PRODUCTION LOGISTICS IN THE INDUSTRY 4.0 ERA

F. SGARBOSSA

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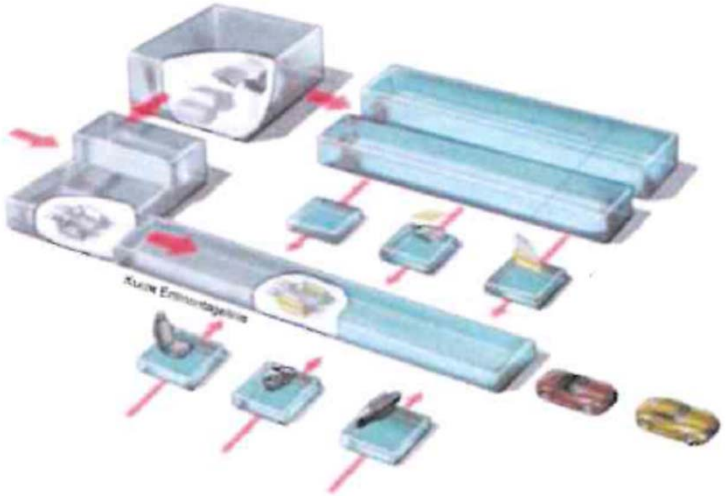
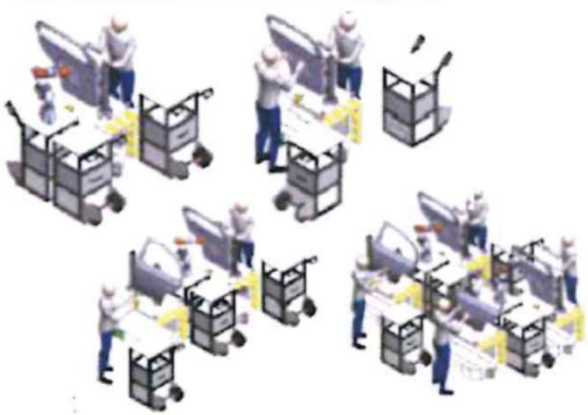
AGENDA

- PRODUCTION LOGISTICS AND INDUSTRY 4.0
- MACRO-LAYOUT & MATERIAL HANDLING SYSTEMS
- MICRO-LAYOUT & HUMAN-CENTERED WORKSTATIONS
- CONCLUSION & FUTURE RESEARCH

PRODUCTION LOGISTICS AND THE 4.0

*CHANGEABLE PRODUCTION SYSTEMS PARADIGM**



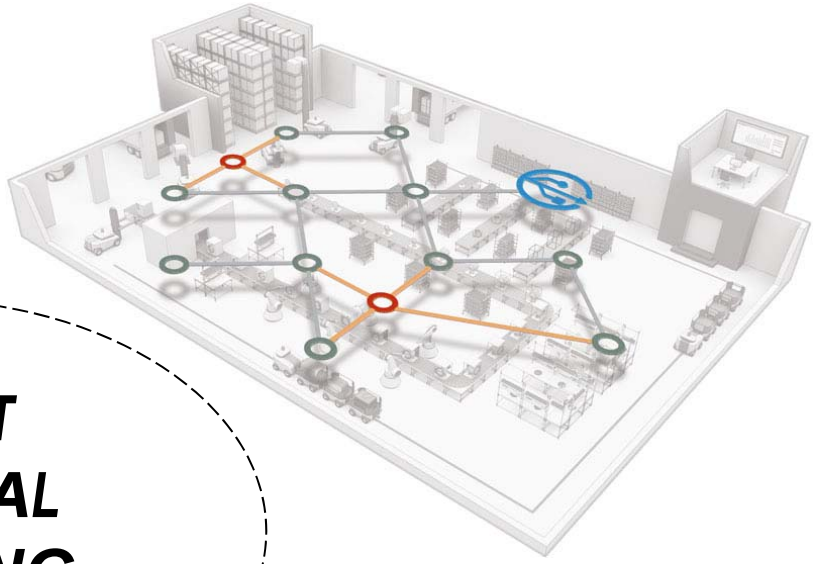


** Fraunhofer Institute (2017). Materials of the Production Academy in Stuttgart - Seminar SPA 385, October 10-11, Stuttgart.*

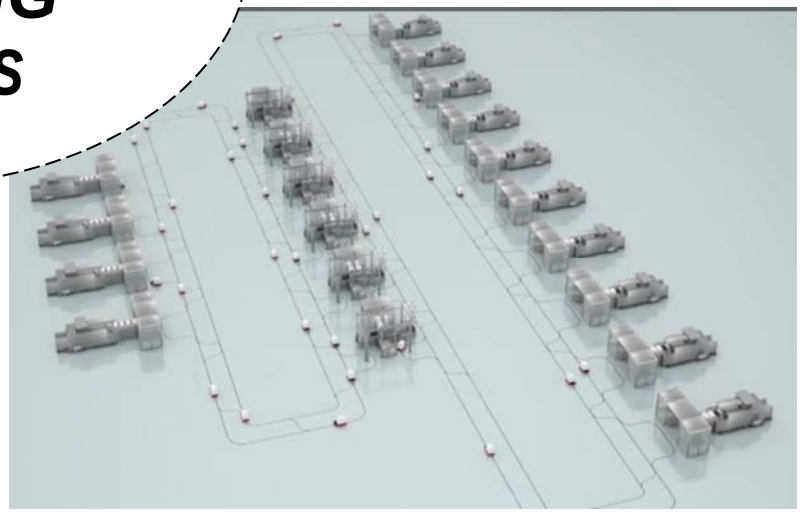
Requirements of production and logistics systems 4.0

- Interconnection of production modules
- Routing flexibility of material handling systems
- Integration of production and logistics systems
- Dynamic reconfiguration
- Scalable automation
- Human-centered workstation
- Human-robot collaboration
- Real time access to production and materials info
- Simulation based on real time data
- …

MACRO LAYOUT LEVEL

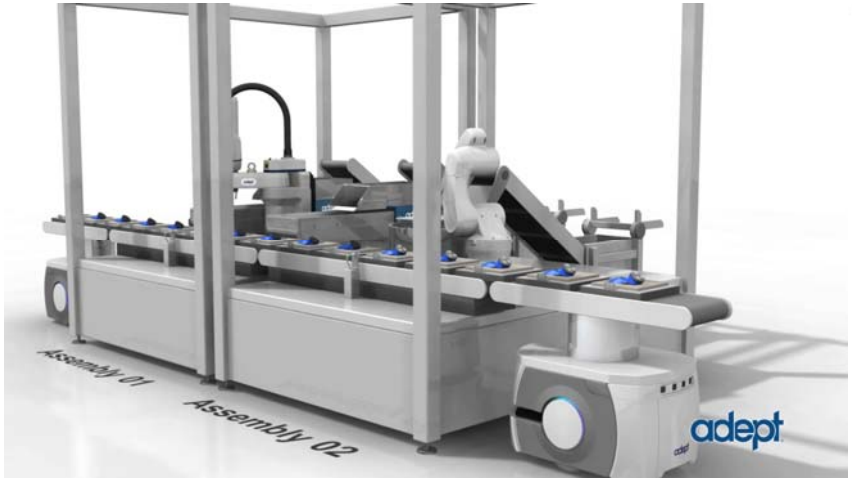


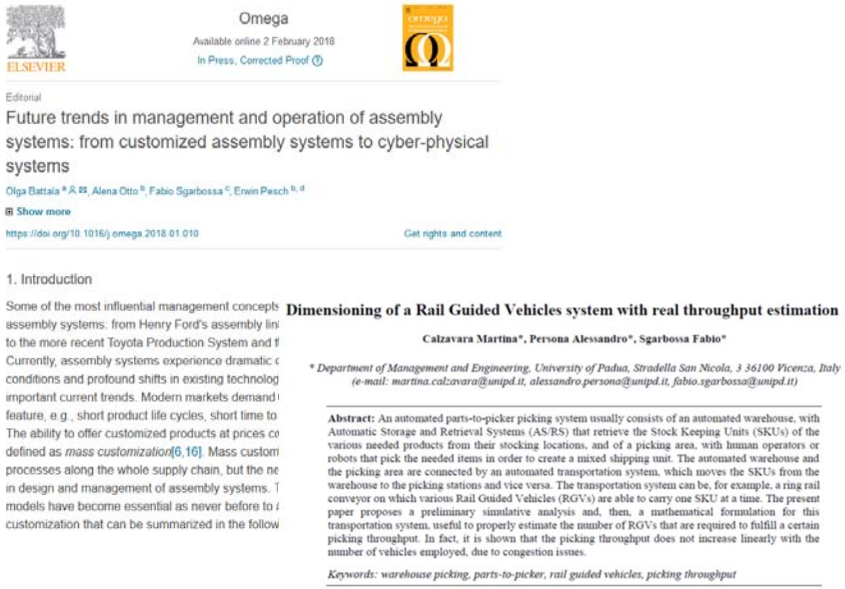
SMART MATERIAL HANDLING SYSTEMS



FLEXIBLE MHS = FLEXIBLE PRODUCTION SYSTEMS

SMALL MOBILE ROBOTS FOR PRODUCTION SYSTEM





Omega

Available online 2 February 2018

In Press, Corrected Proof

Editorial

Future trends in management and operation of assembly systems: from customized assembly systems to cyber-physical systems

Olga Battaïa *, Alena Otto, Fabio Sgarbossa, Erwin Pesch

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https://doi.org/10.1016/j.omega.2018.01.010

