SARIL

Sustainability And Resilience for Infrastructure and Logistics networks

D4.4 Summary Demonstration Synchromodality

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Executive summary

This deliverable introduces the concept of synchromodality—a logistics approach developed around the Port of Rotterdam to improve flexibility, efficiency, and resilience in cargo transport. Traditional end-to-end planning often failed due to unreliable vessel schedules, forcing costly rescheduling and exception handling. Synchromodality reverses this logic by delaying transport decisions until reliable, real-time information is available and by delegating routing choices to logistics nodes rather than planning the full chain in advance. This enables dynamic selection of transport modes and services based on actual conditions, available capacity, and potential disruptions.

Within the SARIL project, synchromodality is applied as a key mechanism for achieving resilient and sustainable logistics, aligned with the ALICE roadmap for zero-emission freight. By shifting from rigid logistics chains to adaptive logistics networks, SARIL demonstrates how hubs can make local decisions that both mitigate disruptions and improve resource utilisation. Digitalisation—including real-time tracking, electronic communication, and unique identification of logistics units (from parcels to containers)—is essential for enabling this network-based operational model.

SARIL studies green resilience in three scenario cases at different geographical scales. In the regional scenario, an exceptional flood of the Mincio in the Province of Mantua closes road, rail and waterway links. At the same time, a cyber-attack degrades the information on which the emergency response depends. In the national scenario, extreme wildfires close motorway and rail links on the Atlantic Corridor between north-west Spain and northern Portugal. In the European scenario, events of continental or global reach, such as a pandemic, the war in Ukraine or a strike closing a major port, disrupt the freight flows between the Far East and Europe. These events also cascade into intra-European traffic. The hazards are different and so are the geographical scales. However, seen from the cargo that is already in the network, the consequence is the same in all three cases. Part of the network becomes unavailable at short notice, and the goods must still reach their destination.

SARIL answers this in two stages. Preparedness comes first. Potential disruption scenarios are analysed across the network to establish which transport services exist, how they may be combined, and which combinations keep the goods flowing when a given part of the network is lost. This means that redundancy is designed into the network in advance and not improvised under pressure. Synchromodality then makes this preparation usable in the operation. The decision about how to move the goods is taken in the hub when the cargo is handled and is not fixed end-to-end before the goods start moving. A service that has become unavailable will therefore not be selected. No central re-planning is required, and the decision is still valid when the information about the network as a whole is incomplete or, as in the regional scenario, has been compromised.

The demonstration reported in this deliverable belongs to the European scenario and illustrates the operational stage. The MIXMOVE logistics management system X-Dock is used in a hub in a small part of the Gebrüder Weiss (GW) groupage network. Its decision rules select between the transport services that are available at the moment the cargo is handled. The services it selects from are those established in the preparedness work, where the ASTROIT simulation tool was used to analyse potential disruption scenarios in the network. The demonstration shows how cargo can be rerouted during a disruption, in this case avoiding Passau, with very few operational changes and while maintaining service levels and improving load factors. The same mechanism applies in the two other scenarios. A flooded crossing in the Province of Mantua or a wildfire closing the AP-9 in Galicia puts the same question to the hub. Only the set of affected services is different.

Overall, the document highlights how synchromodality, digitalisation, and network-based logistics form the foundation for both resilient operations and sustainable resource use and represent essential building blocks for the emerging Physical Internet paradigm. The results of this report will be considered in the work of Task 5.1 (recommendations to be derived from the project work) as well as the work of Task 5.2 (business models)

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List of Acronyms

Acronym	Definition
ALICE	Alliance for Logistics Innovation through Collaboration in Europe
FCL	Full Container Load
FTL	Full Truck Load
LCL	Less than Container Load
LTL	Less than Truckload
MIXMOVE	Logistics management cloud solution
SSCC	Serial Shipping Container Code

1 Introduction

This deliverable outlines how modern logistics can benefit from shifting away from fixed, end-to-end transport plans toward a more adaptive, network-based approach. Originating in the Port of Rotterdam, the synchromodal concept enables hubs to make routing decisions at the moment cargo arrives, using real-time operational data to choose the most suitable transport mode and service. Within SARIL, this method supports both resilience - by allowing rapid rerouting when disruptions occur - and sustainability, through better utilisation of assets and smarter modal combinations aligned with ALICE's decarbonisation objectives.

Digital connectivity, detailed cargo identification, and continuous visibility of transport services form its technical foundation. The demonstration in SARIL, applied to part of the Gebrüder Weiss (GW) network, shows how simple rule changes at hubs can redirect flows instantly, ensuring continuity while improving efficiency.

1.1 SARIL Project

SARIL - Sustainable and Resilient for Infrastructure and Logistics networks - is a European initiative focused on strengthening the resilience, stability, efficiency, and environmental performance of freight transport networks. The project aims to help logistics systems better withstand disruptions while simultaneously reducing their ecological footprint. To achieve this, SARIL develops and tests solutions that combine real-time information, adaptive network-based planning, and smart use of multiple transport modes. Central to the project is the application of synchromodal principles, where logistics hubs make informed decisions about cargo routing based on current service availability, capacity, and potential risks. SARIL also advances digitalisation through improved data exchange, cargo traceability, and tools for simulating network behaviour under different disruption scenarios. This tool development was carried out in Work Package 3. A set of interoperable tools was specified, built and connected into a common tool architecture, and was then applied to the three scenario cases of the project. The tools include the ASTROIT transport simulation, the Disruption Information Interface, which is the central hub for disruption data in the project, the Route Attributes Energy Module, traffic simulation, natural hazard mapping and the synchro-modal decision-making capability described in this deliverable. The tools, their use in the scenarios and the resulting assessment are described in the public deliverable D3.4, General solutions for the resilience of logistic networks (SARIL project, 2025). By integrating resilience and sustainability into the same operational logic, SARIL supports the transition toward more flexible, resource-efficient logistics networks and contributes to the long-term vision of a connected, low-emission European logistics ecosystem.

SARIL organises its work around three scenario cases at different geographical scales. The regional scenario covers the network around the Mincio in the Province of Mantua in Italy, where an exceptional flood is combined with a cyber-attack on the monitoring and information systems. The national scenario covers the cross-border Atlantic Corridor between northern Portugal and Galicia, where extreme wildfires close road and rail links. The European scenario covers the wider European freight network, where global events such as pandemics, the war in Ukraine or a strike in a major port disrupt the flows between the Far East and Europe and cascade into intra-European traffic. This deliverable deals with the operational layer that all three scenarios have in common, namely how a logistics network keeps the goods moving when part of it becomes unavailable. It is demonstrated in the European scenario, using a part of the intra-European groupage network of the SARIL partner Gebrüder Weiss.

2 Synchromodality

2.1 History and Definitions

The concept of synchromodality was developed in and around the Port of Rotterdam. Originally, transport of cargo from Asia to Europe using intercontinental container ships was planned from end-to-end before the cargo left Asia. This meant that hinterland services in Europe were booked before the cargo left Asia.

Even though intercontinental shipping operators had provided schedule information to those planning goods movements, the experience was that the ships were never on time. This resulted in a lot of what was called "exception handling", where hinterland transport had to be reorganised because the ships were not arriving as planned.

To avoid this additional workload, the planning of hinterland transport was postponed until the arrival times of the vessels were known and reliable (typically one or two days before arrival). At this point, planners of hinterland transport could confidently book onward transport for the arriving cargo using hinterland transport services that were available at the time of arrival of the ships and the cargo.

This new method of working was called **synchromodality** and since its introduction, the concept has gained significant interest both in operational practices and in research and development.

Researchers have proposed many definitions, including:

- *The ability to switch freely between transport modes at particular times when a consignment is in transport (Feport).*
- *A network of well-synchronised and interconnected transport modes, which together cater for the aggregate transport demand and can dynamically adapt to network users' individual and instantaneous needs (Tavasszy, LA., Behdani, B., Konings, R. (2015)).*
- *Multimodal transportation planning system, wherein the different agents work in an integrated and flexible way that enables them to dynamically adapt the transport mode based on real-time information from stakeholders, customers, and the logistic network (Jackson, I., Saenz, M., Li, Y., & Moreno, M. (2023)).*

A practical way to describe synchromodality may be as follows:

- Avoid planning end-to-end logistics operations before transport begins. Provide only the origin and destination information, plus the terms and conditions agreed between sender and receiver of the goods.
- Delegate decisions on how to move the goods to the nodes in the logistics operations. The nodes know about available goods (already in place or incoming) and which transport services that are available to use.
- Delay the planning of the goods movements as long as possible to achieve two objectives:
    - Ensuring the best possible match between the cargo to be moved and the resources to move them.
    - Selecting the services that are currently available and not impacted by any form of disruption. Hence, in SARIL, this approach will enable the selection of transport services capable of avoiding disruptions.

2.2 Synchromodality in SARIL

SARIL aims to demonstrate this latter approach to synchromodality. This same principle forms the basis of how cargo is envisioned to move within a Physical Internet. Both in SARIL and in the Physical Internet, the nodes play a key role, key decisions are made in the nodes. To do this, the information systems used in the nodes need to be updated with real-time data about cargo, its movements, and the availability and capacity of transport services.

Resilience in SARIL is not only a question of reacting well. The project follows the disruption cycle of preparedness before an event, robustness during the event and recovery afterwards. Synchromodality contributes to the first two of these, and the contribution starts well before any cargo moves.

Preparedness is where the options are created. ASTROIT, the agent-based simulation tool developed in the project, is used to analyse potential disruption scenarios in the network. The purpose is to establish which services exist, how they may be combined, and which combinations keep the goods flowing when a given part of the network is lost. ASTROIT is a strategic tool and not an operational one. It is not consulted while a consignment is being handled. Its purpose is to ensure that the alternatives already exist, and are known to work, by the time a disruption occurs. This means that redundancy is designed into the network and not improvised under pressure.

What this analysis establishes is carried into the daily operation as the catalogue of transport services available in each hub. The catalogue is prepared in advance and is kept up to date. When information about disruptions arrives from the monitoring and assessment tools of the project, the services affected are marked as unavailable. In this way the catalogue always describes what can actually be used at the present time.

The response is then a local matter. When the cargo is handled, the decision rules in the hub select among the services that the catalogue shows as available. A service that is impaired will simply not be selected. No exception handling is triggered and no central re-planning is required. The decision is also valid when the information about the network as a whole is incomplete or, as in the regional scenario, has been compromised. The three scenarios are different in hazard and in geographical scale. However, each of them puts the same question to the hub, and each of them is answered in the same way. This is illustrated in Figure 1.

Preparedness is only one of the nine resilience factors used in the SARIL green resilience assessment (SARIL project, 2025). The approach described here contributes to several of them. Redundancy is the most important of these, since the network of combinable services is what provides the alternatives. Flexibility follows from the decision rules, which may be changed in less than a minute. Visibility is provided by the catalogue of services, which is kept up to date from the disruption information. Recovery is also supported, because the rules may be changed back when the situation returns to normal. Reliability and Security are weighted highest in the assessment, but they are not addressed by synchromodality. They depend on the infrastructure and on the protection of the information systems.

The reasoning behind the move from logistics chains to logistics networks, on which all of this depends, is set out in Section 4.

