DRAFT TECHNOLOGY SOLUTIONS

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MOVE21 – Multimodal and interconnected hubs for freight and passenger transport contributing to a zero emission 21st century

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Project Executive Summary

The main objective of MOVE 21 is to transform European cities and functional urban areas into climate neutral, connected multimodal urban nodes for smart and clean mobility and logistics. MOVE21 will do this through an integrated approach in which all urban systems are connected, and which addresses both goods and passenger transport together. As a result, MOVE21 will improve efficiency, capacity utilisation, accessibility and innovation capacity in urban nodes and functional urban areas.

The integrated approach in MOVE21 ensures that potential negative effects from applying zero emission solutions in one domain are not transferred to other domains but are instead mitigated. It also ensures that European transport systems will become more resilient. Central to the integrated approach of MOVE21 are three Living Labs in Oslo, Gothenburg, and Hamburg and three replicator cities Munich, Bologna and Rome. In these, different types of mobility hubs and associated innovations are tested and means to overcome barriers for clean and smart mobility are deployed. The Living Labs are based on an open innovation model with quadruple helix partners. The co creation processes are supported by coherent policy measures and by increasing innovation capacity in city governments and local ecosystems. The proposed solutions deliver new, close to market ready solutions that have been proven to work in different regulatory and governance settings. The Living Labs are designed to outlast MOVE21 by applying a self-sustaining partnership model.

MOVE21 partners

The MOVE21 consortium consists of 24 partners from seven different European countries, representing local city authorities, regional authorities, technology and service providers, public transport companies, SMEs, research institutions, universities, and network organisations.

- **Norway**: City of Oslo, Viken County, Ruter, Urban Sharing, MIXMOVE, Institute of Transport Economics, IKT-Norge
- **Sweden**: City of Gothenburg, Rise Research Institutes of Sweden, Business Region Gothenburg, Volvo Technology, Renova, Parkering Göteborg
- **Germany**: City of Hamburg, City of Munich, Hafencity University Hamburg, Deutsche Bahn Station & Service
- **Italy**: Metropolitan City of Bologna, Roma Servizi per la Mobilità, Roma Tre University
- **Belgium**: Eurocities, Polis
- **The Netherlands**: TNO
- **Greece**: Hellas Centre for Technology and Research

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Deliverable executive summary

MOVE21 is about making the best possible use of transportation resources, and the key technological focus in MOVE21 is to support the following:

- Make the combination of public transportation and on-demand services more attractive for travellers than the use of private cars
- Make the best possible use of transportation resources used for transporting goods

The term technology in MOVE21 is orientated towards information systems enabling management of transport and logistics operations. MOVE21 will not engage in vehicle technologies and traffic management.

Samples of information system technologies that are relevant for MOVE21 are applications and solutions that are used:

- By people when travelling, enabling booking and payment, travel information, etc.
- For booking freight transport and monitoring operations
- For transportation management used by those who are providing the transportation (mobility) services, scheduled and non-scheduled
- For cargo consolidation/reconstruction in hubs
- To perform traffic management

The key purpose of technology development in MOVE21 is targeted to support the Living Labs in Oslo, Gothenburg and Hamburg, and later possible replications in Munich, Bologna and Rome. The Living Lab activities are still being defined. Hence, the technologies needed for supporting these activities will be identified in line with Living Lab developments.

Key words

Urban distribution of people and freight,
Transportation Management Systems
Technology integration

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1 List of abbreviations and acronyms

Acronym	Meaning
1D	One-dimensional
2D	Two-dimensional
API	Application Programming Interface
ARKTRANS	Multimodal ITS framework architecture
B2B	Business-to-business
B2C	Business-to-Consumer
CEN	The European Committee for Standardization
DTLF	Digital Transport and Logistics Forum
EC	European Commission
EDI	Electronic Data Interchange
ID	Identity
ISO/IEC	International Standards Organisation on information systems
MaaS	Mobility-as-a-Service
MDS	Mobility on-demand service for seniors
MoD	Mobility on demand
TEN-T	Trans-European Network for Transport
TMS	Transport Management System
WP	Work Package
ZEZ	Zero Emission Zone

2 Purpose of the deliverable

The Living Labs in Oslo, Gothenburg, and Hamburg need access to and application of technologies for implementing new capabilities in urban distribution of people and freight in order to support non-technical innovations.

This document outlines detailed ambitions for the project in general terms and the types of technologies that need to be applied and integrated for achieving this.

2.1 Attainment of the objectives and explanation of deviations

The deliverable has been produced according to plan.

2.2 Intended audience

The key audience for this deliverable is the Living Lab participants.

2.3 Structure of the deliverable and links with other work packages/deliverables

The document presents the overall goals of the project and how they are being applied in Work Package 5. The core of MOVE21 is mobility hubs and different types of hubs are presented with a set of amenities that may be associated with each mobility hub type. Sample technology types needed to support the objectives are shortly described, and the need for them to be integrated.

The document also shortly describes the status for the Living Labs in Oslo, Gothenburg and Hamburg and the technology requirements derived from these.

3 Introduction

3.1 Objectives

Related to technologies and integration of technologies, two issues in the objective statement of MOVE21 are relevant for this deliverable:

- An integrated approach in which all urban systems are connected
- Addressing both goods and passenger transport together

The term “all urban systems” in the statement above refers in MOVE21 to all systems related to mobility of people and goods. Furthermore, the technologies that are within the scope of this deliverable is limited to information and communication systems.

Urban nodes in the TEN-T core network are illustrated in Figure 1. The EU is currently revising the TEN-T regulation, and the number of nodes is expected to grow from 88 (figure 1) to 424 nodes.

Figure 1. Urban nodes in the core TEN-T Network

One of the specific objectives of MOVE21 is to "*Test, deploy, replicate, and upscale zero emission solutions through co-creation in urban nodes and functional urban areas in the TEN-T Scan-Med corridor. MOVE21 does this by co-creating new mobility solutions with quadruple helix partners (public authorities, researchers, businesses, citizens) in a dynamic open innovation process resulting in:*

- *Different types of zero emission mobility hubs employing neutral business services including integrated energy storage and recharging opportunities*
- *Integrated transport services (includes all surface modes) and technological integration for combining services from public and private transport service providers*

In MOVE21, three cities in the Scan-Med corridor are involved as Living Lab cities: Oslo, Gothenburg, and Hamburg. In addition, the solutions that are developed in these living labs will be replicated in Munich, Bologna, and Rome.

In MOVE21 the term "clean" has two meanings:

1. Zero emission mobility – which means that all transportation resources are emission free. Emission free means that they are not emitting greenhouse gases in the local environment in which they operate.
2. Minimum use of energy – to ensure that emissions are also kept to a minimum where energy is generated.

3.2 Zero Emission Mobility

From a technological point of view, zero emission mobility is easy to achieve. It is about the vehicles and the regulation and policies to inspire or enforce the use of emission-free vehicles.

For example, Oslo has already included terms and condition that requires use of zero emission vehicles for last mile transport of all goods procured by the municipality, and this requirement has already been implemented by the suppliers and their logistics service providers. In one of the Living Lab activities in Oslo, implementation of a zero-emission zone is to be tested. One way of enforcing this is to apply the same technology as is used on toll-roads, where either tags or vehicle IDs are scanned and those vehicles that are not allowed will be fined.

At least initially, MOVE21 technology related activities will not be directed to such zero emission mobility issues.

3.3 Minimising use of Energy

In the "Climate Strategy for Oslo towards 2030", the City of Oslo has the following ambitions for 2030:

- Reduce greenhouse gas emissions by 95 per cent compared with 2009
- Reduce traffic by one-third compared with 2015

To reduce traffic, we need to transport more with less resources, which also leads to moving people and freight with less use of energy. This means that we need to make sure that all transportation resources (see Figure 2) are utilised as much as possible.

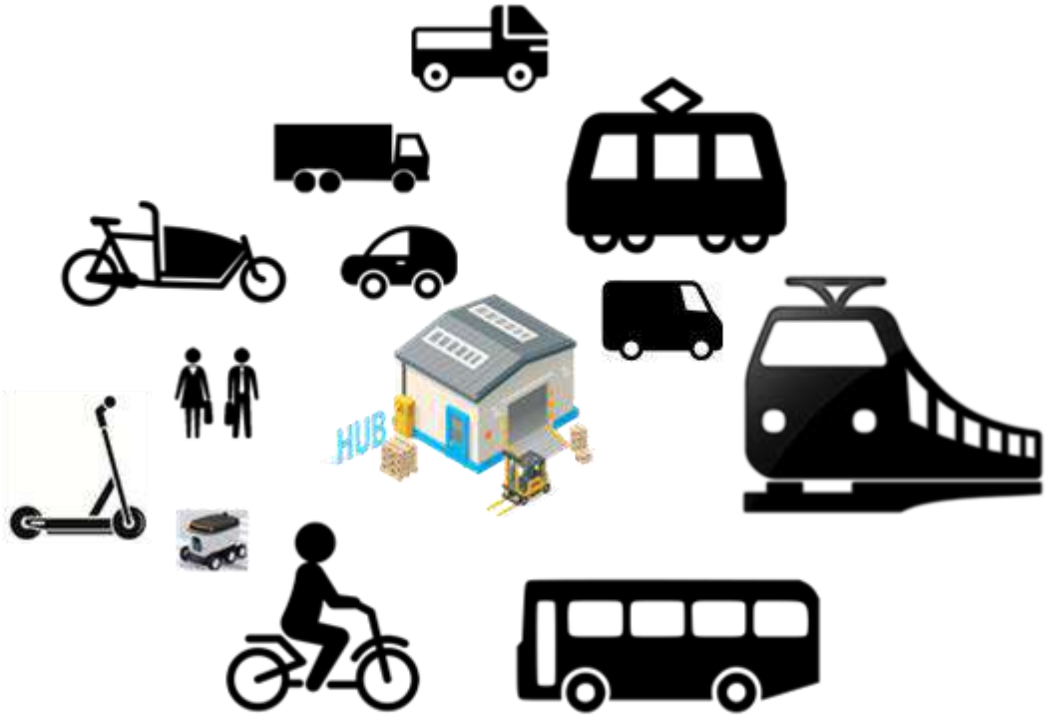

Figure 2. MOVE21 will make smart use of all transport modes, alone or in combination.

It further requires that people and freight need to use the same transportation resources, when possible. One practical implication of this is that buses, trams, trains, etc., both scheduled and non-scheduled, that normally move people should be used to move cargo, at least outside peak hours, when freight may reduce the capacity for moving people.

One immediate implication of a strategy of making the best possible use of resources is that direct transport from origin to destination should become the exception and not the rule. Direct transport of people and freight from origin to destination makes it impossible to utilise transportation resources in the best possible way. The extreme is one person in a car, or one parcel brought in a vehicle. Consolidation, bringing as many people in vehicles and as much cargo as possible, requires an infrastructure that includes consolidation/transhipment points, i.e., mobility points or hubs.

It is also important that as many travellers as possible use public transportation. Hence, it is necessary to provide technologies that make it as easy as possible for people to arrange door-to-door transport which also involve public transportation services. This will require integration of ticketing (booking) solutions, enabling smooth transition across transport modes (scheduled and non-scheduled) through one single interface.

4 Mobility Hubs

4.1 Introduction

4.1.1 Inspiration

In the process of understanding the concept of a mobility hub, The Hamburg Living Lab prepared the illustration in
Figure 3, illustrating that a mobility hub may be much more than just providing transhipment between transportation services.

This illustration inspired a literature search to investigate the possibility of providing a systematic description of hubs and their functions and services.

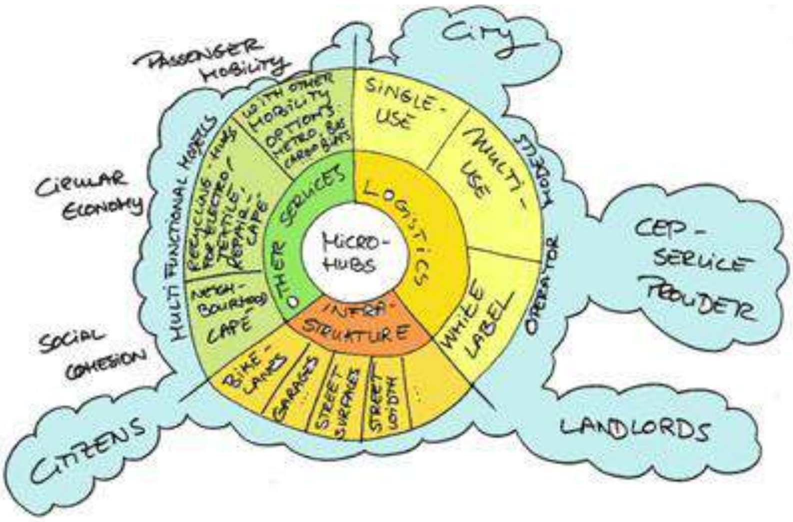

Figure 3. The concept of Micro-Hub in Hamburg

4.1.2 Basics

A transport hub is a place where passengers and cargo are exchanged between vehicles and/or between transport modes.

