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Replicators, Ground Drones and Crowd Logistics A Vision of Urban Logistics in the Year 2030

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Abstract

How will logistics in cities be carried out in the midterm future? To answer this question an overview of different existing and emerging transport logistics operations is provided, the pros and cons of these different operations are set out. Based on these findings a partial qualitative systemic model is presented which shows how these operations are influenced by global and logistics trends on the one hand and by delivery service requirements on the other hand. Based on this model a vision of urban logistics in Europe in the year 2030 as well as the concept of "Post 4.0" is presented.

Peer-review under responsibility of the organizing committee of mobil.TUM 2016.

Keywords: 3D-Printers, Autonomous Electric Vehicles, City-Logistics, Crowd Logistics, Drones, Physical Internet, Post 4.0, Trends

Nomenclature

3DP	Three Dimensional Printing	F2F	Face-to-Face
AGV	Autonomous Ground Vehicle	GVZ	Freight Village (Güterverkehrszentrum)
AM	Additive Manufacturing	IoT	Internet of Things
B2B	Business to Business	N2F	Non-Face-to-Face
B2C	Business to Consumer	PI	Physical Internet (π)
CEP	Courier, Express, Parcel	S2S	Service-to-Shop
e*	electro (like e.g. eBike, eTruck)	sUAS	small Unmanned Aircraft System
EAV	Electric Autonomous Vehicle	T&T	Track & Trace

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1. Introduction

1.1. Problem Statement

How will logistics in cities be carried out in the midterm future? Which logistical structures will emerge? Which means of transport will be used? The answers to these questions are interesting for various stakeholders and their different action options - for political decision makers , city administrators , shippers , logistics service providers , financial investors , real estate traders and last but not least for the citizens.

1.2. Research Objectives

As there is *no robust scientific way to predict the future*, every answer to the above question will remain speculative. However this challenge shall be faced by creating a tangible vision of logistics in European cities in the year 2030 (which is consistent with logistic trends and global trends of today and which considers today's technical innovations) as a basis for further discussions.

1.3. Methodological Approach

First of all the methodological approach of this paper is based on Popper's idea that a hypothesis requires to be falsifiable (Popper 2010, p57). Therefore it was intended to create results, which are easily falsifiable by future events. In order to obtain this goal, the vision of logistics in cities for the year 2030 needs to be formulated as precisely (and tangibly) as possible. I. e. the author prefers being proven wrong by future events to providing non-falsifiable fuzzy or tautological statements.

The methodological approach is based on the assumption that on a mid- to long-term time scale logistics operations will be driven by global *mega-trends* and *trends in logistics* on the one hand and by *delivery service* requirements on the other hand[1]. As the development of new transport logistics operations needs significant lead-time, it can also be assumed that transport logistics operations existing today plus today's innovative concepts are a sufficiently robust basis for a vision for the year 2030 (i.e. technical innovations which are unknown today can be excluded). Thus firstly *mega-trends* and *logistics trends*, existing and emerging alternatives for *transport logistics operations* and *delivery service types* were identified.

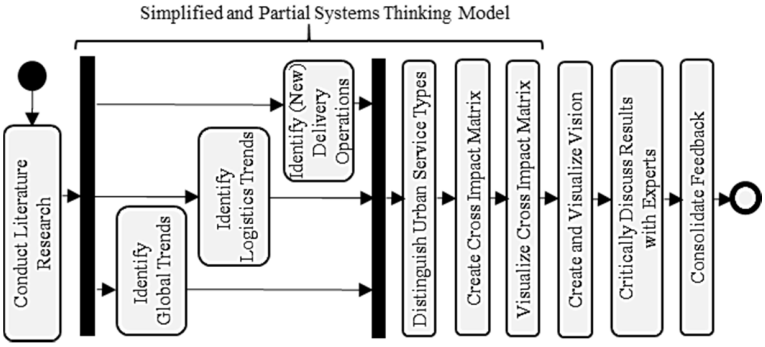

Fig. 1: Methodological Approach

[1] As competitive *inter*-relations of different transport logistics operation schemes are a very complex phenomenon, they are *excluded* in this top-level approach.

Secondly these findings were consolidated in a simplified and partial[2] *systemic model* (see e.g. Vester 2007, p179ff) which helps to understand the effects of trends and service requirements as a conceptual basis for the vision.

Finally - and in accordance with the principle of elimination as introduced by (Popper 2003, p22f) – the results as well as the methodology was presented to the scientific community with the invitation to falsify[3] results and methodology at the mobil.TUM conference 2016.

2. A Simplified and Partial Systems Thinking Model for Trends, Services & Operations

The vision of urban logistics is based on a simplified and partial systems thinking model consisting of mega-trends, logistics trends, delivery service requirements and (innovative) transport logistics operations. In this chapter the elements of this qualitative model are presented.