The rest of the document explains the principles in more detail. The main idea is to “make the most of transport resources through the smart use of transport modes”.

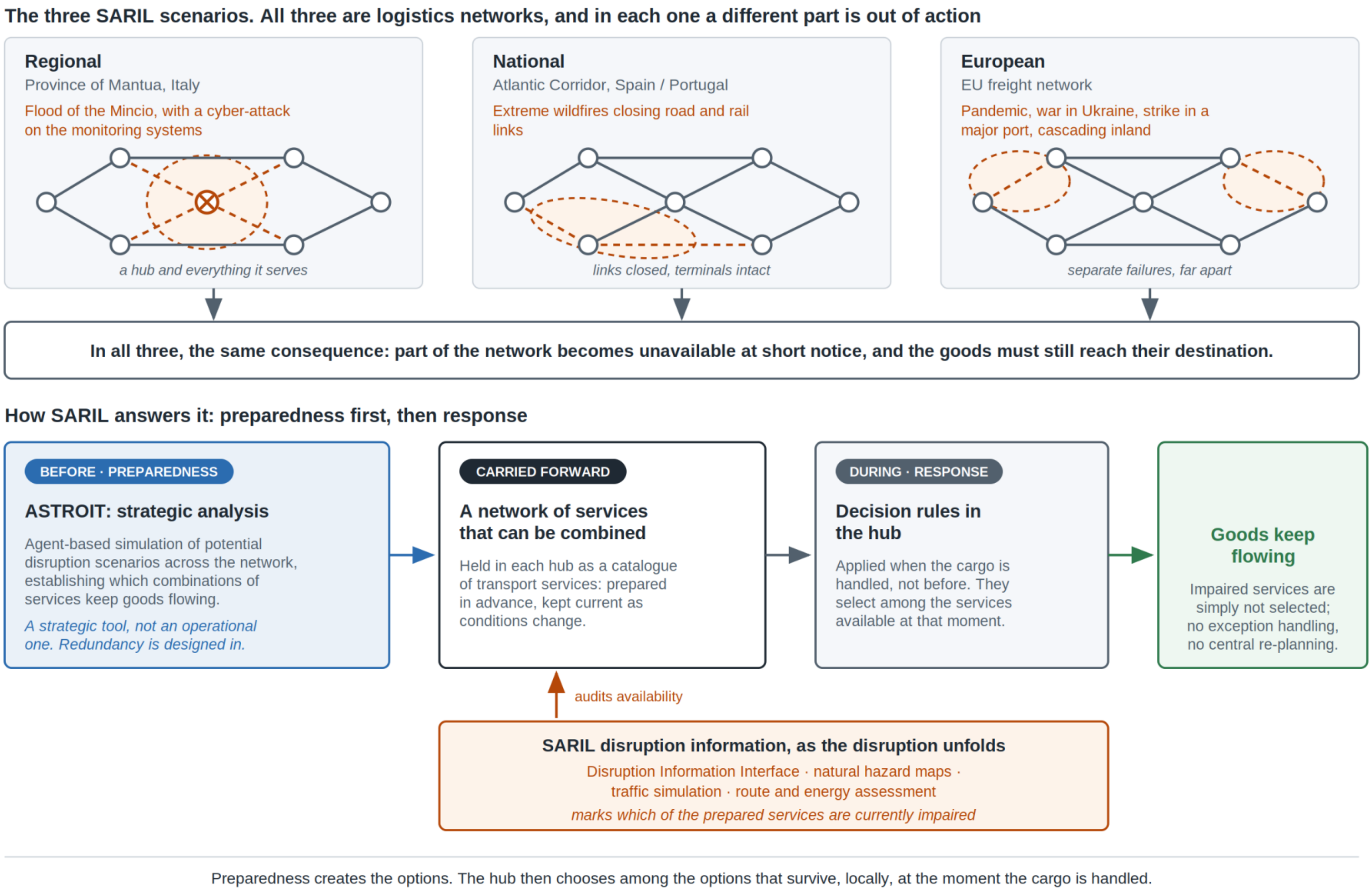

Figure 1: The three SARIL scenarios and the synchromodal response.

3 Logistics Sustainability

The European Technology Platform ALICE (Alliance for Logistics Innovation through Collaboration in Europe)[1] has long been engaged in promoting sustainable logistics. One of the results of this work is the report "*A Framework and Process for the Development of a Roadmap Toward Zero Emission Logistics 2050*", published in December 2019 (ALICE, 2019).

This roadmap is structured around five so-called pillars, illustrated in Figure 2.

For SARIL, four of these pillars are particularly relevant:

(2) Smart and combined use of transport modes

(3) Shared fleets and assets used to their fullest potential.

(4) Utilise of energy-efficient fleets and assets

(5) Use of fleets and assets powered by the lowest- emission energy sources.

The first one is intended to shorten the distance between production and consumption and does not apply to SARIL´s scope.

This raises an important question:

- These pillars offer "solutions" related to reducing the environmental footprint of logistics, but how do they relate to resilience?

Part of the answer has already been indicated in Section 2.2. The following sections develop it in more detail.

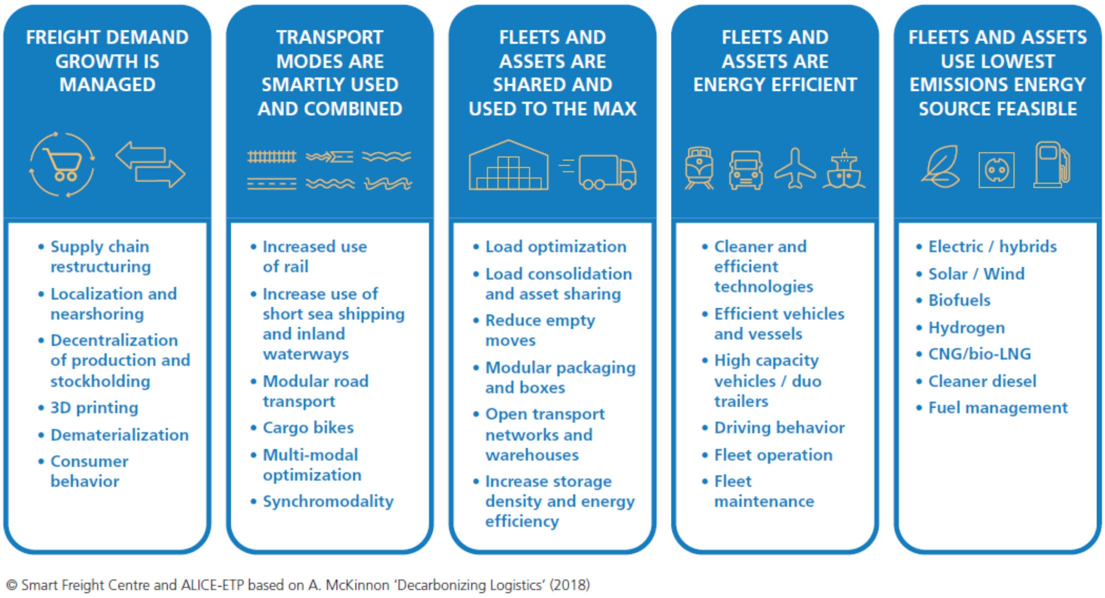

Figure 2: Solutions for freight transport and logistics decarbonisation.

[1] https://www.etp-logistics.eu/

4 Logistics Networks vs. Logistics Chains

The key principles that will be discussed here are relevant both to bulk cargo and unitised cargo, which is typically transported in trailers, containers, and such. This text focuses on unitised cargo, which is the typical type of cargo handled by SARIL partners Gebrüder Weiss (GW) and Rangel.

Logistics is traditionally viewed as a linear transport chain running from origin to destination (Figure 3).

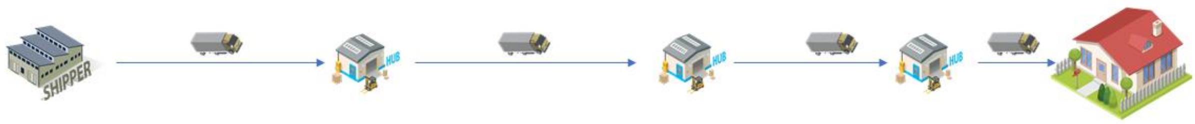

Figure 3: Traditional logistics (transport) chain.

In intra-European transport, these are typical, and normally end-to-end transport has been planned before goods start moving. In most situations, orders are packed at the origin and cargo owners typically do not accept that such packaged cargo is being "tampered with" – that is broken into smaller pieces to be recomposed to make the best possible use of transport resources.

Without disruptions and with little concern about the utilisation of resources, this model has proven to be an efficient and effective way of moving goods.

However, two significant drawbacks have been detected:

- Limited flexibility: Chains, where end-to-end transport is planned in detail, are not flexible. If a disruption occurs, much extra work is required to re-route the cargo to its destination as agreed.
- Poor asset utilisation: Load factors in logistics units (trailers, containers, etc.) are generally below optimal. Several studies (ALICE 2020) have documented load factors of 50% or less (e.g., before implementing the logistics operation described below, the company 3M experienced load factors between 35% and 45%). This is the case both for intra-European transport and for intercontinental container transport.

So, is there an alternative?

ALICE members and in projects where Marlo has been involved offered this alternative:

- Switch from logistics chains to logistics networks (Figure 4).
- Delegate decisions about how to move goods to the nodes (hubs) in the network rather than fixing them at the initial planning stage.

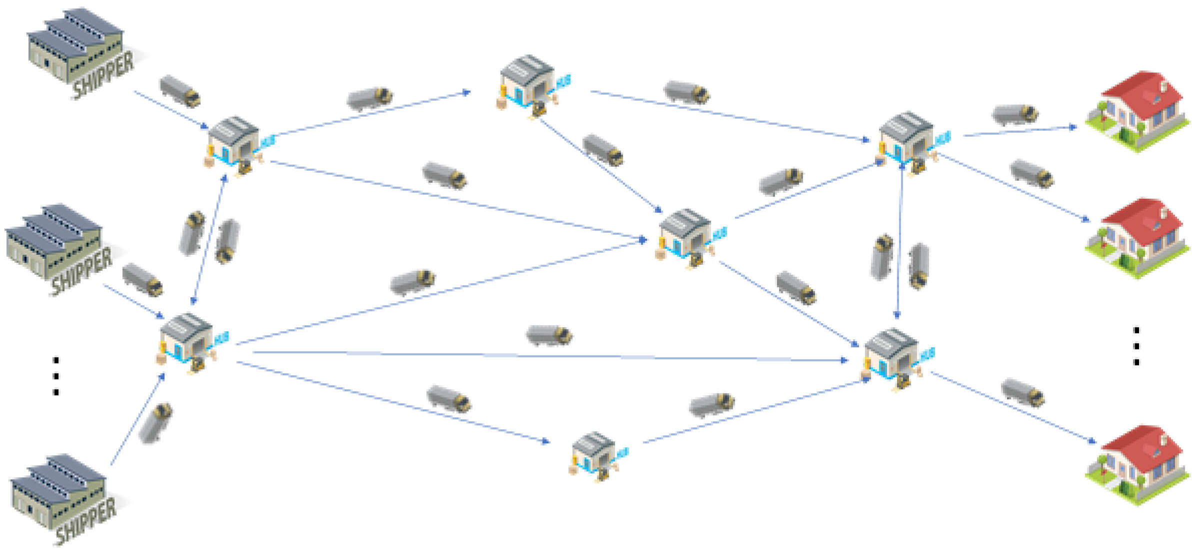

Figure 4: The network approach to logistics.

