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Past, State-of-the-Art and Future of Intralogistics in Relation to Megatrends

After briefly reviewing the history of intralogistics, this paper examines the outlook for the technologies concerned. This is related to the so-called “megatrends”, such as globalisation, urbanisation, demographic shifts and climate change, which are expected to bring about major global transformations over the next few decades, and which are also likely to determine the future functions of intralogistics and the focus of research in the field.

Keywords: intralogistics, megatrends, internet of things.

1. INTRODUCTION

This paper offers a brief introduction to the history of intralogistics and the trends that are likely to shape its future. What changes are to be expected over the next 30–40 years, and how will these influence the focus of intralogistics research? The authors argue that these changes can be deduced from wider global megatrends.

Firstly, however, it is necessary to define the term “intralogistics”, which has only entered the English language fairly recently.

The Intralogistics Forum of the Verband Deutscher Maschinen- und Anlagenbau (VDMA) defines intralogistics as: “The organisation, control, execution and optimisation of in-plant material and information flows, and of goods transshipment in industry, distribution and public sector facilities.” [1]

2. HISTORY OF INTRALOGISTICS

The following section owes a strong debt to *Technische Innovationen für die Logistik* (Technical Innovations for Logistics) by W. Günthner and K. Heptner. [2]

The history of intralogistics goes back to the immediate postwar period, when economic and industrial development was mainly driven by manufacturing. In-plant transportation initially relied on simple equipment such as bag carts, other trolleys and overhead cranes. Goods were stored at ground level as block stacking suffered from poor visibility and accessibility.

This situation began to change in the early 1950s, under the influence of new transportation methods developed in the USA. It was the introduction of pallets as universal loading devices and of forklift trucks that had enabled the US Army to meet its gigantic logistics needs during the two world wars and the Korean War.

This new technology was adapted to German conditions by expert subcommittees which advised the standards committees.

The introduction of standardised loading devices in the shape of containers and pallets promoted the development of forklifts and stacker cranes – overhead cranes with a column and lifting trolley. The advantages of pallet racks for storage were space saving and easy access to all stored goods. The greatest achievement of the experts of the day was undoubtedly the standardisation of the 800 x 1200 mm euro pallet. This was the key to the standardisation of logistics equipment and systems.

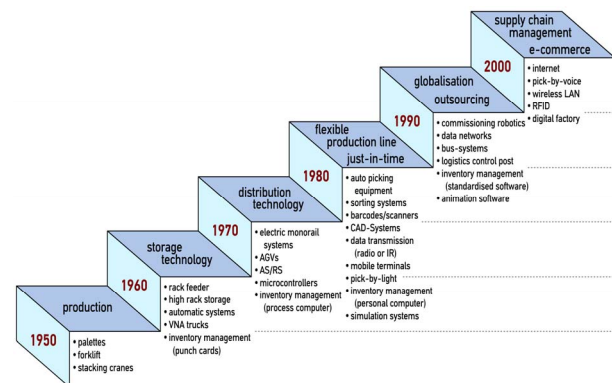


Figure 1. History of intralogistics

The 1960s were a period of strong economic growth, resulting in the rapid expansion of manufacturing, distribution and international trade. A side-effect of the economic boom was escalating labour and material cost inflation. By then managements were already aware that it was necessary to look for efficiencies in all of a company’s operations and not just the manufacturing process. The storage area stood out for its rationalisation potential. To exploit this potential, storage needed to be seen as more than a necessary evil, and to be turned into a useful and efficient buffer between the various production stages, and between production and the market. Using the technology available at the time, it was already possible to integrate the storage function in a company’s work flows, resulting in lower warehousing costs, use of space saving storage systems

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and higher throughput. This inevitably required increased investment, and the changes involved implied a move from labour to capital intensive warehousing methods. The 1960s can be summed up as a decade of rapid progress in warehousing technology.

