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D. 2.4
AEOLIX REFERENCE BOOK

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Abstract
This is a documentation on the AEOLIX Reference Book (ARB), a website created during the project to collect, highlight and present emerging trends, technologies and practices that are of interest to the problem domain of the project (http://reference.aeolix.eu). The purpose of this document is to present the content of the website.

Legal Disclaimer

Abbreviations and Acronyms

Acronym	Definition
EC	European Commission
PO	Project officer
GA	Grant Agreement
WP	Work Package

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Executive Summary

This is a documentation on the AEOLIX Reference Book (ARB), a website created during the project to collect, highlight and present emerging trends, technologies and practices that are of interest to the problem domain of the project (http://reference.aeolix.eu). The purpose of this document is to present the content of the website.

Each entry in the ARB is classified into one of three groups:

- Trends
  - Describe observed changes in paradigms, new areas of interest for the industry, for example Automation.
- Technologies
  - Describe observed new technologies or new uses of existing technologies such as blockchain, beacons, 3D-printing etc.
- Practices
  - Describe observed new or updated *modii operandi* such as off-peak delivery or horizontal collaboration

The following **trends** were observed:
- Automation
- Industry 4.0
- Sharing economy
- Sustainability

The following **technologies** were identified:
- 3D printing
- Autonomous vehicles
- Artificial Intelligence
- Beacons
- Blockchain
- Electromobility
- Intelligent Truck Parking
- Internet of things
- Quantum computing

The following **practices** were observed:
- The FOT Methodology Adapted to Living Labs
- Horizontal Collaboration
- Living Labs and Freight Transportation
- Off-peak delivery
- Servitization

1   Introduction
1.1   Purpose of Document

This is a documentation on the AEOLIX Reference Book, a website created during the project to collect, highlight and present emerging trends, technologies and practices that are of interest to the problem domain of the project (http://reference.aeolix.eu). The purpose of this document is to present the content of the website.

1.2   Intended audience

The intended audience is anyone who is interested in emerging (during the project lifetime) trends, technologies and practices relevant to freight transportation.

2   Description of the work done
2.1   From the WP2 workplan

The following list of actions are taken from the workplan for WP2.

1. This Task establishes a Task force, consisting of **representatives from logistics actors, software developers, authorities and academia from within the consortium**, that performs a **continuous monitoring** of the evolutions of the demand and supply in the logistics market, of the ICT domain, of the information sharing tools etc.

2. Each living lab will be described by a **work domain analysis** and the **constraints of possible solutions** will be the backbone of the work.

3. Starting from the first solutions of each living lab the **co-creation process** will lead to enhanced performance of the cognitive systems involved.

4. The aim is to **intercept at an early stage any trend or innovation** that may be relevant as requirement for AEOLIX.

5. The emerging new functional needs and requirements will also **create an idea about which actors and actor groups are relevant for future AEOLIX solutions**.

6. This Task has the **express mandate to interact with other WPs in this project** with the purpose of ensuring that new knowledge (both produced within the project and elsewhere) is disseminated as quickly as possible.

7. The results will be **continually communicated via a dedicated space on the AEOLIX website**, the AEOLIX Reference Book as well as via direct meetings with representatives of other WPs.

2.2   Key deliverable

This Task differs from others in the project in the sense that the formal deliverable is a web page and not a published report. The web page, called the AEOLIX Reference Book, will be made available under the AEOLIX.net website.

The format of the AEOLIX Reference Book (ARB) will be that of a FAQ/Knowledge base. This page will be public and will contain descriptions of trends, practices and technologies that have been

identified as relevant for the problem domain of AEOLIX. As inspiration, models like the DHL Trend Radar and the Gartner Hype Cycle are studied. Each identified technology/trend/practice will be given a separate page in the ARB. The ARB will be published using Wordpress, enabling the inclusion of rich media, hyperlinking, tagging and categorising of data.

So, to summarise the deliverables:

1. The AEOLIX Reference Book, ARB – public website containing general knowledge on trends, technologies and practices
2. This documentation of the ARB

2.3 Relation to living labs

The Living labs are the backbone of the AEOLIX project, and this Task connects to the labs and to relates to relevant issues there.

2.4 Co-creation

This Task works together with individual LL leaders in order to make sure that knowledge is transferred both ways.

2.5 Identify emergent trends, technologies and practices

This is the main activity in this Task. The Task force is comprised of people that are already monitoring trends as part of their everyday work. The Task force will be responsible for writing and maintaining the ARB as well as the internal documentation. To be able to do this, the Task force is required to:

- (Subscribe to and) read/view relevant news sources, publications and other media channels
- Visit conferences and meetings where new trends, ideas, technologies and practices are presented and discussed (such as ALICE, DTLF, TEDx etc.).

Each ARB entry is structured according to the following specifications:

- Type (Technology, Trend or Practice)
- Name
- Short description
- Images, at least one
- References
  - o Hyperlinks
  - o Relevant research/news sources
- Examples from industry, if any
- Projection
  - o Impact on the problem domain of AEOLIX
  - o Time frame
- Longer description, no word limit, rich content (media, formatted text, links etc.)
- Category (one)
- Tags (many)
- Internal communication (not public and transferred orally within the consortium)
  - o Impact for the project
    - ▪ Urgency (low, high, extreme)
    - ▪ Magnitude (small, medium, big, extreme)
    - ▪ Involved WP:s and Partners
  - o Impact for the future of AEOLIX and perhaps for the next proposal
  - o Proposed action plan based on the above
    - ▪ Responsible partners
    - ▪ Concrete tasks to be performed

2.6 Contribute to the groundwork for the future of AEOLIX

By the end of the project, the knowledge collected in this Task should be used to make sure that AEOLIX can be developed further on a commercial basis and in line with emerging trends, technologies, and practices.

2.7 Creation of task force

The work in this Task is dependent on the people involved, since some expert knowledge is needed in order to identify and generalise trends and technologies. The Task consists of persons from within the consortium that are considered experts in their respective fields and that have the knowledge required.

The Task force consists of the following persons:

- Per Olof Arnäs, Chalmers, Task leader
- Stig Franzén, Chalmers
- Eusebiu Catana, Ertico
- Evangelos Mitsakis, Certh
- German Herrero, ATOS
- Marcel Huschebeck, PTV
- Rein Westra, Giventis

The role of the Task force is to act as editors of the AEOLIX Reference Book. Individual content can be produced by other members of the consortium but the Task force is responsible for the overall quality and content.

3 Technology used for the Reference Book

The ARB is built in Wordpress using the Divi theme. A specific post type is created where the plugin Advanced Custom Fields is used to create the two specific fields *Projected impact* (None, Low, Moderate, High or Disruptive) and *Impact time frame* (Already here, Within 2/5/10 years or >10 years) are defined.