By adopting a network approach and not a chain perspective, delegating the movement of goods to the nodes (hubs) in the network, and delaying the decisions about how to move the goods as much as possible, the principles of synchromodality are applied, combining resilience with sustainability:

- Decisions made at the nodes can incorporate previous, current, or forecasted disruptions, allowing the selection of transport services that remain unaffected and ensuring continued cargo flow.
- Nodes have visibility of both available cargo and transport services, enabling better matching of loads to capacity and more intelligent use of multiple transport modes.

An important term for SARIL is "available transport services"; those services impaired by disruptions will not be available and, hence, will not be selected when onward movement of goods is planned and executed.

This increases resilience, provided that the alternatives are there to be selected. Establishing them is preparatory work, and it is done before any disruption occurs (see Section 2.2). Decisions about movement of goods in the nodes also facilitates better utilisation of resources (resource efficiency).

These are the principles guiding the development of the Physical Internet, and, in the light of sustainability, such a philosophy aligns with ALICE´s four of its five pillars for zero-emission logistics (Figure 2) namely:

- Shared fleets and assets used to their fullest extent.
- Smart and combined use of transport modes.
- Utilising energy-efficient fleets and assets.
- Utilising of fleets and assets powered by the lowest-emission energy sources.

All of these are relevant to SARIL.

5 Types of Cargo and Logistics Units

Most of the logistics operations relevant to SARIL will be unitised transport. Parcels, pallets, containers, and trailers are typical logistics units being utilised for such operations (Figure 5).

Figure 5: Sample logistics units.

When aiming to support the ambitions presented in the previous section, logistics operations should not be limited to handling containers, trailers, and pallets, but also parcels. What is required?

To apply the principles of synchromodality, all aspects of logistics management etc. need to be digital. This means that:

- Communication between actors must be electronic.
- Transfers of cargo must be recorded, either through scanning (of the items being handled) or by manually reporting (them as the operation takes place).
- Movements of vessels or vehicles involved must be monitored continuously.
- Transport services using the hubs must be “visible” in the appropriate management system(s). The availability of the service should be continuously updated, so that services affected by disruptions are seen as not available.

Furthermore, to support resilience and sustainability, all logistics units – from parcels to pallets to containers – must be uniquely identified. Initially, synchromodality was implemented on the “container” level, but to achieve the combined benefits, the operation should be extended to parcel level, so as all trucks, containers etc., are used to maximum capacity whenever possible and make the most of resources available.

Unique identities within the logistic units are therefore essential. One option is using the GS1 SSCC standard for labelling parcels and pallets. The Serial Shipping Container Code (SSCC) is used by companies to identify a logistic unit, for any combination of trade items packaged together for storage and/or transport purposes. Figure 6 shows an example of a SSCC parcel label, widely used in the retail sector and increasingly adopted in transport operations.

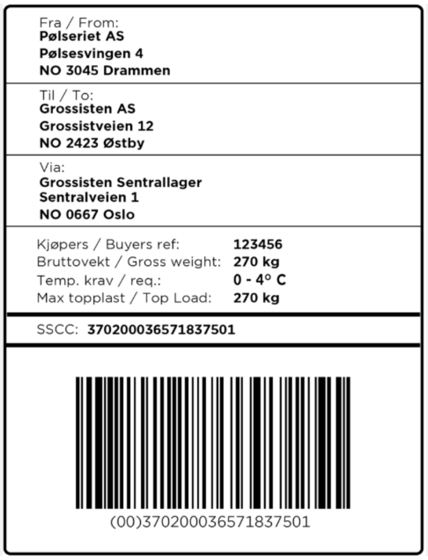

Figure 6: SSCC Label.

While the standard SSCC provides an ID for the logistics unit, GS1 has introduced an advanced label through the initiative Scan4Transport (Figure 7), which includes a 2D barcode on the label in addition to the one containing the SSCC ID.

Figure 7: Scan4Transport label, including SSCC information.

This 2D bar code contains the minimum operational data required for enabling the logistics unit to be moved efficiently from origin to destination, like ship to address, contact person, dangerous goods information, weight, and dimensions, etc.

6 The Demonstration

6.1 Introduction

Work Package 3 of SARIL, called "Modelling and Demonstration of Resilience Solutions", specified and developed the resilience tools of the project, connected them into a common tool architecture organised around the Disruption Information Interface, and applied them to the three scenario cases. Two of these tools are relevant here, and they are used at different points in the disruption cycle. ASTROIT (Agent-based SimulaTion for Resilience Of Intermodal Transportation) represents each cargo unit as an agent that selects its own route based on operating cost, CO_2 emissions and travel time. It is a strategic tool. In the European scenario it was used to analyse potential disruption scenarios in the network, and to establish which services, and which combinations of services, keep the goods flowing when part of the network is lost. The synchro-modal decision-making capability demonstrated in this deliverable is the operational counterpart. It works from the set of services that the preparedness work established, it keeps the catalogue of these services up to date when information about disruptions arrives, and it applies the decision rules of the hub to the services that remain available. The tools, their use in the scenarios and the resulting green resilience assessment are described in the public deliverable D3.4, General solutions for the resilience of logistic networks (SARIL project, 2025).

The demonstration described in this chapter belongs to the European scenario. This scenario deals with disruptions of European freight flows caused by events of continental or global reach, and with the way such events propagate into intra-European traffic. The case used here is recurrent disruption in the Passau region, on the corridor between Lanzendorf and Lauterach. This is a concrete example of such propagation, and it is taken from the operating experience of the SARIL partner Gebrüder Weiss.

For this demonstration, the ASTROIT tool has been used to simulate the cargo flow within a very small part of the logistics network operated by Gebrüder Weiss (GW) (Figure 8).

Figure 8: A very small section of the Gebrüder Weiss logistics network.

This is part of GW groupage network, an organised system of hubs, warehouses, and transport routes designed to efficient collect, consolidate, and distribute Less than Truckload (LTL) or Less than Container Load (LCL) shipments.

The core function of groupage is to combine multiple small shipments from different senders (consignors) into a larger one with full-capacity load; often a Full Truck Load (FTL) or a Full Container Load (FCL) for transport to a hub in the vicinity of the final destinations. This process is also known as cargo consolidation.

Each terminal in the GW is, in addition to forwarding goods to other terminals, responsible for serving a designated postal code area. Within Austria, this logic partly follows the federal state logic (for Vorarlberg, Tyrol, Carinthia) or geographical combinations following a "shortest route" logic.

A map showing postal code areas in Austria is shown in Figure 9.

In reference to the network in Figure 8, the hub in Lauterach serves the region with postal codes from 6700 to 6974.

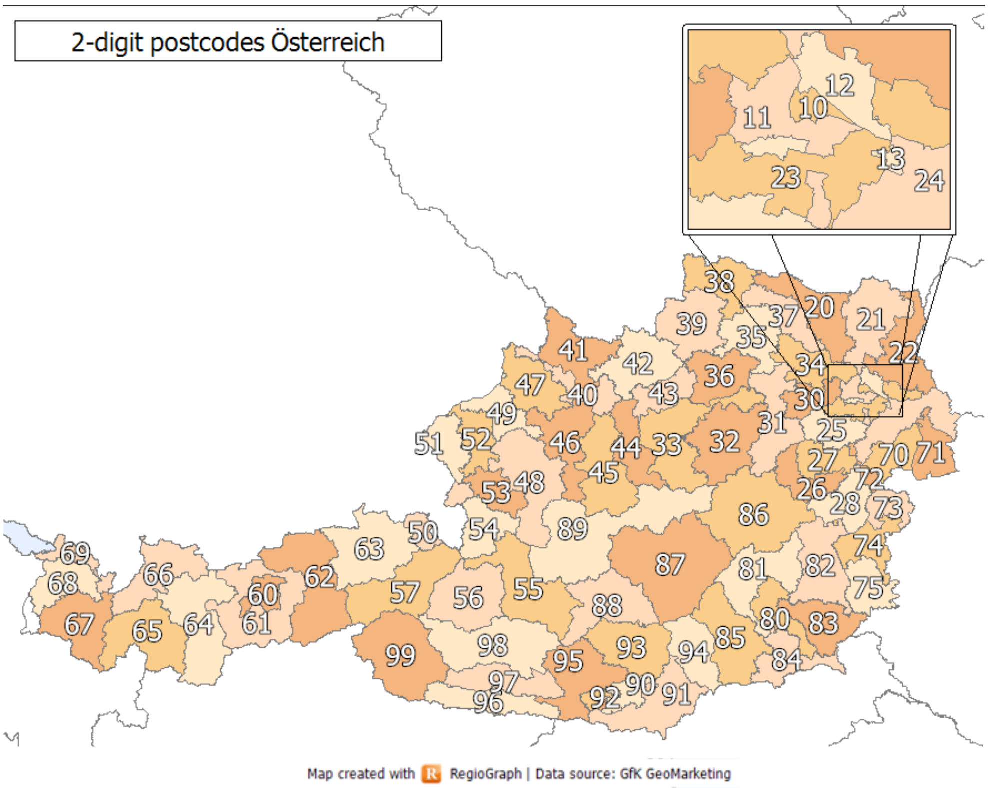

Figure 9: 2-digit postal codes in Austria.

For the purposes of this demonstration, the ASTROIT simulation model uses the network comprising the hubs Lanzendorf, Passau, Salzburg, and Lauterach.

6.2 The Logistics Management System

The MIXMOVE logistics management system being used in the demonstration, X-Dock, was initially developed in the EU project iCargo. It was developed to help companies improve load factors. It was first implemented in all the hubs in a logistics network in Europe for a large shipper, involving more than twenty hubs.

It does not only focus on linear logistics operations but regards linear chains as subsets of logistics networks. In this network approach to logistics, the precise route from origin to destination may not be planned in detail before the movement of goods starts. Instead, the origins and destinations are defined at the outset, together with all terms and conditions that have been agreed between sender and receiver.

Decisions such as to how to further move the goods are delegated to the terminals, or hubs - the nodes in the network. This represents the ultimate implementation of the synchromodality concept. This approach also aligns closely with the principles of the Physical Internet (ALICE 2020) and the X-Dock solution facilitates such operations.

Prior to receiving the goods, the hubs will have received information about the cargo, the final destination and the terms and conditions agreed between sender and receiver. All this information is considered when hubs decide about cargo movements.

The X-Dock system supports all the operational capabilities described in Section 5.

In a MIXMOVE facilitated logistics network, all hubs continue to operate largely like they did before they became part of the network. In hubs where there is no hub management system, X-Dock will function as a stand-alone solution.

In hubs where hub management systems are already in place and used, a specific autonomous logistics process is introduced (Figure 10), without introducing changes to the existing infrastructure or management systems.

