the manual handling of small containers and especially of single items in containers will remain crucial (Ballot, 2016). For that reason, assistance solutions for manual operation like the described wearable devices will play an important role for ensuring error-free and efficient processes, once the Physical Internet is completely implemented.

5.1 Physical Internet scenarios employing wearable assistance solutions

Within the concepts of the Physical Internet the PI containers are described as Smart Containers. The level of smartness may reach from basic possibilities for identifying a container (e.g. via passive UHF RFID) to more complex sensing solutions (e.g. with active location tracking and state monitoring). Yet it is unclear whether the same level of smartness will be required or even be useful on all container size levels. To relate the wearable devices HMD and the RFID Wristband to the Physical Internet, several use case scenarios can be discussed:

- **RFID-based identification of PI containers** Standardized PI containers can be identified by the RFID Wristband in manual handling processes where automation is not feasible but process reliability needs to be secured this can be seen e.g. in C-Part management processes, when small containers flexibly need to be stored in correct locations;
- **AR context information about PI containers** PI containers with a higher smartness level can directly communicate with HMD applications via wireless communication to provide process related context information this can be relevant in processes where certain object states need to be included for process decisions e.g. to keep FIFO rules or to first pick items in a critical state;
- **Interaction of other wearables with PI containers** as PI containers will provide wireless interfaces, also other wearables like smart watches can come into focus for process control interaction. Wearables can be used as control and decision support devices e.g. to assign single PI containers to follow-up processes.

The definition of the smartness level for PI containers will fundamentally influence the possibilities for interacting with these containers not only in automated but also in manual handling operations.

5.2 Current developments for smart load carriers

There is a vast field of concepts and R&D projects for designing and developing smart container solutions. Yet on practical level, there are first products and applications in place where higher volumes of smart load carriers are used. E.g. on pallet level first pallet pools are entirely equipped with passive UHF RFID. Poenicke et al., 2016, described the development and RFID integration in such retail pallets.

On a smaller container level, there are ongoing projects for standardizing RFID tagged containers like the KLTs (Kleinladungsträger) in the German Automotive Industry (see press release of AIM, 2017). Also in the development of PI containers the integration of passive track and trace capabilities for identifying and distinguishing containers are defined as a main function (Landschützer et al., 2015). As Ballot, 2017 stated the necessary standards for using and exchanging the RFID data are already in place (see also GS1, 2016 and VDA, 2016).

Besides the identification solutions based on passive RFID, R&D projects as also first industrial products based on active technologies showed approaches for smaller load carriers with an enhanced smartness (see also Emmerich, 2012 and Hoffman, 2014). Currently emerging Low Power Wide Area Network (LPWAN) technologies like LoRa or NBIoT will further enable new applications for tracking, tracing and monitoring also small load carriers in an efficient and economical feasible way.

6 Summary and Outlook

As an innovation contribution the paper with focus on IT and digitalization gives an overview on the ongoing R&D project AR-LEAN which is focusing on the integration of wearable devices like HMDs and RFID Wristband to assist manual logistics operation. Such assistance solutions still will be relevant in Physical Internet based process environments, as manual processes will remain crucial especially for the handling of small PI containers.

In this context, the debate about the Physical Internet will need further discussions about potential automation levels in current manual processes like order picking. In addition, the possibility for automation of logistics processes needs to be discussed with respect to small and medium sized logistics operators.

Concerning the connectivity of PI containers be it for interfacing with wearable devices or also stationary infrastructure the Physical Internet community needs to focus more on R&D

related standards in line with the Physical Internet approaches. This will e.g. require discussion about what level of IoT functions or smartness is needed for different PI container sizes.

The standardization of information and communication functions on the side of containers will also enable the standardization of assistance applications like the described wearable solution integrating Smart Glasses and RFID Wristband.

References

AIM: AIM unterstützt VDA-Projekt: Analyse, Entwicklung und Prüfung einer neuen VDA-KLT-Generation. https://www.pressebox.de/pressemitteilung/aim-d-ev/AIM-unterstuetzt-VDA-Projekt-Analyse-Entwicklung-und-Pruefung-einer-neuen-VDA-KLT-Generation/boxid/847144, 2017/04/25.

Ballot E.: The Physical Internet: logistics of the future is just around the corner. http://parisinnovationreview.com/2016/10/31/physical-internet-logistics-future/, 2017/04/25.

Baumann H. (2013): Order Picking Supported by Mobile Computing. PhD dissertation, Univ. of Bremen, 2013.

De Koster R., Le-Duc T., Roodbergen K.J. (2007): Design and Control of Warehouse Order Picking: A Literature Review. European J. Operational Research, vol. 182, no. 2, 2007, pp. 481-501.

Emmerich J., Roidl M., Bich T., ten Hompel M. (2012): Entwicklung von energieautarken, intelligenten Ladehilfsmitteln am Beispiel des inBin. Logistics Journal Vol. 2012, 1.

GS1 (2016): EPC Information Services (EPCIS) Standard. http://www.gs1.org/sites/default/files/docs/epc/EPCIS-Standard-1.2-r-2016-09-29.pdf, 2017/04/25.

Guo A., Wu X., Shen Z., Starner Th., Baumann H., Gilliland S. (2015): Order Picking with Head-Up Displays. Computer, vol 48, Issue: 6, June 2015, pp. 16-24.

Hoffmann F.-J. (2014): iBin Anthropomatik schafft revolutionäre Logistik-Lösungen. In Baurenhansl T., ten Hompel M., Vogel-Heuser B. (Hrsg.): Industrie 4.0 in Produktion, Automatisierung und Logistik, Springer, pp. 207 220.

Intel (2017): Vision Picking with Intel Recon Jet Pro.

Kirch M., Poenicke O.: Using the RFID Wristband for Automatic Identification in Manual Processes. SmartSystech 2014, Dortmund.

Landschützer C., Ehrentraut F., Jodin D. (2015): Containers for the Physical Internet: requirements and engineering design related to FMCG logistics. Logistics Research, Oct. 2015.

Logistik Heute (2015): 25 Prozent effizienter. Logistik Heute, no. 3, March 2015, p. 32.

Montreuil B. (2012): Physical Internet Manifesto, v1.11.1, www.physicalinternetinitiative.org, 2017/04/25.

Poenicke O., Kirch M. (2016): RFID Based Pallet Management Manufacture and Implementation of RFID Pallets in Retail. SmartSystech 2016, Duisburg.

Schulze M. (2016): Fehlerfrei kommissionieren mit dem RFID-Armband. IFFokus, no. 1, 2016, pp. 22-25.

VDA (2016): VDA 5501 RFID-Einsatz im Behältermanagement. https://www.vda.de/de/services/Publikationen/rfid-im-beh-ltermanagement.html, 2017/04/25