The front page is clean and highlights one Trend, Technology and Practice, see image below:

Figure 1 The front page of the AEOLIX Reference Book

Each individual entry contains several sections:
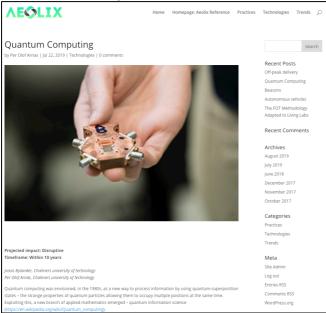
Figure 2 Top of entry with Title, Projected Impact, Timeframe, Author(s) and main body of content

In the lower part of each entry, dedicated sections display any references and/or examples from industry as well as a comment section:
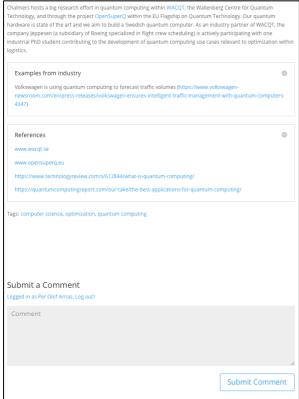
Figure 3 Lower part of entry with sections for Examples from industry, References, content tags and a comments field

4   Content in the Reference Book

4.1   Classification

Each entry in the ARB is classified into one of three groups:

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- Technologies
    - Describe observed new technologies or new uses of existing technologies such as blockchain, beacons, 3D-printing etc.
- Practices
    - Describe observed new or updated *modii operandi* such as off-peak delivery or horizontal collaboration

4.2 Delimitations

In the ARB, content has been chosen in relation to the specific domain of the AEOLIX project. The methodology can be applied to other contexts as well and may then yield several more entries that are relevant for these contexts.

4.3 Summary of content

The following **trends** were observed:
- Automation
- Industry 4.0
- Sharing economy
- Sustainability

The following **technologies** were identified:
- 3D printing
- Autonomous vehicles
- Artificial Intelligence
- Beacons
- Blockchain
- Electromobility
- Intelligent Truck Parking
- Internet of things
- Quantum computing

The following **practices** were observed:
- The FOT Methodology Adapted to Living Labs
- Horizontal Collaboration
- Living Labs and Freight Transportation
- Off-peak delivery
- Servitization

4.5 Reference Book Entries - Trends

4.5.1 Automation
Projected impact: Disruptive
Timeframe: Within 5 years

Mankind has, for as long as we can remember, strived to create tools to help us in our daily struggle. In that sense, we have used technology to solve everyday problems since the dawn of man. The development in machinery that began in the mid 18th century and from there grew into the industrial revolution brought with it massive societal, financial and environmental changes. That development has continued to accelerate and today, many aspects of society is, or can be, automated.
In production, automation has been the method of choice for more than a century, bringing precision and scalability to otherwise work-intensive industries. We see now see a dramatic increase in automation, partly due to advances in digital technologies such as sensors, processing power and algorithms.

Figure 4 Industry robot

In logistics, we see large scale fully automated warehouses[1,2] where high order volumes are picked and shipped almost entirely without human involvement. These massive facilities will require equal precision and capacity from the transportation system.

Another example is autonomous vehicles (see separate article). Tesla has recently launched their semi truck with (allegedly) autonomous driving and startups like Einride are aiming to disrupt the haulage industry with their T-pods (In essence an AGV made for long-range transport).
Even if automation of the individual vehicle may lie sometime in the future, we are already seeing automation in the bordering systems, such as intelligent delivery boxes:

For the traditional transportation industry, automated interfaces with adjacent systems will be more and more common as these systems all strive to be as costs efficient as possible.

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[1] Ocado: https://youtu.be/EeMTZd68fOU

[2] JD.com: https://youtu.be/RFV8IkY52iY

4.5.2 Industry 4.0[3]

Projected impact: Disruptive
Timeframe: Within 5 years
Industry 4.0 is a collective term for several trends within manufacturing and industry. Industry 4.0 encompasses, among others, the following concepts:

- Smart manufacturing/smart factories
- Dark factories (factories without humans and thus with no need for lights)
- Industrial internet of things

Even though the concept mainly focuses on manufacturing, some aspects are still highly relevant for freight transport. A smart factory inevitably needs to be serviced by vehicles delivering or picking up cargo, thereby needing interaction with systems that (normally) are out of the control of the factory itself.

4.5.3 Sharing economy
Projected impact: High
Timeframe: Already here

The sharing economy – when a long tail of supply is matched with a long tail of demand using technology – is rapidly gaining ground, even in B2B-systems.

The sharing economy, when we use digital platforms to match supply with demand, has disrupted several industries already (taxi, hotel, media etc.). The basic foundation behind the sharing economy is quite simple: create digital information on either supply or demand in a market and use the internet to make this information accessible to those who need it, thereby enabling a match between supply/demand that may never have taken place otherwise.

Many of the disrupted markets have a sharing economy already, but due to sub-critical mass these economies have failed to reach market penetration. We had private persons renting and letting apartments already, we also had ride sharing, buy-and-sell listings etc. But now we have the internet. And we have access to inexpensive sensors like GPS antennas to help us publish the needed data. By using technology, diligent actors have managed to tap into an already existing market, changing the rules by offering a supply that can set prices much lower due to a pure marginal cost reasoning (a flat owner does not have to take fixed costs into account when setting the price, but a hotel does). The same actors have also managed to understand the needs of the customers, the demand, and are quickly becoming the preferred supplier of decision support. This development has in part taken place at the expense of the established actors with large balance sheets and therefore large fixed costs. The matchmaker gets a transaction fee and in many cases also gets the advance payment that can be invested until the fulfilment of the transaction (which can take place much later).

For the logistics industry, sharing economy mechanics may have several effects:
- Capillary (last- and first mile) flows may be taken over by other actors like private persons or dedicated companies
- Owning the vehicle and employing the driver may be the least profitable strategy, leading to a decrease of especially smaller haulage companies
- The transportation market may become more transparent and it will be easier to get back hauls etc.

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[3] References:
- Was hinter Begriffen wie Industrie 4.0 steckt – https://www.computer-automation.de/steuerungsebene/steuern-regeln/artikel/93559/0/
- Wikipedia – https://en.wikipedia.org/wiki/Industry_4.0

Regardless of the effects, the sharing economy constantly forces actors into temporary business agreements. These agreements will need digital support to function, and when it comes to B2B, this support is crucial. Therefore, an eco-system like AEOLIX will be needed in order for the actors in the transportation industry to fully tap into the power of the sharing economy.

4.5.4   Sustainability[4]
Projected impact: Disruptive
Timeframe: Already here

Sustainability concerns has gained a considerable attention in the recent years due number of factors including abrupt changes in weather conditions, increase in population and demand of additional resources. This has clearly been reflected in various UN goals for sustainability especially goal 12 on 'Responsible Production and Consumption'. According to the UN goal 12 on sustainability 'Responsible Production and Consumption', we will be in need of three times of current resources by 2050.. Like other industries and business sectors, the sustainable production and transport of goods has been a key concern in logistics and supply chain.