The first automated 20-metre high rack warehouse was built in Germany in 1962. The advent of this type of storage ushered in a period of advances in the development of rack feeders, either suspended from rails or running on ground level rails. The designs featured one or two masts, composed of lattice or solid web girders, drive systems using direct current or three-phase current motors, and automatic analogue or digital positioning. Performance improved steadily, with speeds reaching 3 m/s, and rack heights rising to 30 m. Other advances were the automation of transport and storage processes, and computerised storage management by punch card.

In the early 1970s the emergence of a buyer's market and associated changes in consumer behaviour forced businesses to rethink their approach to production and distribution. The market was now demanding quality products, and a wider range of product variations. Beside this, high availability and short delivery times were now expected.

Existing storage systems were unable to cope with these shifts in consumer behaviour. New concepts were needed if companies were to respond to these demand patterns at reasonable cost. As a result new warehousing, order picking and dispatching methods took on an ever increasing significance.

The decade witnessed a wave of investment in automated high rack warehouses and associated materials handling equipment by manufacturing and distribution companies. The expansion of the order picking and distribution functions transformed simple warehouses into distribution centres. Wholesalers were particularly alive to the advantages of modern distribution centres in terms of operating costs and service quality. During this period materials handling was strongly influenced by the introduction of new technologies such as electric monorail systems, AGVs, AS/RS and long goods storage systems.

However, the biggest force for change was enabling electrical engineering, electronics and information technology. The arrival of the first usable microprocessor in 1972 can be said to mark the dawn of a third industrial revolution. Microprocessor based technologies were first put to work with AS/RS, for functions such as control, positioning and data transfer, as well as error reports. Later, they began being employed to control functions upstream and downstream of warehousing. Microprocessors took over the control and monitoring of both material and data flows. All in all, the 1970s were a period of big strides in the automation of materials handling technology.

The economic situation in the early 1980s and the desire to emulate Japanese production methods triggered a drive for more flexible manufacturing, aimed at cutting the cost of short production runs. Manufacturers turned to automated production cells and adaptable NC machine tools. However in-house logistics was still being managed by conventional

automated handling systems. As a result plant designers began looking at manufacturing as a whole, including both internal and external processes. This gave rise to the so-called "just-in-time" philosophy, which sought to optimise the whole supply chain by achieving prompt deliveries all along it. Reorganising production processes in this way depended on the deployment of new IT systems and communication technologies. New electronic data transfer systems were rolled out, and standards established for information exchanges. The identification of goods by barcode labels and scanners was brought to full maturity for industrial applications, making it possible to meet the demand for reliable linking of flows of goods and information. The introduction of barcode systems can probably be singled out as the main landmark of the 1980s for intralogistics.

The replacement of manual by automated identification boosted the efficiency of sorting systems. With the potential performance improvements now sufficient to justify heavy investment in automated sorters, they made rapid inroads in a wide variety of industries.

A new development phase was initiated by the availability of better PCs from the mid-1980s on. PCs were used for warehouse management, and in storage planning for calculations, design and simulation.

The search for further efficiencies along the entire supply chain during the following decade was labelled "lean production". Another key trend at this time was efforts by companies to refocus on their core competencies, which led to increased outsourcing of logistics operations.

On the logistics equipment front the main focus was on "mini-load storage" technologies, using lighter, faster and more efficient load handling devices, for small part storage. These permitted big increases in storage and retrieval capacity. Following initial setbacks, AGVs now claimed substantial shares of the in-plant transportation market.

During the 1990s there were also striking advances in the integration of computers and peripherals with Ethernet based data networks. The introduction of ring and star bus topologies brought down network installation, maintenance and troubleshooting costs.

At the outset of the new millennium globalisation took over as the dominant force in industry and trade. Logistics had the task of merging the supply chains of different partners into global networks. "Supply chain management" became the holdall term for the design, optimisation and operation of these networks. Central goals were optimising the portfolio of assets in the supply chain by applying the pull principle, and expanding the pool of bulk buyers in just-in-time and just-in-sequence organisations. These strategies have encouraged the construction of industrial parks close to customers.

An important impetus for new developments has come from the internet and the related rise of e-commerce – between businesses (B2B), between businesses and consumers (B2C), and peer to peer between consumers (C2C). One of the first online retailers was Seattle headquartered Amazon, which has since rolled out a global IT, fulfilment and warehousing

network, connected by modern satellite communication technology.