2.1. Global Mega Trends

Different commercial consulters and institutions state different global trends in different words – but interestingly a rather robust pattern of global trends can be detected as shown in Table 1 – Global Mega TrendsTable 1

Table 1 – Global Mega Trends

Global Trend	Siemens AG	PwC	Ernst & Young	McKinsey & Company	Zukunftsinstitut
I. Digitalization & Technology Change	Digitalization	Technological Breakthrough	Digital Future	Accelerating Technological Change	Connectivity
II. Demographic Change	Demographic Change	Demographic Change	Health Reimagined	Responding to the Challenges of an Aging World	Silver Society, Health, Gender Shift
III. Climate Change	Climate Change	Climate Change & Resource Scarcity	Resourceful Planet	-	Neo-Ecology
IV. Urbanization	Urbanization	Urbanization	Urban World	Age of Urbanization	Urbanization; Mobility; New Work
V. Globalization	Globalization	Shift in Economic Power	Global Marketplace	Greater Global Connections	Globalization
Other Trends	-	-	Entrepreneurship Rising		**VI. Individualization**; Culture of Knowledge; Security
Source:	(Siemens 2015)	(PwC 2015)	(Ernst & Young 2015)	(McKinsey 2015)	(Zukunftsinstitut 2015)

Even if Table 1 is based on five different sources, only, the author considers it to give sufficient evidence for accepting the existence of at least 5 global mega trends. With special regard to urban logistics “Individualization” (which was stated by Zukunftsinstitut, only) is regarded as a relevant trend for the model, too.

It can be assumed that these mega trends influence trends in logistics as well as logistics services. These interdependencies will be described later in this chapter.

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[2] Note that this top-level model does only use 3 out of the 9 system tools introduced by (Vester 2007, p179ff) as the goal is not to create a full system model, but to just better understand effects of important factors. Therefore the author suggests that this model should be called “simplified and partial”.

[3] It is obvious that the closer we get to the year 2030, the easier it will be to falsify this vision.

2.2. Logistics Trends

A recent study conducted by BVL (Bundesvereinigung Logistik – one of the leading nonprofit logistics associations in Germany) has detected trends in logistics as shown in Table 2

Table 2 – Logistics Trends (Translated from German)

Logistics Trend	Percentage of Experts Stating this Trend
1. Digitalization in Logistics	31%
2. Compliance, Processes & Organization	17%
3. Supply Chain Risks	16%
4. Development of Infrastructure	12%
5. Shortage of Trained Staff	10%
6. New Forms of Mobility	5%
7. Green & Sustainable Logistics	4%
Other Trends	5%

Source: (Statista 2015)

On the one hand these logistics trends are influenced by the mega trends and on the other hand they show inter-dependencies. Therefore these inter-dependencies shall be briefly discussed.

1 "Digitalization in Logistics" is part of the megatrend Digitalization & Technology Change. It can be observed by the rise, growth and professionalization of track & trace (T&T) applications - details see (Kunze 2014). But digitalization is more than T&T. Digitalization is also a prerequisite for new forms of cargo mobility, as e.g. crowd logistics services, which can be seen as one variant of the physical internet (PI)[4] - details see e.g. (Crainic & Montreuil 2015). And digitalization even has the potential to significantly change the nature of logistics – away from shipping physical goods towards transporting information, only, and re-producing the goods on site by means of additive manufacturing (AM) concepts together with 3D printer technology.

2 "Compliance, Processes and Organization" is driven by the need to standardize and synchronize transport processes on a global scale (Globalization). These transports increasingly include the "last mile" to private end consumers (Individualization) due to the rise of eCommerce. These processes standards require adequate IT-systems and interfaces and thus they highly depend on digitalization.

3 "Supply Chain Risks" are the other reason why transport process standardization and digitalization is needed. Only up-to-date quality data enable efficient fallback processes in case problems occur at the end of the supply chain from a customer's perspective.

4 "New Forms of Mobility" in urban logistics range from crowd logistics concepts via drone logistics operations (air drones as well as ground based drones) to pipeline logistics operations. Without digitalization these transport logistics operations wouldn't be possible today, even if non-digitalized antecedents of these transport logistics operations exist[5].

5 "Shortage of Trained Staff" is an increasing problem in the logistics branch (at least in Germany). This shortage of staff also applies to drivers – details and reasons see e.g. (Bollig 2014). Hence transport logistics operations, which

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[4] PI or π is a concept of goods moving around like information in the internet. "Similarly to the Digital Internet, the movements of freight in the PI are independent of the actual operations of the transportation and terminal handling and storage infrastructure and services, and proceed in an openly consolidated way through a series of carrier services and relay facilities". (Crainic & Montreuil 2015)
Note that this concept is different to the concept of Internet of Things (IoT) where technical devices communicate with each other through the internet.

[5] Note that singular trans-city pipeline based delivery services were in use before the age of digitalization, as e.g. the Berlin pneumatic tube (1865–1976), and that dabbawala (an Indian food logistics concept) could be interpreted as a non-digitalized antecedent of crowd logistics.

do not require drivers are currently widely discussed not only from a technical but also from a commercial perspective. Therefore as soon as driverless transport logistics operations can operate on a lower cost basis than driver-based systems, a change towards these new transport logistics operations is plausible.

6 "Development of Infrastructure" is clearly driven by the mega trend Urbanization. Even if this trend applies to existing infrastructure (roads, rails, freight villages etc.) this trend is extremely important for additional infrastructure enabling new transport logistics operations (e.g. charging infrastructure for electric vehicles; parcel drop points for close to home delivery, etc.). If this infrastructure is not built, the relevant transport logistics operations cannot evolve.