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1. Introduction

Some of the most influential management concepts
assembly systems: from Henry Ford's assembly lin
to the more recent Toyota Production System and t
Currently, assembly systems experience dramatic c
conditions and profound shifts in existing technolog
important current trends. Modern markets demand
feature, e.g., short product life cycles, short time to
The ability to offer customized products at prices co
defined as *mass customization*[6,16]. Mass custom
processes along the whole supply chain, but the ne
in design and management of assembly systems. T
models have become essential as never before to
customization that can be summarized in the follow

Dimensioning of a Rail Guided Vehicles system with real throughput estimation

Calzavara Martina*, Persona Alessandro*, Sgarbossa Fabio*

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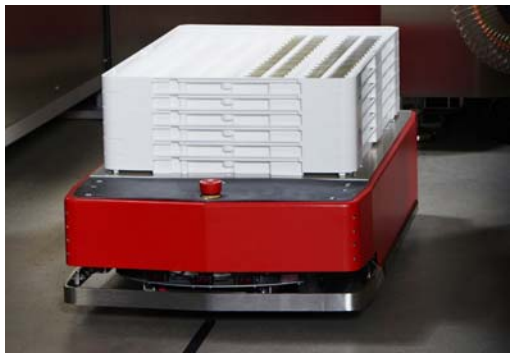
(e-mail: martina.calzavara@unipd.it, alessandro.persona@unipd.it, fabio.sgarbossa@unipd.it)

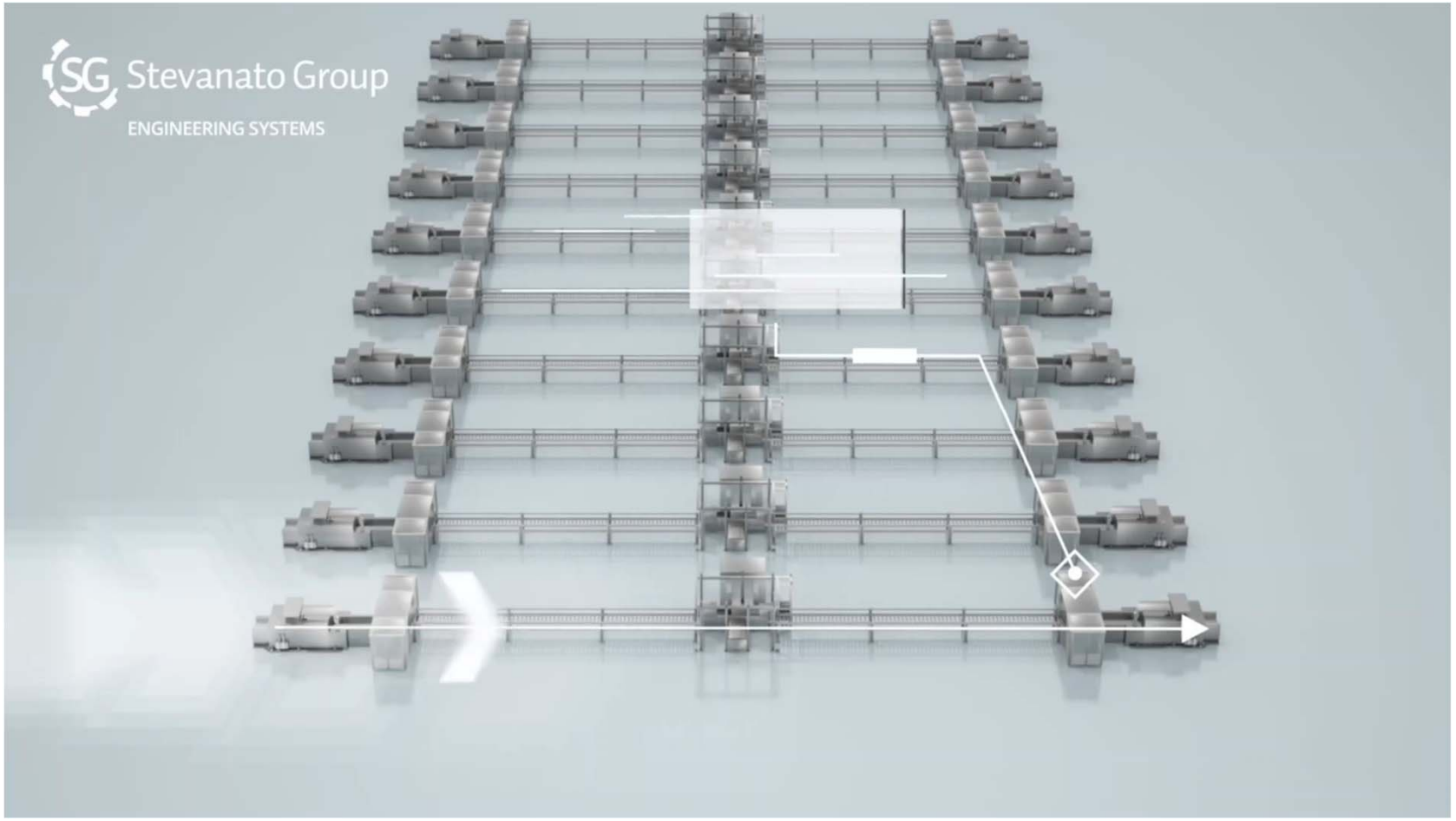
Abstract: An automated parts-to-picker picking system usually consists of an automated warehouse, with Automatic Storage and Retrieval Systems (AS/RS) that retrieve the Stock Keeping Units (SKUs) of the various needed products from their stocking locations, and of a picking area, with human operators or robots that pick the needed items in order to create a mixed shipping unit. The automated warehouse and the picking area are connected by an automated transportation system, which moves the SKUs from the warehouse to the picking stations and vice versa. The transportation system can be, for example, a ring rail conveyor on which various Rail Guided Vehicles (RGVs) are able to carry one SKU at a time. The present paper proposes a preliminary simulative analysis and, then, a mathematical formulation for this transportation system, useful to properly estimate the number of RGVs that are required to fulfill a certain picking throughput. In fact, it is shown that the picking throughput does not increase linearly with the number of vehicles employed, due to congestion issues.

Keywords: warehouse picking, parts-to-picker, rail guided vehicles, picking throughput



FLEXIBLE MHS = FLEXIBLE PRODUCTION SYSTEMS

SMALL MOBILE ROBOTS FOR PRODUCTION SYSTEM



FLEXIBLE MHS = FLEXIBLE PRODUCTION SYSTEMS

INTELLIGENT MATERIAL HANDLING SYSTEMS

Ultra Wide Band Indoor Positioning System: analysis and testing of an IPS technology

Zuin Silvia*, Calzavara Martina*, Sgarbossa Fabio*, Persona Alessandro*

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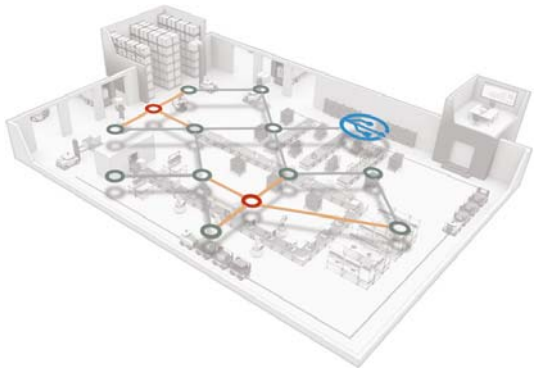
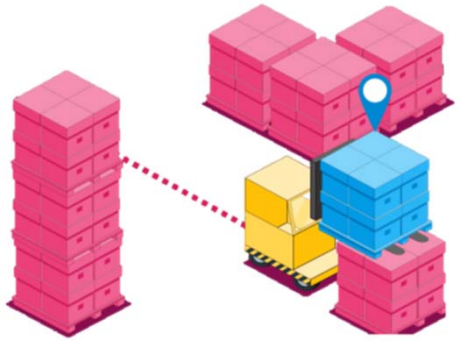
Abstract: Due to their current operating context, all logistics processes, from the simplest to the most complex ones, are facing always more interesting challenges in terms of management of a huge variety of products and, at the same time, strict lead times. In such a framework, it turns out that logistics inevitably has to aim at avoiding or, at least, reducing, all the possible inefficiencies that could emerge during the execution of the various activities that are needed to deliver a required product to a customer. These inefficiencies could be, among others, delays in the searching of the needed product code within a warehouse, errors in the retrieval or in the picking of an item, waste of time for carts or for operators' travelling activity, lack of availability of warehouse facilities and devices due to failures and breakdowns. Of course, the overcome of the inefficiencies has to pass through the retrieval of the information that can be useful to increase the awareness of such existing lacks. For example, it would be important to have the data related to the movements of resources and to objects handling. In this paper, an innovative indoor positioning system is presented. Based on a real-time indoor location technology using Ultra Wide Band, it can be used for having an effective overview of a logistic system. After an introduction of the possible technologies for indoor positioning and tracking, the configuration of the system is showed, together with a description of a simple test and of an industrial application. The reported examples highlight some preliminary insights about the system accuracy and its applicability.