This new autonomous process prepares cargo for onwards transport, either to a new hub or to the final destination. The new process is managed by a MIXMOVE cloud solution; it receives information on incoming cargo originally intended to be sent to the hub management system, it manages the process and then sends information on reconstructed cargo as indicated (Figure 10).

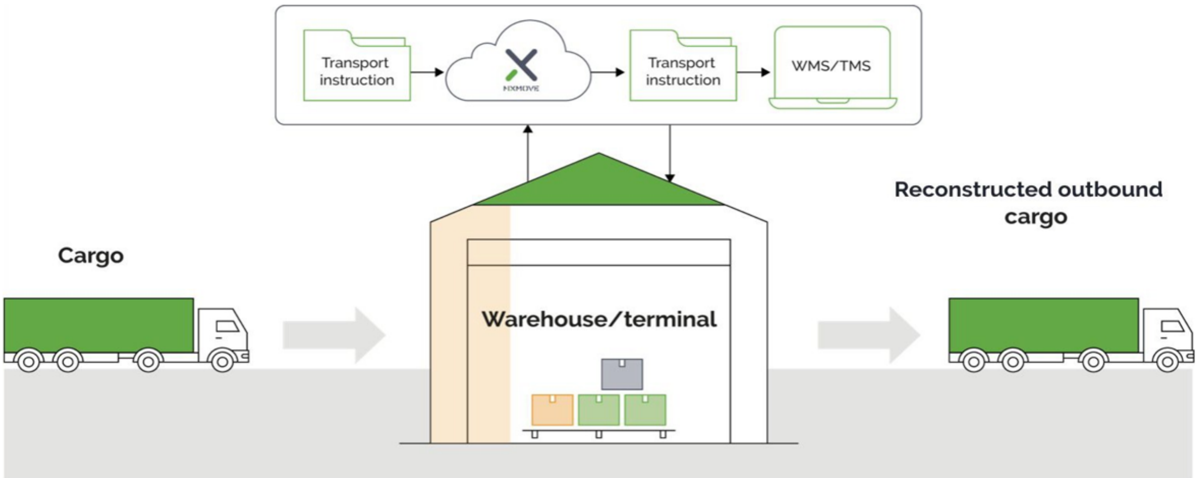

Figure 10: New autonomous process.

The „MIXMOVE Process“ in Figure 10 is detailed in Figure 11.

What is key in the context of this report is that the stripping, sorting and stuffing processes are not “hard wired”, but instead, guided by a set of decision rules. These decision rules may be different in each hub and may even differ for cargo from different shippers within the same hub.

The decision rules may be changed at any time, and cargo will be handled based on the new rules as soon as they have been implemented.

Examples of these decision rules are shown later in the report.

The architecture of X-Dock is illustrated in Figure 12

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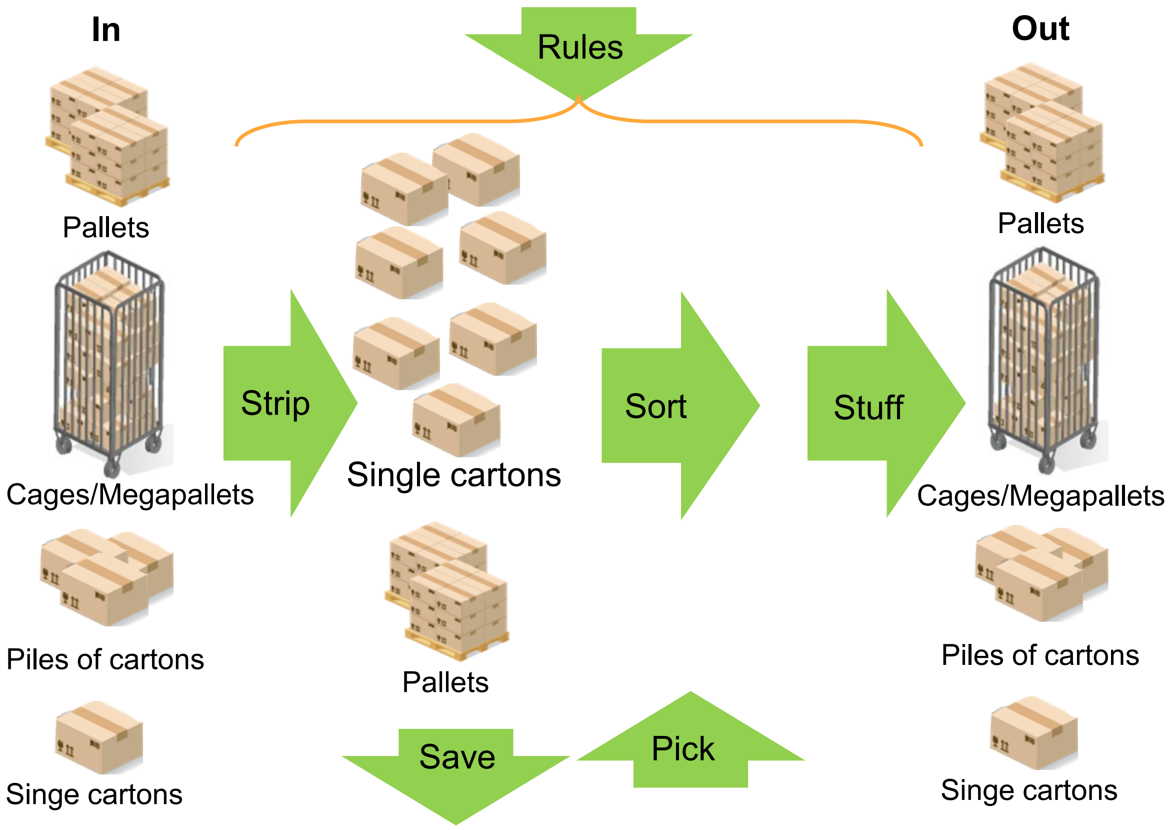


Figure 11: The MIXMOVE process.

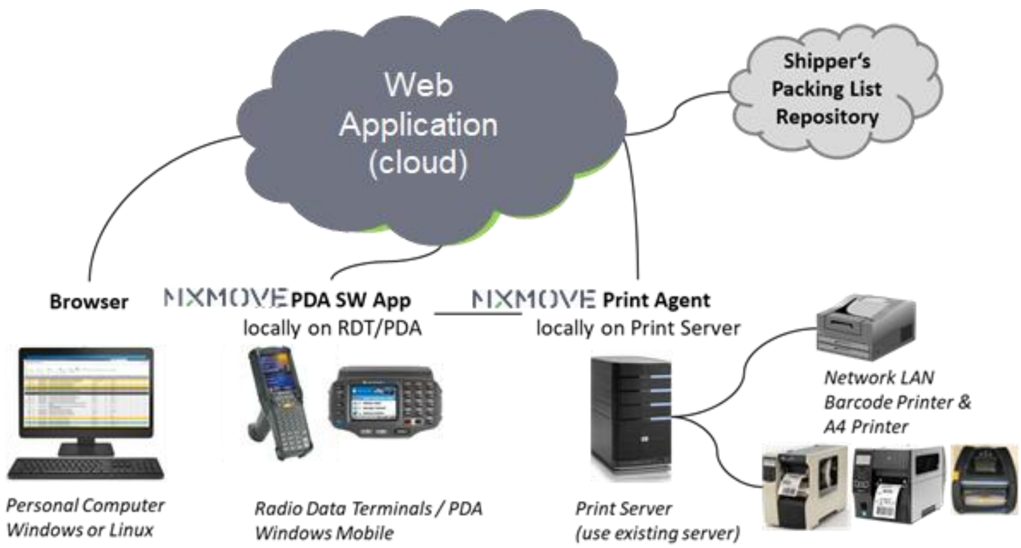


Figure 12: The X-Dock architecture.

6.3 The Operations

The operation illustrated in Figure 8 handles all types of cargo that can be transported by road, except living animals, temperature-sensitive goods (such as frozen products) and dangerous goods cargo class 1 (explosives) and 7 (radioactive materials).

This cargo has been categorised as:

- Cargo weighing less than 5 tons. This cargo is transported using the GW groupage network, with the exception that if trucks can be completely filled with cargo for one destination (customer), then this cargo will be consolidated and transported directly to its destination.
- Cargo weighing more than five tons, which will be transported directly to the destination, not in the groupage network.

The part of the network used in this demonstration is illustrated in Figure 13, namely cargo originated in and around the Lanzendorf hub to receivers in and around the Lauterach hub.

The normal groupage service for the cargo in this demonstration follows the route from Lanzendorf through Passau to Lauterach (Figure 13).

However, the region around the Passau hub is now and then affected by disruptions. To mitigate the impact of such disruptions, GW has defined an alternative route in which cargo from Lanzendorf to Lauterach will be transported via the Salzburg hub (Figure 14).

As a result, the following set of transport services should be available:

- Groupage service between Lanzendorf and Passau
- Groupage service between Lanzendorf and Salzburg
- Groupage service between Passau and Lauterach
- Groupage service between Salzburg and Lauterach
- Truck service for movement of cargo items above 5 tons
- General truck service

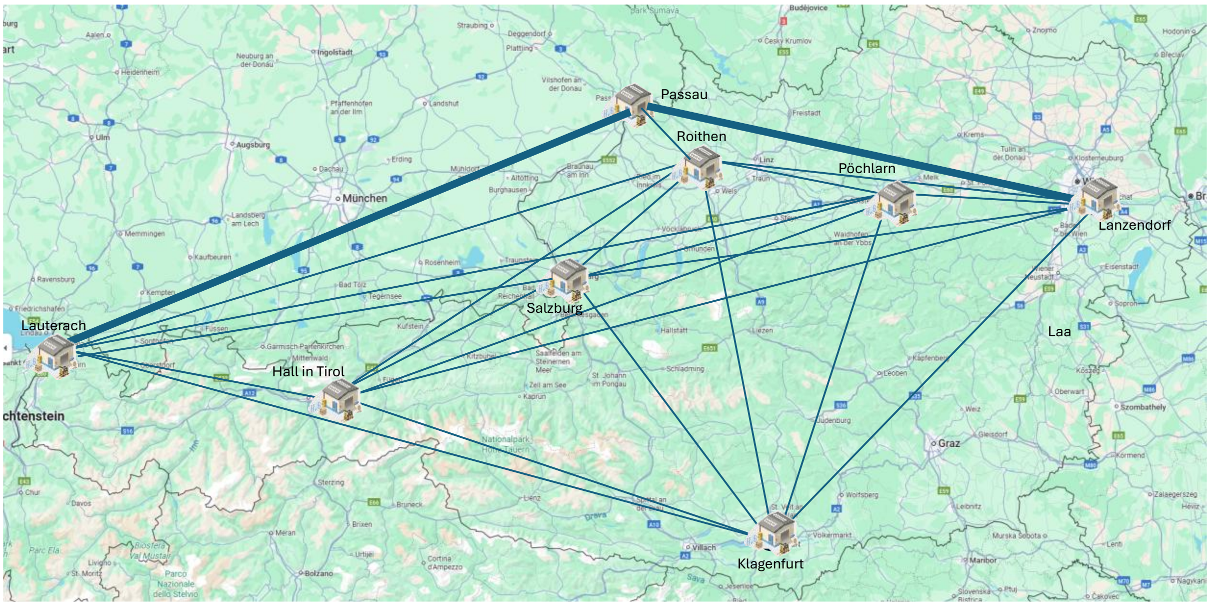


Figure 13: The preferred path for cargo between Lanzendorf and Lauterach.