7 "Green and Sustainable Logistics" – this trend[6] is induced by the mega trend Climate Change as well as by the aim of citizens to live in a healthy, unpolluted and noise-limited environment. This logistics trend therefore should promote low emission transportation not only with regard to global CO_2-emissions but also to local urban emissions like particles and noise.

2.3. Logistics Services

Before the different transport logistics operations are discussed the different delivery service types in urban logistics shall be distinguished.

S2S - Classically shops in cities display goods, customers go there, buy the goods and carry the goods home[7]. The author suggests to call the replenishment service to commercial shops *"service-to-shop (S2S)".* The order sizes (and thus the transport volumes) of S2S-services are usually significantly higher than the relevant order sizes in home deliveries due to the consolidation effect of shop-sales.

F2F - The classical home delivery service is the "*face-to-face home & office delivery service (F2F)*" where a *person* brings the goods to the customer and hands them over face to face. These services encompass part of the classical van based CEP-services as well as bicycle or scooter based courier services. It includes the fallback-neighbor-delivery (handover parcel face to face to neighbor if customer is not home). Considering the mega-trend "Demographic Change" the author sees a twofold impact on F2F. On the one hand, single seniors in an ageing urban society will appreciate F2F home deliveries (which reduce the need to carry heavy items and which will provide a minimal social contact). On the other hand many seniors will have to face a declining monthly income, and thus healthy seniors may be inclined to offer such F2F services for reasons of income, social contact and/or the aim to just help others.

N2F - As it is difficult and expensive to schedule a precise face-to-face delivery and not all deliveries require a face-to-face delivery, a variety of new forms of "*non-face-to-face home & close-to home delivery services (N2F)*[8]" has evolved. These delivery services encompass home deliveries as e.g. letter box delivery (if parcels are small enough), parcel box delivery (if dedicated parcel boxes at private homes or condominiums exist), and they encompass close-to-home-deliveries as e.g. parcel shop deliveries (deliveries to dedicated shops close to customers, which have agreed to accept such deliveries – e.g. Hermes Paket-Shops), drop box deliveries (deliveries to public drop box facilities, where a one-time-access code is transmitted to the customer - e.g. DHL Packstation) or car trunk deliveries (deliveries to trunks of parked private cars – details see (Reischel 2015)).

Linking F2F and N2F to mega-trends, they can best be interpreted as results of the mega-trend "Individualization" considering that they are enabled by the mega-trend "Digitalization".

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[6] Note the relatively low percentage of experts stating this trend - see Table 2

[7] The relevant induced traffic from the shops to the homes of the customers is not considered to be commercial traffic, but is usually considered to be part of the individual traffic, whereas the transports to the shops are a classical part of commercial traffic.

[8] The author suggests distinguishing F2F and N2F services, because F2F-orders *require a person* to perform the delivery (e.g. to collect money, or to hand over fresh food items, or because it is the wish of the customer to meet a person) whereas N2F-orders don't require a person in the last mile delivery process. Therefore it is the *order attribute* that is the delimiter and not the chosen logistics operation (i.e. a human may of course also perform N2F deliveries, but a drone cannot perform an F2F delivery).

2.4. Transport Logistics Operations

As of today, urban goods logistics is predominantly carried out by trucks and vans. But there is a number of other means of transport either existing or emerging. Therefore a brief overview on these means of transport with a focus on their key assets and key problems shall be presented next.

2.4.1. Classical Vehicles

Trucks and vans powered by combustion engines currently conduct most of the deliveries in cities.

Their key asset is

+ their "installed base", i.e. their established technical and organizational structures and their established profitable commercial business models.

Their key problems are:

- their dependency on fossil fuels and the resulting emissions (gases, particles and noise)
- their requirement to employ a driver
- their consumption of space - either parking space consumption or street space consumption during delivery stops in second lane (including delaying impact on through traffic)

2.4.2. Electric Vehicles

Trucks and vans powered by electric engines could substitute classical vehicles for deliveries in cities.

Their key assets are

+ that they could substitute classical vehicles in established transport organizations almost 1:1 and
+ that they would significantly reduce local emissions. Depending on how the electricity is generated, they could also contribute to lower global CO_2 emissions, provided that their electric propulsion energy is generated without the use of fossil energy.

Their key problem is not necessarily their reach related to battery capacities – due to the urban context a shorter reach could be overcome by adequate re-charging concepts and enhanced battery capacities.

Therefore their key problems are

- the lack of recharging infrastructure,
- the current low of fossil fuel prices (which is a commercial hindrance to substitute classical vehicles by electric ones), and
- their requirement to employ a driver and
- their consumption of space (see classical vehicles).

2.4.3. Bikes & Scooters

Bikes & scooters are currently used for courier services (e.g. for urgent document transfer or pizza delivery).

Their key assets are

+ their possibility to better navigate on congested streets and
+ their reduced parking space requirements (i.e. no need for second lane parking in streets).