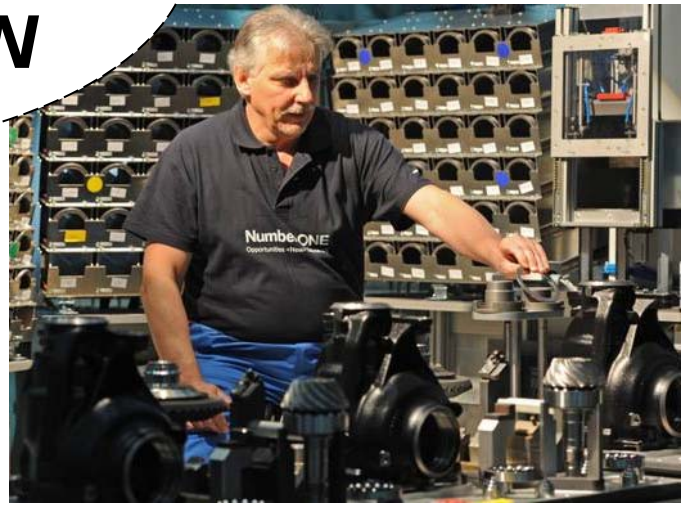
Keywords: indoor positioning, Ultra Wide Band, system test





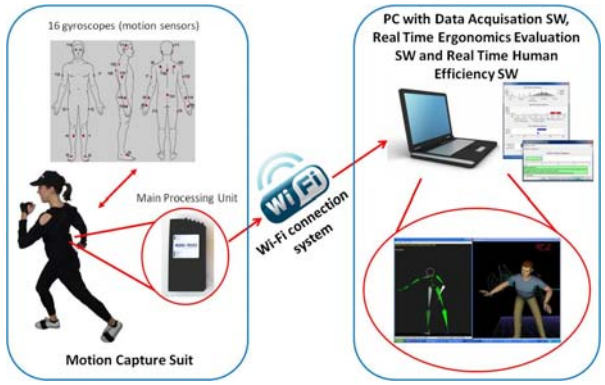
MICRO LAYOUT LEVEL

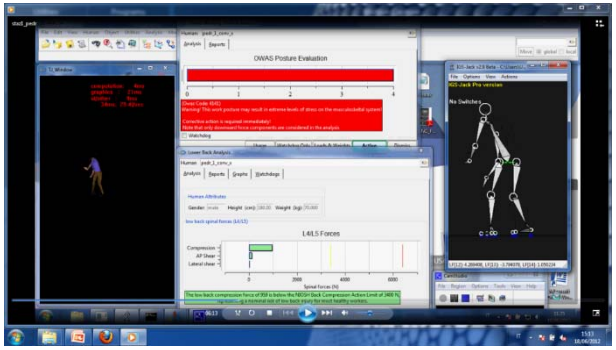
HUMAN CENTERED WORKSTATION

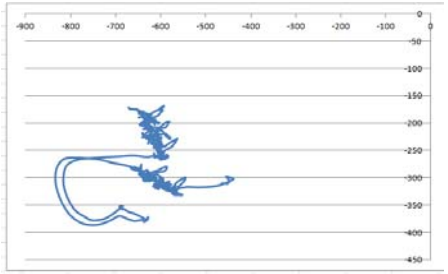


OPERATOR WELL-BEING = PERFORMING SYST.

WEARABLE DEVICES FOR ERGONOMICS EVALUATION







Contents lists available at ScienceDirect

International Journal of Industrial Ergonomics

journal homepage: www.elsevier.com/locate/ergon

New methodological framework to improve productivity and ergonomics in assembly system design

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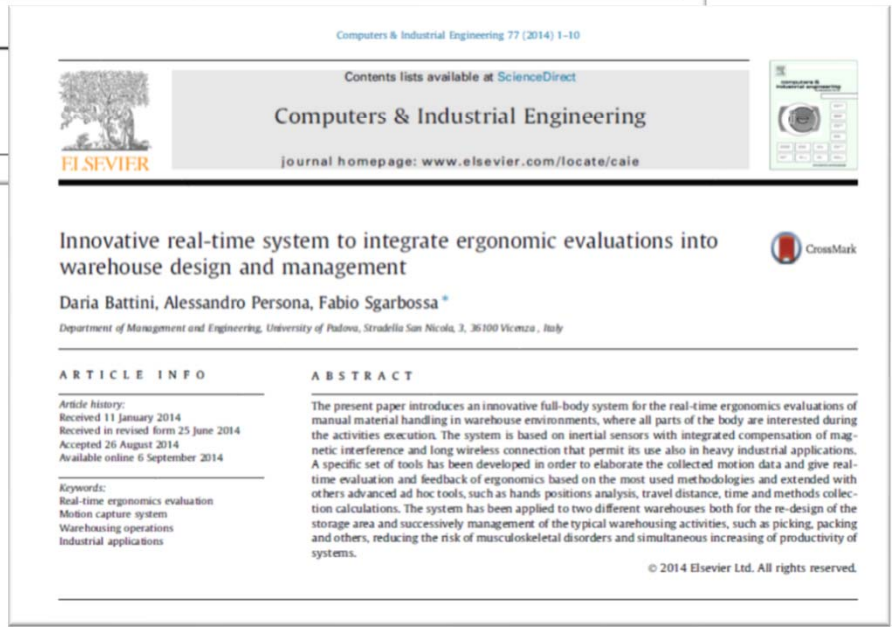
ARTICLE INFO

Article history:
Received 17 June 2009
Received in revised form
18 October 2010
Accepted 2 December 2010
Available online 5 January 2011



Contents lists available at ScienceDirect

Computers & Industrial Engineering

journal homepage: www.elsevier.com/locate/caie

Innovative real-time system to integrate ergonomic evaluations into warehouse design and management

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ARTICLE INFO

Article history:
Received 11 January 2014
Received in revised form 25 June 2014
Accepted 26 August 2014
Available online 6 September 2014

Keywords:
Real-time ergonomics evaluation
Motion capture system
Warehousing operations
Industrial applications

ABSTRACT

The present paper introduces an innovative full-body system for the real-time ergonomics evaluations of manual material handling in warehouse environments, where all parts of the body are interested during the activities execution. The system is based on inertial sensors with integrated compensation of magnetic interference and long wireless connection that permit its use also in heavy industrial applications. A specific set of tools has been developed in order to elaborate the collected motion data and give real-time evaluation and feedback of ergonomics based on the most used methodologies and extended with others advanced ad hoc tools, such as hands positions analysis, travel distance, time and methods collection calculations. The system has been applied to two different warehouses both for the re-design of the storage area and successively management of the typical warehousing activities, such as picking, packing and others, reducing the risk of musculoskeletal disorders and simultaneous increasing of productivity of systems.

OPERATOR WELL-BEING = PERFORMING SYST.

WEARABLE DEVICES FOR ERGONOMICS EVALUATION

IMDS
118,4

714

Received 10 May 2017
Revised 27 July 2017
6 September 2017
Accepted 27 September 2017

A device to monitor fatigue level in order-picking

Martina Calzavara, Alessandro Persona, Fabio Sgarbossa and Valentina Visentin
Department of Management and Engineering, University of Padua, Padua, Italy

International Journal of Production Research, 2018
https://doi.org/10.1080/00207543.2018.1497816

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A model for rest allowance estimation to improve tasks assignment to operators

Martina Calzavara, Alessandro Persona, Fabio Sgarbossa* and Valentina Visentin

Department of Management and Engineering, University of Padua, Padova, Italy

(Received 13 May 2017; accepted 30 June 2018)

Manual activities ar
systems, loading an
efficiency is strictly
productivity but als
resting period. It is
for the design and r
This paper aims t
activity. According
The energy expendi
physiological factor
activities where the
the scheduling of a
performance in term

Keywords: manual

International Journal of Production Research, 2015
http://dx.doi.org/10.1080/00207543.2015.1074299

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Ergonomics in assembly line balancing based on energy expenditure: a multi-objective model

Daria Battini[a], Xavier Delorme[b], Alexandre Dolgui[b], Alessandro Persona[a] and Fabio Sgarbossa[a]*

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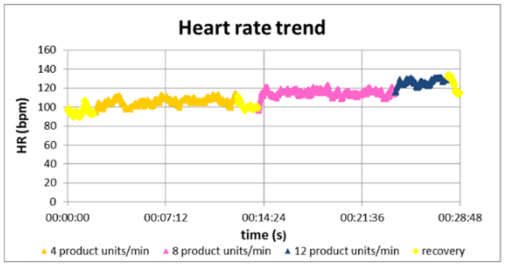
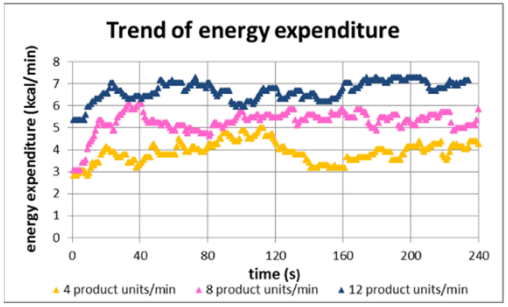
(Received 27 December 2014; accepted 15 July 2015)

In many assembly systems, ergonomics can have great impact on productivity and human safety. Traditional assembly systems optimisation approaches consider only time and cost variables, while few studies include also ergonomics aspects. In this study, a new multi-objective model for solving assembly line balancing problem is developed and discussed in order to include also the ergonomics aspect. First, based on main features of assembly workstations, the energy expenditure concept is used in order to estimate the ergonomics level, thanks to a new technique, called Predetermined Motion Energy System, which helps rapidly estimate the energy expenditure values. Then, a multi-objective approach, based on four different objective functions, is introduced in order to define the efficient frontiers of optimal solutions. To complete the study, a simple numerical example for a real case is presented to analyse the behaviour of Pareto frontiers varying several parameters linked to the energy and time value.