Based on the information above, the decision rules in Lanzendorf are as follows:

- If cargo items weigh less than 5 tons and a truck can be fully loaded for a single receiver, use the general truck service and send directly to destination.
- If cargo items weigh more than five tons, use the heavy-cargo truck service and send directly to destinations.
- If cargo items weigh less than 5 tons and have destination within the Austrian postcodes ranging from 6700 till 6974, select groupage service and sent to the hub in Passau.

The decision rules in Passau and Salzburg are as follows:

- If cargo items weigh less than 5 tons and a full truckload can be created for a single receiver, use general truck service and send directly to destination.
- If cargo items weigh more than five tons, select the heavy-cargo truck service and send directly to destinations.
- If cargo items weigh less than 5 tons and have destination within Austrian postcodes 6700 - 6974, use the groupage service and send to the Lauterach hub.

GW has experienced disruptions in the Passau area and has prepared an alternative route, which is illustrated in Figure 14.

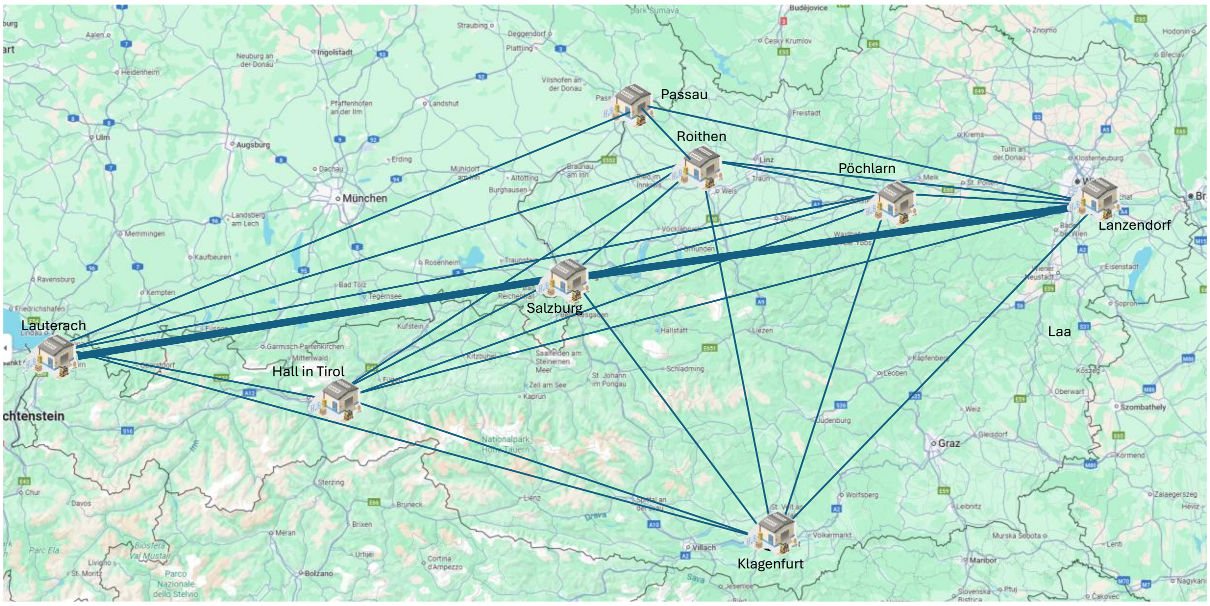


Figure 14: Alternative route when the Passau region is affected by disruptions.

When disruptions happen in the Passau region, the only adjustments required to avoid the disruption within the network is the modification of one of the decision rules in Lanzendorf. The original rule:

- If cargo items weigh less than 5 tons and have destination within the Austrian postcodes ranging from 6700 till 6974, select groupage service and sent to the hub in ***Passau***.

Will be modified as follows:

- If cargo items weigh less than 5 tons and have destination within the Austrian postcodes ranging from 6700 till 6974, select groupage service and sent to the hub in ***Salzburg***.

This change was implemented in less than a minute, after which the cargo is immediately changed to its new route, avoiding the disruption.

6.4 Use of the System

6.4.1 Introduction

The section below assumes that the X-Dock system has not yet been used in the hub in Lanzendorf and includes the actions needed to configure and operate the system for this exercise. It only shows a fraction of the X-Dock capacities.

The following sections describe the following:

- Defining the Lanzendorf hub and the hubs with which the Lanzendorf is connected in the network. (Section 6.4.2)
- Work in hubs are typically organised in lanes (on the hub floor), and in this exercise three lanes are used. (Section 6.4.2)
- The transport services that may be used to move cargo from the hub are also described. (Section 6.4.3)
- The key to implementing synchromodality is the decision rules. There are two of them:
    - Reconstruction rules that are used to organise cargo for outbound transport. Those are the rules that are referred to as "Rules" in Figure 11. (Section 6.4.4)

  - There are also rules for defining what to do with the cargo when it arrives at the hub. These are called pre-sorting rules. (Section 6.4.4)
- After configuring the system (the previous steps), the incoming cargo is identified. Information about incoming cargo arrives at the hub in the form of electronic messages, like indicated on the top left in Figure 10. The format of the message used in Figure 10 is a so-called Transport Instruction. It includes information about the cargo and the destination. One sender sends one or more shipments. During transport, shipments are combined into consignments, making then easier to handle. Hence, the incoming cargo arrives as a consignment. (Section 6.4.5)
- Now planning can start. The result of the planning is which cargo can travel together (in new consignments) and which services that will be used to transport them. (Section 6.4.6)

The following describes the two case studies (logistics plan) and practical demonstration of synchro modality:

1. The first planning assumes that cargo shall go from Lanzendorf to Lauterach via Passau.
2. The second planning assumes that the region in and around Passau cannot be accessed due to disruptions. (Section 6.4.7)

Even if the network comprises several hubs, and four of the hubs in the network are used in the example, only the Lanzendorf hub and operations performed there will be used in the description of this report. All the capabilities described in the Lanzendorf hub would just have been repeated in the report, with no new insight.

6.4.2 The Hubs

The layout of the X-Dock user interface and the identification of the hub in Lanzendorf is illustrated in Figure 15.

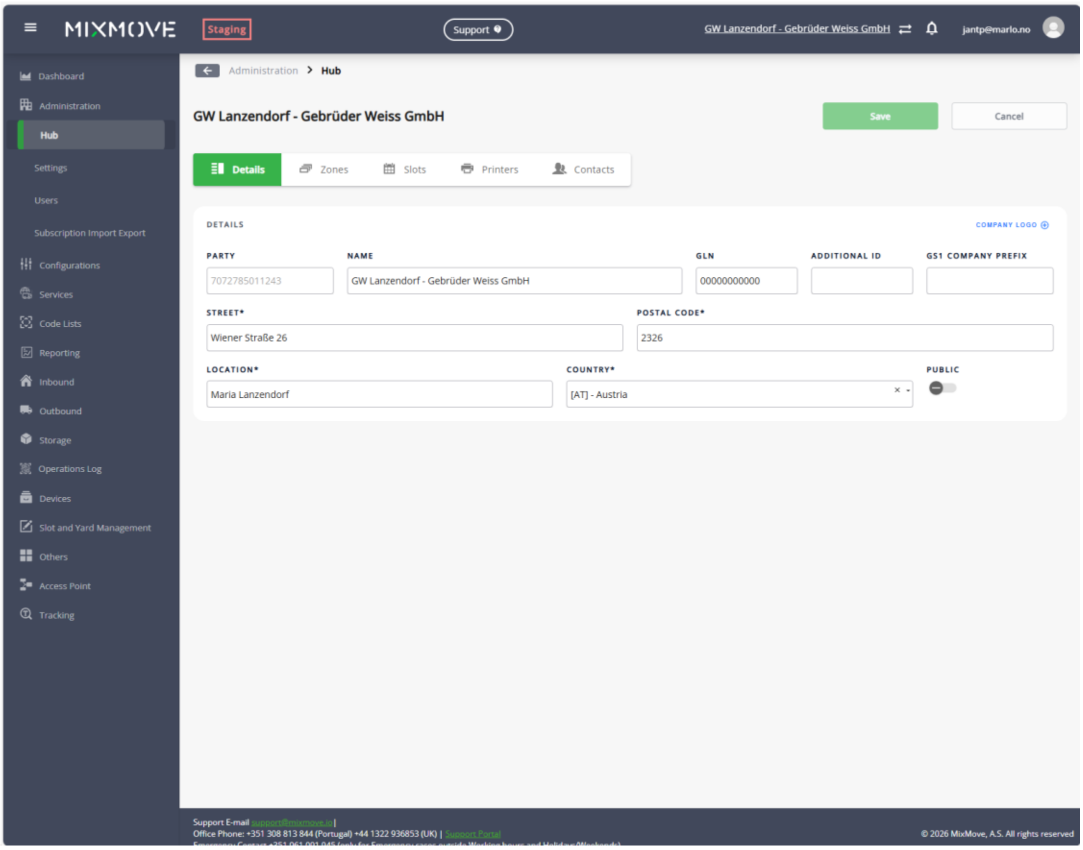
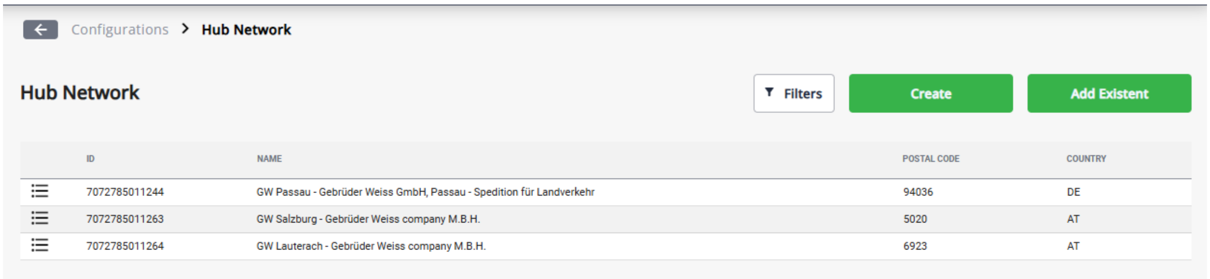


Figure 15: User interface and hub ID.

In Figure 16, the three other hubs in the network are visible to those operating in Lanzendorf.


Configurations > Hub Network

Hub Network

Filters | Create | Add Existent

	ID	NAME	POSTAL CODE	COUNTRY
	7072785011244	GW Passau - Gebrüder Weiss GmbH, Passau - Spedition für Landverkehr	94036	DE
	7072785011263	GW Salzburg - Gebrüder Weiss company M.B.H.	5020	AT
	7072785011264	GW Lauterach - Gebrüder Weiss company M.B.H.	6923	AT

Figure 16: The other hubs in the network.

For the purpose of this exercise, the three reconstruction lanes have been identified in the Lanzendorf hub, see Figure 17.