- Public transport hubs include train stations, rapid transit stations, bus stops, tram stops, airports and ferry slips
- Freight hubs include classification yards, airports, seaports, and truck terminals
- For private transport by car, bicycle, etc., parking areas function as hubs

A hub may also combine all of the above. Hubs may be permanent or movable (particularly for freight). The latter uses space in cities when it is not used for other activities.

For public transport, the concept of a transportation network with multiple, connected mobility points is well known and applied. The people utilising this network typically have the possibility, at each mobility point to decide onward transportation from it – a person may stay on or change vehicle or mode of transport, if relevant, at a mobility point.

Mobility points for passenger transport are normally part of the publicly established infrastructure (bus stops, train and tram stations, taxi stands, etc.).

For freight, however, the situation is different. The infrastructure for freight transport in cities is normally established by private companies – typically logistics service providers (LSPs), and each LSP is catering for only for their own cargo. As an example, at Filipstad, one of the test sites in the Oslo Living Lab in MOVE21, the Norwegian Post, DB Schenker, and DHL all have their own hubs for urban distribution of cargo.

As a result, there is typically no coherent infrastructure for freight transport in cities. Specifically, there is no established infrastructure (at least in the MOVE21 cities) where there are convenient capabilities for using transportation resources normally used for passenger transport to also transport goods.

To achieve the ambition of reducing traffic, such a coherent infrastructure needs to be established, and it needs to be established in such a way that there is easy access for people and freight to make use of all types of transportation resources, scheduled or non-scheduled. Mobility hubs serving both people and goods are key to such an infrastructure.

One of the issues that should be addressed in MOVE21 is how much, if anything, of the infrastructure for moving goods in cities should be a public responsibility. This question is addressed in Work Package 4.

4.2 Basics may not be Enough

4.2.1 Amenities may make the Difference

In recent developments and studies, the term “transport” has been replaced by the terms “Mobility-as-a-Service (MaaS) or Mobility-on-Demand (MoD). MaaS originated in Europe while MoD originated in the US. These terms have essentially been used about mobility of people, providing services that aim to *replace car ownership with a combination of multiple modes of mobility on-demand* (Mobility-as-a-Service Blog, 2021).

Mobility hubs may be much more than points where one changes between transportation services. Direct door-to-door transportation using a private car is perceived as easier and faster to using alternative services, since, in most cases, one must move when the services are available and typically change services at least once to get from origin to destination. To make such alternatives more attractive, it has been suggested that mobility hubs themselves should be made attractive to people that need to travel by adding several amenities beyond just facilitating transportation services connectivity.

The report *Mobility Hubs - A Reader’s Guide (*Urban Design Studio, 2016) has recognised this, but has also recognised that there are different types of mobility hubs and that different types of hubs may need different amenities. The *Reader’s Guide* introduced the following hierarchy: *neighbourhood hubs*, *central hubs,* and *regional hubs*. The tiers are differentiated by scale, amenities, and context.

The *Reader’s Guide* has also classified amenities as:

- Vital – those that must be available for the mobility point to fulfil its key purpose.
- Recommended – those that should be available to make the mobility point attractive beyond transhipment.

- Optional – those that may be added to make the mobility point ultimately attractive to people and freight.

This deliverable will use the same terms.

The study *Multimodal Transport Hubs – Good Practice Guidelines* (Agance Francaise de Developpement, 2020) has also recognised the need to provide a taxonomy of mobility hubs and has made the classification shown in Figure 4. The Good Practice document is also describing attributes of mobility hubs, implying the importance of amenities; see Figure 5.

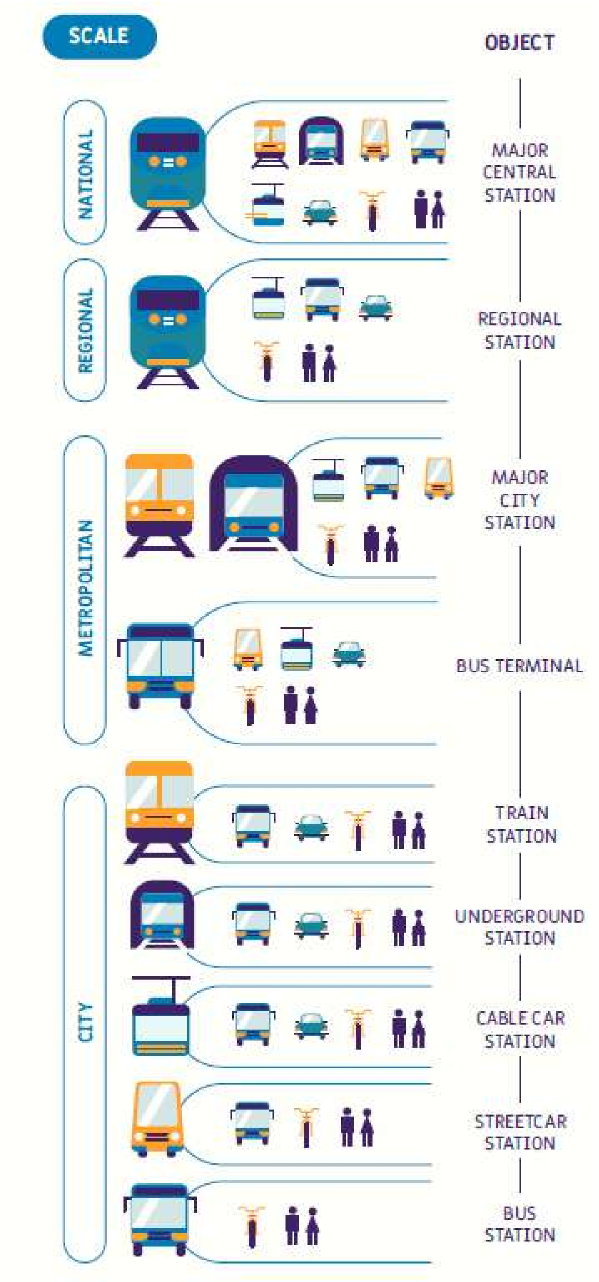

Figure 4. Typology of multimodal transport hubs

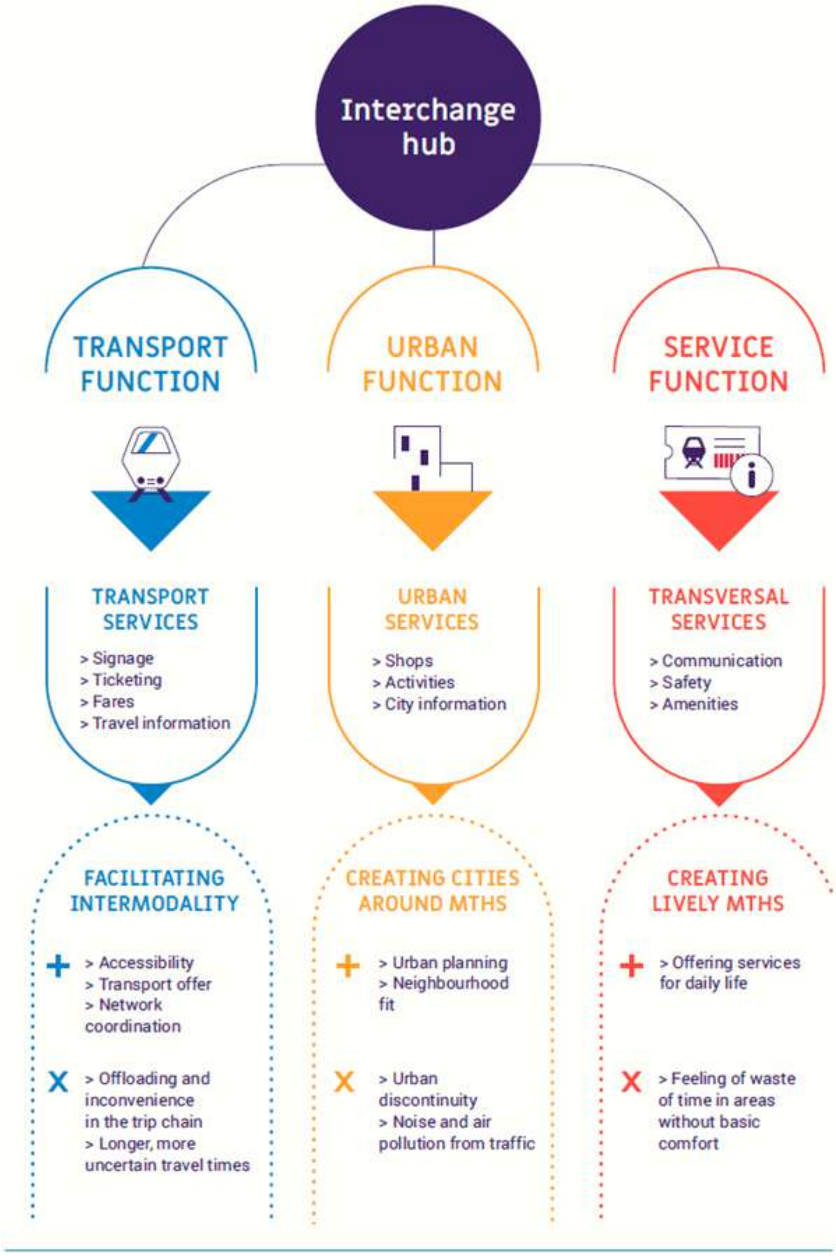

Figure 5. Functions of mobility hubs and related services and actions

4.2.2 MOVE21 Mobility Hub Taxonomy

Before, however, detailing amenities, we will pick up on the taxonomy or hierarchy of hubs. The MOVE21 taxonomy is inspired by the input of the initiatives described above. However, while the above studies are only concerned with passenger transport, MOVE21 also considers the combination of freight and passenger transport.

The major addition to the MOVE21 taxonomy compared to that introduced in the *Mobility Hubs - A Reader's Guide* is a hub enabling individuals to pick up and deliver cargo "at home". The MOVE21 hub hierarchy then becomes:

Nano-Hub: Movable hub serving individuals. These are focused on freight. They can be positioned whenever and wherever needed (space permitting) and removed when mission completed – if needed.

Micro-Hub: Permanent hub serving a community. Relevant for people and/or freight.

District Hub: Permanent hub servicing a set of Micro- and Nano Hubs. It may act as a Micro-Hub for surrounding community and is relevant for people and/or freight.

Regional Hub: Permanent hub serving a set of set of District Hubs and possibly Micro-Hubs. Relevant for people and/or freight.

The functions/amenities in each of these hub types will be investigated in the MOVE21 project.

4.2.3 Amenities

The *Regional Mobility Hub Implementation Strategy – Mobility Hubs Features Catalog* (San Diego Association of Governments - Imperial County Transportation Commission, 2017) provides the basis for the MOVE21 description of mobility hub amenities or features.

These are divided into five groups:

Transit These are features/amenities located in the immediate transit area to help people plan their trips and make connections while offering them a safe and comfortable place to wait for their ride.

Pedestrian These features/amenities are located within a five-minute walk to transit and may include safe and convenient walkways and crossings.

Bike These features are located within a five-minute bike ride to transit and may include an efficient network of bikeways, secure options for parking a bike, and conveniently located options for bikeshare.

Motorised services These features are located within a five-minute drive to transit and may include on-demand, motorized shared services and infrastructure improvements that support their efficient operation.

Support services etc. These features may exist within all mobility hub access zones and can include wayfinding, mobile retail services, and integrated trip planning and payment options.

The first version of the amenities that may be relevant for MOVE21 that are included in these groups are visualised in Figure 6. As MOVE21 progresses, the chart in Figure 6 will be amended both with amenities and with an indication of the importance (Vital, Recommended, Optional) of the amenities in each type of hub.