Keywords: assembly line balancing; ergonomics; multi-criteria decision-making; optimisation

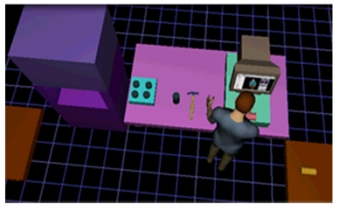


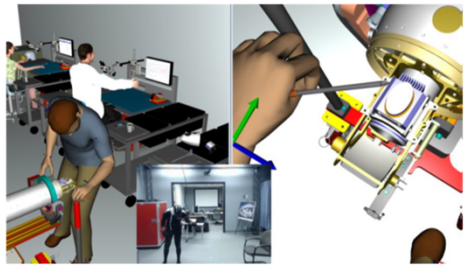


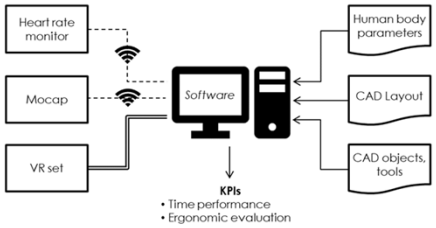
OPERATOR WELL-BEING = PERFORMING SYST.

WEARABLE DEVICES FOR IMPROVING KNOWLEDGE AND ASSIST OPERATOR

Ergo-Log – IMMERSIVE REALITY







Integrating mocap system and immersive reality for efficient human-centred workstation design

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(daria.battini@unipd.it; martina.calzavara@unipd.it; alessandro.persona@unipd.it; fabio.sgarbossa@unipd.it; visentin@gest.unipd.it; ilenia.zennaro@unipd.it)

Abstract: The paper presents the VR-Ergo Log system, an inertial motion capture system integrated with immersive reality and combined with a heart rate monitoring. By using immersive reality, the operator will be able to move and interact within a virtual workplace environment, in order to permit a fast and efficient ergonomic assessment of future workplace solutions and to avoid all cost-consuming activities related to the pre-production design of the workplace or to the prototyping of new products. This integrated system allows to evaluate in advance the time-based and ergo-based indices which can help the practitioners on understanding how to design the workplace and the devices to be used by operators. In addition, the use of the heart rate monitor permits to have a real-time feedback regarding the fatigue the operator is perceiving. The use of such a system will help to make more efficient the early design phases of an industrial workspace, by also considering the impact of human diversity and avoiding non-ergonomic solutions especially when an ageing workforce will be enrolled in the system.

Keywords: motion capture system, virtual reality, ergonomics, human-centred workspace, ageing workers

The current issue and full text archive of this journal is available on Emerald Insight at:
www.emeraldinsight.com/0263-5577.htm

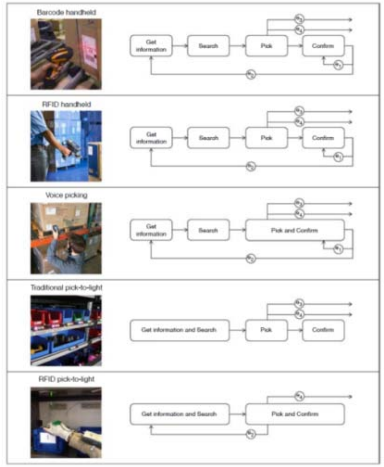
A comparative analysis of different paperless picking systems

Daria Battini, Martina Calzavara, Alessandro Persona and Fabio Sgarbossa
Department of Management and Engineering, University of Padua, Vicenza, Italy

Received 27 October 2014
Revised 16 January 2015
Accepted 1 February 2015

Abstract

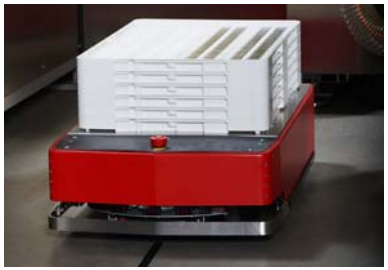
Purpose – Warehouse picking is often referred to as the most labour-intensive, expensive and time consuming operation in manual warehouses. These factors are becoming even more crucial due to recent trends in manufacturing and warehousing requiring the processing of orders that are always smaller and needed in a shorter time. For this reason, in recent years more efficient and better performing systems have been developed, employing various technological solutions that can support pickers during their work. The purpose of this paper is to introduce a comparison of five paperless picking systems (i.e. barcodes handheld, RFID tags handheld, voice picking, traditional pick-to-light, RFID pick-to-light).



CONCLUSION & FUTURE RESEARCHES

...to make production and logistics systems smarter, more flexible, more adaptable, more scalable, more interconnected, in the industry 4.0 era it is necessary to:

FLEXIBLE MHS = FLEXIBLE PROD. SYST.




- New MHS (small mobile robots)
- Interconnection of prod. & log. syst.
- New models to design them
- New models to manage them
- Impact of real-time info
- New models for buffer design
- Impact of automation
- ...

HUMAN-CENTERED WORKSTATIONS


- Wearable systems for HF analysis
- Integration of assistive technologies
- New models for workstation design
- New models for operator mng
- Materials Exposure and Mng
- Human-Robot Collaboration
- Ageing workforce
- ...

CICMHE
COLLEGE-INDUSTRY COUNCIL
ON MATERIAL HANDLING EDUCATION

dtg

THANKS FOR YOUR ATTENTION

ANY QUESTIONS FOR MY ANSWERS?

fabio.sgarbossa@unipd.it

FABIO SGARBOSSA
Department of Management and Engineering
- University of Padova – ITALY

Pr. Eric Ballot

2018

A Decade of the Physical Internet: Informing Future Initiatives

Development timeline

- A worldwide initiative

NSF

PREDIT

P&G

SEVENTH FRAMEWORK PROGRAMME

Alliance for Logistics Innovation through Collaboration in Europe

alice

Mix Move Match

FLEXE

2007 2009 2011 2013 2015 2018

SCs collaborations

The name is found…

Projects in Fr & USA

Dissemination, industry and awards

European dimension

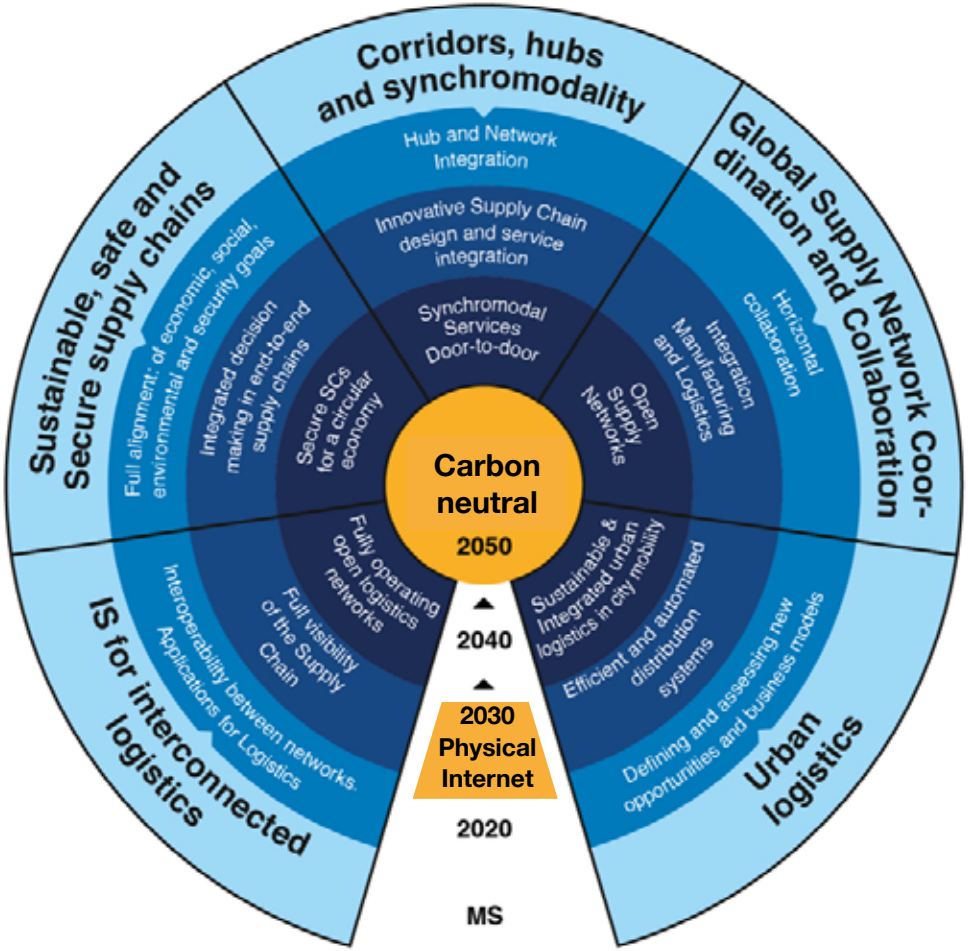
Academic recognition 1st IPIC

Start-ups

Chaire

An opportunity and responsibility

- How to build coordination and trust in a new system?
  - Collaborative design of 5 roadmaps towards physical internet components and guidelines
  - **At European level only…**