In order preparation, voice picking systems have achieved the necessary maturity, and the error rates are now acceptable.

Wireless LAN based technology is being applied to in-house logistics – notably, the control of AGV systems, and communication with mobile terminals in assembly plants and distribution centres.

However the biggest breakthrough of the past decade has certainly been the introduction of the new RFID identification technology. RFID tags enable goods and transportation devices to carry much more information with them, enabling them to fulfil a far wider range of functions than barcode labels. The technology has numerous applications in all areas of logistics.

3. MEGATRENDS

Following this brief review of the history of intralogistics we should now like to examine the trends that are likely to have a substantial influence on life in the near to medium term, and their potential impact on intralogistics.

The term “megatrend” was first used in 1982 by John Naisbitt to designate “large social, economic, political, and technological changes ... (that) influence us for some time.” [3] Today megatrends are regarded as an important strategic concern by many corporate headquarters organisations. For instance, the fact that the Siemens Group aligns its business segments to the “urbanisation” and “demographic changes” megatrends shows how seriously it takes this subject.

Megatrends have three defining characteristics that set them apart from other trends: [4]

- **Time horizon**

Megatrends are observable over a period of decades. There are quantitative, empirically distinct indications of their existence in the present which can reliably be projected at least 15 years into the future.

- **Reach**

Megatrends are ubiquitous; their scope extends throughout the world. Moreover, they cause multidimensional interactions between all the main political, social and economic subsystems. However their characteristics differ from region to region.

- **Effect strength**

Megatrends have radical effects on all social agents – governments, consumers and businesses.

Z_punkt GmbH – a German consultancy which specialises in strategy innovation – lists the following 20 key megatrends of the present. (See Table 1.) [4]

4. IMPLICATIONS OF THE MEGATRENDS FOR INTRALOGISTICS

The following is a brief discussion of the above megatrends that are likely to be of particular relevance to intralogistics.

Table 1. Megatrends according to Z_Punkt GmbH

1.	Demographic change
2.	New grade of individualization
3.	Rapidly improving health standards
4.	Women on the advance
5.	Cultural diversity
6.	New mobility patterns
7.	Digitalisation
8.	Learning from nature
9.	Ubiquitous intelligence
10.	Convergence of technologies
11.	Globalisation
12.	Knowledge-based economy
13.	Business ecosystems
14.	Change of the professional life
15.	New consumption patterns
16.	Revolution in energy and resource use
17.	Climate change and environmental impact
18.	Urbanisation
19.	New political world order
20.	Growing global security menaces

Globalisation

- Globalisation is the process of increasing global interdependence in all areas (the economy, politics, culture, the environment, communication, etc.). This intermeshing of global relationships is affecting individuals, companies, institutions and governments. The main drivers of globalisation are technical progress, particularly in communications and transportation, and political decisions to remove trade barriers.

Urbanisation

- Rapid growth of megacities.
- Development of appropriate infrastructure solutions.
- New lifestyles and approaches to housing.

Revolution in energy and resource use

- Scarcity of strategic resources (fossil fuels, fresh water, metals and minerals).
- Use of alternative energy sources and renewables.
- Energy efficiency revolution.
- Decentralised energy supplies.

Climate change and environmental impact

- CO2 emissions and global warming.
- Growing environmental problems in emerging and developing countries.
- Clean technologies.
- More responsible approach by companies.

New level of individualisation

- Ever wider range of products to meet individual needs.

Ubiquitous intelligence

- Rapid technological advances in information technologies such as the internet and email, and convergence between technologies such as materials engineering and drive systems.
- The linking of virtual and real worlds, neural networks, swarm behaviour, artificial intelligence and robotics.

Growing global security threats

- Smouldering cultural conflicts.
- Procurement and sales risks.
- Strikes and collapse of supply chain partners.
- Global terrorism.

Demographic change

- Aging and declining populations in the West.
- High birth rates in developing countries.
- Increasing migration flows.