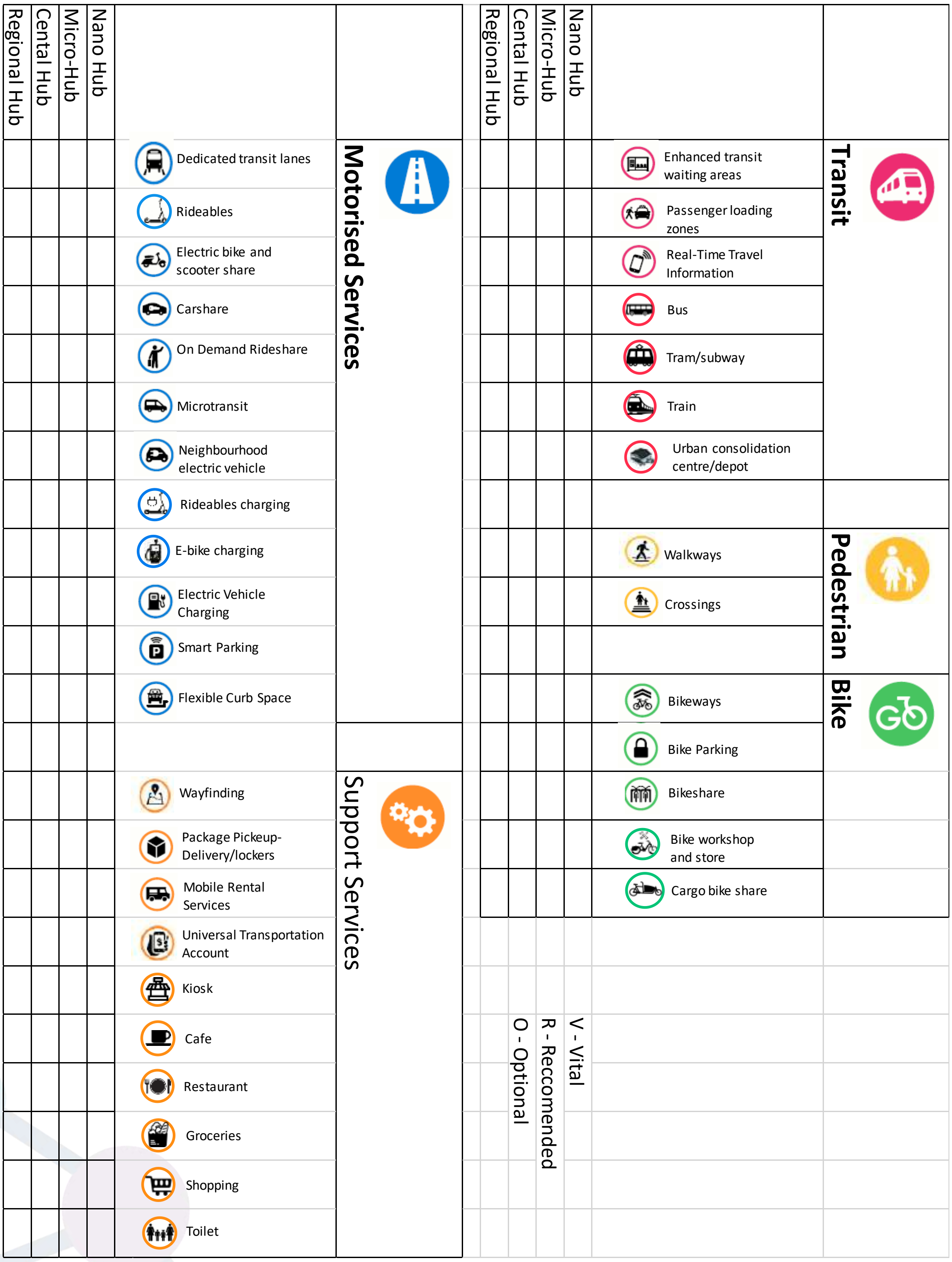

Figure 6. MOVE21 amenities chart

Definitions of these amenities are found in **Annex A** - Amenities Definitions.

5 Relevant Technologies

5.1 Scope

For mobility of people and goods to be effective and efficient, several technologies are involved. Some of these are:

- Applications and solution used by people travelling, involving booking and payment, travel information, etc. The services may be regular (scheduled) provided by public transport companies or on-demand services provided by both public transport companies and private companies.
- Solutions for booking freight transport. These may be used by individuals wanting to send goods or by companies that need to deliver goods to the buyers of the goods. Such solutions will typically also offer the possibilities for presenting status in the form of estimated arrival times for the goods.
- Solutions for transportation management used by those who are providing the transportation (mobility) services.
- In hubs, there is a significant difference between people and freight. To properly support the best possible use of transportation resources, cargo needs to be consolidated/reconstructed in hubs. Special management systems need to manage such activities, and potentially book the transportation services needed for moving cargo from the hub, either to the final address or to another hub.
- Solutions for traffic management. Typical systems are managing traffic lights or registering vehicles on toll-roads.

The MOVE21 project will not develop applications or solutions like those mentioned above. However, Work package 5 in MOVE21 will assist the different Living Labs in identifying the relevant technologies that may be applied to achieve the ambitions in the various demonstrators and help integrate these technologies when required.

5.2 Why we Need to Integrate

In transport and logistics of both people and freight, we are looking for easy and effective transport from door-to-door. In MOVE21, Mobility-as-a-Service is relevant for both people and freight, for people, this concept is typically illustrated as shown in Figure 7.

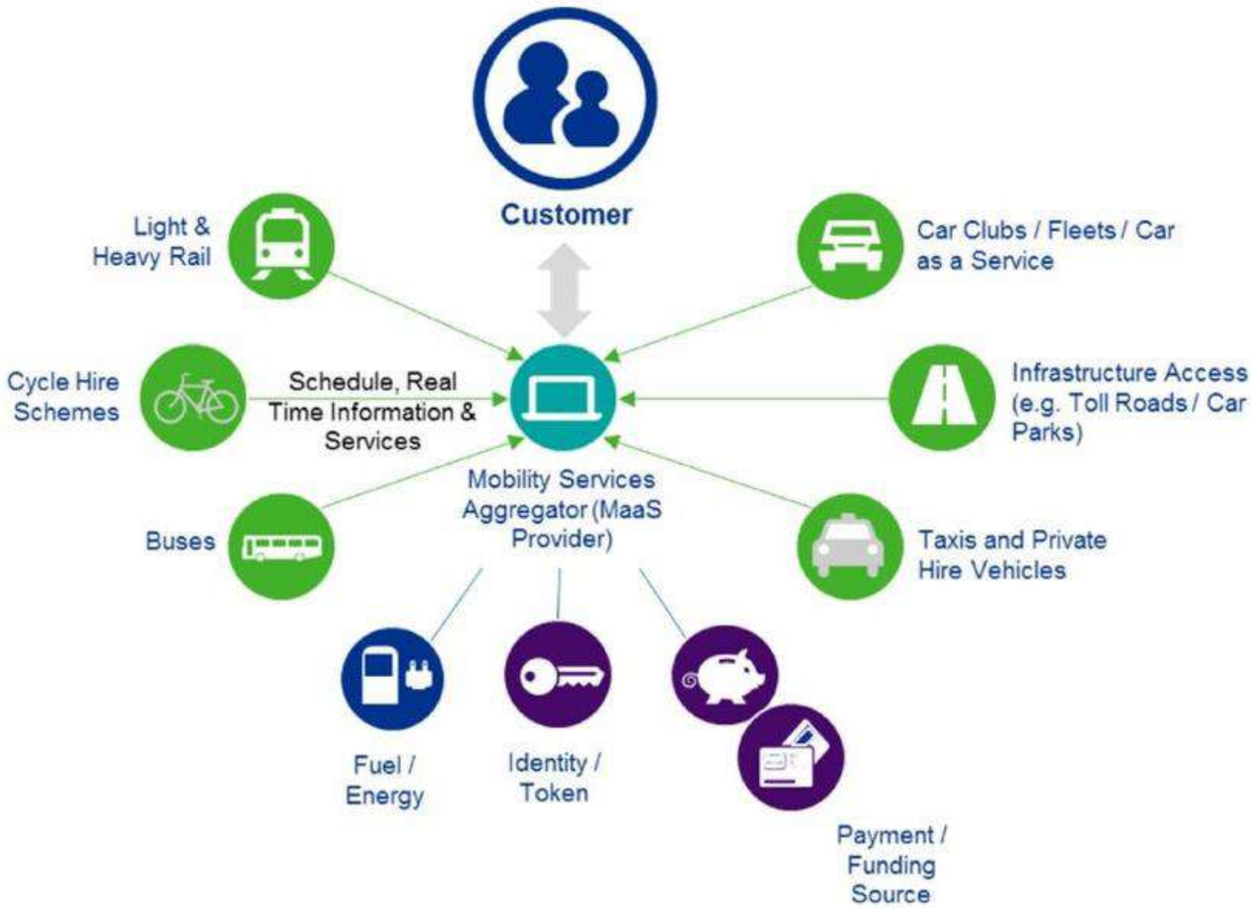

Figure 7. Mobility-as-a-Service for people (Martinelli, 2020)

Figure 7 illustrates that many stakeholders are involved to secure simple access for the traveller to end-to-end services. Hence the information of all these stakeholders need to interact for MaaS capabilities to be properly implemented.

For freight transportation, the end-to-end process is typically illustrated as in Figure 8.

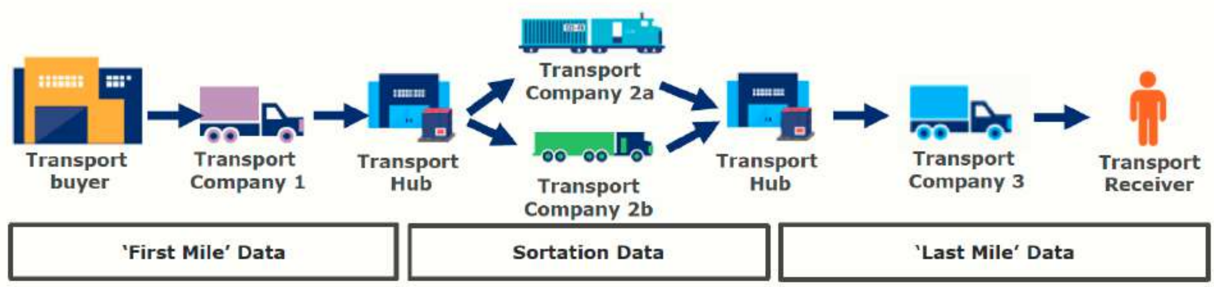

Figure 8. Illustration of end-to-end freight transport

Also, here information must be "shared" between the stakeholders for effective and efficient movement of goods.

5.3 Integrating Technologies

Data models are being developed for integration and interoperability both for transporting people and goods. The Norwegian initiative ARKTRANS (Natvig et al, 2009) developed a data (reference) model including both passenger and freight transport. However, lately, the passenger and freight domains have developed their own models with little or no overlap.

5.3.1 Public Transport

Commission Delegated Regulation (EU) 2017/1926 (EU, 2017) provides the governance basis for standards for the provision of EU-wide multimodal travel information services.

Transmodel (CEN, 2022) is the CEN reference data model for public transport information. According to the Transmodel website, Transmodel provides an abstract model of common public transport concepts and data structures that can be used to build many kinds of public transport information system, including timetabling, fares, operational management, real time data, journey planning etc.

Transmodel v6 covers multimodal conventional Public Transport, including flexible transport and thus also Demand Responsive Transport: most of the needs of bus, tramway, light-rail, metro, coach, long distance rail is considered.

Transmodel is supplemented by NeTEx (CEN, 2021), which is a CEN Technical Standard for exchanging Public Transport schedules and related data.

Another supplement is the Service Interface for Real Time Information (SIRI), which specifies a European interface standard for exchanging information about the planned, current, or projected performance of real-time public transport operations between different computer systems.

The Norwegian government-owned company Entur is using these standards and have developed, in collaboration with other Nordic Countries, a Nordic NeTEx profile (Syversen, 2021). A SIRI profile is now developed in Sweden, based on the Norwegian SIRI profile (Syversen, 2020).

These standards will be used in MOVE21 when integrating scheduled and non-scheduled passenger transport.

5.3.2 Freight

The freight transport and logistics sector has developed many standards over time; some of them are shown in Figure 9.