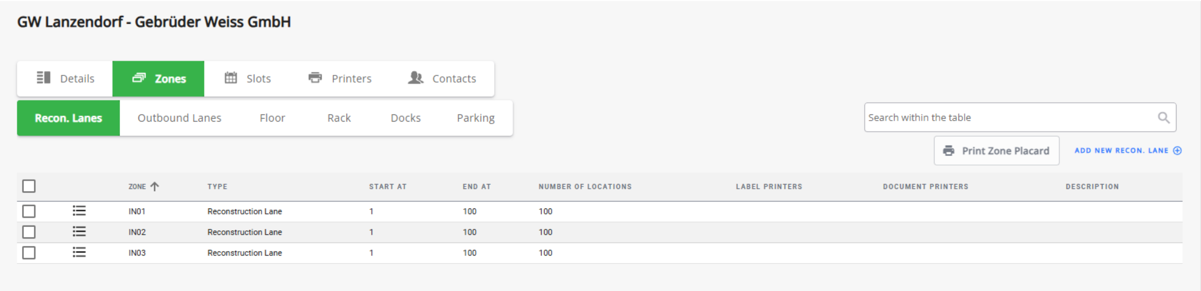


Figure 17: 3 lanes made available.

The three lanes are used as follows:

IN01 Used to handle cargo weighing less than 5 tons and full load to final destination possible.

IN02 Used to handle cargo items weighing more than five tons.

IN03 Used to handle cargo where items weigh less than 5 tons and are destined to addresses with Austrian post codes between 6700 and 6974.

6.4.3 Transport Services

As can be seen in Figure 18, there are four transport services available in the Lanzendorf hub, for the purpose of this exercise.

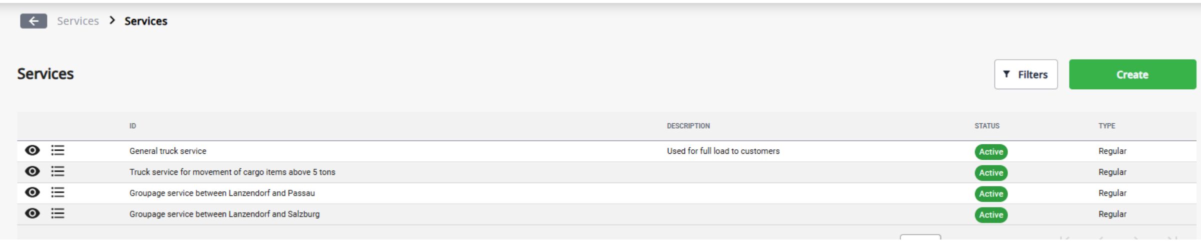


Figure 18: Transport servicers used in the Lanzendorf hub.

- One general truck service, which will be used if the vehicles can be fully loaded when delivering to a single address.
- One truck service for moving goods items weighting more than three tons. These will also be delivered directly to the destination.
- One groupage service between Lanzendorf and Passau. This service will be used to ensure full truck loads between these hubs. Cargo with destinations in the appropriate postal codes will use this service. This is the standard service to be used when sending cargo from the Lazendorf hub to destinations withing the postcode range between 6700 and 6974.
- One groupage service between Lanzendorf and Salzburg. These services will be used to ensure full truck loads between these hubs. Cargo with destinations in the appropriate postal codes will use this service. This is the fallback service to be used when there are problems in the Passau region sending cargo from the Lazendorf hub to destinations withing the postcode range between 6700 and 6974.

The identification of the groupage service between Lanzendorf and Passau is illustrated in Figure 19

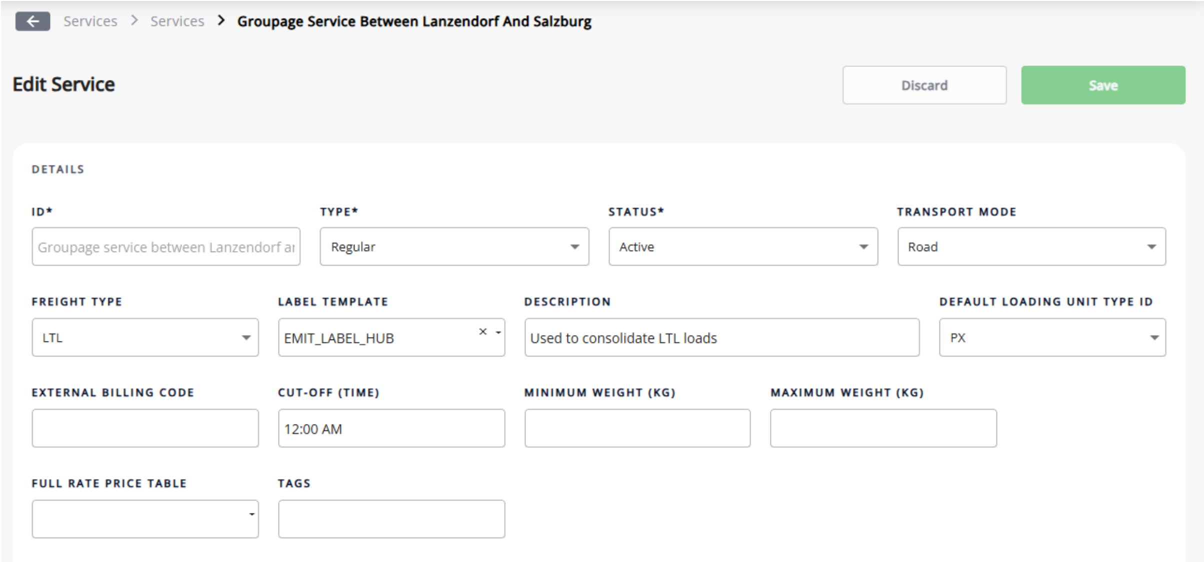
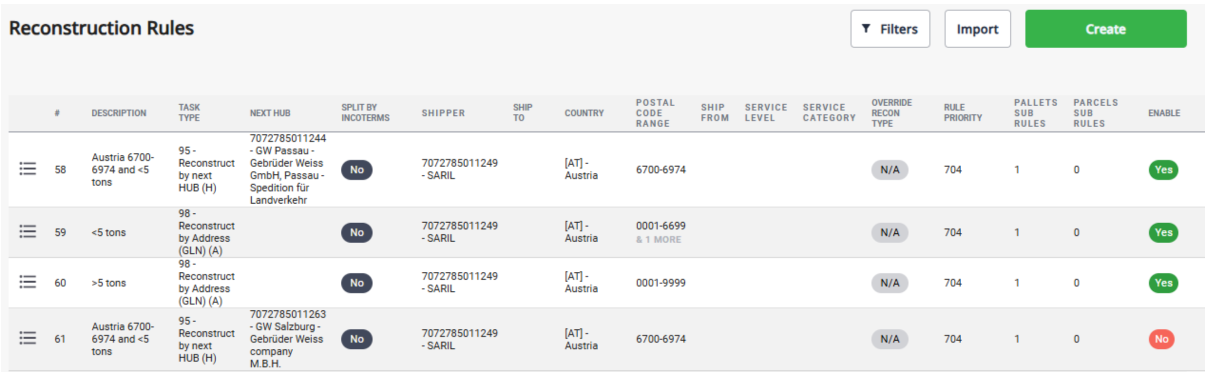


Figure 19: The groupage service between Lanzendorf and Passau.

6.4.4 Decision Rules

There are two types of decision rules:

- Reconstruction rules (Figure 20) and
- Pre-sorting rules (Figure 21).



Reconstruction Rules

Filters | Import | Create

#	DESCRIPTION	TASK TYPE	NEXT HUB	SPLIT BY INCOTERMS	SHIPPER	SHIP TO	COUNTRY	POSTAL CODE RANGE	SHIP FROM	SERVICE LEVEL	SERVICE CATEGORY	OVERRIDE RECON TYPE	RULE PRIORITY	PALLETS SUB RULES	PARCELS SUB RULES	ENABLE
58	Austria 6700-6974 and <5 tons	95 - Reconstruct by next HUB (H)	7072785011244 - GW Passau - Gebrüder Weiss GmbH, Passau - Spedition für Landverkehr	No	7072785011249 - SARIL		[AT] - Austria	6700-6974				N/A	704	1	0	Yes
59	<5 tons	98 - Reconstruct by Address (GLN) (A)		No	7072785011249 - SARIL		[AT] - Austria	0001-6699 & 1 MORE				N/A	704	1	0	Yes
60	>5 tons	98 - Reconstruct by Address (GLN) (A)		No	7072785011249 - SARIL		[AT] - Austria	0001-9999				N/A	704	1	0	Yes
61	Austria 6700-6974 and <5 tons	95 - Reconstruct by next HUB (H)	7072785011263 - GW Salzburg - Gebrüder Weiss company M.B.H.	No	7072785011249 - SARIL		[AT] - Austria	6700-6974				N/A	704	1	0	No

Figure 20: Sample reconstruction rules.

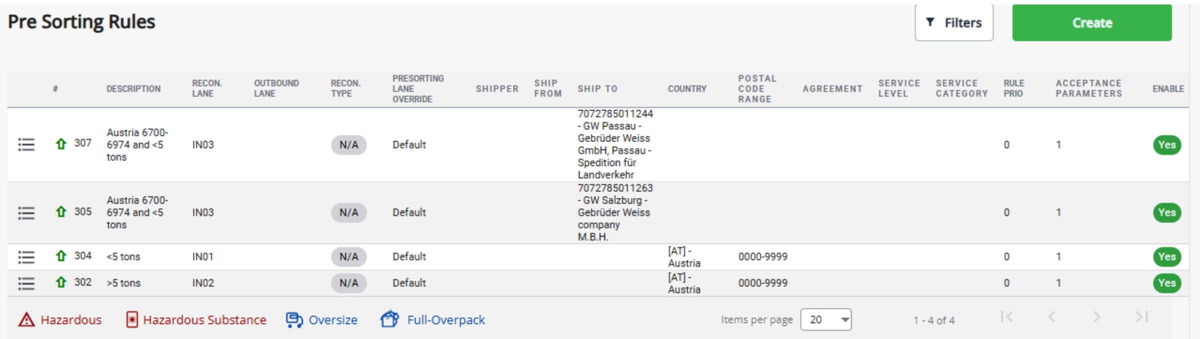
As we can see from Figure 20, there are four rules, mirroring the once that have been specifies in Section 6.3. Note that the rule with ID is not enabled (see the "no" sign at the bottom right of Figure 20). This rule has been created in preparation for the situation that there may be problems transporting cargo to Lauterach via Passau. The other three are enabled and are the rules that are used as in normal operations, when cargo items weighing less than 5 tons are sent to the Lauterach area using groupage services via Passau.

The column "Task Type" indicate that there are several ways to perform reconstruction. In this example two have been chosen.

Rule number 58 (the one dealing with individual items weighting less than 5 tons) defines that cargo is reconstructed by "next hub" and that the next hub is "70727850-GW Passau-Gebrüder Weiss GmbH, Passau – Spedition für Landverkehr". The rule indicated that the destination country is Austria, and that it applies to cargo with post code between 6700 and 6974.