The Bundesvereinigung Logistik (German Federal Logistics Association) reaches similar conclusions (Fig. 2). The chart also plots the significance that industrial companies in Germany, the USA and China attach to the various trends at present and expect them to have in 2015. [5]

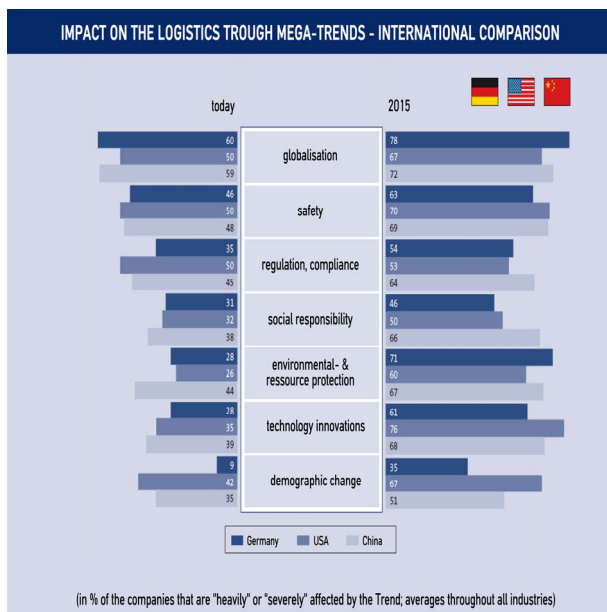


Figure 2. Impact of megatrends on logistics [5]

5. FUTURE CHALLENGES FOR INTRALOGISTICS

What do these trends mean for intralogistics, and what future research thrusts do they suggest?

The megatrends outlined in sections 2 and 3 point to the research thrusts summarised in Fig. 4. We shall now look at three of these research areas in detail, giving examples.

The **globalisation** and **urbanisation** megatrends, and the **global logistics** and **supply of megacities** challenges indicate a need for more, and more powerful logistic systems: The watchword, to borrow from the Olympic motto, will be "higher, faster, further".

One example of this trend is the use of shuttle systems instead of AS/RS. This can raise handling capacities per lane from 120 LE/H to approximately

1,000 LE/H. [6]. Other advantages of shuttle systems are greater flexibility and scalability.

Industry surveys and publications have lately been signalling a major wave of innovation in AS/RS systems. This partly involves improvements to conventional S/R equipment.

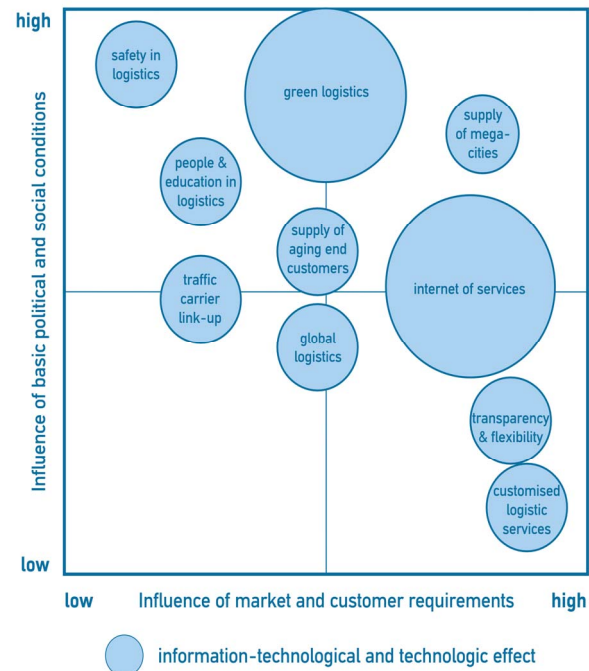


Figure 4. Future challenges for intralogistics [7]

These mainly relate to lighter designs to reduce weight and manufacturing costs, and increased travel and lift speeds, as well as the use of advanced control, information and communication technology to increase throughput and enhance energy efficiency (particularly through energy recovery). At the same time, however, novel technologies, in the form of so-called shuttle systems, are also appearing on the scene.

In the constantly growing small parts market, widespread implementations and industry debate reveal a rapidly growing interest in shuttle systems.