Figure 9. Information system standards in freight transport and logistics

Some of these standards have developed within industry communities, and include rudimentary messaging for transport:

- PapiNet is the standard used in the forestry industry
- Odette is used by the automotive industry
- RosettaNet is in electronics

Others are developed more related to transport and logistics:

- IATA develops standards in the air transport industry and developed their own standard for paperless ait freight
- SMDG is the standard mostly used in intercontinental transport of containers
- TAF TSI is a standard developed for rail transportation in Europe
- UIRR has aimed at developing standard for the combination rail and road transport
- Logink is a standard for transport and logistics developed China
- NEAL-NET is a standard related to maritime transportation developed in collaboration between China, Japan, and South Korea

Then there are organisations aiming at global standards:

- ISO, the International Standards Organisation which is closely collaborating with
- CEN, which is the European standards organisation; and
- OASIS UBL, which is a non-profit global standardisation body
- UN/CEFACT, the United Nations standardisation organisation, and
- GS1, a global standardisation starting out with barcodes for products and is now covering many industries, including transport and logistics

Different information systems may use different standards. APIs or EDI between systems that apply different standards will not function well as they are not interoperable. In these situations, information needs to be converted on the way from one system to another.

Lack of interoperability has been an issue for many years, and the European Commission have had initiatives related to interoperability in the freight sector for more than 25 years.

The need to improve interoperability and simplify integration can be seen from the illustration in Figure 10. Here there are separate connections established between each of the standards. When we also know that it is possible to interpret standards differently, the situation becomes even more complex.

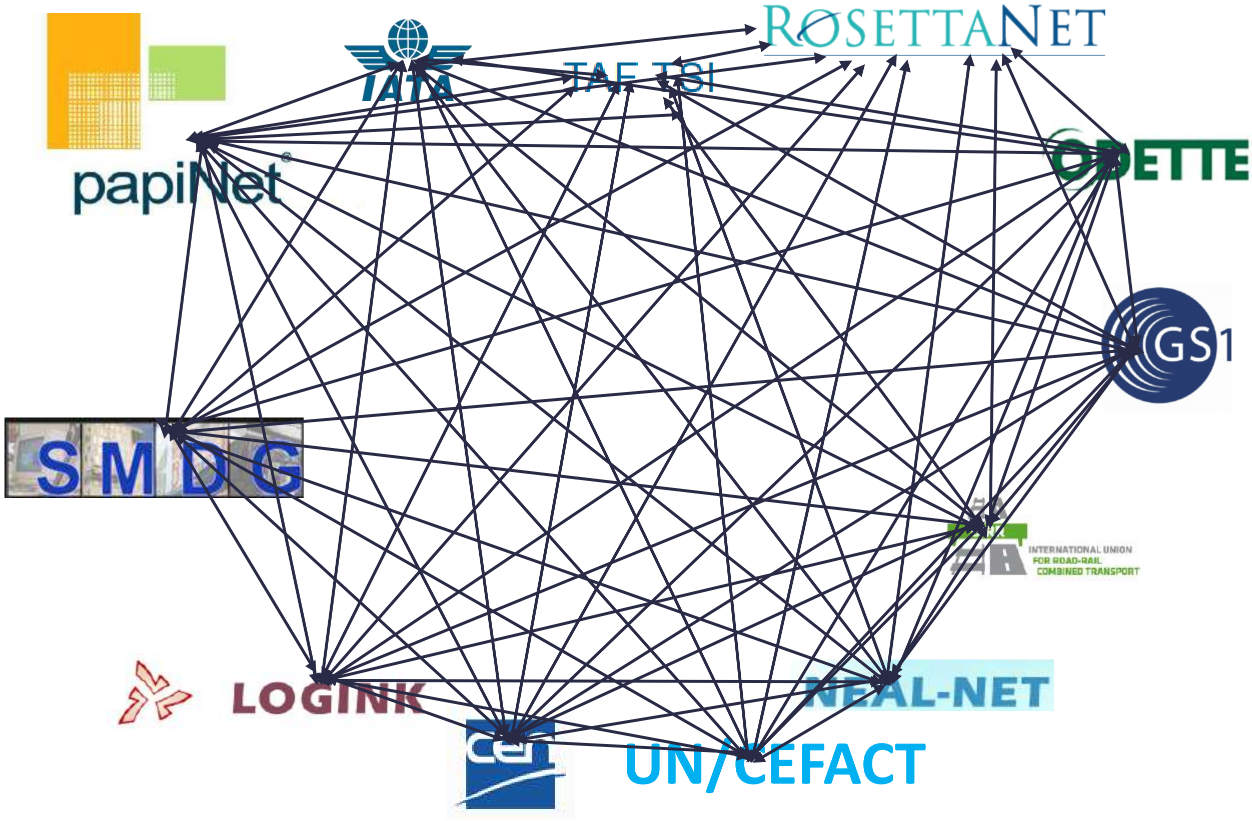

Figure 10. One-to-one connections between standards

Many projects have developed reference models etc. for multimodal interoperability in the sector. Most of these ended up as reports, but there are exceptions. One of them is ISO/IEC 19845:2015, which is a standard covering information technology. The freight related elements of this standard are results from the effort of several EU-funded projects that, based on ARKTRANS originally, produced what was called the "Common (or eFreight) Framework".

Earlier EU projects have then used the ISO/IEC standard as a "common format" in such translations, resulting in simpler situation, illustrated in Figure 11.

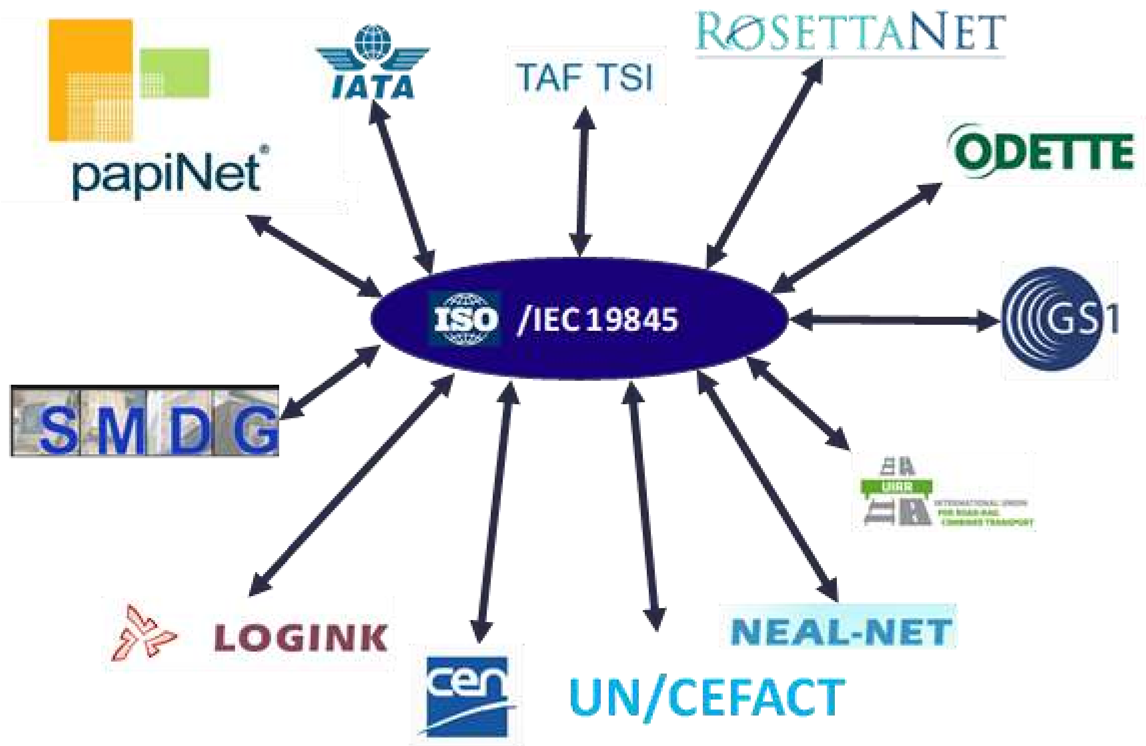

Figure 11. Using a common format (ISO/IEC 19845) as a common format when converting between different standards

This means that conversion between one standard and the common format is implemented once only.

Even with the establishment of the ISO/IEC 19845 and the structure illustrated in Figure 11, the European Commission wanted even better solutions for sharing information and formed the Digital Transport and Logistics Forum (DTLF) in 2015 with the aim to further harmonise interoperability issues in the sector of transport and logistics. The first DTLF initiative was completed in 2018, with clear recommendations for further actions. The result was a new DTLF session and two projects developing the ideas further:

- FEDeRATED - An EU project for digital cooperation in logistics, "developing the foundation for a secure, open, and neutral data sharing infrastructure" (FEDeRATED, 2022)
- FENIX, supporting the development, validation, and deployment of the digital information systems along the EU transport Core Network (FENIX, 2022)

FEDeRATED and FEINX collaborate closely and aim to develop and validate architectures and related semantics for efficient and effective data sharing.

5.3.3 MOVE21

Even with the standards/architectures referred to above, the most common way of integration information systems Is to connect them as follows:

- EDI. This means that the systems are sending and receiving messages and that the communication systems are adapted to understand the syntax and semantics of these messages in the same way.

- API. Like EDI in the form of systems being adapted to understand messages in the same way, but rather than sending messages they are communicating directly through an Application Programming Interface.

Integrations in MOVE21 will be done using both capabilities, depending on the situation. There is, however, an alternative to these two traditional integration techniques to integrate solutions. That is, the use of a special form of digital twins.

When information systems need to be integrated using EDI of API, the information about all items that are transported are kept in the information systems of all involved stakeholders, and that information is exchanged between these systems as the transport and logistics operations progress. The approach illustrated in the previous section is one way of providing such integrations.

An alternative to EDI/API integration is to establish electronic "copies" of all the items being transported where all relevant information is being kept. The information systems of all relevant stakeholders will be able to access and update this information, such that there is a "single source of truth" about the item being transported, its status and progress. This electronic copy is the *digital twin* of the transport item.

So, what information is typically kept in these digital twins, and how may that information be accessed? Some of the information that needs to be available in the digital twin of transport items is:

- Unique ID such that the item can be easily identified by all
- Content – type of product (relationship between container/vehicle-pallet-carton, product…), etc.
- Weight and dimensions
- Origin and destination
- Estimated arrival times updated continuously
- …

The most common way to provide access to this information is to add a 2D label (QR code) to the transport unit, see Figure 12.

Figure 12. 2D bar code (QR-code)

This 2D barcode will include the web address to the digital twin of the transport item carrying the 2D labelled.

In 2021, the organisation GS1 launched a concept called Scan4Transport (GS1, 2021). The concept is simple: when planning the transport of an item (carton, pallet, big ticket item, etc.) a digital twin of the item is created in the cloud. This copy has a unique web address. Anyone may access this electronic copy to obtain information about it. The information is all that is needed for planning and executing end-to-end transport for the item. The concept is illustrated in Figure 13.

Figure 13. Scan4Transport vision

The 2D bar code is in the middle of the label (the barcode at the bottom of the label is considered a 1D bar code). The 2D bar code contains the web address of the appropriate digital twin of the item on which the label is connected. By scanning this bar code, all information about the item is available and may be updated. This approach has (at least) two benefits:

- With small cargo volumes, where investment in electronic connectivity between information systems is not justified, then use of the 2D label and digital twin (where all relevant information about the transport unit in question is kept) may be used to manage movement of goods in logistics networks anyway. The solution has been tested in urban distribution.
- If an item arrives unannounced in a terminal, use of the digital twin information makes it easy to include the item in the already ongoing logistics management activities. This has already been validated in road-only terminals.

The digital twin concept is also an integral part of the FEDeRATED/FENIX approach, see Figure 14.

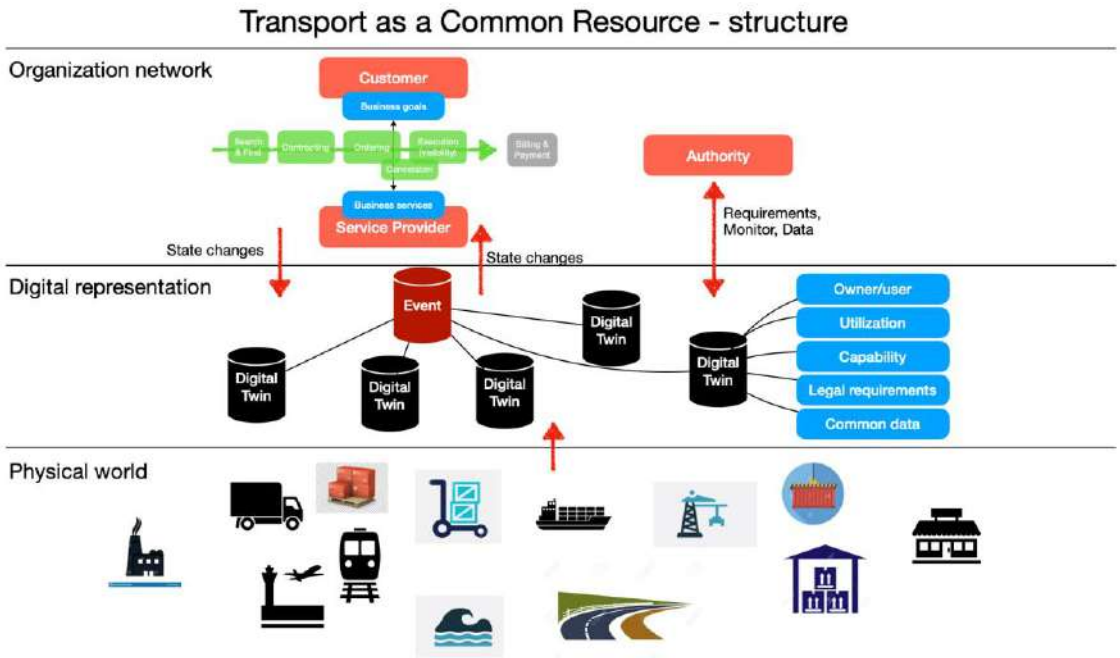

Figure 14. The FEDeRATED/FENIX illustration of the real-world vs digital world

When the needs for integration emerge in MOVE21, we will consider using the digital twin approach, at least for freight-related integrations. The experience from working with the MOVE21 Living Labs will then be the basis for documenting the MOVE21 Technology Framework (identify and document the framework and interfaces, message definitions and APIs, etc.).