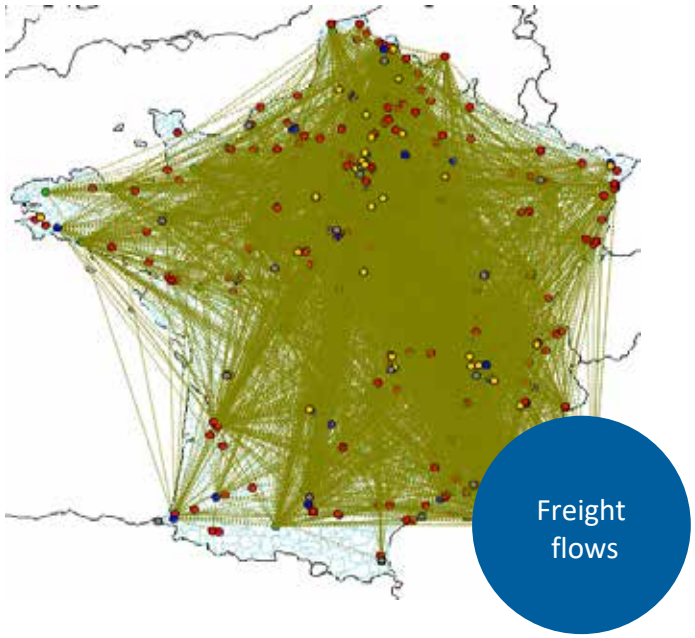
alice | Alliance for Logistics Innovation through Collaboration in Europe

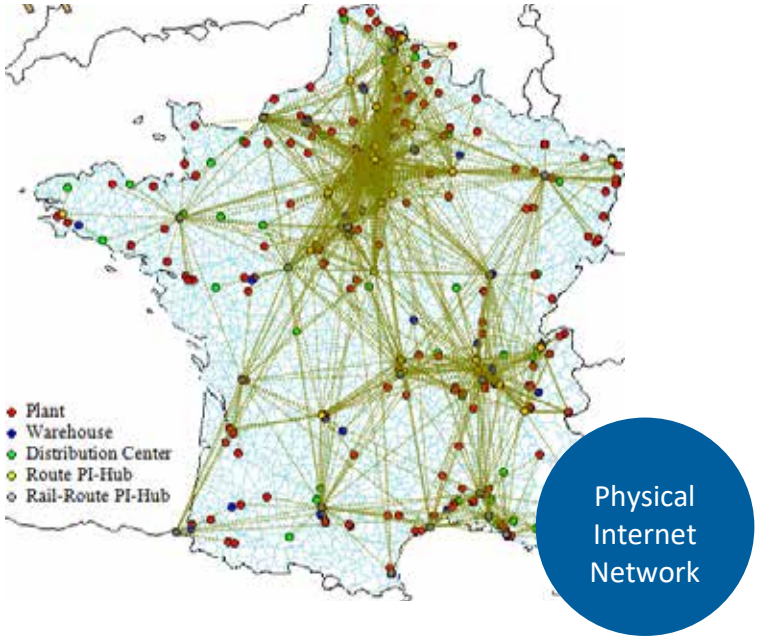
http://www.etp-logistics.eu

Physical Internet works when it exists!

- If we have a reconfigured network, the right cost function, the goodwill of the players then it works…

How?





Do we have an evidence it could exists somewhere?

Ballot É., B. Montreuil, R. Meller (2015), The Physical Internet: The Network of Logistics Networks, Doc. Française.

Interconnection platforms: typical solutions

- How to interconnect?

Fragmentation

"Silo effect"

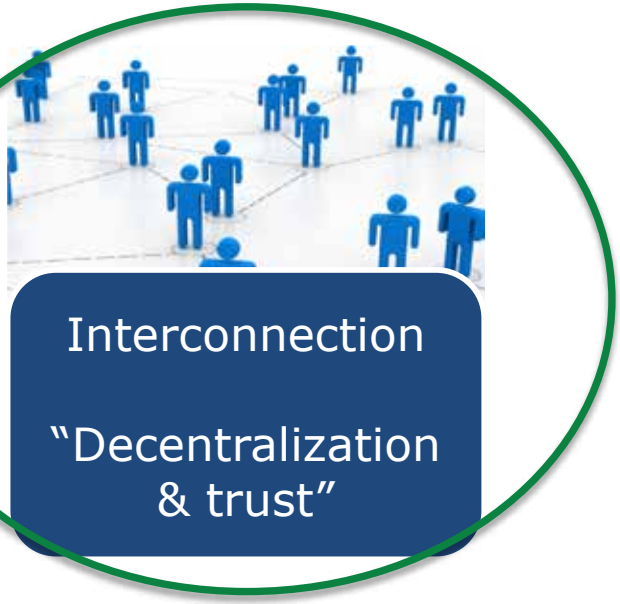
Dominant position

"The winner takes all"

UPU UNIVERSAL POSTAL UNION

International treaty

"UN bureaucracy"



Interconnection

"Decentralization & trust"

An example with ecommerce deliveries

When consignees are not part of the system: missed deliveries, multiple deliveries per day…

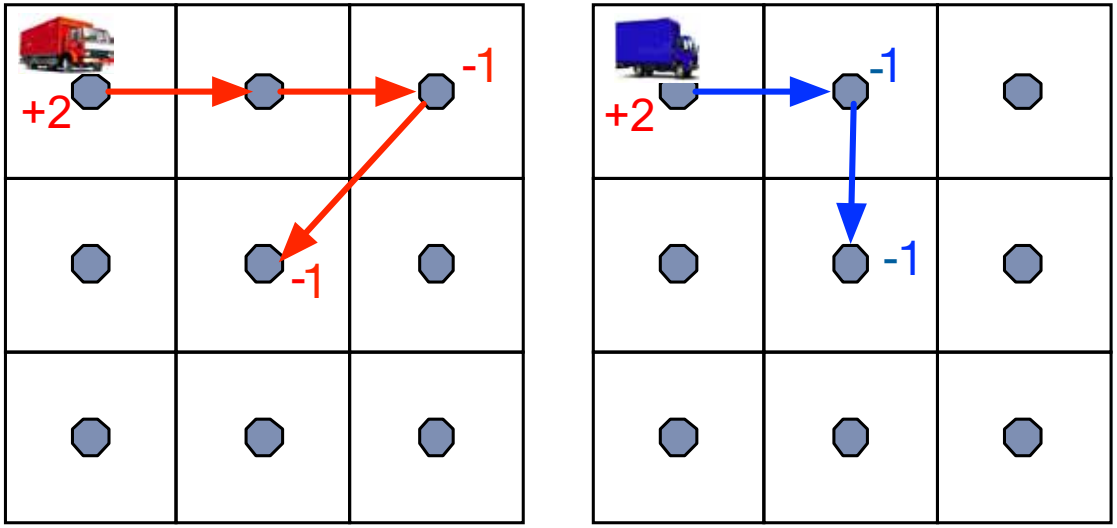
Eric.ballot@M^{R} Pasha

What we have not been able to solve yet

- The reallocation problem: an example

Red carrier:
3 v.d
5 u.d
Blue carrier:
2 v.d
3 u.d

Total: 5 v.d and 8 u.d

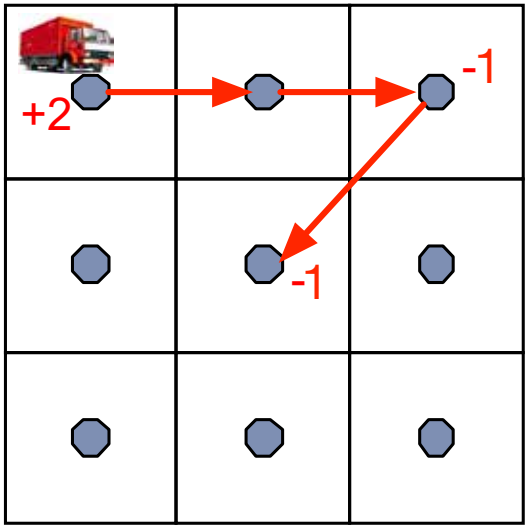


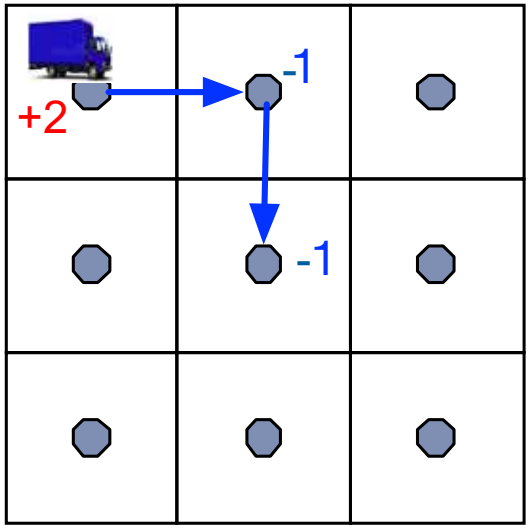
2 transport requests for each carrier

Reallocation?