Typical features of shuttle systems as compared to convention S/R equipment are:

- Smaller, lighter and faster vehicles without columns, equipped with the usual load-carrying equipment;
- Use of multifunctional rails at each shelf level as drive rails for the shuttles, as well as vertical conveyors in front of the lanes to accept the loading devices or transport the shuttles;
- High energy efficiency because of the low power consumption of shuttles and the vertical conveyors;
- Good scalability because of the flexible, modular design.

Table 2 summarises the main advantages and disadvantages of the competing systems. This comparison demonstrates that both approaches to storage and retrieval systems have their pros and cons, and as a result there will probably continue to be room for both. Opting for the right system or a combination of the two will cost money, and will require advice and support from competent and impartial engineers.

Table 2. Comparison between classical stacker cranes und shuttle systems [8]

	classical stacker crane	shuttle system
PROS	<ul style="list-style-type: none"> ▪ proven technologies (equipment, control, utilisation) ▪ low complexity at overall control of the plants ▪ energy recovery ▪ less engineering-effort ▪ low investment (pallet rack) ▪ cheaper with large storage space and mediocre throughput 	<ul style="list-style-type: none"> ▪ high performance (in sequence delivery at goods-to-man-strategy (up to 1000 picks per hour)) ▪ good scalability (performance, capacity) ▪ Good energy efficiency through lower energy consumption (approx. 100W per shuttle) ▪ Use of new energy supplies (supercaps) ▪ Service platforms in aisle (service, troubleshooting) ▪ Autonomous Vehicles (shelf + storage feed area)
CONS	<ul style="list-style-type: none"> ▪ limited performance of the equipment thus for the aisle (max. 120 double cycles per hour) ▪ high power consumption (20 kW) and more complex electrical installation due to high starting currents ▪ low redundancy ▪ Increased effort for extensions 	<ul style="list-style-type: none"> ▪ Higher investment (rack, power rails, lifts) ▪ Increased complexity of storage management (more interfaces through more vehicles and lifts) ▪ Vertical conveyors determine the throughput ▪ limits on weights and dimensions of the stored goods ▪ Increased engineering effort

The revolution in energy and resource use, climate change and environmental impact, business ecosystems and learning from nature megatrends will give birth to a new discipline, green logistics.

Environmental protection and resource conservation in logistics are no passing fad, and their growing importance will drive long-term changes. Energy efficiency is at the heart of the EU's Europe 2020 Strategy [9] for smart, sustainable and inclusive growth and of the transition to a resource efficient economy. Energy efficiency is one of the most cost effective ways to enhance security of energy supply, and to reduce emissions of greenhouse gases and other pollutants. In many ways, energy efficiency can be seen as Europe's biggest energy resource. This is why the Union has set itself a target for 2020 of saving 20% of its primary energy consumption compared to projections, and why this objective was identified in the Commission's Communication on Energy 2020 as a key step towards achieving our long-term energy and climate goals [10].

Environmental awareness becomes increasingly important in every aspect of human's life: politics, economics and everyday life. The issue of emissions in the changing global climate and recent economic uncertainties is pushing policy makers and industries to promote strategies and technologies for reduction of emissions and fuel consumption. In addition to this, the public is placing demands for more environmental operations of industries, but without jeopardizing current comfort and consumers' habits [11]. The climate change combat placed some industries more than others under complete scrutiny – the transport industry and as well as logistics/intralogistics. The issues of ecology, sustainability and social responsibility are becoming increasingly important aspects of business enterprises everywhere. The (intra)logistics industry is no exception, of course. It is transport and (intra)logistics sector that has allowed huge leap in growth of companies over the past few decades, and it could be said that development in these sectors is what's contributing most to globalization [12]. Transport systems have significant impacts on climate change, accounting for about 20-25 percent of world energy consumption and CO₂ emissions [13]. Greenhouse gas emissions from transport are increasing at a faster rate than any other energy using sector [14]. Intralogistics

can be influenced directly by the recent initiatives of becoming a green sector and meets the categories such as are plant layout and material flow systems, handling and conveying equipment (cranes, industrial trucks, port handling equipment, conveyors, etc.), stock (bigger the stock we keep, bigger the building needed), the assignment of new technologies respectively, as well as transport packaging. Some green logistics projects have already been implemented. So, we have a permanent increase in researches concerning environmentally friendly technologies in intralogistics sector. Most of them have been presented during the world's leading fair in this field CEMAT-Hannover in 2011. Moreover, the motto of the last CEMAT was sustainability in intralogistics and accordingly during the fair several presentations and forums discussed various aspects in this field.