Their key problem also is

- their requirement to employ a driver – and due to the small cargo volume which can be transported on a scooter or a bike (compared to a van or a truck) this problem is more severe than for vans or trucks. Therefore a natural commercial limit to this type of logistics operations can be stated (i.e. only applicable for cases where high last mile delivery costs are commercially justified or where congestion hinders in-time truck or van delivery).

2.4.4. Autonomous Electric Vehicles (EAVs)

"Ground Drones" or EAVs have been in use in intra-logistics for decades. There they are known by the names "driverless transport system", "automatic guided vehicles", "autonomous ground vehicles" (AGV) or in German "Fahrerloses Transportsystem FTS". Today a "renaissance" of this technology can be observed in extra logistics, as

car and truck producers strive to provide autonomous vehicles, and thus pave a path for EAVs commercial use in extra-logistics.

The key asset of this concept is

+ the dispensability of drivers (leading to reduced operating costs) and
+ the principal possibility for small EAVs to co-use public transport infrastructure during off peak hours.

The key problems are

- the necessity to load and unload the vehicles, and this either requires on-board mechanisms (which cause higher investment costs) or this requires loading- and unloading-devices on both ends of the last mile transport (which cause investment costs to the recipient of the goods[9]). As a corollary one would also need
- standards for physical unloading as else technical compatibility problems could jeopardize the delivery at the destination location (which could e.g. be drop boxes, commercial unloading bays or private homes). Last but not least there are the issues of
- security (or theft protection), and
- safety (or the risk of causing harm to humans walking or driving by).

2.4.5. Air Drones (sUAS)

"Air Drones" or small Unmanned Aircraft Systems (sUAS) provide the key assets:

+ dispensability of drivers (but not necessarily the dispensability of drone operators – this depends on future administrative regulations)
+ inbuilt loading & unloading device, and
+ access speed due to theoretical beeline delivery (if regulations don't require other routes).

Their key problems are:

- noise emission,
- security (risk of damaging cargo in cases of collision, technical defect or sabotage),
- safety (or the risk of causing harm to humans or assets under the flight path of the drone or potential danger to helicopter rescue operations),
- energetic efficiency,
- local ecologic impacts (e.g. on birdlife),
- lack of adequate near ground air traffic regulations

2.4.6. Crowd Logistics & Physical Internet (PI)

"Crowd Logistics" solutions are trying to enter the urban logistics market with mixed success, as e.g. DoorDash Inc. and Postmates Inc. in the US, MyWays (DHL) in Sweden or bringbee (PolyPort GmbH) in Switzerland show. The idea is to co-use private transportation and thus create a win-win-win-situation (home delivery service for customer, additional income for service crowd member and revenue for service organization). The keys to success are a good ICT-solution, image (trustworthiness) a robust win-win-win-business model and sufficient momentum to get started. Crowd logistics services can be interpreted as one possible instance of the PI.

Key assets of these solutions are:

+ that no own transport resources are needed (i.e. existing private travels are co-used[10]) and thus these solutions are considered
+ environmentally friendly

Problems and reasons for failure have been discussed by (Hüsing 2014) and include

- problems to generate sufficient local momentum

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[9] Alternatively one could keep the EAV waiting till the recipient manually unloads the vehicle. This concept might work in a B2B context, but in a B2C context this would keep a significant number of EAVs of a fleet in an idle state, and thus unnecessarily bind transport resources.

[10] Note that customer specific detours usually are induced, i.e. the co-use rate is not 100%

- guaranteed service levels

An additional shortcoming is today's

- lack of infrastructure to exchange goods for part-way transports. A network of electronic drop boxes would enable private commuters and travelers to contribute to crowd logistics without the need to make significant detours, provided that multi-hand-over processes are robustly established.

2.4.7. Cargo Pipelines and Cargo Tubes

Cargo tubes have a tradition of more than 100 years. Pneumatic pipeline systems for telegram and letter transport used to be operated in several European cities (as e.g. Berlin, Vienna, London, Prague or Paris) in the 19th and 20th century. In Hamburg a small postal urban pipeline-system (named "Großrohrpost") with a tube diameter of 45cm was in use from the late 1960ies till the early 80ies. In the 70ies research with regard to cargo-pipelines was conducted e.g. at the technical university of Karlsruhe (today KIT Karlsruhe Institute of Technology) at the "Institut für Fördertechnik" (today IFL). Today the project "Cargo sous terrain" is in preparation in Switzerland (Schneeberger 2016) which shall employ EAVs in a 6m-diameter tube for inter-city cargo transport. It is not designed to be used for urban last mile logistics though – details see (Cargo sous terrain 2016).

Key assets of these solutions are:

+ insensitivity to traffic jams
+ environmental friendliness and
+ "invisibility"

The key drawback of this solution is the

- Infra-structure investment volume, as infrastructure has to be built from scratch.