6 Living Labs and their Technology Requirements

The Living Labs in Oslo, Gothenburg and Hamburg are driving acquisition and integration of technologies in MOVE21. This section describes the status of each of these Living Labs and the technological consequences of these.

As can be seen below, the description of the first practical implementation and test in the Oslo Living Lab is more detailed than the others in month 9 of the project. Similar descriptions of implementations in Gothenburg and Hamburg are in progress. As the project develops many such descriptions will emerge in WP6 and technologies and integration solutions will be identified in the support of WP5 supporting the Living Labs.

6.1 Living Lab Oslo

6.1.1 Introduction

The Oslo Living Lab activities are centred around three test sites:

- Zero Emission Zone in the centre of Oslo
- Mobility hub at Filipstad, an area close to the city centre, in a location which is being prepared for development of mixed-use urban development
- Mobility hub at the Ski rail station, a smaller community 25 kilometres south of Oslo. A new rail service is being built between Oslo and Ski, which will lead to an extension expansion of the Ski community

As this deliverable is being prepared, a concept involving Filipstad has been developed. This is the one that will be implemented first and will define technology decisions in 2022.

6.1.2 Mobility on-demand for Seniors Extended to also Carrying Cargo

6.1.2.1 Prelude

The MOVE21 partner Ruter currently operates a mobility on-demand service for seniors (age 67 and above) – hereafter called MDS – in certain areas of the city of Oslo; see Figure 15.

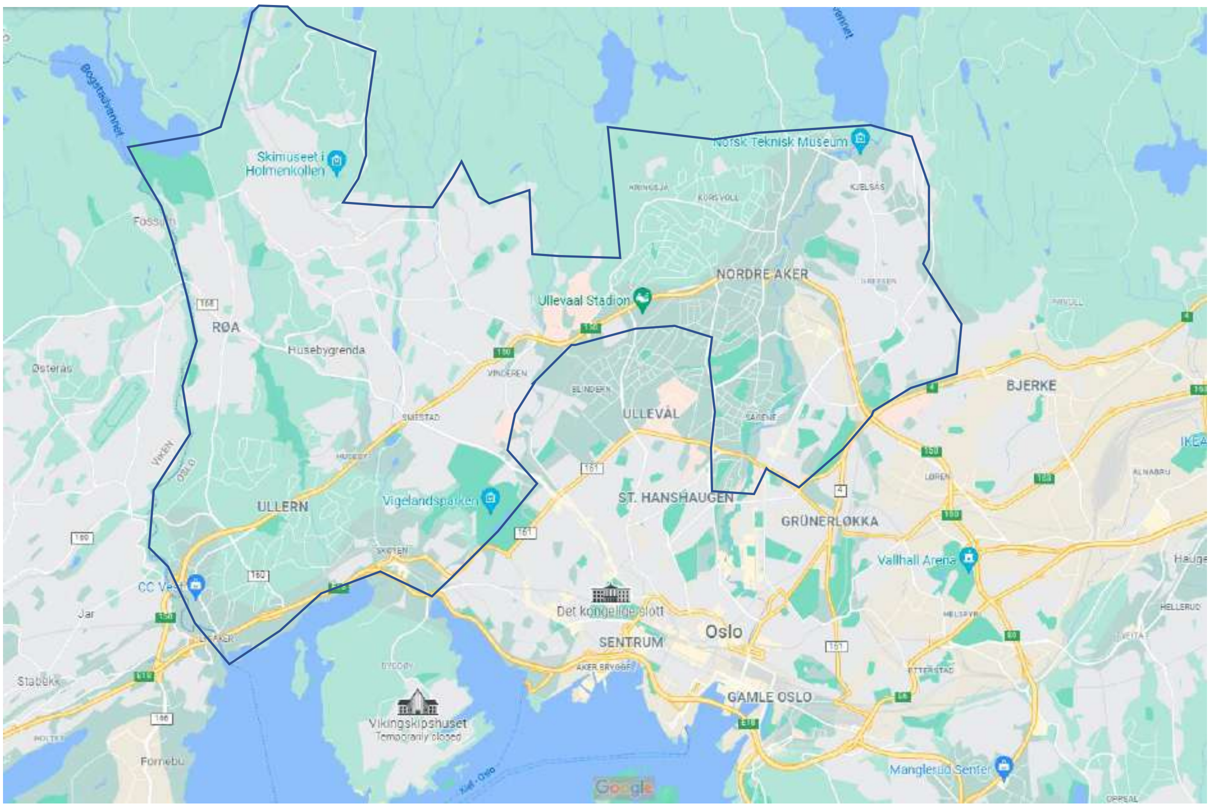

Figure 15. Current test area for mobility on-demand for seniors in Oslo

The transport is door-to-door and transport takes place essentially when needed. There is no fixed schedule.

The transport is performed by dedicated buses; see Figure 16.

These services are attractive to the people needing those services, and Ruter wants to expand the services to cover the entire municipality.

Figure 16. Buses for on-demand transport for seniors

Ruter, a publicly owned transport company, essentially providing passenger transport (scheduled and unscheduled), is investigating the possibility of combining freight and passenger transport for better utilisation of resources. One of the areas that have been identified by Ruter as interesting is to combine passenger and freight transport in the mobility on-demand services for seniors. This may help making the services more financially sustainable and allow spreading the services to cover the complete municipal area.

To make the best possible use of vehicles, it is necessary to introduce consolidation points, or hubs, where cargo may be reconstructed. Such hubs may be in shopping centres, but also elsewhere. Since the Filipstad test site is already an integral part of the MOVE21 project, Filipstad will be used as a hub in this Living Lab activity.

6.1.2.2 Cargo

Transport units that may be suited for MDS services are illustrated in Figure 17.

Figure 17. Transport items applicable for the MDS services

Envelopes may require any space in the vehicles normally used by people, but cartons, boxes and newspaper/magazine piles may require space in seats. Cargo cages on wheels may be loaded, unloaded, and secured like wheelchairs and will potentially occupy wheelchair space.

6.1.2.3 The Set-Up

To test this possibility, The City of Oslo will collaborate with certain suppliers. These are still to be selected. Rather than sending cargo directly to the relevant destinations, these shippers will send the cargo via the consolidation hub at Filipstad. Here cargo is consolidated, picked up by MDS and delivered at the destinations.

Once the initial capabilities are implemented, the capabilities may be increased so that individuals and companies also may use these services for moving goods in the city of Oslo.

The participants (those involved in moving the goods in this set-up) are illustrated in Figure 18.

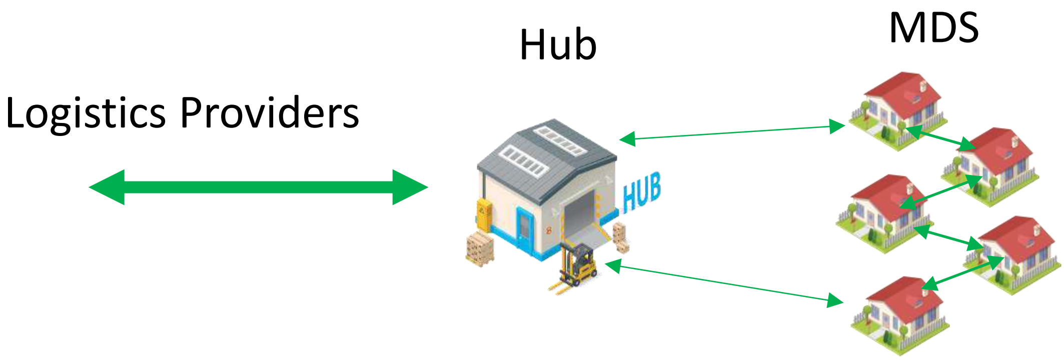

Figure 18. MDS for freight structure

The logistics companies involved are those already moving goods for the City of Oslo. These are typically Bring, DB Schenker, DHL, Ramberg Transport and potentially others. The hub will be operated by a neutral party. The party is not identified, but there are candidates interested.

6.1.2.4 Technologies

The logistics companies involved will be using their existing transport management systems (TMS) as they are. They will be sending information about the cargo to the hub before the cargo arrives. They will be using their existing formats (EDI/API).

In current and future urban distribution, eCommerce will be a significant contributor. eCommerce is not about large shipments, but about small and many shipments.

Cargo consolidation/reconstruction in hubs, therefore, needs to be able to handle shipments on the parcel level. It may also be that all elements in a shipment will not travel together from origin to the hub closest to the receiver, so shipments need to be reconstructed before final delivery, such that the receiver receives cargo as expected.

The MIXMOVE Hub solution is a Software-as-a-Service application for managing cargo consolidation/reconstruction activities in hubs and select transport outbound transport services. Hence, it is designed for operations like the ones described above and is available for use in MOVE21. A more detailed description of the cargo handling process supported by the MIXMOVE Solution is found in **Annex B** Enhancing Load Factors Through Cargo ReconstructionAnnex B Enhancing Load Factors Through Cargo Reconstruction.

The MIXMOVE Hub solution will be integrated with the TMS systems of the logistics providers involved in the Oslo Living Lab activities.

In various locations around Europe, the MIXMOVE Solution is integrated with TMS solutions used by companies like DHL, DB Schenker, DSV, CEVA, Gebrüder Weiss, and others. Hence, integration between the Hub management systems and TMS systems is just a job to be done.

The MIXMOVE solution will also have to be integrated with the management system used by those operating the transport operations, herein called the MDS management system.

This will be done by MIXMOVE adapting to the API/EDI specification of that system.

The MDS management system typically comprises two components:

- The "back-office solution" that receives bookings, allocates tasks to vehicles, optimises routes, etc.
- The application used by drivers, either hand-held devices (mobile phones etc.) or in vehicle computers.

In an Oslo Living Lab context the following modifications need to be made to such a solution:

- The "back-office solution" needs to be able to receive booking (ticket requests) for cargo, in addition to passengers of various types. They also then need to be able to allocate the cargo to vehicles and spaces in the vehicles. They need to be able to confirm electronically that the booking has been accepted.

  Route optimisation and other features in such systems should not be affected.

- The application used by the drivers will have to be modified to be able to provide status of the movement of the goods and proof of delivery

6.2 Living Lab Gothenburg

6.2.1 Introduction

Gothenburg has identified three test sites/areas to be involved in MOVE21:

- Klippan
- Nordstan
- Lindholmen

The following description is based on a set of requirements documented internally in MOVE21 regarding each of these test arenas.

6.2.2 Klippan

Klippan, which is located along the Göta river to the west of the centre of Gothenburg has the potential to become a major public transport hub for commuters to local businesses, housing, and other visitors. While there are many opportunities for increasing the efficiency of the location, the challenge will be to make it attractive for passengers.

The current situation in and around Klippan is that problems and requests for improvements have been documented for both passenger and freight mobility.

The vision is to develop the area at Klippan into an attractive mobility hub essentially for travellers. Using theses documented problems and requests may then be used to decide the set of amenities that should be implemented, possibly enriching the content of Figure 6 and investigating what would be considered Vital, Recommended, and Optional amenities for Klippan to meet expectations. This classification may then be helpful in planning the sequence in which development and implementation should be made.

6.2.3 Nordstan

Nordstan is an area, including a major shopping centre located close to Gothenburg Central Railway Station.