The changes at global level have led our attitudes to think more about sustainability of products, we use. Many customers in developed countries are adopting sustainable way of transport and food. This, for example, can easily be observed by visiting a supermarket where the information about the environmental impact of various food products are described. Similarly, electric cars and alternative fuel options in the automotive sectors depicts the necessity to consider sustainability as a part of everyday practices. However, the adoption of sustainable products varies in different cultures across Europe and even regions within the same cultures. A recent study has also shown that the full-scale adoption of sustainable products is quite slow and can take up to 10 years (Akram et al., 2019). In this regard, different stakeholders within logistics can play crucial role in motivating people to adopt sustainable, and not only the government. What is needed most is – a comprehensive awareness and communication strategy on regional, national and international levels.

4.6   Reference Book Entries – Technologies

4.6.1   3D printing[5]
Projected impact: Disruptive
Timeframe: Already here

3D printing as part of 'additive manufacturing' describes various processes applied in the manufacturing of products by fusing materials layer by layer. The origin of these processes date back to the 80s were additive manufacturing was used for rapid prototyping in specialised industrial applications and work settings.

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[4] References:
https://www.un.org/sustainabledevelopment/sustainable-development-goals/
Akram, A., Chuanwen, D., and Arnäs, P-O. (2019) Will environmental friendly products be preffered? – Lessons from Delphi Study in Europe

[5] European Commission – Digital Transformation Monitor "The disruptive nature of 3D printing", 2017
https://ec.europa.eu/growth/tools-databases/dem/monitor/category/3d-printing
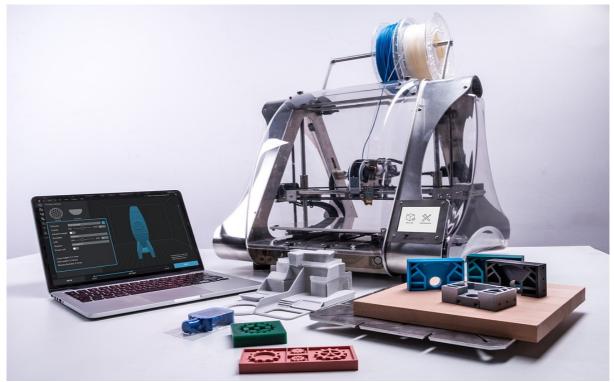https://cordis.europa.eu/project/rcn/104749/reporting/en

Figure 5 3D printer

Due to the enhanced ease of use and increased number of useable materials, 3D printing processes are introduced into many manufacturing settings. This opens up new ways in which products are designed, developed, manufactured and distributed. Opportunities are in the areas of product design and development, customization service and restructuring of supply chain for higher efficiency. As well as potential advantages in the areas of intricate product design with little additional costs, assembly certain pieces in a single run, enhanced flexibility and customization since each unit is built independently and cost-effective low volume production. Currently 3D printing is still mostly used for rapid prototyping, product customization, experimenting, product innovation and to a lesser extend for the creation of final parts due to relativlty low throughput and printing quality.

Additive manufacturing enables decentralised manufacturing of products and could therefore effect / reduce the length of transportation. Moreover, costs and time savings, improved responsiveness and flexibility, management of demand uncertainty and reduction of required inventory. This could lead to reduction of logistics costs and would influence the business models of logistics companies, which could turn warehouses into types of mini factories. At a later stage, probably distribution companies themselves would become factories. Therefore 3D printing may impact the location of plants and possible reshore effects by brining manufacturing back to western countries.

In 2013, the EU funded project Support Action for Standarisation in Additive Manufacturing (SASAM) delivered a roadmap for standardisation activities. 3D printing still brings lot of challenges, difficulties and open questions like the quality of the printed products; trade-off between printing speed and quality; legal barriers like patents, copyrights and trademarks; manufacturing of illegal objects; lack of expertise and accompanied education and learning to cover a wider range of the population.

4.6.2 Autonomous vehicles
Projected impact: Disruptive
Timeframe: Within 10 years

Automation of the operation of a vehicle is developing rapidly, especially in the passenger car segment, but also in heavier vehicles such as trucks, buses, trains and ships. There are several potential benefits with automation such as:

- More reliable – humans tend to cause errors
- Safer – humans are not very good drivers, especially when it comes to reaction time
- Cheaper – if a haulage company can remove the driver, a significant portion of the operating cost is eliminated. Also, an automated system can work longer time periods than humans.

Automation can be implemented gradually, often a 0-5 scale is used to classify the level (see table below, from Wikipedia).

SAE Level	Name	Narrative definition		Execution of steering and acceleration/ deceleration	Monitoring of driving environment	Fallback performance of dynamic driving task	System capability (driving modes)
Human driver monitors the driving environment							
0	No Automation	The full-time performance by the human driver of all aspects of the dynamic driving task, even when "enhanced by warning or intervention systems"		Human driver	Human driver	Human driver	n/a
1	Driver Assistance	The driving mode-specific execution by a driver assistance system of "either steering or acceleration/deceleration"	using information about the driving environment and with the expectation that the human driver performs all remaining aspects of the dynamic driving task	Human driver and system			Some driving modes
2	Partial Automation	The driving mode-specific execution by one or more driver assistance systems of *both steering and acceleration/deceleration*		System			
Automated driving system monitors the driving environment							
3	Conditional Automation	The driving mode-specific performance by an automated driving system of all aspects of the dynamic driving task	with the expectation that the *human driver will respond appropriately to a request to intervene*	System	System	Human driver	Some driving modes
4	High Automation		*even if a human driver does not respond appropriately to a request to intervene*			System	Many driving modes
5	Full Automation		*under all roadway and environmental conditions* that can be managed by a human driver				All driving modes

When it comes to commercial vehicles, there are currently (2019) a few pilots running. Notable mentions are Einride, Volvo Vera and Daimler Inspiration.

Einride[6] has developed the T-Pod, basically an AGV made for public roads. They aim at Level 4 where a remote control can take over when needed.

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[6] http://einride.tech/

Figure 6 The Einride T-Pod

Volvo has recently launched the Vera[7], an autonomous trailer tractor also Level 4.

Figure 7 Volvo Vera

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[7] https://www.volvotrucks.com/en-en/about-us/automation/vera.html

Daimler has developed the Inspiration truck where the driver can switch to autonomous mode.[8]

Figure 8 Daimler Inspiration

There is also an intense debate on the ethical aspects of the technology. Some issues that are discussed are:

- Loss of jobs – will autonomous cars and trucks put people out of work?
- Liability/responsibility – if an accident occurs, who is responsible?
- Will lowered cost lead to more transportation?