2.4.8. 3D-Printers (3DP) and Additive Manufacturing (AM)

Three dimensional printers (3DP) also termed "replicators" or Additive Manufacturing (AM) have the potential to revolutionize urban logistics for some[11] goods. Instead of shipping physical products, the information on how to 3D-print the product is transferred, only. This is a *revolutionary change from physical logistics to information logistics*. The production material (in analogy to print cartridges) can generically be used, and thus it can be transported in larger lots and with lower delivery frequency than traditional pre-manufactured goods. Therefore this new type of logistics can be considered to be part of ecological logistics concepts. But it also is promoted by the mega-trend Individualization, because especially the consumer goods industry could come up with highly individualized consumer products as can be seen by the attempts of Adidas to tailor-make shoes in shops using their 3D-printing concept "Futurecraft" - see (Glüsing, Jung & Zand 2016; p61).

The key assets of this concept are

+ high potential to create individualized goods in line with the global trend of individualization,
+ reduction of miles in the upstream transport chain[12] in line with the logistics trend of "green and sustainable logistics"
+ reduction of availability times in case of need (e.g. for urgent spare parts)

Still there are a number of issues which need to be solved from a conceptual, structural and commercial point of view.

- Different Printer Types: Today different 3D-printes are required to handle different uniform materials like e.g. plastics, metals and even food. Even if multi-material printers are currently in development, there still is a need to have different printers for different materials in the midterm future.

[11] Today many material wise uniform goods can be 3D printed. First mutli material printers are currently being developed.

[12] As 3D-printing material can usually be transported in drums, logistical volume synergies and frequency synergies lead to less upstream transports.

- Location Structure: As 3D-printers are relatively costly, and at the same time different materials require different types of printers, it is unlikely that a majority of private households will run a farm of several 3D-printers in the mid-term future. But local centers could pool different printer types and thus offer a wide range of 3D-print-on-demand products. Therefore a geographical structure of 3D-print-on-demand locations could be similar to (former) post-office structures.
- New Business Models: These would be required for the vendors as they would sell reproduction licenses instead of products if they don't print their products within their own shop-network. But this change of business models already has a precedent in the music industry (change from vinyl, CD and DVD sales to download business models).

2.5. Systemic Impacts on Transport Logistics Operations

Next the above reasoning is summarized by means of a simple partial and qualitative systemic model[13] (see Fig. 2 and Fig. 3).

In the model *small, significant and strong* effects as well as *positive and negative* effects are distinguished. Note that Fig. 2 only depicts significant and strong effects due to transparency reasons. Fig. 3 shows the assumed strengths of all effects.

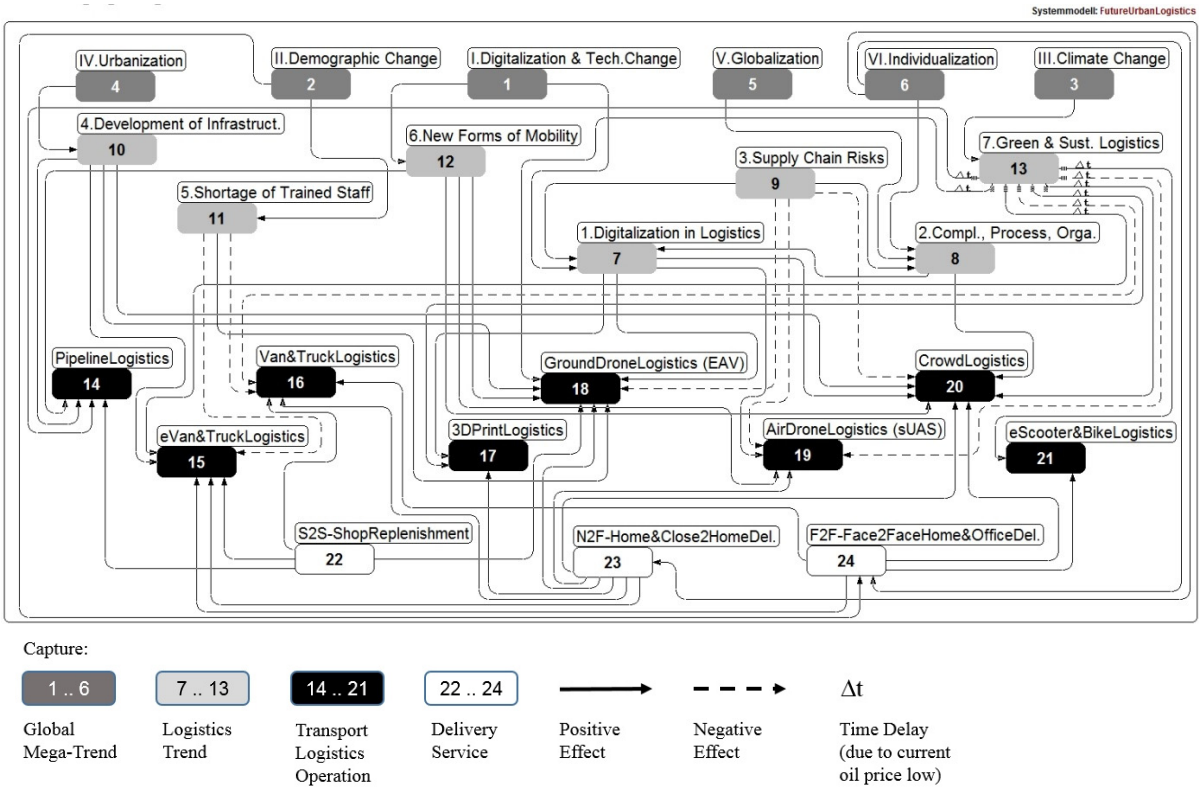

Fig. 2: Systemic Impacts on Transport Logistics Operations (Positive and Negative Effects)

[13] Figures 2 and 3 were generated by the Software "Malik Sensitivitätsmodell ® Prof. Vester Version 9.2"

This purely qualitative model shows, which logistics trends support and threaten the different transport logistics operations, and how the development of the different delivery service markets of S2S, F2F and N2F drives the different transport logistics operations.