An operation for organising local distribution of cargo was active in the Nordstan shopping centre for some time, but it is no longer operational. A sister project to MOVE21, Smooth – involving MOVE21 partners, is investigating the possibilities of re-establishing such services again.

The current status of the Nordstan is like that of Klippan. For both arenas a set of ambitions (criteria) have been identified. The ones in Nordstan are:

- Improve safety 24/7
- Improved accessibilities and parking for bicycles
- Improve information to visitors about how to best move around
- Plan to avoid peak hours for both people and freight
- Establish (try out) new collaborative solutions for freight distribution, involving proactive stakeholders
- Improve the feeling of well-being when visiting the area

6.2.4 Lindholmen

Lindholmen Science Park is an attractive and stimulating environment and home to two universities, 375 businesses (both national and international), six secondary schools as well as the Gothenburg Film Studios. It is situated in central Gothenburg (north of the river, away from the city centre) and has become the most knowledge-intensive and expansive area in Gothenburg, and an important hub for the expanding city.

MOVE21 activities in the Lindholmen arena have initially been directed to freight, expanding the operations Lindholmenleveransen that performs local distribution of cargo.

Issues that are being addressed at Lindholmen are:

- Combining deliveries of cargo and waste, including household waste
- Use existing areas as battery depot for electric bicycles and scooters
- Establishing charging infrastructure for heavy vehicles
- Implementation of Nano-Hubs for small businesses

6.3 Living Lab Hamburg

The Living Lab Hamburg is focused around the Altona area of the city. A set of locations have been identified as interesting for the MOVE21 in Hamburg, and a staged process has been identified:

Phase 1: Development/integration of 3 hubs in the core area of Altona

Phase 2: Connection of these hubs via real life/ simulated intra-hub traffic; for that purpose: integration of an additional test site area/ hub that serves as start and end point for the intra-hub traffic

Phase 3: Integration of wholesale in industrial area Schnackenburgallee as well as potentially an additional test site in a suburban area; simulation of an extension of the route to highway A7; simulation and – ideally also physical test of – combined freight transport in mobility vehicles (e.g., on-demand-shuttle)

In the very short term, the ambition is to develop one multi-functional hub that integrates solutions for freight and passenger transport and offers additional services.

6.4 Identifying Specific Technologies

As the Living Labs are progressing and becoming more specific, the technologies, and the integration between these, and what is required to properly implement them, will be documented in the Living Lab specifications, and will be turned into integration specifications to be used in Work Package 5 activities when supporting the Living Labs.

The experience from these implementation activities will be used to prepare Deliverable D5.2 *MOVE21 Technology Framework* (specifications and requirements), due in Month 30 of the project.

6.5 Cargo is King

To test new solutions for urban distribution of freight, access to cargo is important. The cities involved in MOVE21 procure large volumes of cargo for their own use.

One possibility in MOVE21 is to use some of this cargo in the Living Labs.

Normally, the standard procurement condition is the Incoterm® Delivered Duty Paid (DDP). This gives the seller the responsibility to arrange and pay for the transport to the agreed destination. The seller also bears the risk of loss or damage to the goods until the moment he transfers the goods to the buyer at the agreed place of delivery.

The effect of this is that the buyer has no influence of the movement of the goods.

One way to influence the movement of the cargo and, thereby actively contribute to consolidated deliveries is to find an alternative to the DDP condition, facilitating cargo to be moved through the infrastructure in the city that results in more consolidated deliveries.

To secure cargo for use in the Living Labs in MOVE21, the cities will investigate the possibilities of collaborating with providers of goods to rethink procurement terms and conditions, thereby taking more control over cargo movement.

7 Conclusions

The Living Labs in Oslo, Gothenburg and Hamburg are still in early stages of being defined.

However, from a technological point of view, we may conclude as follows:

Two issues are key when it comes to selecting and integrating technologies in MOVE21

- Making the use of public transportation more attractive than using private cars when people need to travel:

  This will require integration between the ticketing (booking) systems used in public transportation with systems being used to book the used of on-demand transportation services (use of bicycles, e-scooters, taxis, and appropriate amenities in the Mobility Hubs).

- Making the best possible use of resources needed to move cargo:

  This will require establishment of a coherent infrastructure for urban distribution of freight. A key element here is establishing capabilities for cargo consolidation/reconstruction, including information systems to manage such operations.

The partner MIXMOVE has made its solution for cargo consolidation/reconstruction available for use in MOVE21 Living Lab operations when needed.

The solutions for managing cargo consolidation/reconstruction need to be integrated with the information systems of those companies performing hub to hub transport and those performing first and last mile operations.

Companies offering passenger transport either regular or on-demand should extend their ticketing (booking) systems to cater for movement of cargo in addition to moving people. They should also extend their “in vehicle” (driver) solutions so that the status of movements and proof of delivery of goods may be recorded and reported electronically to electronically to the appropriate stakeholders.

Detailed specifications for technology integrations will be prepared as the Living Lab activities are being detailed further.

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Annex A - Amenities Definitions

Transit Amenities

- **Enhanced transit waiting areas**
  Waiting areas provide a safe and comfortable place for passengers to wait for their transit or shared mobility ride. Area enhancements may include seating, landscaping, lighting, shade and rain cover, trash receptacles, complimentary Wi-Fi, real-time transit arrival alerts, and daily schedule information. These amenities support the mobility hub concept by improving a passenger's overall transit riding experience, encouraging new riders to try transit, and increasing a passenger's sense of security.

- **Passenger loading zones**
  Passenger loading zones are places where passengers can be dropped off or picked up, conveniently and safely. They are typically marked as designated curb spaces that can be used by a wide variety of shared mobility services – shuttles, taxis, carpools, vanpools, and on-demand rideshare services.

- **Real-time travel information**
  Real-time travel information helps passengers make informed travel choices based on the availability of nearby mobility options. People can plan their time more effectively, wait less for transit options, and ultimately become happier with alternatives to driving alone. Realtime travel information also may work in combination with other transit station improvements, improving the overall transit experience.

- **Urban consolidation centre/depot**
  Urban consolidation capabilities are used to consolidate/reconstruct cargo such that the transportation resources needed to move goods from the mobility hub to final destination are utilised as much as possible. This means decomposing larger transport units (containers, pallets, cargo cages, etc.) into smaller units, possible into individual cartons, sorting these to fit the services available for onward transportation, and composing appropriate transport units. Such areas may also be used to store goods for shop owners and others who lack storage capacity on their premises.

Pedestrian Amenities

- **Walkways**
  Pedestrians walking to and from public transit and other mobility services want a safe, attractive walking environment. Wide walkways, landscaping, pedestrian scale lighting, enhanced paving, pedestrian cut-throughs, and other urban design enhancements all can serve to make walking safe and attractive.

- **Crossings**
  Pedestrian crossings help keep people safe. The most effective ones keep walking distances to a minimum, make pedestrians and others more visible to drivers, and include signals to stop traffic so people can cross the street easily and safely. Existing crossings may be enhanced to provide a safer environment for people, or improvements may be incorporated into newly designed facilities. Many transit riders are pedestrians at some point during their trip, so enhancing crossings can improve safety for transit customers while also making transit vehicle operations more efficient.

Bike Amenities

- **Bikeways**
Bikeways can encourage cycling to, from, and within a mobility hub, offering bike riders easier access to transit and other nearby destinations (e.g., work, shopping, recreation). They provide a safe and comfortable riding experience for people of all ages and abilities, and alert drivers to the presence of bike riders on or near the roadway. Bikeways make cycling a priority on certain routes, and an important part of the local and regional travel network.

- **Bike Parking**
Offering people places to park and lock up their bikes goes a long way toward encouraging biking as a transportation choice for short trips. That's especially true for people biking to and from transit stops. Mobility hubs can offer bike riders a variety of bike parking options, and secure and convenient bike parking facilities provide transit riders with an alternative to bringing their bikes onto transit. Parking options that are highly visible, convenient, and secure make mobility hubs an attractive destination for people who choose biking over driving alone.

- **Bikeshare**
Bikeshare aims to provide convenient, affordable, on-demand access to bikes for short-term use in urban areas while enhancing access to transit. Bikeshare stations typically are situated near transit stops and major residential and commercial destinations. Bikeshare programs can help reduce traffic congestion, air pollution, and the demand for vehicle parking. Bikeshare also may be attractive to people who'd rather not own a bike because of the risk of theft and vandalism, a lack of parking or storage, and maintenance costs.

Motorised Services Amenities

- **Dedicated Transit Lanes**
Dedicated transit lanes typically are provided for major routes offering frequent service or where congestion may significantly impact service reliability. These lanes may be physically separated from traffic with curbs or paint to discourage drivers from entering them. Prioritizing transit service with dedicated transit lanes can help make transit more convenient for people than driving alone.

- **Ridables**
A rideable is a portable device with wheels that makes people more mobile. Non-motorized skateboards and scooters have existed for decades, but a new generation of small, electric travel options are available for people of all ages. Motorized rideables typically use an electric power source and feature a floorboard for the rider to stand on. Scooters, electric skateboards, hoverboards, and self-balancing boards with one or two wheels are all examples of rideables.

- **Electric bikes and scootershare**
A shared fleet of electric bikes (e-bikes) or motorized scooters can make it easier for people to travel to work or other destinations when topography is challenging, or parking is scarce. While there are different business models, the service may operate much like bikeshare: electric bikes or scooters are docked at a station, and they can be released after check-in and payment at a kiosk. Members are typically charged by the hour, day, or month if they use the service regularly. Given the typical speeds of electric bikes and scooters, they are well suited for short trips of 2-3 miles – too far for many to walk.

- **Carshare**
  Carshare services offer access to vehicles 24 hours a day, seven days a week. These cars can be found within a specified service area, at transit stations, and other locations, and people can find them by using a smartphone app. Users are typically charged according to how long they use the cars or how far they drive. Fees cover car insurance, parking, emergency roadside service, and other car-related expenses. Carsharing offers people a convenient way to make connections beyond the first and last mile of a public transit stop. It also offers an alternative to owning a vehicle.

- **On-demand rideshare**
  On-demand rideshare services allow someone to request a ride in real-time using a mobile app. They link passengers with available drivers based on a trip's origin and destination, while also identifying the quickest route.

- **Microtransit**
  Microtransit often targets peak period commute travel, offering a flexible, on-demand option for small groups of people. It's ideal in places where high-frequency transit isn't warranted, or where or it's too costly to operate. Microtransit can be particularly convenient when traditional fixed-route transit options are full or when they simply don't serve certain destinations. Microtransit services use smaller vehicles that carry between five and 12 passengers, and riders typically can order service through a mobile app that directs them to gather at common locations along the service route for pick-up.

- **Neighbourhood electric vehicles**
  Neighbourhood electric vehicles (NEVs) offer a low speed, zero-emission motorized travel option for some mobility hub applications. NEVs typically have a maximum speed of 25 miles per hour (mph) and a maximum driving range of 40 miles on a single charge. Models range in size accommodating one to six people and may be used on local roads with posted speed limits of 35 mph or less (regulations differ by state). NEVs are used mostly for local trips in self-contained areas such as planned communities, resorts, college campuses, and industrial parks. They offer older adults and other licensed drivers who don't want to use a conventional auto but may not be able to walk or ride bikes easily a way to get around.

- **Electric vehicle charging**
  An electric vehicle charging station gives people the opportunity to charge plug-in electric vehicles at a mobility hub. Battery-powered electric vehicles, plug-in hybrid electric vehicles, and electric vehicle conversions of hybrid or internal combustion engine vehicles are examples of plug-in electric vehicles. Passenger cars, microtransit vehicles, shuttles, and large transit buses can all be plug-in electric vehicles.

- **Smart parking**
  Smart parking uses technology to make searching and paying for parking more convenient and efficient. Smart parking solutions can be used to better inform people of available parking, streamline enforcement and maintenance, provide data on parking patterns within the community and give people a better parking experience overall.

- **Flexible curb space**
  For a wide variety of transit, shared mobility, and supporting services to operate efficiently within a mobility hub, curb space should be used flexibly. For example, specific curb space can be

designated for some mobility services during their peak demand periods, while the same space can be designated for other uses during off-peak periods. “Flexible curb space” allows the mobility network to better balance street demands as they change throughout the day.

Support Services and Amenities

- **Wayfinding**
  Wayfinding is a tool that helps people navigate from place to place. In the context of a mobility hub, these places might include transit stations, civic and community buildings, parks, and more. Static and interactive signs can provide maps and directions to points of interest, transit schedules and routes, and other information on available mobility services and facilities. This mobility hub feature can exist throughout the five-minute walk, bike, and drive access sheds and be customized based on user type and travel mode.