For instance, reduction of emissions concerning industrial trucks could be achieved by the use of environmentally friendly and efficient drive engineering. In 1997 with the Toyota Prius, the first series of hybrid vehicles were brought on the market. After the change of the emission levels of work machines at the latest, this theme reached the attention of forklift producers. The industrial trucks can be suited for cross breeding because of their dynamic drive and load profiles, because of the fact that the percentage of stop and go process for short distances driving in a constant speed is very high [12]. Today the forklift can be powered by a number of fuel options including gasoline, diesel, electrical battery, compressed natural gas (CNG) and liquid propane gas (LPG). Mitsubishi Heavy Industries have developed the world's first engine/battery hybrid forklift trucks with 4.0 to 5.0 ton rated capacities. By integrating a lithium-ion secondary battery developed in-house and high-efficiency motors with small-size, low-exhaust emission diesel engines that comply with new emission regulations, the company has realized outstanding environment-friendly, fuel-efficient performance: approximately 39% greater fuel efficiency and CO₂ emissions are 14.6 tons less than the standard internal-combustion powered trucks. On the other hand, during CEMAT 2011 German company Still presented its serial production of hybrid forklift trucks.

Among different parts of intralogistics sector the container sector is currently the fastest growing industry. Container shipment and handling division is experiencing explosive growth due to containers pouring from Asia, mainly from China [15]. In the U.S. only, container shipments more than quintupled in from 1980 to 2006. Shipment to and from U.S. ports rose from roughly 8.4 million Twenty Foot Equivalents (TEUs) to 44.4 million TEUs in this period. Over the last decade alone, container shipments rose 80.8 percent [11].

Consequently, the growing container shipment industry, affects the growth of seaports and container terminals and corresponding cargo handling equipment (CHE) as well. The scale of above mentioned growth is expected to reach its peak after 2025, additionally increasing share of container handling in global CO₂ emissions [16]. This massive growth will account for a significant increase of emissions by container port operations. Container port operations can be divided into three sectors. The first is offshore and involves the passage of transoceanic ships to their berths, the second involves activities within the port boundaries such as unloading of containers from the ships and their transfer by cargo handling equipment (CHE) and the third includes the trucks and trains that originate within or near the port, but which leave the ports on highways and rail lines to serve distant markets [11]. Each sector is significant source of air pollution, but CHE is probably the major part of port emissions contributing to regional and community environmental degradation, since their emissions occurs near residential areas bordering the ports. Thus environmental efficiency of port operations is equally important as key performance figures such as number of TEU operations and overall capacity of terminals. This fact challenges port authorities and industries behind port operations to increase number of container handlings and at the same time to reduce overall emissions and environmental impact [11].

Deeper look into the impact of CHE emissions reveals that Rubber Tired Gantry (RTG) cranes which are used to move intermodal containers from truck to stack and back again, have share of more than 40 percent. In response to this, CHE industry developed a variety of technologies and systems, to reduce fuel consumption and emissions and improve overall RTG efficiency. This includes emerging technologies such as, variable speed generators (VSGs), hybrid RTGs with regenerative braking and super caps technology (Eco-RTGs) and electrified zero emission models (E-RTGs). All of these solutions show significant improvements over conventional cranes, reducing CO₂, NO_x and SO₂ emissions and cutting operation costs up to 90 percent. Beside emerging technologies listed above, industry is experimenting with alternative fuels for CHE and RTG such as LPG, CNG and biofuels [11]. For instance, an example of evaluating environmental benefits of emergency technologies is given in [11], where the state-of-the-art technology for RTGs is being analyzed in order to find out the most eco-efficient solution. A conventional RTG crane is compared to hybrid Eco-RTG with super-cap energy storage system and electrified E-RTG crane. The last two solutions represent the latest trend in CHE industry. The