Impact of Variable ⇩ on Variable ⇨		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	AS	P
1	I.Digitalization & Tech.Change	X	0	0	0	0	0	3	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	6	0
2	II.Demographic Change	0	X	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	2	5	0
3	III.Climate Change	0	0	X	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	3	0
4	IV.Urbanization	0	0	0	X	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0
5	V.Globalization	0	0	0	0	X	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0
6	VI.Individualization	0	0	0	0	0	X	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	3	9	0
7	1.Digitalization in Logistics	0	0	0	0	0	0	X	0	0	0	0	0	0	1	1	1	3	2	2	3	1	0	0	0	14	126
8	2.Compl., Process, Orga.	0	0	0	0	0	0	3	X	0	0	0	0	0	1	1	1	1	1	1	3	1	0	0	0	13	117
9	3.Supply Chain Risks	0	0	0	0	0	0	3	3	X	0	0	0	0	1	1	1	1	3	3	3	1	0	0	0	20	0
10	4.Development of Infrastruct.	0	0	0	0	0	0	0	0	0	X	0	0	0	3	2	1	1	2	1	2	1	0	0	0	13	39
11	5.Shortage of Trained Staff	0	0	0	0	0	0	0	0	0	0	X	0	0	1	3	3	1	2	1	1	1	0	0	0	13	39
12	6.New Forms of Mobility	0	0	0	0	0	0	0	0	0	0	0	X	0	2	1	1	1	2	2	2	1	0	0	0	12	36
13	7.Green & Sust. Logistics	0	0	0	0	0	0	0	0	0	0	0	0	X	2	2	3	2	2	3	2	2	0	0	0	18	54
14	PipelineLogistics	0	0	0	0	0	0	0	0	0	0	0	0	0	X	0	0	0	0	0	0	0	0	0	0	0	0
15	eVan&TruckLogistics	0	0	0	0	0	0	0	0	0	0	0	0	0	0	X	0	0	0	0	0	0	0	0	0	0	0
16	Van&TruckLogistics	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	X	0	0	0	0	0	0	0	0	0	0
17	3DPrintLogistics	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	X	0	0	0	0	0	0	0	0	0
18	GroundDroneLogistics (EAV)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	X	0	0	0	0	0	0	0	0
19	AirDroneLogistics (sUAS)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	X	0	0	0	0	0	0	0
20	CrowdLogistics	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	X	0	0	0	0	0	0
21	eScooter&BikeLogistics	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	X	0	0	0	0	0
22	S2S-ShopReplenishment	0	0	0	0	0	0	0	0	0	0	0	0	0	2	3	3	1	3	1	1	1	X	0	0	15	0
23	N2F-Home&Close2HomeDel.	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3	3	3	3	3	2	1	0	X	0	19	57
24	F2F-Face2FaceHome&OfficeDel.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	3	0	0	0	3	3	0	0	X	12	60
		0	0	0	0	0	0	9	9	0	3	3	3	3	14	20	20	14	20	17	22	13	0	3	5	PS	
		∞	∞	∞	∞	∞	∞	156	144	∞	433	433	400	600	0	0	0	0	0	0	0	0	∞	633	240	Qx100	

Capture: 0 no effect 1 small effect 2 significant effect 3 strong effect

Fig. 3: Strengths of Effect Impacts

Let's now want to pay special attention to the key obstacles for the different transport logistics operations.

2.5.1. Missing infrastructure

Pipeline Logistics strongly depends on infrastructure investments. Without these investments to build the transport network it will not materialize in the mid-term future. As these investments currently are not detectable (note that the Swiss cargo sous terrain project is not an urban logistics initiative) this operation doesn't seem to be a highly probable option in the midterm future.

The other logistics operation which depends on new infrastructure is eVan&Truck logistics. It requires a standardized re-charging network. But as this network is needed for private mobility, too, and a few privately funded local re-charging stations would suffice to get started, one can assume that eVan&Truck logistics are a realistic option for the near and midterm future.

2.5.2. Shortage of Trained Staff

Let's take the assumption that the shortage of trained staff will contribute to a tendency to move away from driver based operations to autonomous transports. But this move is also commercially driven by the need to pay drivers wages, which are an operating cost factor, and the need of drivers to be able to make a living. Thus in case a sufficient number of drivers will accept minimal wages, this move will be slow, but in case the shortage of staff at current low wage levels remains, this move towards EAVs will occur faster. The same problem, but on a higher scale occurs for drone logistics, if regulations require a 1:1 human operator for each drone.