4.6.3 Artificial Intelligence[9]
Projected impact: Disruptive
Timeframe: Already here

The term Artificial Intelligence (AI) encompasses many meanings and definitions, ranging from popular culture to computer science. It is often described as an opposite to human, or natural, intelligence. Basically, AI is when a machine displays "cognitive functions" that are normally attributed

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[8] https://www.daimler.com/innovation/autonomous-driving/freightliner-inspiration-truck.html
[9] References and further reading:

- Otto uses AI to reduce returns in E-commerce - https://www.economist.com/business/2017/04/12/how-germanys-otto-uses-artificial-intelligence
- Einride uses AI to automate vehicles - http://einride.tech/
- Volvo and IBM implements predictive maintenance - https://www.ibm.com/case-studies/volvo-group
- 5 examples from Forbes - https://www.forbes.com/sites/blakemorgan/2018/09/17/5-examples-of-how-ai-can-be-used-across-the-supply-chain/#3e657444342e
- Elements of AI – a free online introductory course - https://www.elementsofai.com/
- A short explanatory text on AI - https://becominghuman.ai/ai-machine-learning-deep-learning-explained-in-5-minutes-b88b6ee65846

to humans such as problem solving and learning. Advances in the area are extremely high-paced and boundaries of what becomes possible are pushed constantly.

In logistics and supply chain management, several applications of AI are possible, such as:

- Route optimisation. Determine how to best apply resources (vehicles and load units) t0 solve a large transportation problem such as the distribution in a city.
- Stock management. Decide what to keep in stock and in what quantity in order to maximise service level and minimise cost.
- Resource allocation. Determine the optimal allocation of for instance production recources to meet demand.
- Forecasting. Predict future behaviour of customers and other actors in order to make informed decisions.
- Procurement. Determine what, how much and when to buy products/articles or services.
- Automation. Use AI to automate tasks, such as driving or loading/unloading.
- Smart maintenance. Determine when to exchange spare parts or when to best perform maintenance task.
- Smart brokering. Use AI to match supply and demand on a market, for instance freight exchange.
- Sales support/CRM. Use AI to individualise customer relationship management.

Common for all of the applications are that they require large amounts of data. Sensors are of course critical here as well as access to other types of (digital) data. Also, in order for an AI to learn it needs training, something that also needs large volumes of data.
AI or related technologies will play large roles in the transportation system of the future, and platforms like AEOLIX are crucial for the collection of data but also as vessels for the functionality that AI may bring.

4.6.4   Beacons
Projected impact: Moderate
Timeframe: Already here

Beacons are small Bluetooth-enabled transmitters that have gained some popularity recently. Basically, the beacon transmits a short-range signal with a specific data content such as a UUID (Universally Unique IDentifier) together with some data like a hyperlink.

Figure 9 Beacons

When a Bluetooth enabled device (a mobile phone for instance) gets in range of the beacon, the signal can be picked up and depending of the context, an app on the phone may recognize the UUID and trigger some action.

An example:
1. A truck approaches a port to pick up a container
2. A beacon that is placed 2 km from the port gate is recognized by the driver's mobile phone where a special app is installed
3. The beacon contains a hyperlink that is activated and directs the app on the phone to an online check in service. The app is preloaded with data regarding the shipment that is being picked up.
4. The check in is finished before the truck arrives at the gate
5. The truck is identified, perhaps by a new beacon at the gate that triggers a response from the app in the phone
6. Since the port has had advance warning, the stevedores have already found the container and are waiting for the truck just inside the gate

The case above does not need beacons *per se*, it can be realized by other means also. Often this means that systems need to be integrated or that expensive technology needs to be installed (such as OCR for license plates etc.). Beacons cost around €40, so with this solution a geo-fence that is scalable, easily implemented and prepared for ad hoc-usage is possible.

4.6.5   Blockchain[10]
Projected impact: Disruptive
Timeframe: Within 2 years

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[10] Read more:
https://www.ibm.com/blockchain/supply-chain/
https://www.coindesk.com/blockchains-will-turn-supply-chains-demand-chains/
https://www.logisticsbureau.com/how-blockchain-can-transform-the-supply-chain/

Blockchains are distributed ledgers that create a transparent, permanent, and tamper-proof record of transactions with digitalized asset representations. As a technology, the blockchain has a disruptive impact on supply chain management in three main ways:

- it enables transparency in immutable data records that are widely shared yet kept anonymous at the same time,
- smart contracts can reduce manual work, and
- it is a protocol for secure and trustless value exchange that enables interoperability and has the potential to disintermediate the supply chain.

These claims seem impressive, but how is it possible? A blockchain's technical features are the result of a unique combination of three domains of knowledge: cryptography, distributed networks, and game theory. Cryptographic hash functions secure an immutable trail of data records where it is possible to audit and trace material flows and responsibilities. Cryptography also ensures enables data to be publically shared yet intelligible only to the extent necessary and to those who need it. Distributed networks maintain this data state and ensure that there is not necessarily a central point of influence of failure. Game theory opens up for the ability to design human interaction in these distributed networks to an extent that was never possible before.

The specific way these three domains are combined varies between different blockchains and their suitability are highly context dependent. For instance, some blockchains rely on cryptography to obfuscate transactions, others do not. Some blockchains run on publically distributed networks without any central coordinating authority. Others run on consortium networks. Some run on private networks. Finally, some blockchains utilize mechanism design to incentive certain behaviours and punish others, other blockchains do not as they can rely on established legal systems. This variability between blockchains makes it very hard to clearly define what a blockchain actually is and what its properties are.

This lack of definitional clarity makes it hard to understand what a blockchain is by simply looking at one specific implementation. The technology allows for an amazing range of customization and offers the ability to design solutions according to preferences in data access and data availability. Although highly customizable, it is important to keep in mind that a blockchain is not some go to solution for distributed databases. The technology works best for situations characterized by low trust, where efficiency is reduced because of intermediaries, and/or where there is a need to establish an auditable trail of goods and material flows.

It is also important to recognize that the technology, disruptive as it may be, is still nascent and rapidly developing.

4.6.6   Electromobility
Projected impact: Moderate
Timeframe: Within 10 years

When transforming combustion based transportation to electric, there are a number of effects that can be observed. Even though passenger cars have been the first to go fully electric, we now see heavier vehicles entering the scene.

Needless to say, electricity as a power source for transportation is growing fast.

Figure 10 Charging station

Coupled with the development in propulsion, there is an equally complex and important development vector in energy supply. As the transportation market shifts from combustion to electric, we see a new supplier base emerging that threatens to oust the petroleum industry from the market – the electricity producers. With these new suppliers we will see new types of distribution. Electric highway is one such method, intermittent charging when idle/loading/unloading is another. Real estate companies need to accommodate the needs of this emerging fleet, grid providers need to ensure enough capacity and charging spots at the right locations.