methodology used to carry out RTG cranes environmental impact comparison is Life Cycle Assessment (LCA) outlined in ISO 14040, as a tool which offers possibility to address entire product's life cycle in a consistent way. The obtained results of RTG cranes LCA are presented in accordance to ISO 14040 principles with the highlight on CML and TRACI impact assessment methods. Based on the obtained results, the recommendations on reducing environmental footprint of ports are done by necessary improvements on RTG cranes. The objective of the research presented in [11] was twofold, the use of LCA methodology as a tool in the early stage of design is promoted due to its possibility to offer preliminary information and details of processes and materials.

Finally, current developments present new challenges for ports and terminals. Environmental aspects reflect in [17]:

- climate change
- scarcity of space
- globalization
- improved quality of life
- hunger for energy, consumer demand
- ecological market economy - combining economy and ecology

According to [17] forms of environmental impacts in ports particularly relevant for manufacturers of handling equipment are:

- noise and light
- exhaust gas
- dust
- space
- energy wastage;

other forms of environmental impacts in ports are:

- waste
- excavation work and removal of the excavated material
- loads hazardous to the environment
- refueling
- disposal of wastewater from the ships

Considering that most of our energy resources are based upon fossil energy sources and therefore necessity of implementing environmentally friendly technologies in bulk materials handling industry, there is still an enormous potential to save energy and costs as well [11]. Since most of the energy is consumed by electric motors big costs and energy savings can be achieved by energetically optimizing drives.

In future, it will be essential to address company-wide sustainable logistics concepts. Green logistics will be expected to prove that it is not merely sustainable but also efficient.

According to polls of logistics experts, more than 65% rate environmental management as "very important" or "quite important" (Fig. 5). Every fourth retailer and almost every third service company has plans to develop environmentally friendly products and services. Green logistics undoubtedly has excellent prospects but it is still in its infancy. On average, only 20–30% of the managers say that progress has been made towards implementing it. As would be expected, public and listed enterprises, and other large companies are leading the way. [7]



Figure 5. Perceived importance of environmental management [7]

In line with overall trends in technology, in recent years environmental aspects have grown in importance in intralogistics.

Nevertheless, survey results show less than 15 percent of all industrial and distribution companies subjecting their operations to carbon footprint checks, so far.

Options for improving environmental and resource conservation performance include: minimisation of moved dead weight and resultant lower energy demand, energy recovery and energy efficient conveyor system design.

The digital life and ubiquitous intelligence megatrends are connected with the diffusion of new technologies including the “internet of things” and cellular conveying technology:

Increased demands are being placed on in-house material handling systems. Growing product variety and shorter product life cycles are making order loads and order structures harder to predict, meaning that handling systems must be dynamically adaptable without giving rise to excessive costs. Modularisation and decentralisation, both in control software and in the design of conveyor systems, have great potential in terms of flexibility, robustness and reusability. Technological progress in sensors, data processing, communications, orientation and identification will also make it easier to find innovative new solutions to transportation problems. [6]

In this changed environment, characterised by fluctuating order volumes and a growing number of products in distribution networks, intralogistics will face severe tests. Material handling systems in distribution centres and manufacturing facilities be confronted with an increasingly complex and dynamic environment that is likely to overtax the capabilities of monolithic control architectures and rigid materials handling systems. There will be a need for research to develop decentralised, modular and adaptive solutions for the control of goods and information flows. A start has been made, and the industry already offers conveyor systems that support low-cost modular expansion and partially decentralised control.

The idea behind decentralised control architectures is to assign the goods in transit the controlling role in the material handling system. They use the transport modules and additional software to perform this role. The three basic components of the “internet of things” are:

- Self managed transport units (TUs);
- Handling modules; and

- Software that coordinates the transport units and modules (eg. directory services) or provide system transparency (eg. visualisation).