2.5.3. Supply Chain Risks

Mastery of last mile supply chain risks or in other words security aspects like theft and sabotage protection will be significant decisive factors for the evolvement of ground and air drone services as well as for crowd logistics services. Both drone services also have to solve safety issues.

2.5.4. Green Logistics and Current Oil-Price Low

Green Logistics may be a trend, but if strict legal regulations will not be implemented in order to reduce emissions, this trend has very little impact. On the contrary, the current oil price low will significantly delay the move towards more ecologic transport logistics operations, as it takes away the economic pressure to move in this direction. Even if one assumes that adequate regulations will come in the future, and that the global oil price level will significantly rise again, a delay which is indicated in Fig. 2 by the "Δt" symbol needs to be considered.

3. A Vision of Urban Logistics in the Year 2030

Inspired by the systemic model presented in section 2 a vision of urban logistics in the year 2030 as visualized by Fig. 4 has been created. References in squared brackets denote factor IDs in Fig. 2.

First of all there are some *transport logistics operations which don't seem highly probable* in European city logistics in the year 2030.

As construction of pipeline infrastructure requires years of planning, official approval of planning and construction works on the one hand and because initiatives to finance such projects could not be detected, yet - with the exception of (Cargo sous terrain 2016), and this project is not designed for urban logistics, but for inter-city logistics, only – it is difficult to envision significant urban *pipeline logistics.* [missing effect 10→14].

Urban *air drone logistics* on a larger scale are also improbable because they are neither energetically efficient, it's unlikely that the urban population will tolerate air drone noise emission [13→19], security and safety concerns remain unsolved [3→19] and business models still have to prove their profitability [commercial competition on 23]. One may see chances for use cases in rural areas, where today's transport logistics consolidation potential is low and therefore air drone logistics might be a profitable option for the future [23→19].

Secondly let's discuss which of the *current transport logistics operations may still be operative in the year 2030*.

Bike courier services are an established concept in today's urban logistics in the niche of courier transports. They serve a specific service demand and have profitable business models [24→21]. They are ecologically friendly [13→21] and would remain so if the bike-fleet is expanded by *eBikes or eScooters*.

Van&Truck logistics and *eVan&Truck* logistics will not stop operating till the year 2030. Their uniform applicability to all 3 service types [22,22,23→15,16] and existing business models will help them to remain operative. In total their market share will diminish in percentage due to other evolving transport logistics operations and their dependency on humans [5→15,16]. In addition to that an internal volume shift from Van&Truck logistics to eVan&Truck logistics is likely, provided that the ecologic trend [13→15,16] gathers momentum.

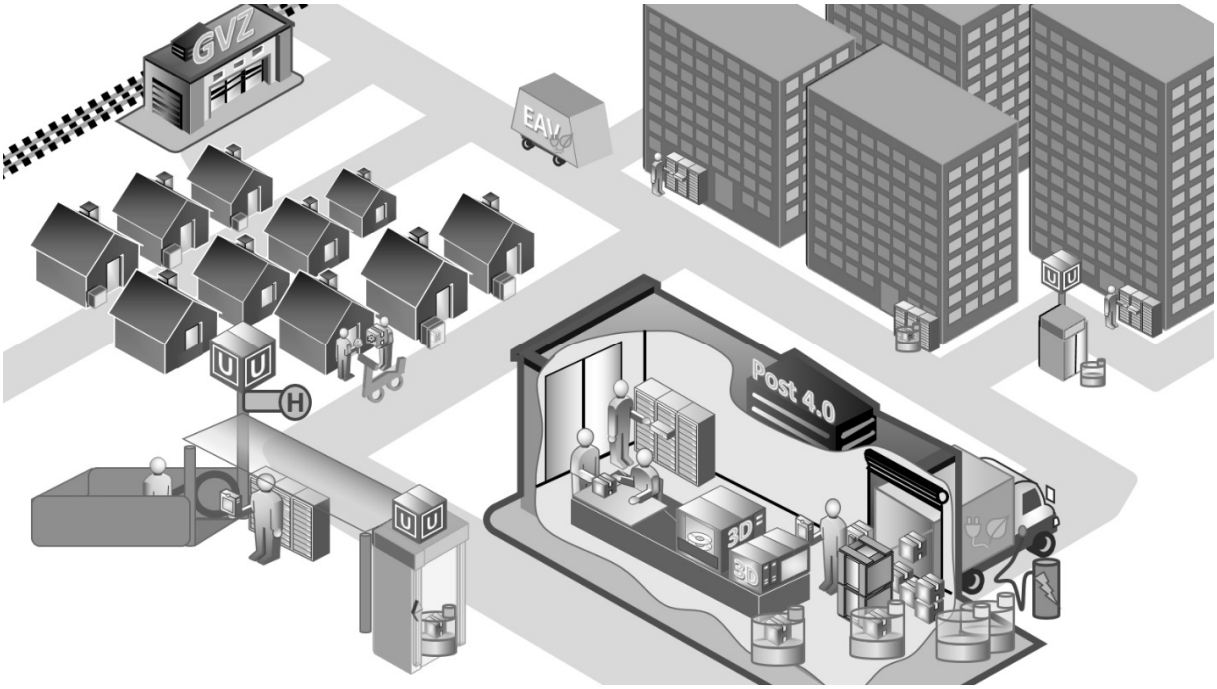

Fig. 4: Visualization of the Vision of Urban Logistics in the Year 2030 (as presented on mobil.TUM 2016)

Thirdly let's discuss *emerging transport logistics operations*.