Another area that is developing rapidly is of course battery technology. This is a critical component, especially when it comes to freight transport due to the weight of the vehicle needing much battery power, thus adding more weight.
Examples from industry
- Buses, both fully and partly electric (Volvo[11], Scania[12], numerous implementations in China[13])
- Semi-trailers (Tesla[14])
- Autonomous pods (Einride[15])
- Electric highways (in Sweden[16])
- Specialised vehicles (garbage trucks[17])
- Ships (China[18])
- Aircraft (drones[19] and heavier[20])

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[11] https://www.electricitygoteborg.se/en
[12] https://www.scania.com/group/en/scania-has-created-a-very-good-battery-bus/
[13] https://www.wri.org/blog/2018/04/how-did-shenzhen-china-build-world-s-largest-electric-bus-fleet
[14] https://www.tesla.com/semi
[15] http://www.einride.tech
[16] https://www.scania.com/group/en/worlds-first-electric-road-opens-in-sweden/
[17] https://electrek.co/2018/05/09/volvo-all-electric-garbage-truck/
[18] https://www.ndtv.com/world-news/china-launches-worlds-first-all-electric-ship-1775327
[19] https://www.globhe.com
[20] https://www.chalmers.se/en/departments/ims/centres-collaborations/electric%20aviation%20in%20Sweden/Pages/default.aspx

4.6.7 Intelligent Truck Parking (ITP)[21]
Projected impact: Moderate
Timeframe: Already here

Truck drivers in Europe often face the challenge of finding an appropriate parking facility and therefore frequently use unsafe and not secured parking areas (like e.g. hard shoulders) which brings high risks of accidents and potential thefts. Moreover, rules on working time and maximum driving times, breaks and minimum rest periods must be complied.

Figure 11 Intelligent truck parking. Image source/Copyright: ASFINAG

Therefore, one of the top priorities in the ITS Action Plan and the ITS Directive 2010/40/EU is to secure parking facilities for trucks and commercial vehicles. Truck drivers in Europe need to have suitable information on safe and secure parking places. The revised 2013 TEN-T guidelines aim to develop appropriate safe and secure parking areas on the road transport infrastructure of the core network every 100km.

The European Commission adopted specifications (delegated Regulation (EU) N°. 885/2013) in order to facilitate the support the exchange of data and to ensure EU-wide accessible information providing an up-to-date inventory of safe and secure parking spaces for trucks along the main European transport corridors to enable the provision of services.

In recent years and at present various EU funded projects (Connected Europe Facility) address the deployment of Intelligent Truck Parking (among other things), like e.g. CROCODILE or URSA MAJOR. There are various efforts to find the ideal combination of technology (like e.g. RF, microwave, laser, infrared, ultrasonic, camera, Inductive loops, piezo detectors …) for parking spots occupancy, entrance and exit detection on different demonstration sites within Europe. Other topics

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[21] Further reading:
https://crocodile.its-platform.eu
https://ursamajor.its-platform.eu
https://ec.europa.eu/transport/themes/its/road/action_plan/intelligent-truck-parking_en
http://open-data.europa.eu/en/data/dataset/etpa

are the continuous calibration (auto) process, quality criteria and, of course, the exchange of data to ensure EU-wide accessible information.

The implementation status varies in the different member states and the current deployment is manifold. From manual updating (i.e. staff monitors and updates the occupancy of the parking facilities on the motorways and the information is provided via overhead signs, updated notification boards along the routes as well as in addition, on website, app and webcams) to (semi-)automatic approaches via e.g. camera technology.

In the delegated Regulation (EU) No 885/2013 it is foreseen that public or private parking operators and service providers shall share and exchange data related to safe and secure parking areas through a national or international access point. Therefore, the European Commission provides a European Access Point for Truck Parking Data to enable continuity of services throughout the EU, based on DATEX II format. Currently only static data is supported by the Access Point and each member state is responsible for updates, maintenance and data quality.

4.6.8   Internet of things
Projected impact: High
Timeframe: Already here
Consumer preferences and technological breakthroughs add up to a fundamental shift in the future mobility behaviour in the transport and logistics.

Good and services are increasingly delivered to consumers. As consequence, the traditional business model of transport and logistics will be completed by a range of diverse IT solutions. The connection of vehicles to the Internet offers new possibilities and applications which bring new functionalities to the logistics companies that will make the transport easier and safer. New mobile ecosystem based on trust, security and convenience to mobile/contactless services and transportation applications are created and the developments such as Internet of Vehicles are connected with Internet of Energy for providing services in an increasingly electrified mobility industry.

In the same time representing human behaviour in the design, development and operation of cyber-physical systems in autonomous vehicles is a challenge. Incorporating human-in-the-loop considerations is critical to safety, dependability and predictability. There is currently limited understanding of how driver behaviour will be affected by adaptive traffic control cyber-physical systems.

Self-driving vehicles today are evolving and the vehicles are equipped with technology that can be used to help understand the environment around them by detecting pedestrians, traffic lights, collisions, drowsy drivers and road lane markings. Those tasks initially are more the sort of thing that would help a driver in unusual circumstances rather than take over full time.
Technical elements of such systems are smart vehicle on-board units which acquire information on board systems (e.g. vehicle status, position, energy, usage profile, driving profile). They interact with external systems (e.g. traffic control systems, parking management, vehicle sharing management, electric vehicle charging infrastructure).

The parallel emergence of the megatrends in the last 2 years mobility, such as automated driving and digital experience and electrification will trigger many changes in the logistics and transport domain in the next 10 to 15 years, the logistics and transport domain will be effectively reshaped.
In reality the reshaped logistics and transport domain will trigger the replacing of the sensory functions of the drivers with technology such as:

From	To
manual driving	autonomous driving
decision making capabilities	machine learning algorithms
memory	maps/environmental models
eyes	sensors
ears	vehicle to X communication (vehicle, infrastructure, machine)
reflexes/coordination of movement	actuator control

In the field of connected autonomous vehicles for logistics IoT and sensing technology replace human senses and advances are needed in many areas such as:

- vehicle's location and environment: as there would no longer be active human input for vehicle functions, highly precise and real-time information of a vehicle's location and its surrounding environment will be required (e.g. road signs, pedestrian traffic, curbs, obstacles, traffic rules).
- prediction and decision algorithms: advanced concepts based on Artificial neural Networks (unsupervised/deep learning, machine learning) will be needed to create systems to detect, predict and react to the behaviour of other road users, including other vehicles, pedestrians and animals.
- high accuracy, real time maps: detailed and complete maps must be available to provide additional and redundant information for the environmental models that vehicles will use for path and trajectory planning.
- vehicle driver interface: a self-adapting interface with smooth transition of control to/from the driver, mechanisms to keep the driver alert and a flawless ride experience will be instrumental in winning consumer confidence.