Fig. 6 shows how the control principle of the internet of things differs from conventional, hierarchical material flow control. Functions that were previously located on different hierarchical levels of the control pyramid are distributed among the modules and transport units.

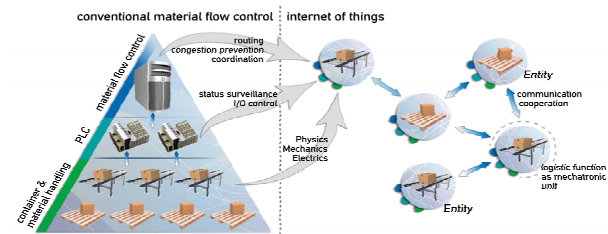


Figure 6. Decentralisation in the internet of things: autonomous, cooperating units combine to form a non-hierarchical materials handling system [18]

The proposed control paradigm of the “internet of things” introduces modular and flexible control systems based on RFID technology and software agents. To make the material flow control and the handling modules flexible, in future rigid, fixed conveyor systems will have to be replaced by mobile units that can perform autonomous or cooperative logistic functions. The Fraunhofer Institute for Material Flow and Logistics has introduced the notion of “cellular materials handling” by a collective of standardised, autonomous small vehicles. This concept extends to all kinds of conveyor modules, including stationary units, provided that they use the plug-and-play principle and can automatically merge into a material handling system, permitting organic growth. To leverage the full potential of cellular transport systems the handling modules themselves would need to be designed for maximum flexibility.

The “internet of things” paradigm, i.e. a degree of intelligence on the part of the goods to be transported, yields the vision of logistic objects that can move themselves within a given physical space. Within this space a set of services (transportation and software services) is available to the transport units. The objects use these services to execute their workflow. They request the transport services required and negotiate to obtain the best available service in cases where there are multiple vendors.

This detachment from fixed, hierarchical structures, with a central computer programmed to control modular and flexible distributed control systems, is referred to in current literature as the “internet of things”.

Unique identification of objects by barcodes or 2D codes is possible, but automatic identification using RFID is often regarded as crucial to the “internet of things”, since transponder technology can transmit far larger amounts of data. A simple application of the “internet of things” is package tracking via the internet. Today postal operators offer the tracking of parcels in their transport processes as an online service.

When we speak of the “internet of things” in connection with intralogistics, usually a degree of autonomous control is implied. Self-controlling objects

do not necessarily need network structures that run on the global internet. Since in an intralogistics context the network will be local, it might be more accurate to refer to an “intranet of things”.

The “internet of things” and cellular materials handling are possible answers to the challenges of modern logistics. Here, intelligent, on-demand interaction between autonomous units replaces inflexible, centralised processes, leading to reduced system complexity and increased robustness, versatility and expandability.

The demographic change megatrend deserves an additional mention, as the man-machine interface should not be forgotten. For instance, excluding errors by designing logistics components that are easy to operate will make it easier to employ personnel with little training.

6. CONCLUSIONS

Of the 20 global megatrends proposed by Z_punkt, we picked the following trends as most significant for intralogistics:

- **Globalisation**
- **Urbanisation**
- **Individualisation**
- **Demographic change**
- **Climate change and environmental impact**
- **Ubiquitous intelligence**

Based on these megatrends we were able to identify challenges for intralogistics and research topics that are likely to play a major role over the next few decades. In our opinion the main research thrusts will be:

- **“Higher, faster, further”**
- **Green logistics**
- **The “internet of things” and cellular conveying technology**

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ПРОШЛОСТ, САДАШЊЕ СТАЊЕ И БУДУЋНОСТ ИНТРАЛОГИСТИКЕ У ОДНОСУ НА МЕГАТРЕНДОВЕ

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Након кратког прегледа историје интралогиистике, овај рад изучава поглед на наведене технологије. Оне су у вези са т.з.в. „мегатрендовима“ као што су глобализација, урбанизација, демографске и климатске промене, за које се очекује да донесу глобалне промене у неколико следећих деценија и које ће највероватније одредити будућу улогу интралогиистике и фокус истраживања у овој области.