Crowd logistics can be applied to F2F and N2F delivery services [23,24→20]. It is also considered ecologically friendly [13→20]. Even if some crowd logistics operations failed, other operations seem to be commercially successful. If security issues [9→20] can be solved by means of process improvement and digitalization [1,2→20], an even higher potential for crowd logistics is likely provided that a drop-box infrastructure to hand over goods to other couriers develops within public transport interchange stations [10→20]. This would allow partial last mile transports by different persons whilst reducing avoidable deviations.

Ground drone logistics has two different potential options to develop. One option are fast moving street based van-like drones (EAVs) – the decisive factor here would be the ability to come up with 100% autonomously driving vehicles approved for road traffic, a technology which currently is developed by several car manufacturers and ICT-enterprises like Alphabet. Should this endeavor work for individual private traffic it could be used for driverless logistics [11→18], too. The other option are slow moving sidewalk based mini-drones. Their basic technologies have been used in intra-logistics for decades. These slow moving EAVs could also be seen as another instance of the PI [7→18], and they would be able to co-use means of public transport (as e.g. subways) during off peak hours [12→18]. Both options can be considered ecologically friendly [13→18]. Still, as both options require automated solutions to unload (either onboard or at the recipient's site), recharge [10→18] and solutions for security issues (especially theft protection) [9→18] they may not develop rapidly but still are a realistic option for the year 2030.

The most intriguing innovation in urban logistics seems to be *3DP logistics*. This option is difficult to assess, as it would be driven by product development, production and sales strategies of producers rather than by logistics aspects

[7,10,12,13→17]. Still this option would reduce upstream transports and it would be complementary for the different discussed means of urban transport logistics.

Last but not least it shall be pointed out that two infrastructure elements would be beneficiary to several means of future urban logistics before the year 2030. One of these elements are local multi-channel cross-docking centers for last mile transports in a geographic spread which is similar to (former) post-offices. The author suggest to term these centers as "***post 4.0 centers***". Here people could pick-up their goods (similarly to today's drop-box or Paket-Shop concept) as well as cross docking from lager vehicles (e.g. fast moving EAVs or eVans) to crowd logistics, ground drones or eScooters&Bikes could be performed. There is a very good chance that 3D printers could complement the "post 4.0" infrastructure locations. The other element are ***drop boxes***. They are a crucial element if home delivery failures shall be minimized. If they are placed at public transport interchanges, people commuting by public transport could easily pickup their goods en route, and these drop boxes would also be an enabling technology for crowd logistics.

4. Critical Discussion

Focusing only on trends and three delivery service types in order to predict urban logistics for the year 2030 in Europe is an approach which can fundamentally be criticized. It ignores a wide range of other factors like economic development, social imbalances, migration issues, or dramatic short term climate changes to name but a few. So if e.g. sub-minimal wage jobs should become a reality for an increasingly class divided European society, all above thoughts about drones and EAVs will be rendered invalid, as workers would accept sub-minimum wages and thus promote classical Van&Truck logistics. Or should oil-prices stay low for the next decades, a shift to more sustainable ways of urban transport is unlikely. And if air drone lobbying together with free-trade treaties should prove strong enough to repress the need for noise reduction in cities, of course air drones will emerge in contradiction to the presented vision.

One can also criticize that just *3 out of the 9 system tools* suggested by (Vester 2007) were used. But again it was not a goal of the author to build a full 360° systemic model for future urban logistics.

Finally the approach to use *sheer reasoning* to a) build the systemic model and to b) transfer the insights from this model into a vision can be criticized.

Therefore the criticism that the provided results remain speculative is valid. Still the results presented at the poster session of mobil.TUM 2016 didn't raise major objections from the audience. The key debated questions at the conference were:

- Role of safety and security issues for ground and air drone logistics
- Which levels of air-drone noise emissions seem to be acceptable by citizens

The author hopes to inspire the discussion on future urban logistics, and is looking forward to be proven either right or wrong by future events.

5. Need for Further Research

Further research is needed with respect to the methodological assessment of *business models* (including investments and operating costs) for different urban transport logistics operations. Based on such assessment-methodologies, inter-dependencies of different operations (which were widely ignored in this paper) could be assessed based on their market potential. Once these models are available, different scenarios could be modelled and commercial sensitivity analyses could be conducted. This would help industrial and administrative decision makers to avoid unsuccessful investments.

There also is a need for further research in the methodological assessment of urban *ecological impacts* beyond CO_2-emission for different urban transport logistics operations. Especially noise, particle emission and congestion (due to 2nd lane short time parking) should be analyzed in greater detail.

From a conceptual point of view, the suggested definitions of S2S, N2F and F2F may require further refining, as these definition mix geographical aspects (shop vs. close to home vs. home) and interactional aspects (face-to-face- vs. non- face-to-face).

Last but not least the author would like to stimulate research and discussions around the topic “post 4.0”.

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