Red carrier:
3 v.d
5 u.d
Blue carrier:
2 v.d
3 u.d

Total: 5 v.d and 8 u.d

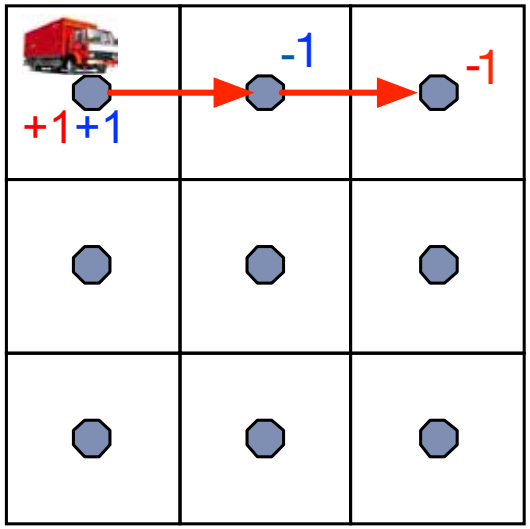


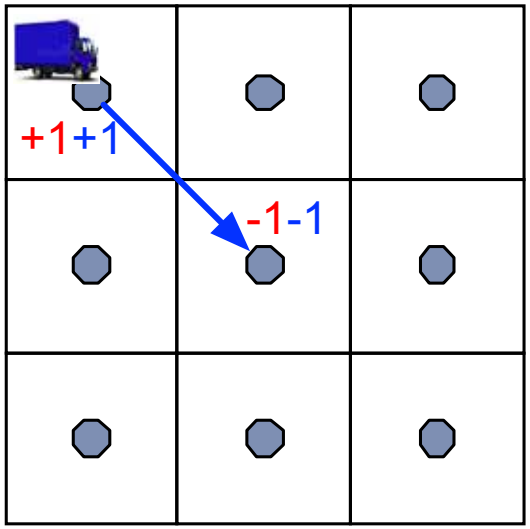


2 transport requests for each carrier

Red carrier:
2 v.d
3 u.d
Blue carrier:
1 v.d
2 u.d

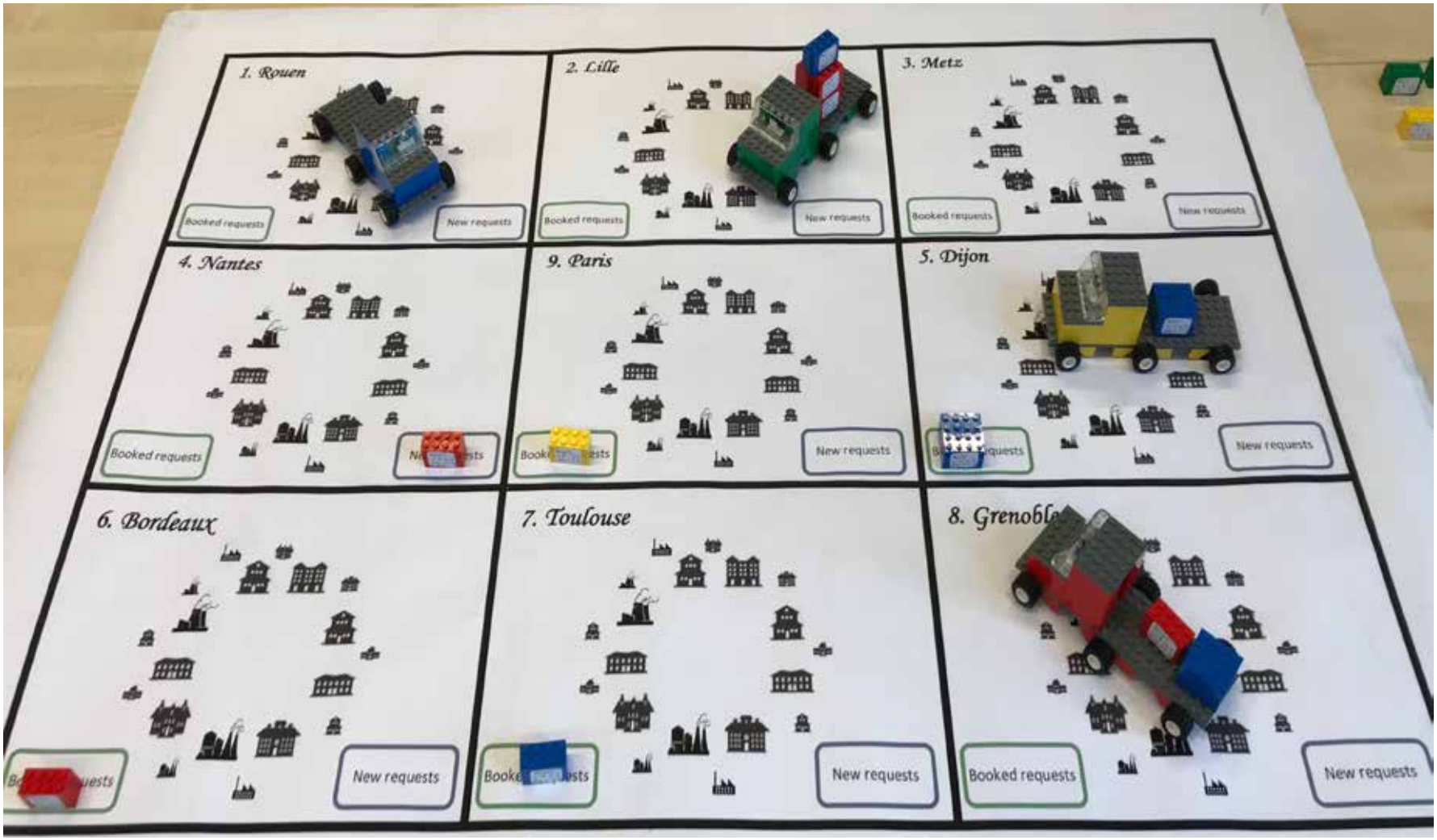
Total: 3 v.d and 5 u.d





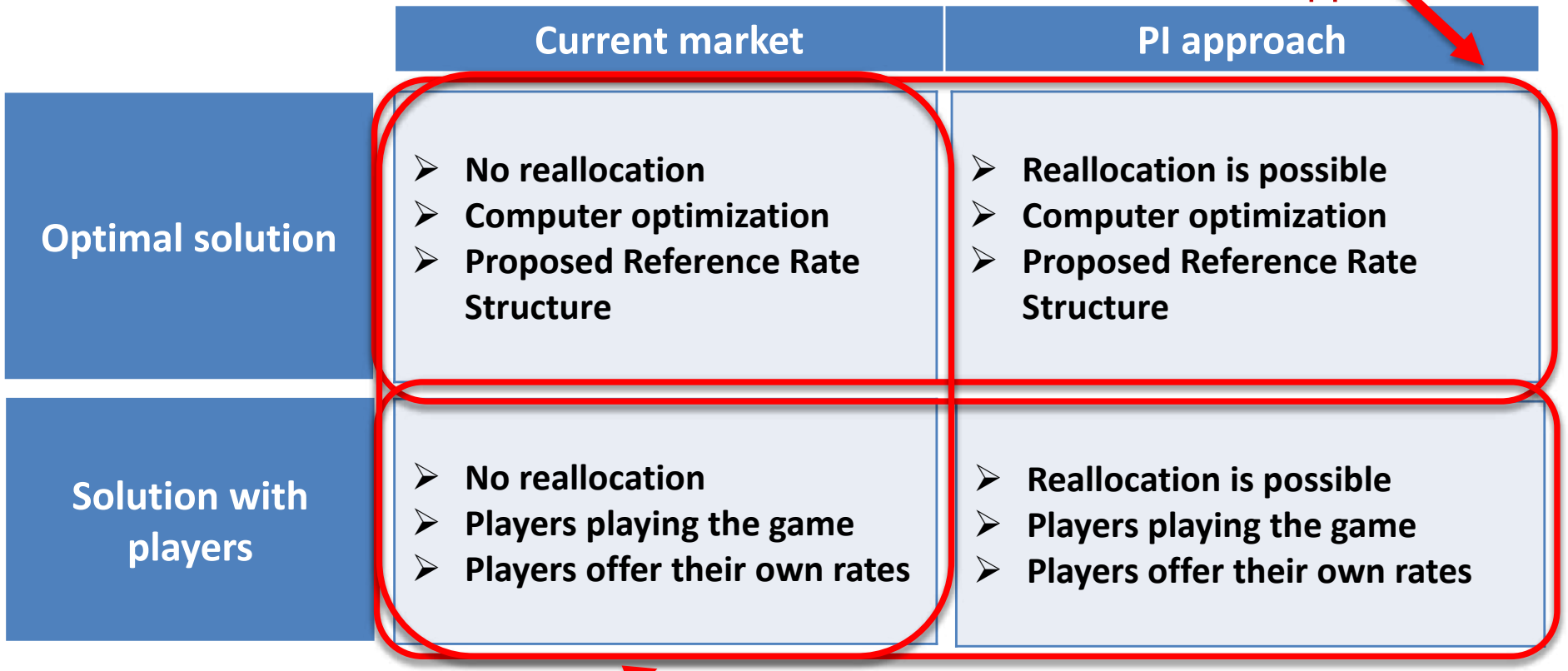
2 transport requests for each but reallocated

Our latest research tool



The methodology

Analysis of the performance of the PI approach



Study the performance of the players comparing to the optimal solution

Analysis of player behavior with new mechanisms

In action

Player interface - Truck Game

You are the player 2

You are in the round 1

Which road do you choose ? (ex : 1-4-5)

Which request do you choose ? (ex : 8-14-9)

Which margin ? (percentage between 0 and 100)

Send the file

If you do not want to submit a price for this round, go to the next round and wait click here

Summary :

You choosed the road 1-5-8

You choosed the request {2-3}

You choosed the margin 13 %

If you want to add a new offer in this round : click here

If you want to go to the next round click here

Data has been correctly added !