- **Package Delivery**
  Package delivery stations are secure lockers in which online orders can be held for pick up at any time of day. They can be conveniently situated at retail centres or transit stations. Offering package delivery services within a mobility hub can save people an extra trip by car to pick up a package – offering them one more reason to embrace an alternative to driving alone.

- **Mobile retail services**
  Mobile retail services can offer people a convenient way to complete regular errands without relying on a personal car. In other words, businesses come directly to customers, instead of the other way around. What’s more, when mobile vendors are situated at a mobility hub people may be more willing to choose public transit over driving alone to get their errands done. Examples of mobile vendors include food trucks, mobile dry cleaning, grocery delivery, salon services, and florists. Many of these services operate during normal business hours, so people visit them when they’re heading to work, during lunch, or when they’re on their way home.

- **Universal transport account**
  The vision for a universal transportation account (UTA) is to provide people with an integrated payment solution for a wide variety of mobility services. A single smartphone app can be used to find, access, and pay for transit, parking, tolling, shared mobility services, EV charging, and more. The UTA also can be used to administer travel-based incentives to reward people who seek alternatives to driving alone.

Annex B Enhancing Load Factors Through Cargo Reconstruction

Introduction

One of the key ambitions in MOVE21 is to develop multimodal mobility points/hubs that help reduce the number of vehicles that are being used to move goods. By minimising the number of vehicles, through the best possible use of those that are used, we help reduce the energy needed for transporting cargo.

In December 2019, the European Technology Platform ALICE prepared *Framework and process for the development of a Roadmap Towards Zero Emissions Logistics 2050*. This plan rests on 5 pillars; see Figure 19.

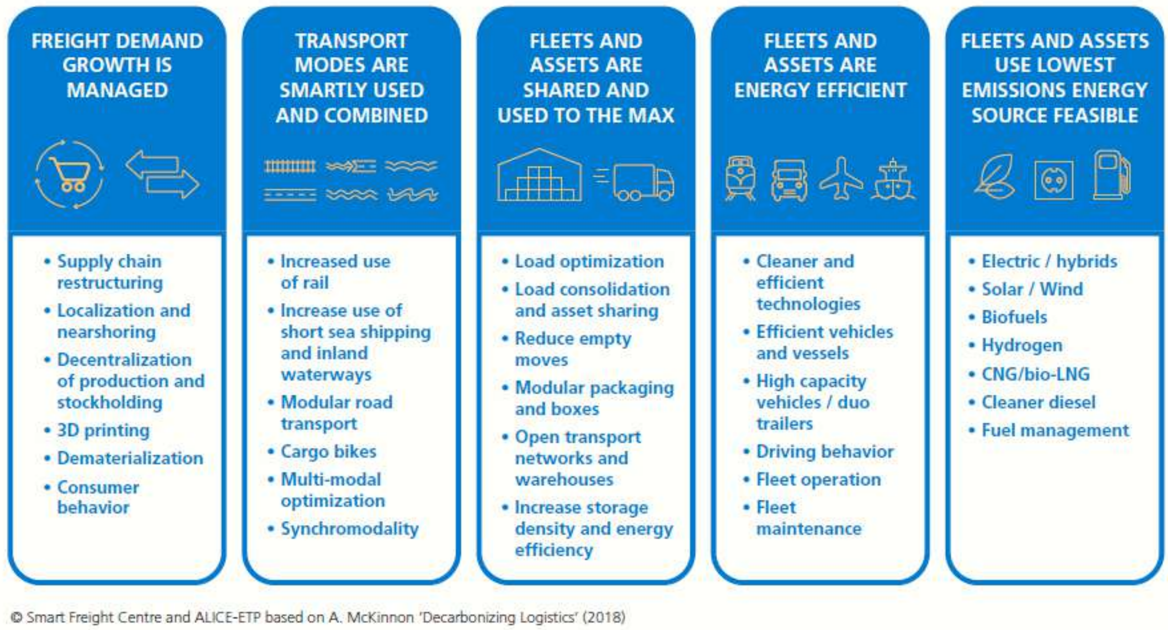

Figure 19. The 5 pillars of the ALICE Zero Emissions Logistics 2050 roadmap

All these pillars are relevant for MOVE21, but only two of them can be dealt with in the project:

- Fleets and assets are shared and used to the max – essentially ensuring the best possible use of them, maximising load factors.
- Transport modes are smartly used and combined. This means that the right (combination of) transport modes are always used.

Cargo consolidation/reconstruction means stripping the incoming transport units, possibly down to the individual parcel level. Once stripped, cargo will be sorted and combined, such that all vehicles or transport units that leaves the hub where consolidation/reconstruction takes place are being used to the full. The process of consolidation/reconstruction is described in detail below.

Cargo consolidation is not new. Logistics service providers have been performing such operations for a long time. Less than truck loads (LTL operations, see Figure 20) are operated by most logistics operators. In LTL operations, pallets are sorted and consolidated, not smaller transport units.

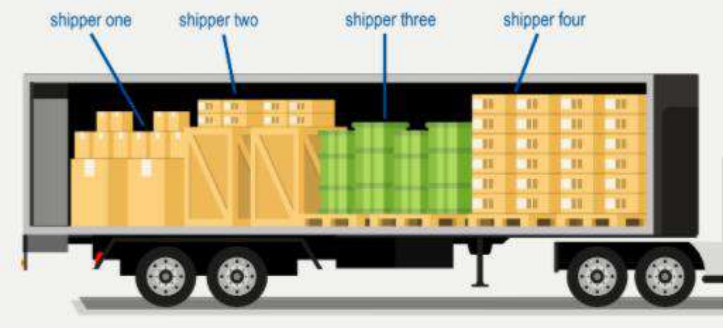

Figure 20 Less-than-truckload

In the age of eCommerce, shipments become smaller, and the number of shipments becomes larger. We may now introduce the concept of less than pallet loads (LPL operations, see Figure 21). Traditional consolidation is no longer sufficient. Many shipments are only one parcel and future urban distribution hubs need to be able to coherently handle any combination of transport units, container, pallet, and parcel. Newspaper and magazine bundles may also be included.

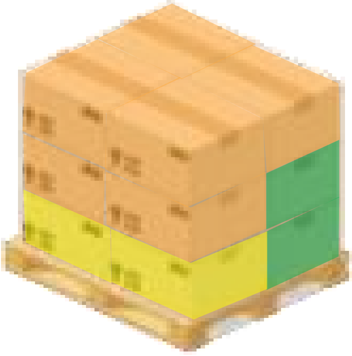

Figure 21 Less-than-pallet-loads

A hub for consolidating/reconstructing cargo comprises a physical process for handling the cargo, which may be manual or automatic, and a management system that is used to plan and execute the consolidation/reconstruction process.

MIXMOVE provide, in MOVE21, a solution for such consolidation/reconstruction management. This solution may be used in any MOVE21 cargo consolidation/reconstruction activity.

Cargo Consolidation/Reconstruction.

Introduction

To be able to manage consolidation/reconstruction of cargo in a hub, the MIXMOVE Solution needs information about the incoming cargo. This information needs to arrive before the cargo arrives, such that planning of the consolidation/reconstruction process is completed before the cargo arrives. Such information is provided by the logistics service provider (LSP) brining cargo to the hub. This can be done either by sending an EDI message or that the MIXMOVE solution has been connected to the management system use by the LSP through an application programming interface (API). Use of a digital twin concept like the GS1 Scan4Transport is also a possibility.

The schematics of a typical hub dealing with cargo consolidation/reconstruction is illustrated in Figure 22.

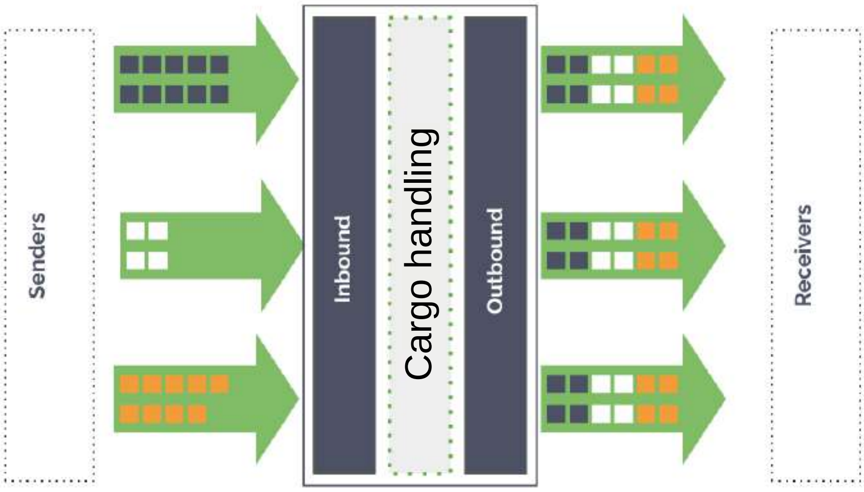

Figure 22 A typical consolidation/reconstruction hub

The Process

The cargo consolidation/reconstruction process taking place in a CFS comprises two phases:

- **Planning**, where information about incoming cargo is used to plan and prepare the actual operation,
- **Execution**. If the containers are full, they will be transhipped as is. If they are not full, the containers will be stripped. If cargo on pallets inside the containers have destinations that enable the cargo to "travel together", the pallets will be transhipped as they are. Pallets will be stripped when needed. Cargo is now sorted. If needed, some of the cargo is temporarily stored in the terminal. New pallets are created. Containers are stuffed, ready to be picked up for onwards transportation.

The planning process is illustrated in Figure 23.

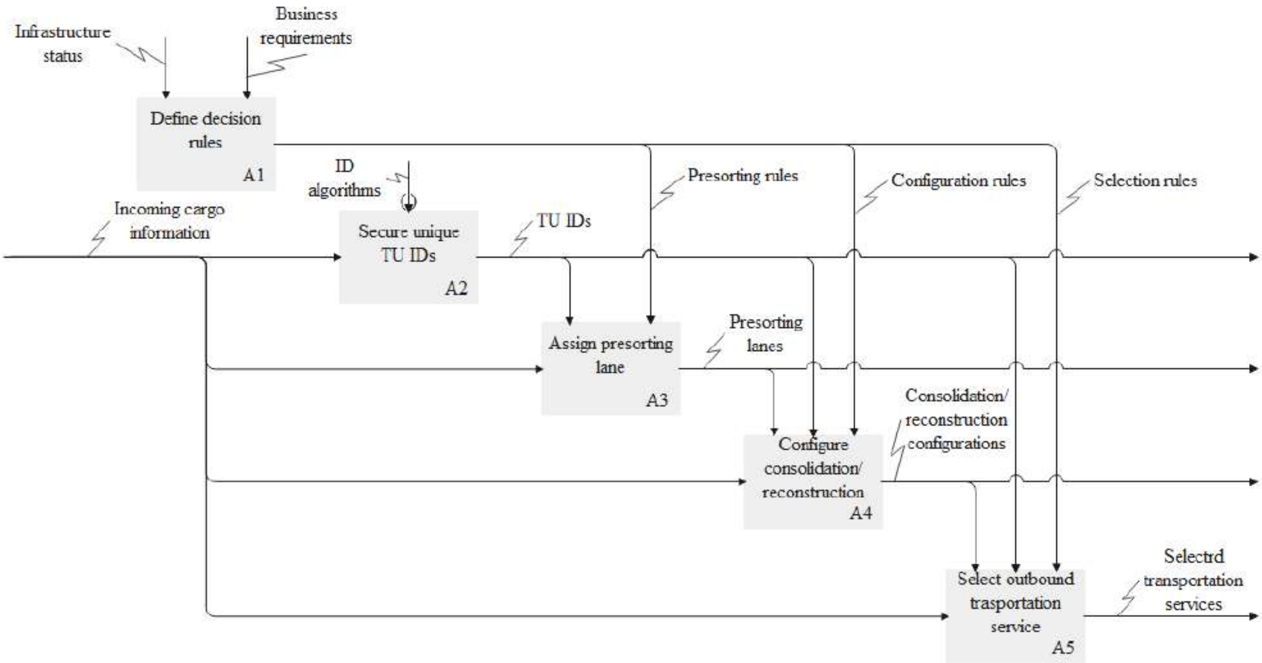

Figure 23 Planning the cargo consolidation/reconstruction

The functions are:

- **Define decision rules**. These are rules that control the complete consolidation/reconstruction operations. They need to be flexible to ensure the best possible use of all resources involved in the logistics operations. They span from using post codes (see the example below) to consolidating cargo to determine the conditions for starting certain reconstruction processes. Sample decision rules are:

    - Sort by order, sort by address, sort by postal code, if the number of cartons are few – select carton carrier, etc.
    - Compliance with consolidation constraints (e.g., frozen vs ambient, applying Hazardous Material (HazMat) rules to avoid dangerous combinations of cargo) and Customer specific pallet/consignment building rules.