Successful deployment of safe and autonomous vehicles (SAE international level 5, full automation) in different use case scenarios using local and distributed information and intelligence is based on real-time reliable platforms managing mixed mission and safety critical vehicle services, advanced sensors/actuators, navigation and cognitive decision-making technology, interconnectivity between vehicles (V2V) and vehicle to infrastructure (V2I) communication. Level 5: Full Automation means the automated system can perform all driving tasks under all conditions that a human driver could perform them compared to the Level 4: High Automation, where an automated system can conduct the driving task and monitor the driving environment, and the human need not take back control, but the automated system can operate only in certain environments and under certain conditions.
In particular, with regards to the high density truck platooning for logistics and transport domain, there is a need for ultra-reliable, low latency V2V safety-relevant communication between the platoon leader and the following trucks in the platoon. There is certainly a need for critical adaptations on side of the trucks, as well as a need for the establishment of close cooperation between the mobile network operators and the truck industry in order to guarantee the requested minimum service level agreements (SLA) for the truck platooning to take place.

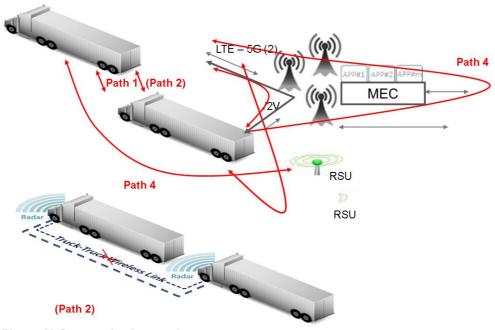Such a communication environment is depicted in the next figure.

Figure 12 Communication. environment

In order to be implemented such autonomous vehicle in logistics and transport domain, to evaluate and demonstrate dependability, robustness and resilience of the technology over longer period of time and under a larger variety of conditions, there is a huge need to demonstrate in real-life environments (e.g. highways, congested urban environment and/or dedicated lanes), mixing autonomous connected vehicles and legacy vehicles the functionalities.

The evolutions in the global automotive industry are influencing the logistics and transport industry through different factors that are driving the change in the automotive ecosystem, the move to new business models such as mobility-as-a-service, logistics-as-a-service and the best conditions and the technologies that are supporting the digital transformation.

Nevertheless, there is a need to clarify the business use cases in truck automation on both the private and public sector sides. Standards are needed to support interoperability of trucks that are coupled into platoons and standard methods need to be developed and adopted for measuring the energy savings that can be gained from truck platooning.

4.6.9 Quantum computing[22]
Projected impact: Disruptive
Timeframe: Within 10 years

Quantum computing was envisioned, in the 1980s, as a new way to process information by using quantum-superposition states – the strange properties of quantum particles allowing them to occupy multiple positions at the same time. Exploiting this, a new branch of applied mathematics emerged – quantum information science (https://en.wikipedia.org/wiki/Quantum_computing).
Whereas a conventional (classical) algorithm works by manipulating data bits (0 or 1), a quantum algorithm is a sequence of operations on quantum bits (qubits) in quantum superposition of 0 and 1. This "quantum parallelism" enables new ways of processing information which are impossible on a classical computer.[23]

Many large problems relevant to transportation and supply chain management – such as finding the optimal route or resource allocation – are computationally hard and require significant computer resources; they can even be impossible to solve within a realistic time on an ordinary, classical computer.

Instead, some hard problems can be mapped onto a mathematical expression describing the energy of a system of coupled qubits. The solution of the optimization problem is then given by the minimum-energy configuration of the qubits. One can build a quantum computer adapted to this type of problem and devise quantum algorithms to solve them. There is widespread belief in the quantum information science community that quantum algorithms can solve such problems efficiently, whereas a conventional computer algorithm cannot; this is sometimes called "quantum supremacy."

Quantum computer technology is currently a very active research field worldwide, including academic groups, institutes, large companies, and venture-backed start-ups. There are still many hurdles on the road to constructing a practically useful quantum computer. Most significantly, there is need for research into better, scalable quantum hardware, which is prone to errors because of the very nature of the fragile quantum states of the qubits, and ways to operate quantum processors in the presence of errors. Also important are the development of software for the quantum computer as well as relevant use cases, for example within the transportation industry.

Chalmers hosts a big research effort in quantum computing within WACQT, the Wallenberg Centre for Quantum Technology, and through the project OpenSuperQ within the EU Flagship on Quantum

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[22] Further reading and references:
www.wacqt.se
www.opensuperq.eu
https://www.technologyreview.com/s/612844/what-is-quantum-computing/
https://quantumcomputingreport.com/our-take/the-best-applications-for-quantum-computing/
[23] Here, quantum computing is explained by IBM: https://youtu.be/OWJCfOvochA

Technology. Their quantum hardware is state of the art and they aim to build a Swedish quantum computer. As an industry partner of WACQT, the company Jeppesen (a subsidiary of Boeing specialized in flight crew scheduling) is actively participating with one industrial PhD student contributing to the development of quantum computing use cases relevant to optimization within logistics.

In industry, the technology is starting to be exploited. For instance Volkswagen is using quantum computing to forecast traffic volumes (https://www.volkswagen-newsroom.com/en/press-releases/volkswagen-ensures-intelligent-traffic-management-with-quantum-computers-4347).

4.7 Reference Book entries - practices

4.7.1 The FOT Methodology Adapted to Living Labs
Projected impact: Moderate
Timeframe: Already here

The (Field Operational Test) FOT methodology of FESTA, must be adapted to freight transportation to clarify the different steps in the evaluation process. The evaluation approach must also consider that the AEOLIX functions and their impacts to be evaluated take place in a context which is the Living Labs. The co-creation element of living labs will put forward one stage in the FOT Methodology that is seldom highlighted, i.e. the iteration to be in play when use cases, hypotheses and PIs are determined. N.B. The iteration is omitted in the "FESTA V" (see figure) for reasons of clarity of all the other steps in the process.

A FOT is defined (FESTA 2016)[24] as a study undertaken to evaluate a function, or functions, under normal operating conditions in road traffic environments typically encountered by the participants using study design to identify real-world effects and benefits.

However, the overall approach used is the Field Operational Test Support Action (FESTA) methodology, must be tailored to the needs of AEOLIX as AEOLIX is not specifically related to the road traffic environment. The AEOLIX evaluation framework follows the procedures outlined in the FESTA handbook. The sequence of activities for the FESTA evaluation methodology is shown in the figure below.
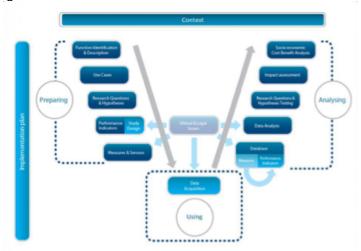

Figure 13 FESTA methodology for AEOLIX evaluation – The FESTA V. (FESTA 2016)

A horizontal bar on top of the diagram summarises in principle the context in which the FOT is supposed to take place. For instance, the choice of a function to be tested implies that there is either a problem to be addressed and that the chosen function is defined to solve the problem, or that a policy objective is stated and that the function tested can be used to reach the objective. An FOT can

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[24] FESTA Consortium 2016: FESTA Handbook, version 6

always be related to a wider perspective than is defined by just a description of the function to be tested.