Rules 59 and 60 performs reconstruction by address. This means that all relevant cargo with the same destination (address) will be reconstructed together. This is the case both when cargo items weigh above 5 tons and when cargo items weighting less than 5 tons with re same end destination (address) can fill a vehicle completely.

The pre-sorting rules are used when cargo arrives at the hub. The pre-sorting rules used here are shown in Figure 21.



Pre Sorting Rules

Filters | Create

#	DESCRIPTION	RECON. LANE	OUTBOUND LANE	RECON. TYPE	PRESORTING LANE OVERRIDE	SHIPPER	SHIP FROM	SHIP TO	COUNTRY	POSTAL CODE RANGE	AGREEMENT	SERVICE LEVEL	SERVICE CATEGORY	RULE PRIO	ACCEPTANCE PARAMETERS	ENABLE
307	Austria 6700-6974 and <5 tons	IN03		N/A	Default			7072785011244 - GW Passau - Gebrüder Weiss GmbH, Passau - Spedition für Landverkehr						0	1	Yes
305	Austria 6700-6974 and <5 tons	IN03		N/A	Default			7072785011263 - GW Salzburg - Gebrüder Weiss company M.B.H.						0	1	Yes
304	<5 tons	IN01		N/A	Default				[AT] - Austria	0000-9999				0	1	Yes
302	>5 tons	IN02		N/A	Default				[AT] - Austria	0000-9999				0	1	Yes

Hazardous | Hazardous Substance | Oversize | Full-Overpack | Items per page 20 | 1 - 4 of 4

Figure 21: Sample pre-sorting rules.

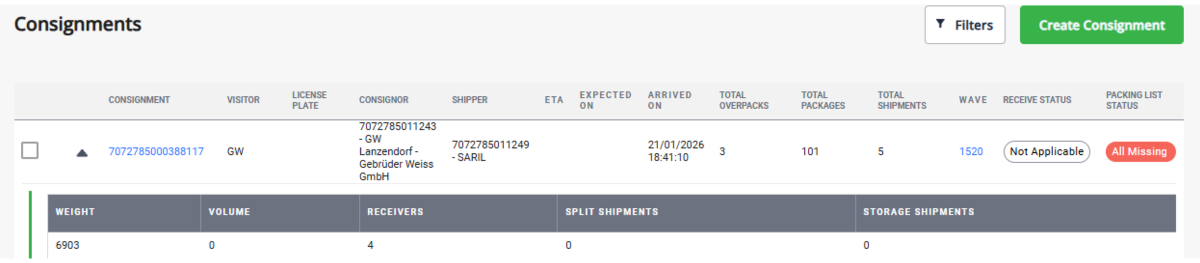
The most interesting rules here are the ones labelled 305 and 307. The purpose of the pre-sorting rules is to direct cargo to the correct lane in the terminal or warehouse. This shows that cargo weighing less than 5 tons and are destined to addresses with Austrian post codes between 6700 and 6974 are to be directed to lane IN03. Since one of the hubs in the network, Passau, is located in Germany, two pre-sorting rules are needed. The lanes are illustrated in Figure 17.

Cargo weighing more than five tons are directed to lane IN02, and cargo item weighing less than 5 tons and with the possibilities that cargo to one single destination can fill one vehicle, is directed to lane IN01.

6.4.5 Incoming Cargo

Cargo may originate in the vicinity of the hub, or it may have travelled long distances before it arrives at the hub. What the hub is concerned about is information about incoming cargo items.

In this demonstration, there is one incoming consignment, see Figure 22



Consignments

Filters | Create Consignment

CONSIGNMENT	VISITOR	LICENSE PLATE	CONSIGNOR	SHIPPER	ETA	EXPECTED ON	ARRIVED ON	TOTAL OVERPACKS	TOTAL PACKAGES	TOTAL SHIPMENTS	WAVE	RECEIVE STATUS	PACKING LIST STATUS
7072785000388117	GW		7072785011243 - GW Lanzendorf - Gebrüder Weiss GmbH	7072785011249 - SARIL			21/01/2026 18:41:10	3	101	5	1520	Not Applicable	All Missing

WEIGHT	VOLUME	RECEIVERS	SPLIT SHIPMENTS	STORAGE SHIPMENTS
6903	0	4	0	0

Figure 22: Incoming consignment.

The total weight of the consignment is 6.9 tons and there are four receivers. The consignment details are shown in Figure 23.

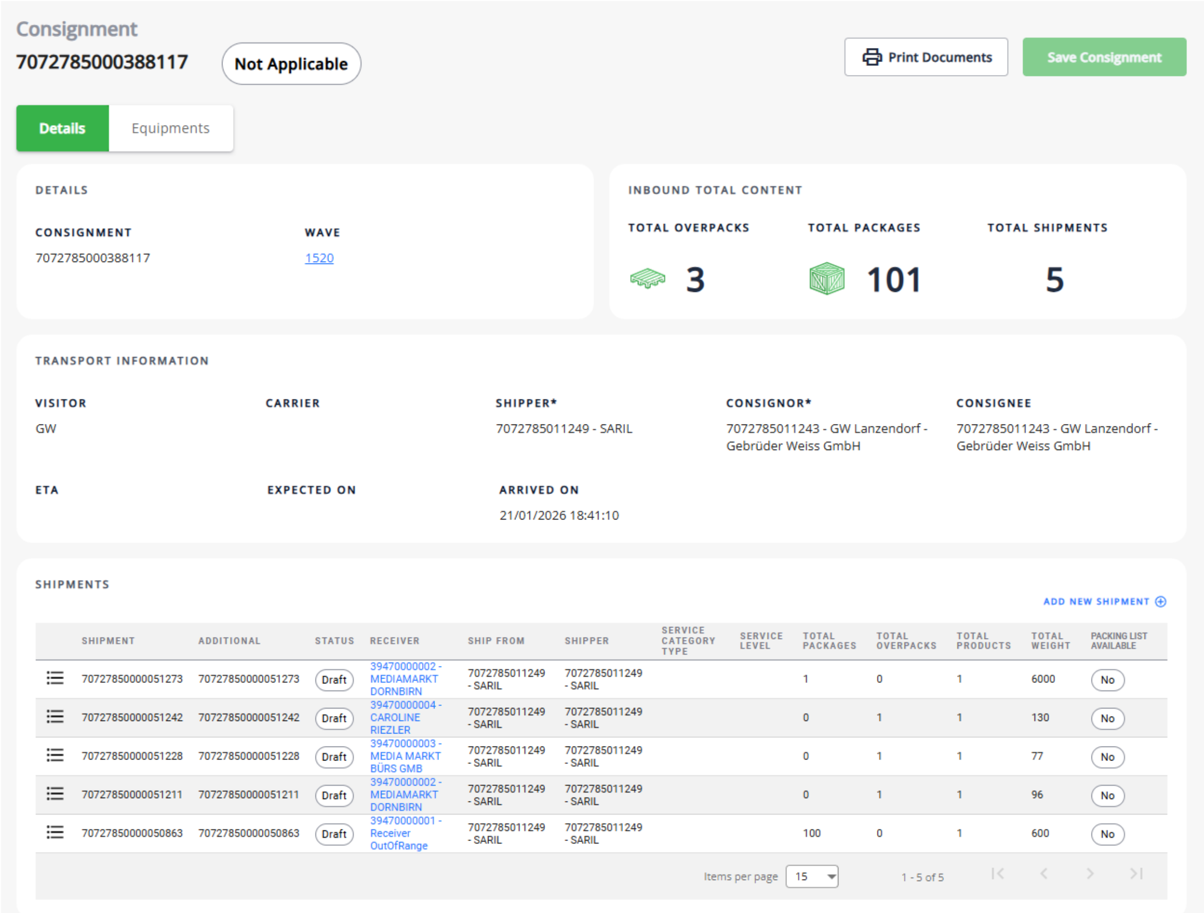


Figure 23: Consignment details.

The details show that there are five shipments in total. Three pallets and one hundred and one boxes. This is confirmed when looking at a different list of shipments, see Figure 24.

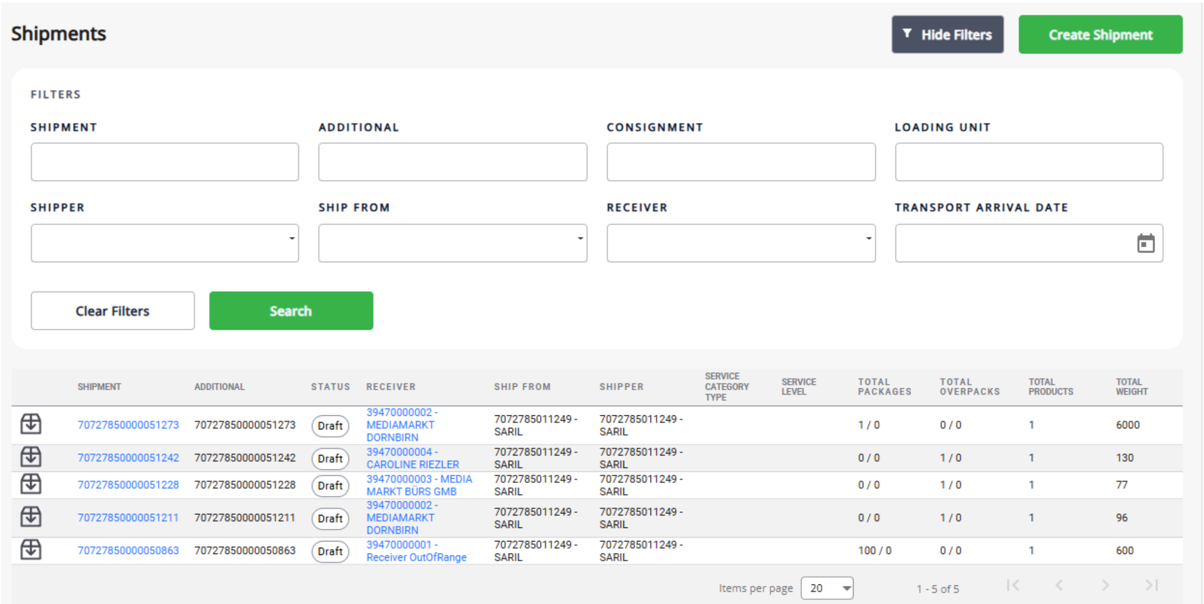


Figure 24: List of shipments.

The details of one of the shipments is illustrated in Figure 25.