- **Secure unique TU (Transport Unit) IDs**. Transport units are parcels, pallets, containers, etc. To be able to perform proper consolidation/reconstruction operations, all TUs need to have unique IDs. This includes cartons. The GS1 SSCC code is to be applied. If incoming cargo does not have unique IDs, then the solution needs to be able to assign such IDs.

- **Assign pre-sorting lanes**. To be able to perform the processes, the “shop floor” of the CFS needs to be configured such that the consolidation/reconstruction process is efficient. This means dividing the floor into lanes, depending on the composition of the incoming cargo and related destinations. If automatic sorters are to be used, the software as a service solution that will manage the consolidation/reconstruction process will have to be able to program such machines; see Figure 24.

Figure 24. Manual and/or automatic handling

Decision rules are important to provide flexibility etc. regarding handling of cargo in terminals. In the example in Figure 25, post codes and countries are being used to indicate post codes where the cargo could be directed through a hub at Filipstad.

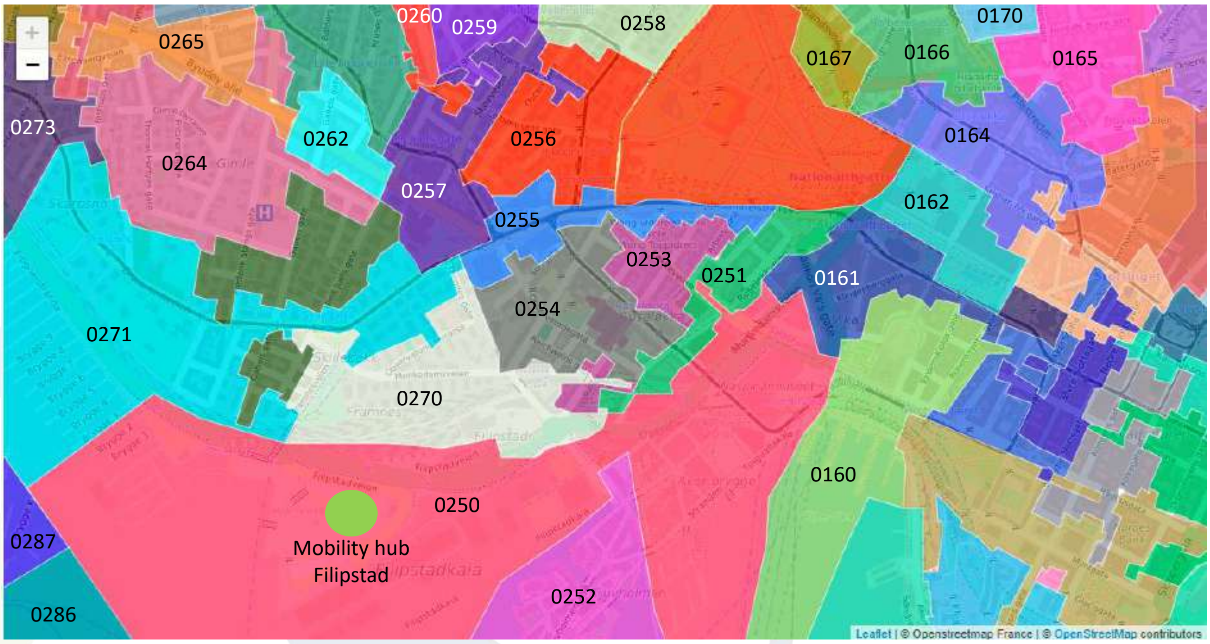

Figure 25. Extract of post codes in Oslo

As an example, in the consolidation process in Filipstad, decision rules might state that:

- All cargo to post code 0271 is to be allocated to one vehicle
- All vehicle to post codes 0251, 0253, and 0254 is to be allocated to the same vehicle
- …

In a consolidation/reconstruction hub outside the city centre, a decision rule might say that all cargo with post codes in the intervals 0160-0167 and 0250-260 and 0262-0265 and 0270-0271 and 0273 and 0286-0287 will not be distributed directly but will be sent to the Mobility Hub at the mobility hub at Filipstad for final reconstruction, if needed.

Decision rules may be changed at any time and the changes take effect immediately after the changes have been made. That way use of decision rules will support flexibility and resilience (should disruptions occur, decision rues may be changed to bypass these).

- **Configure consolidation/reconstruction**. This essentially means preparing the plan for consolidation/reconstruction and the instructions that need to be given to operators or machinery when executing the consolidation/reconstruction process.

- **Select outbound transportation service.** The transportation service to be used to move cargo from the Mobility Hub is decided here. Choice of transportation services are not to be selected a priori by freight forwarders. The freight forwarding responsibility is essentially to be delegated to the Mobility Hub. The choice of service is dependent on the actual cargo to be moved (the cargo already in the Mobility Hub and cargo about to arrive) and the transportation services available when the cargo needs to move.

  It is during the process of selecting transportation services for onward transportation that services combining passengers and freight will be made available. The decision rules may be defined such that vehicles carrying only cargo will not be used if the vehicles carrying both people and freight has capacity to do both if agreement between sender and receiver of the goods can be accommodated.

The consolidation/reconstruction execution process is illustrated in Figure 26. This illustration implies that the Mobility Hub may also include local storage. This is not what may be considered a complete warehousing capability, but the ability to keep cargo for a short time to comply with the ambition to utilise resources as well as possible. The solution needs to support this process.

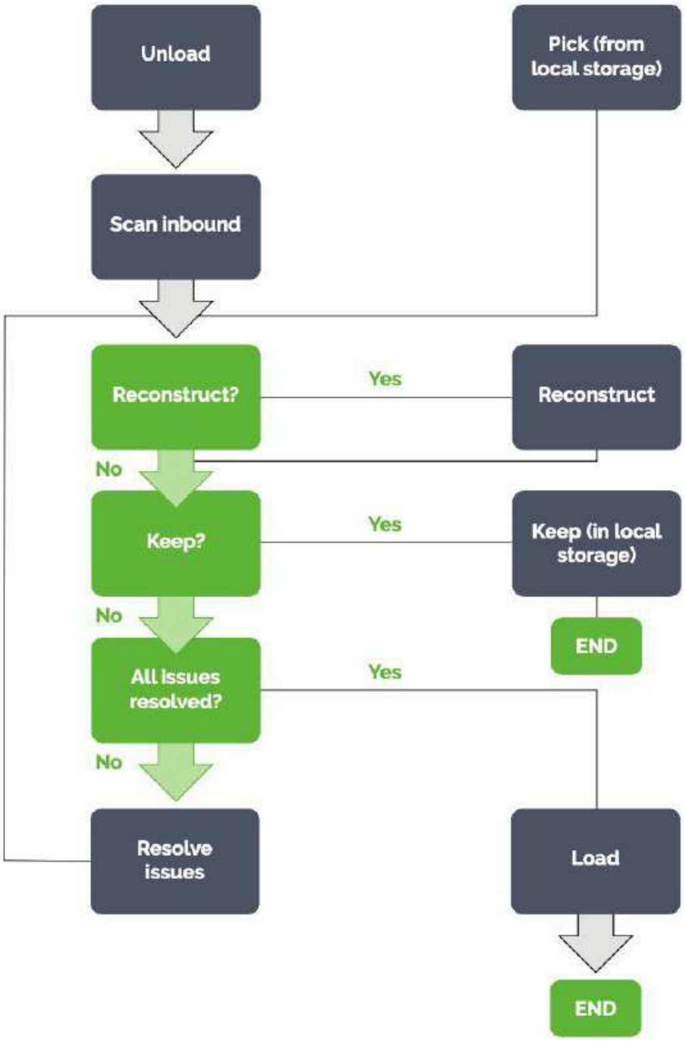

Figure 26 Consolidation/reconstruction process

The reconstruction process should have two sources:

- Incoming TUs transported in all modes,
- Cargo already in the Mobility Hub, using the ability to store cargo as explained above.

All cargo is scanned. The first decision to be made is if the incoming TUs need to go into the reconstruction process or not.

The reconstruction process is essentially a process where all incoming TUs are stripped into individual cartons, if necessary. The cargo is sorted, based on the set of elaborate decision rules, such that cargo that may "travel together" in the next segment of the transport chain (long distance or last mile) is identified and grouped. The sorted cargo is compiled into new TUs, and the process continues.

The next decision to be taken about the TUs (reconstructed and those that do not require reconstruction) is if they are to leave the Mobility Hub immediately or if they are to be kept in intermediate storage. If the cargo is to leave immediately, a final check is made to find out if there are any unresolved issues. If there are none, the cargo is ready to be moved into the loading area. This may be inside the existing warehouse or terminal, or it may be a loading area directly connected to the consolidation/reconstruction operation area.

The consolidation/reconstruction process may be illustrated as shown in Figure 27.

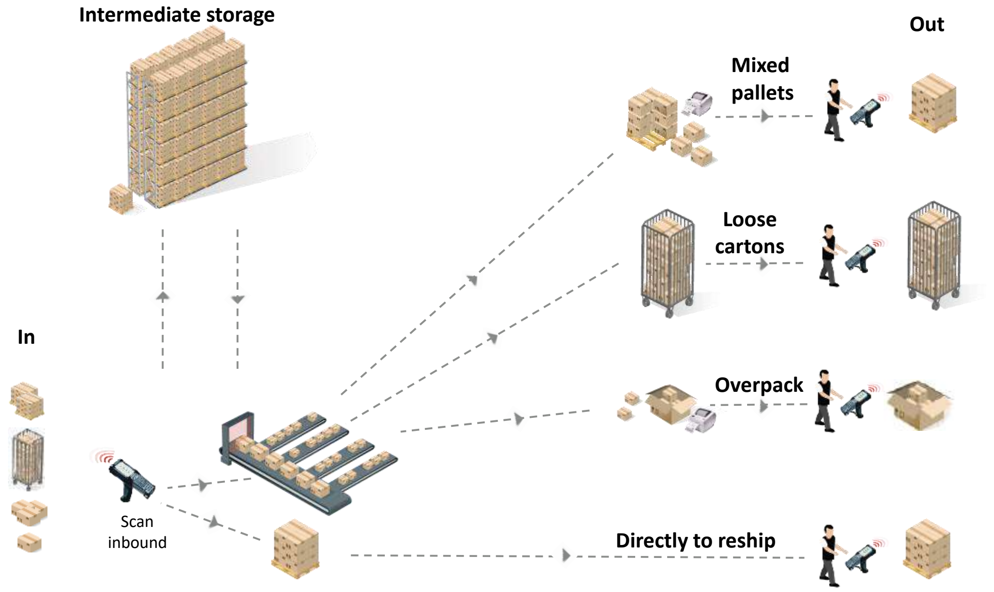

Figure 27. The cargo handing process (consolidation/reconstruction)

Visibility – to all Stakeholders

Visibility is an important aspect of all modern logistics operations. Senders and receivers of cargo need visibility for ensuring that cargo is delivered as promised. Logistics stakeholders need visibility to be able to take actions if things are not going as planned. Consequently, the solution needs to support full visibility (Level 4) as illustrated in Figure 28.

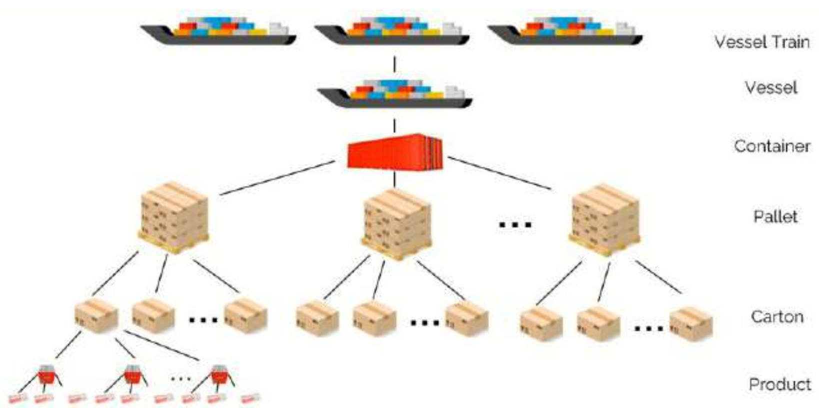

Figure 28. Level 4 visibility (product in carton on pallet)