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THE INDUSTRY THAT MAKES SUPPLY CHAINS WORK™

Warehousing 4.0

Tone Lerher
University of Maribor
Faculty of Mechanical Engineering
Faculty of Logistics

University of Maribor

Savannah, July 24, 2018

Agenda

→ Intralogistics 4.0 and warehousing

→ Smart bins, containers, storage rack

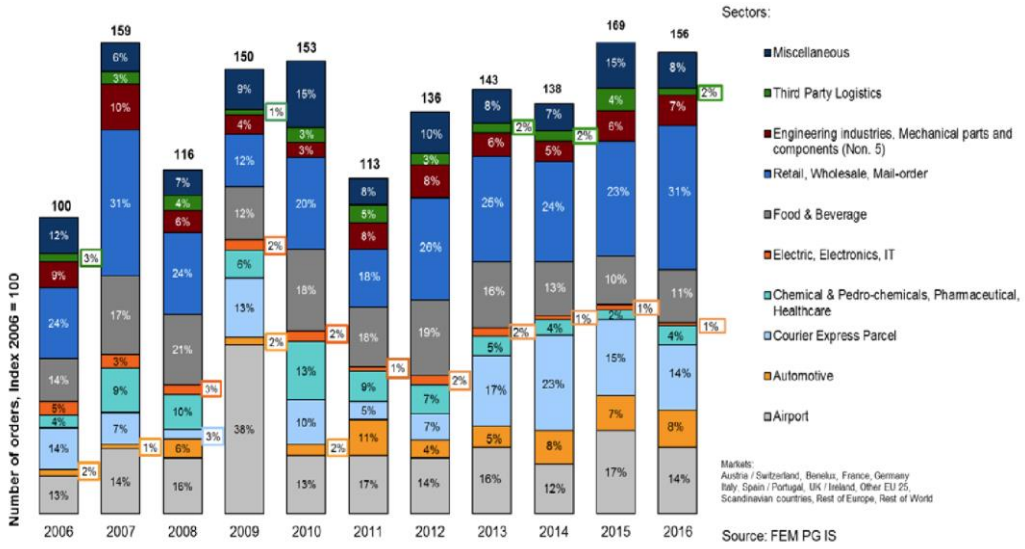
→ Robotized storage and picking systems

→ Conclusions

Intralogistics 4.0 and warehousing

European materials handling federation

FEM Statistics – Order Intake Intralogistics Systems



Source: https://www.fem-eur.com/

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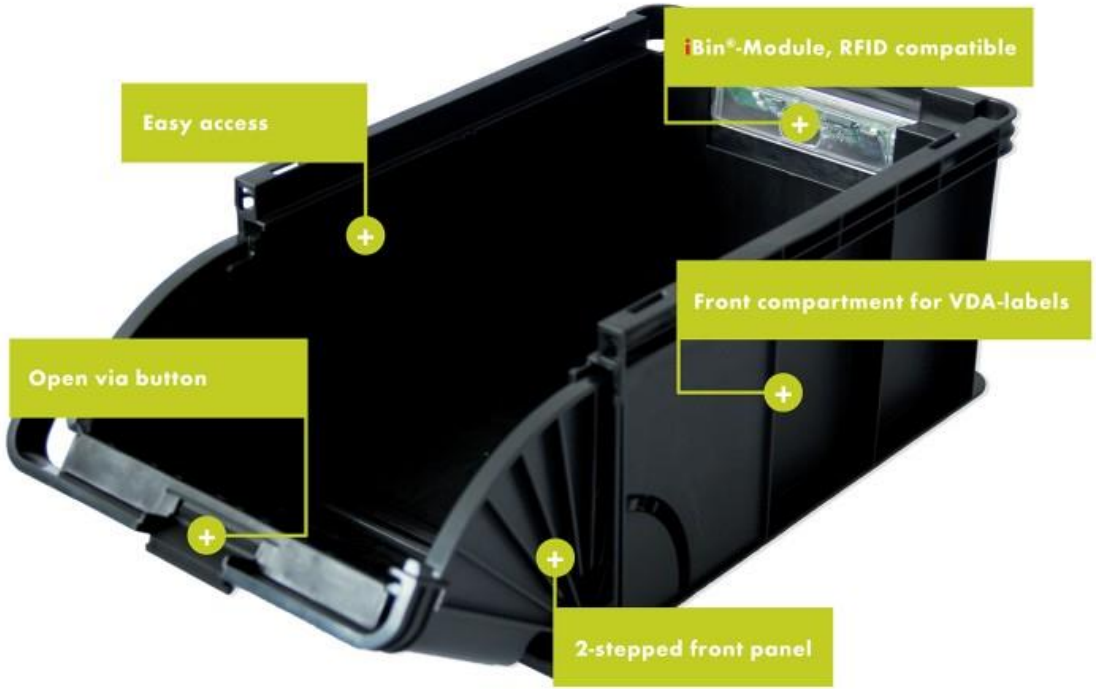
Smart Bins

→ IBIN® - THE FIRST INTELLIGENT BIN

© IBIN ist eine Marke der Würth Industrie



Würth Industrie Service was the first C-Parts supplier (January 2013) to introduce an optical ordering system that will revolutionize materials management for a long time to come.

The quantity, number and ordering information for the item can be obtained at bin level via the built-in camera; this is then transmitted to the ERP system automatically.

Source: https://www.wuerth-industrie.com/web/en/wuerthindustrie/cteile_management/kanban/ibin_intelligenterbehaelter/ibin.php

Smart Containers

→ self supported
→ graphic display
→ 256 bit µProcessor
→ energy storage
→ communication

The first real intelligent bin communicates with people and machines, takes decisions independently, supervises its environmental conditions and controls logistics processes. The charge carrier transforms itself into a »co-thinker«.

Source: https://www.iml.fraunhofer.de/
Source: https://www.internet-der-dinge.de/en/projects/inbin1.html

Smart Storage Racks and Pick-by-Vision

The classic "human-machine-interface" is changing.

Before: Operator enters a terminal / machine.

Afterwards: An operator is permanently connected to the "social networks" of an Industry 4.0 via an "Assistant Device". Operator communicates with other people as well as with cyber-physical systems.

Source: Michael ten Hompel, Logistik 4.0, Auswirkungen von Industrie 4.0 in Logistik und SCM.
Source: https://www.doag.org/formes/pubfiles/5817351/2014-Logistik-IND40-Michael_ten_Hompel-Keynote__Logistik_4_0_Auswirkungen_von_Industrie_4_0_in_Logistik___SCM-Presentation.pdf

Robotized storage and picking systems

→ AVS/RS

Source: SSI Schäfer

→ Movable racks with robots

Source: Amazon Robotics

→ AGV based picking

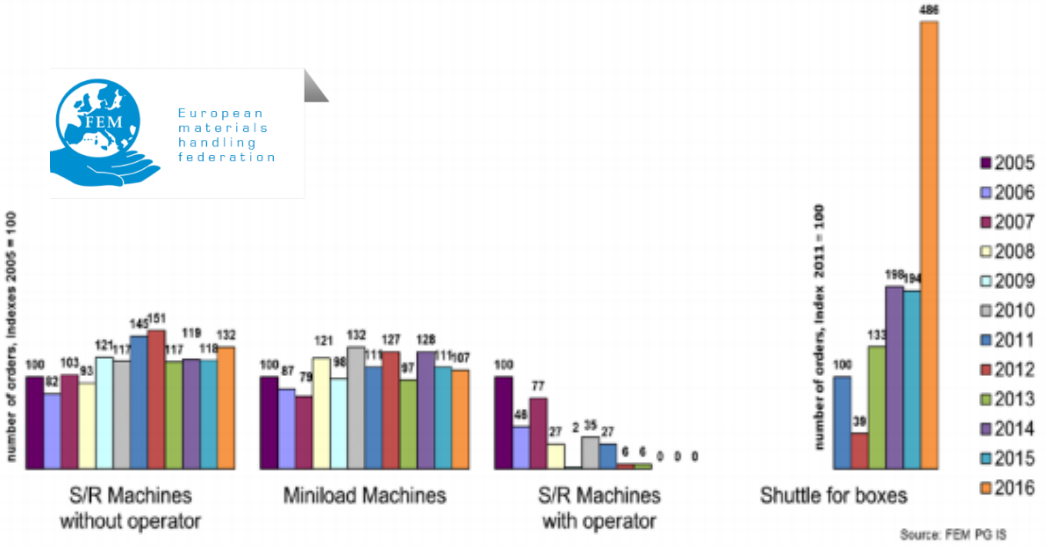
Source: Bastian Solutions, Kuka, Dematic

Autonomous vehicle storage/retrieval systems

→ **Shuttle carrier horizontal movement, only**

- SSI Schaefer
- Knapp
- Vanderlande
- Dematic
- others…

Source: Knapp



Source: https://www.fem-eur.com/

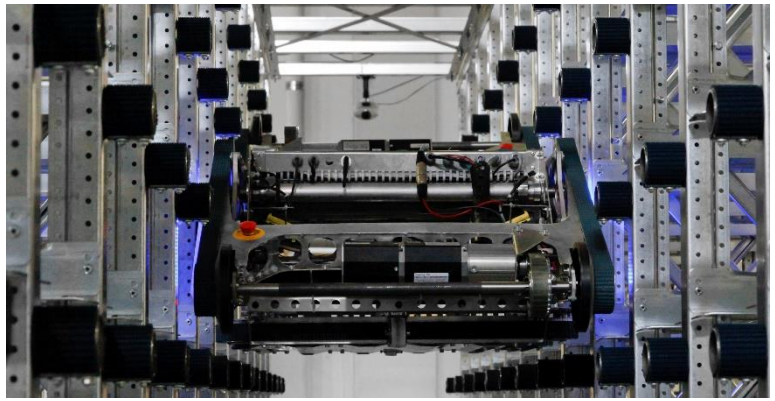
→ **Shuttle carrier horizontal and vertical movement**

- Swisslog (Autostore)

Source: Swisslog

→ **Shuttle carrier horizontal and diagonal movement**

- Rack Racer (Fraunhofer IML)