The first step in the FESTA V is the identification of functions to be tested. Sometimes this may not be the best step to start with. When there is a large set of functions available from which a few need to be selected as candidates for testing, definition of the research questions may help the selection process. For example, a FOT may not be driven by the technical systems that need to be tested but by a research question or an impact area.

The next step is to state the situation in which the function/functions will be used, i.e. use cases should be identified. Each use case will explain how the function is used and what the expected effect will be. That will be the starting point in stating the research questions to be addressed and the related hypotheses to be tested. This will in turn lead to the identification of suitable (but ideal) performance indicators. To grasp the possibility to identify a baseline scenario for each impact area, models must be developed that make it possible to compare the different stages (e.g. before and after) in the evaluation process.

There will be several logistics services/functions with potential improvements through the implementation of the Living Labs. Each Living Lab may implement more than one logistics service/function. Each Living Lab's actors should focus on different logistics services/functions according to their needs and fields of expertise (Terminal Operators, Logistics service providers, Technological companies). The evaluation framework is built to determine whether and to what extent user needs and requirements have been addressed by the services offered by the AEOLIX platform.

4.7.2   Horizontal Collaboration[25]
Projected impact: Moderate
Timeframe: Already here

Collaboration has long been regarded as one of the intelligent features of human beings to increase efficiency and capability. Participants joining the collaboration can benefit from each other and achieve goals that are hard for any single individual to reach. We might have had the experience to share a car with others for the sake of less gasoline or simply as a nice treat to friends. The collaboration among passengers not only benefits themselves but also contributes to the local economy in economic and environmental terms.

Similar collaborations happen in freight transport. Two or more shippers bundle their freight and jointly load transport vehicles. This process is defined as horizontal collaboration. The word horizontal means that actors on the same level of the supply chain, in this example, all shippers, are forming the team (European Union, 2001). It distinguishes from vertical collaboration, in which actors from different levels of the supply chain, e.g., a shipper and a carrier, team up.

There are advantages of horizontal collaboration. Shippers could consolidate their freight for large shipment loads, which encourages scale economics. For example, rail transport generally incurs lower unit transport cost and discharges less unit greenhouse gas emission, but it exhibits economies of scale. A single shipper might not have sufficient volume, but multiple shippers could accumulate their freight and trigger the scale of rail transport. Besides the scaling effect, horizontal collaboration could foster more stable flows and therefore a better utilization of the vehicles' capacity. For example, when a shipper had a slump in its volume, the others might still have sufficient freight to maintain

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[25] References:
- Doherty, S. and Hoyle, S. Supply chain decarbonisation: The role of logistics and transport in reducing supply chain carbon emissions. Logistics and transport partnership programme,
- World Economic Forum, Geneva, Switzerland, January 2009.
- European Union, 2001. Commission notice: guidelines on the applicability of Article 81 of the EC Treaty to horizontal cooperation agreements (2001/C 3/02).
- European Commission, 2012. Measuring road congestion. URL ttp://ftp.jrc.es/EURdoc/JRC69961.pdf.
- World Economic Forum, 2016. Digital Transformation of Industries: In collaboration with Accenture White paper.

adequate capacity utilization of the vehicles. If the total freight volume in the market is unchanged, a higher capacity utilization will lead to less number of vehicles and consequently, savings in money and emissions.

There is a mounting body of research justifying that horizontal collaboration is critical to maintaining logistics industry and our society sustainable. Despite the increasing freight flow, the road transport network is already over-utilized, and there is too much traffic in cities. European Commission (2012) finds that the total monetary cost of congestion mounts up to 134.3 billion euro in 2012, which is equivalent to about one percent of the total GDP of EU-28. On the other hand, however, trucks travel up to half of their return trips empty (World Economic Forum, 2016), and the loaded trucks are typically only using 57% of their maximum gross weight (Doherty and Hoyle, 2009). If shippers could collaborate and load trucks together, the number of truckss will be reduced.

However, though horizontal collaboration is generally regarded as a good practice, it remains difficult to implement. There are in general two types of barriers, the technical barrier, and the trust barrier. From the technical side, a standardized, cloud-based logistics ecosystem is required so that shippers could participate and seek for collaboration opportunities in it. AEOLIX is such an ecosystem. It allows stakeholders with different background to share freight flow information and enhance collaboration. Even an advanced platform such as AEOLIX will not be able to solve all the problems. Compared to the technical issues, the mindset of people is, to some extent, a bigger barrier. Are firms willing to collaborate with others? Are they keeping their freight flow data as confidential as their core IPs, or they can share that for collaboration purpose? Or, is a third-party required as a trustee so that competing firms could load trucks together via it? Via the implementation of AEOLIX, these questions will be answered.

4.7.3 Living Labs and Freight Transportation[26]
Projected impact: High
Timeframe: Already here

The European Network of Living Labs (ENoLL) defines Living Labs as a user-centred, open innovation ecosystems, based on a systematic user co-creation approach integrating research and innovation processes in real life communities and settings. The focus of the Living Lab concept is not only in the development process, but also enhances the interaction between all participating stakeholders such as research organisations, public partners, SMEs, private companies or ICT professionals. In fact, the participation of all the involved stakeholders is of vital importance to operate a Living Lab successfully (de Vries, et al 2017). This methodology of stakeholders' integration can

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[26] References:
- de Jong, G., Tavasszy, L., Bates, J., Grønland, S. E., Huber, S., Kleven, O. (2016). The issues in modelling freight transport at the national level. Case Studies on Transport Policy, 4(1), 13-21. Wiley, New York.
- de Vries L., S. Franzén (2017): Living Labs: a forum for enabling co-creation between multi-disciplinary actors in the workplace? NES 2017 Conference proceedings.
- Feurstein, K., Hesmer, A., Hribernik, K.A., Thoben, K.D. & Schumacher, J., 2008, 'Living Labs – A New Development Strategy', in J. Schumacher, European Living Labs: A New Approach for Human Centric Regional Innovation, pp. 1-14, Wissenschaftlicher Verlag, Berlin.
- Leminen, S. (2013). Coordination and Participation in Living Lab Networks. Technology Innovation Management Review, 3(11), 5-14.
- Leminen, S. (2015). Q&A. What Are Living Labs? Technology Innovation Management Review, 5(9), 29-35.
- Leminen, S., Westerlund, M. and Nyström, A.-G. (2012). Living Labs as Open-Innovation Networks. Technology Innovation Management Review, 2(9), 6-11.
- Nyström, A.-G., Leminen, S., Westerlund, M. and Kortelainen, M. (2014). Actor roles and role patterns influencing innovation in living labs. Industrial Marketing Management, 43(3), 483-495.
- Quak, H., Lindholm, M., Tavasszy, L. and Browne, M. (2016). From Freight Partnerships to City Logistics Living Labs – Giving Meaning to the Elusive Concept of Living Labs. Transportation Research Procedia, 12, 461-473.

reduce risks in the development process of a new product, service or application. Open and unlimited cooperation among suppliers and potential customers is crucial including SMEs and larger firms. The service development and the evaluation process of a Living Lab in a multi-contextual sphere instead of the traditional user-centric methodologies, constitute the core advantage of the concept. The novel aspect of the Living Lab approach is the evaluation in the daily life environment and the fact that all users are involved in all stages of the product lifecycle. As mentioned above, the Living Lab concept is primarily characterized by the fact that every stakeholder can take part in the development process of an innovative product or a service. Therefore, the researchers should use methods that allow interaction or co-creative approach between the potential consumer and the researcher during the whole development process (Feurstein et al., 2008).