Source: Fraunhofer IML

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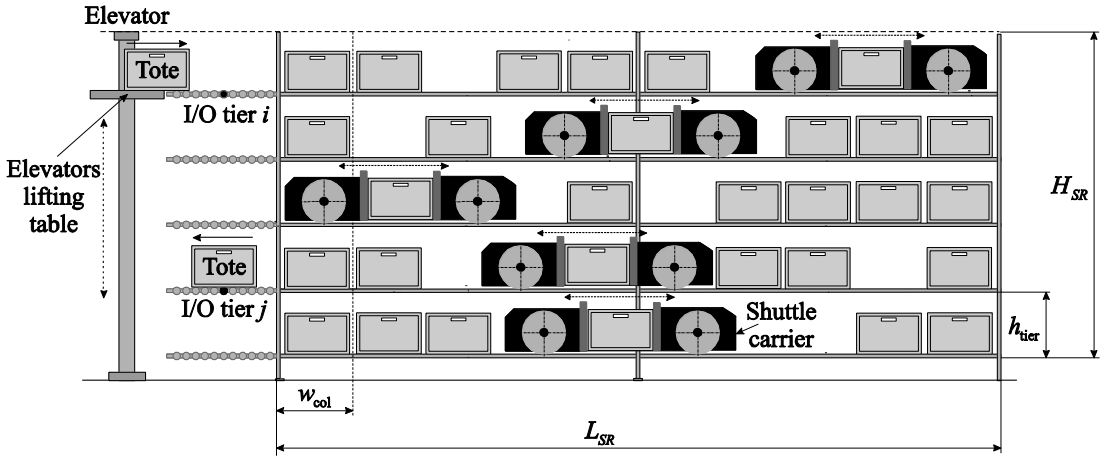
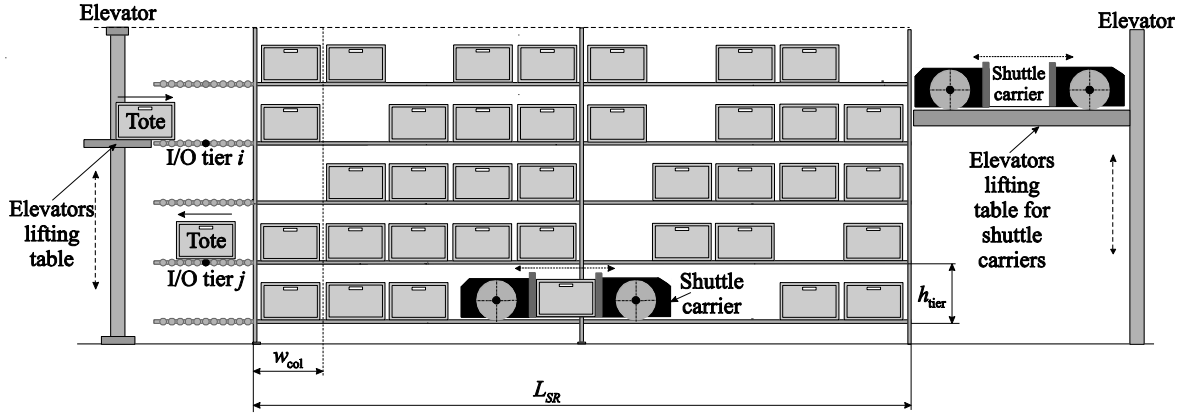
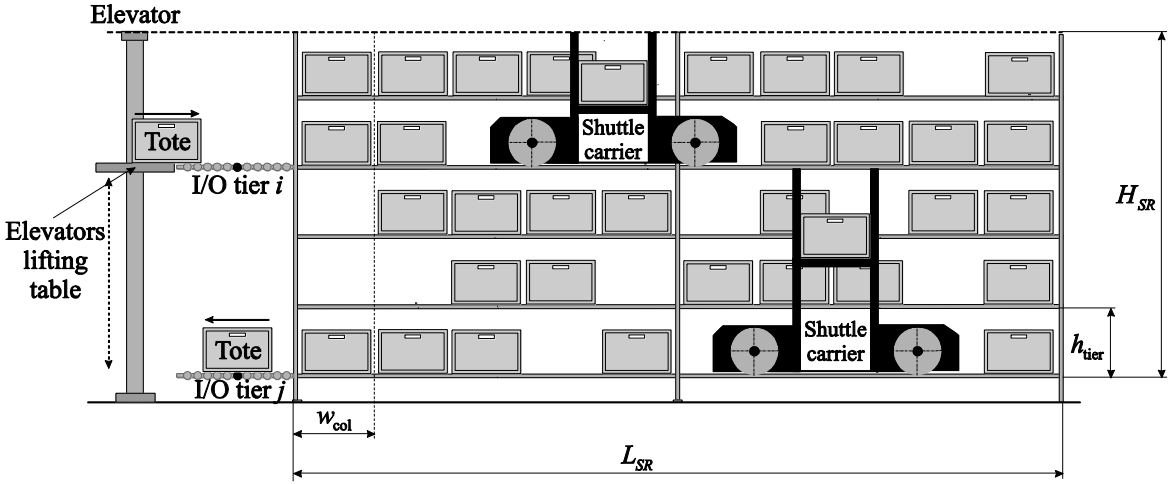
Autonomous vehicle storage/retrieval systems



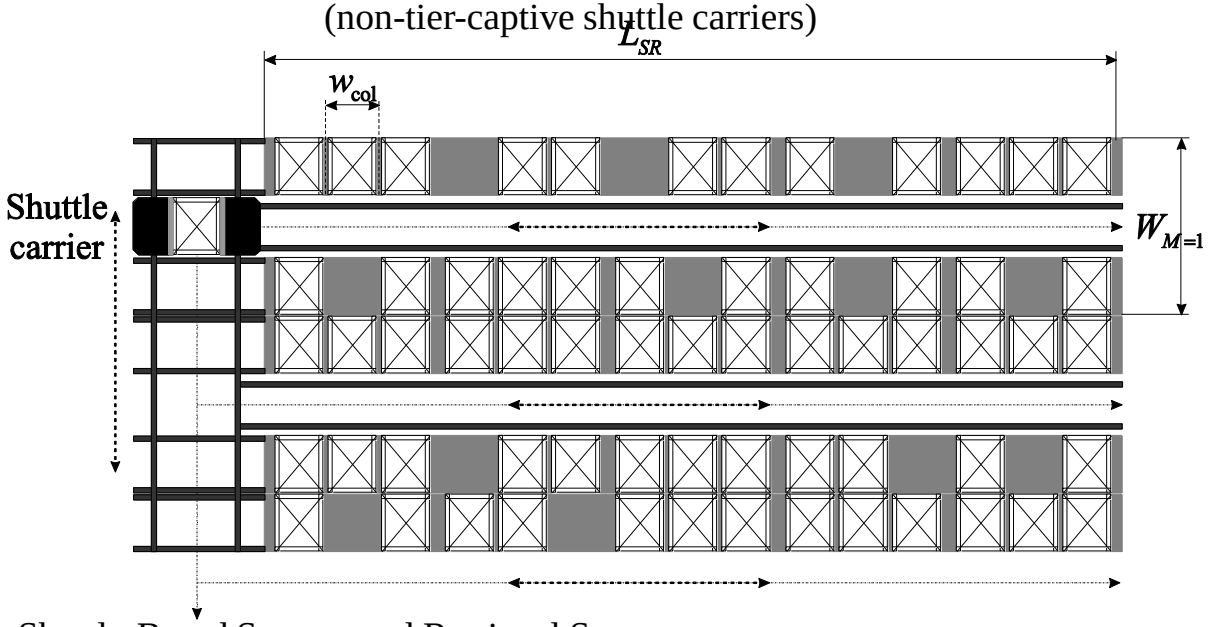
Shuttle-Based Storage and Retrieval Systems (tier-captive shuttle carriers).



Shuttle-Based Storage and Retrieval Systems (non-tier-captive shuttle carriers)

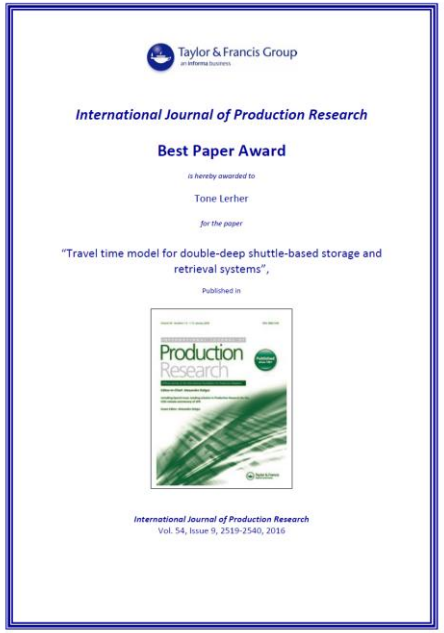


Shuttle-Based Storage and Retrieval Systems (multi-tier-captive shuttle carriers)



Shuttle-Based Storage and Retrieval Systems (3D-level-captive shuttle carriers)

Shuttle-based systems



Source: SSI Schäfer (http://www.ssi-schaefer.de/lagertechnik/shuttle-systeme/cuby-einebenen-shuttle.html)

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Movable racks with robots

→ Amazon Robotics

→ Grey Orange

→ Grenzebach

→ Scalog

→ and others…

Source: Kaveh Azadeh, René de Koster and Debjit Roy, Robotized Warehouse Systems: Developments and Research Opportunities

AGV based picking

→ Manual picking

Source: Kollmorgen

→ Automatic picking

Source: Bastian Solutions, Kuka, Dematic

Conclusions and further research

→ Robotic Mobile Fulfilment System
- is an automated, parts-to-picker storage system where robots bring pods with products to a workstation.

Source: Amazon Robotics

→ Manual order picking with AGVs
- routing, control, assignment

Source: SSI Schäfer

→ Interaction Man - Robot
- operator 4.0

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Thank you for your attention

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