For example, Living Labs claim to be a new way of working collaboratively between multi-disciplinary actors in real-life settings, which is different from test beds, demonstrators and so on (Leminen, 2015). One distinguishing feature is the awareness of users that they are actively involved as a partner throughout a co-creation process, rather than as an informant or participant at discrete stages of the development process This user awareness and co-creative focus distinguishes Living Labs from similar approaches within the areas of user-/human-centred or participatory design and from traditional research and innovation projects (Leminen, 2015).

Leminen et al. (2012) do not define a 'best practice', but instead provide a framework for 'choosing' a Living Lab type based on the purpose and outcomes one wishes to achieve, and the typical organisational form, available actions and expected lifespan. Four main actor roles (user, utiliser, enabler, provider) are usually present in all Living Labs, but the type will be determined by which party is the driving force, and the coordination (top-down or bottom-up) and participation approach used (Leminen, 2013. According to Leminen et al. (2012) the Living Labs are either enabler-driven (a funder or public authority); provider-driven (a university or consultant) or; user-driven (by users or communities of users). A user-driven Lab (i.e. not led by ICT service providers, politicians, public authorities, or arguably researchers) which engages the active, long-term participation of users has the greatest chance of success.

Nyström et al. (2014) further characterise the roles that users may take in Living Labs, namely as informant, tester, contributor or co-creator. Even if there are numerous existing methodologies, under the umbrella of user-centred or participatory design, where the user's role is that of informant, tester or contributor) the involvement of the aware user as co-creator may be an indicator of a 'best practice' Living Lab.

Freight transportation may be viewed as a complex sociotechnical system, consisting a network of multi-disciplinary actors, and involving vehicle technology, ICT applications, regulation, user practices and markets, several special networks, such as infrastructure, supply and demand, and maintenance. Quak et al. (2016) consider freight partnerships the current best practice within freight transportation: freight partnerships provide a forum for knowledge sharing, discussion and collaboration between local public and private stakeholders, but seldom lead to tangible outcomes.
They argue that Living Labs may go beyond freight partnerships by enabling action and focusing on the implementation of solutions in their real environment. de Jong et al. (2016) emphasise that, due to the systemic nature of freight transportation, one should consider both its high-level strategic characteristics and lower-level tactical and operational aspects, which occur in the workplace and are often overlooked; these become visible and may thus be communicated between actors in Living Lab-style settings.

The complex socio-technical system a logistics supply chain constitutes is not easily addressed as the human beings involved have an agenda of their own in order to complete the tasks at hand. It is important that all relevant actors involved in the Living Lab to be studied has a good understanding of all the information flows made available as well as other actors on the scene.

4.7.4   Off-peak delivery
Projected impact: Low
Timeframe: Within 5 years

To avoid congestion in urban environments, deliveries can be planned for periods with lower traffic volumes, so called "off-peak" or "out-of-hours" delivery. The basic premise is that deliveries are done outside of normal business hours, often in the night or early morning. For the haulage company this increases productivity since less time will be spent queueing thereby freeing up resources for productive work instead.

When doing off-peak deliveries, there are some considerations that need to be made:
- Reduce noise level. The normal handling of goods and equipment is often quite noisy, something that must be handled when delivering 24/7. Special wheels on forklifts, electric engines instead of combustion and low noise hydraulics are all important.
- Increased personnel costs per truck. The driver who is working off-peak normally gets paid more than a daytime driver. However, since productivity may increase (each driver will be able to service more stops), the total cost may still be reduced.
- Demands for consignee to invest in equipment to handle unmanned reception of goods. Normally, the consignee will not be present during the delivery. Therefore, there is a need for unattended reception of goods where risk of pilfering, vandalism etc. is reduced. This reception may very well be technological but can also be outsourced to actors that are available at the time of delivery to act as proxy consignee.

Some examples from Stockholm[27] and New York[28].

4.7.5 Servitization
Projected impact: Moderate
Timeframe: Already here

In supply chains, value of goods and products increase as they approach the final consumer. Servitization is when a company combines a product with bundled services to create a more comprehensive offering to the market. It can take several forms, from added services like installation at delivery or recycling of old products to complete functional responisbility where the customer pays for usage instead of for the product. In a film from The Advanced Services Group servitization is explained[29].

In the domain of freight transportation, the effects of servitization can be noticed in several ways.
- The Transportation company´s supply of transport services, some signs of servitization:
    - Sharing operational information like ETA, goods state, emissions etc.
    - Sharing tactical information like plans, schedules etc.
    - Sharing strategic information like market projections, planned offerings (e.g. new shipping lines) etc.
    - Bundled services like installation, waste removal, packaging removal, education in usage, sorting, kitting, returns handling etc.
- The Transportation company´s demand for vehicles and resources etc., some signs of servitization:
    - "Power-by-the-hour" – Instead of buying the truck, the haulier pays for uptime[30]
    - Usage of 3:rd party logistics services to rent storage space etc.
    - Usage of matchmaking services to outsource some of the planning activities
- The Manufacturing company, some signs of servitization:
    - Selling functions instead of products, e.g. a customer paying for printed copies instead of the copying machine.
    - Adding aftermarket services like periodic maintenance or product support etc.
    - Selling subscriptions instead of products like cloud based hosting service that charges by month

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[27] Off peak in Stockholm: https://www.kth.se/en/forskning/artiklar/switching-to-off-peak-delivery-times-reduced-city-congestion-1.730783
[28] Off peak in New York: https://www1.nyc.gov/html/dot/html/motorist/offhoursdelivery.shtml
[29] Servitization explained: https://youtu.be/i9VBS8D56Gk
[30] Power by the hour at Rolls Royce: https://youtu.be/XfoQaaYofcI

Supply chains containing bundled services or subscription type models are more complex than the traditional, clear-cut customer-supplier relationships. A manufacturer might well be the owner of the product that is shipped, long after the physical delivery, for instance.

For the domain of AEOLIX, servitization brings increased demands on trusted data sharing, preferably in real-time as well as increased complexity in designing interoperability platforms.

5 Conclusion

This deliverable is a documentation of an existing webpage. To best experience the content, it is recommended to visit reference.aeolix.eu where references and supplementary material are included.