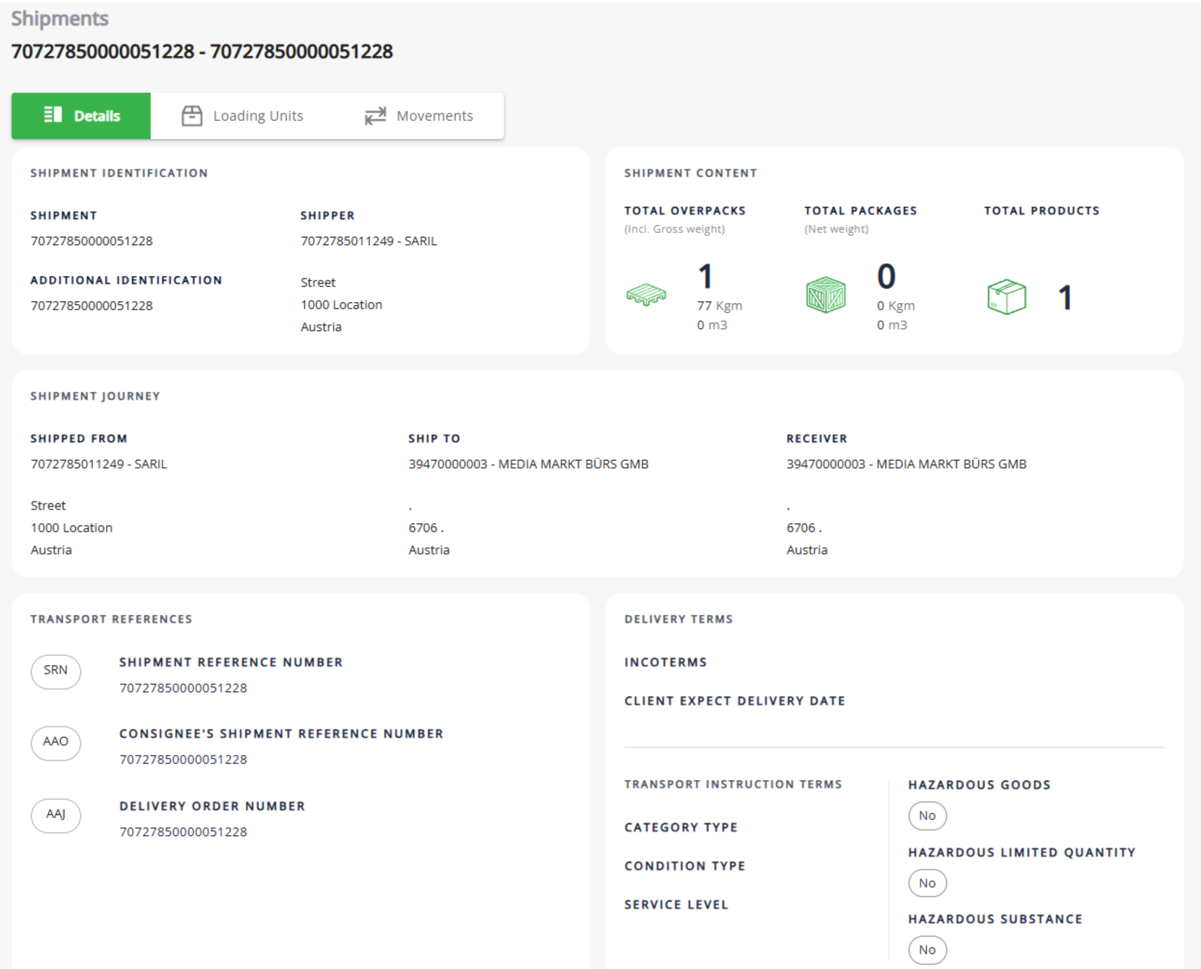


Figure 25: Sample shipment details.

6.4.6 Planning the Hub Operation

When a number of trucks arrive at a hub or warehouse, and the cargo that they carry should be handled together, the task at hand is called "planning a wave". In logistics terminals and warehousing, a wave is a planned batch of orders or tasks released together for execution (e.g., picking, packing, shipping), typically grouped by criteria like carrier cutoff time, route, zone, or priority to optimize labour and throughput.

The illustration in Figure 26 shows that there is, in this case, there is only one wave.

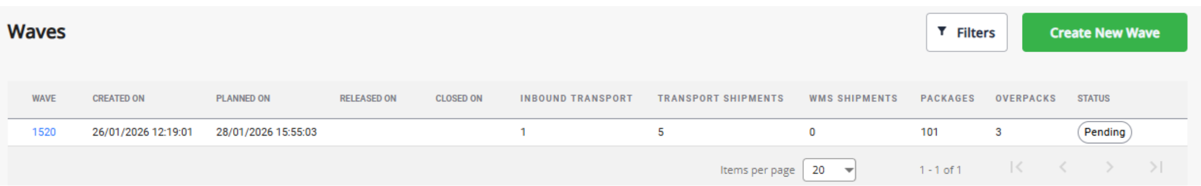


Figure 26: Number of waves that may be planned.

The opening screen of the planning window is illustrated in Figure 27.

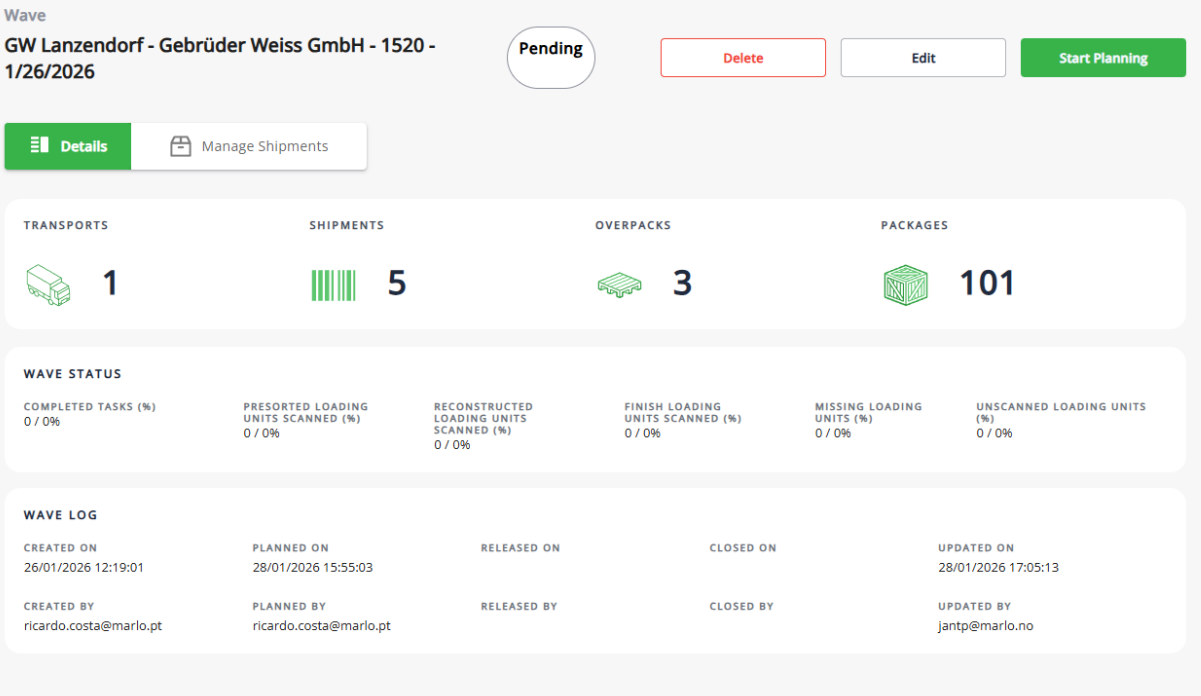


Figure 27 Start planning a wave.

What is to be planned in one transport, five shipments containing three pallets (overpacks) and hundred-and-one packages.

After pressing the “Start Planning” and letting the planning take place, it completes by showing a screen like the one in Figure 28.

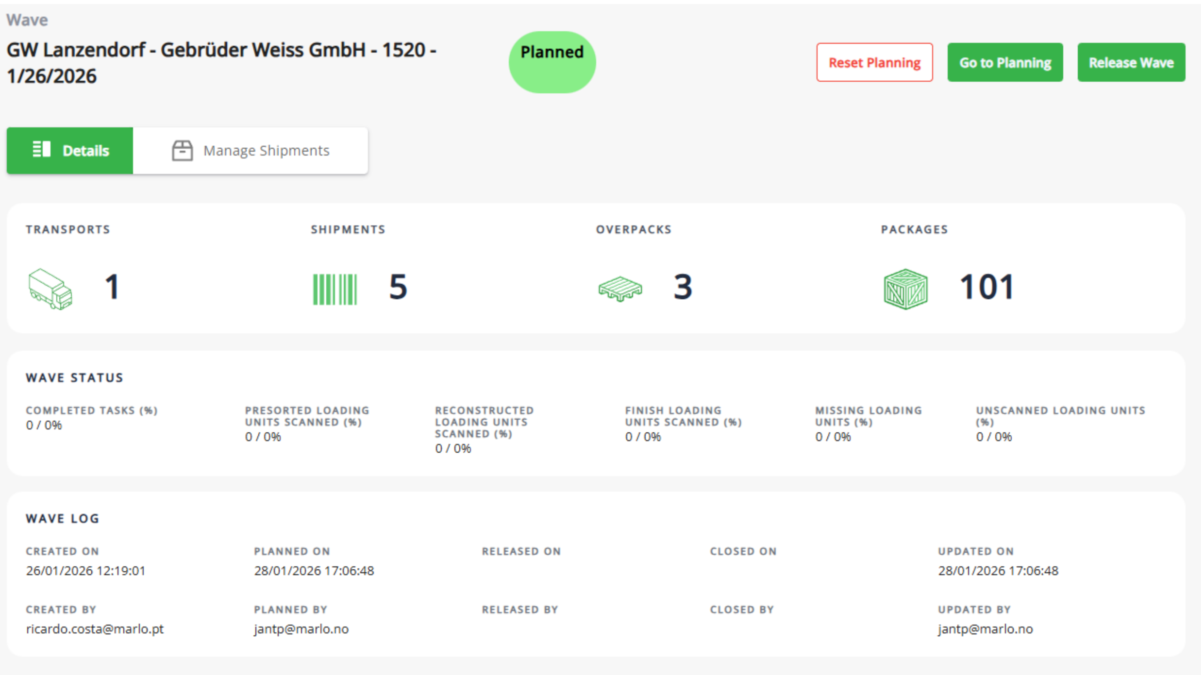


Figure 28: Planning completed.

To see what the plan looks like, the "Manage Shipments" folder is opened. It looks like Figure 29

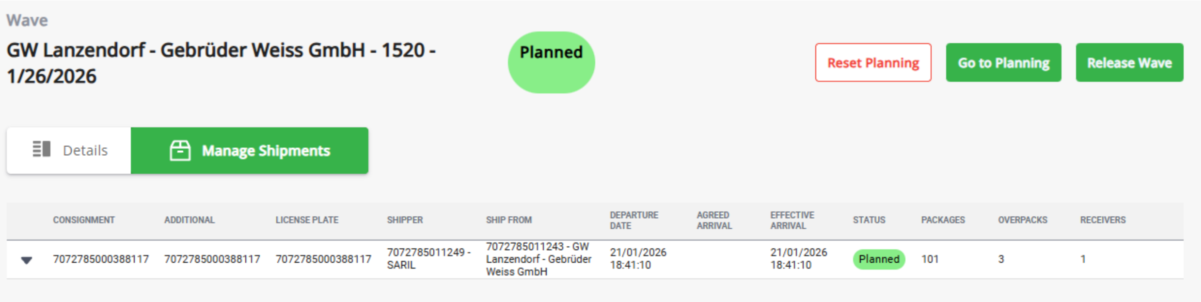


Figure 29: Managing shipments.

By pressing the "down arrow" on the left-hand side, the details are shown as in Figure 30.

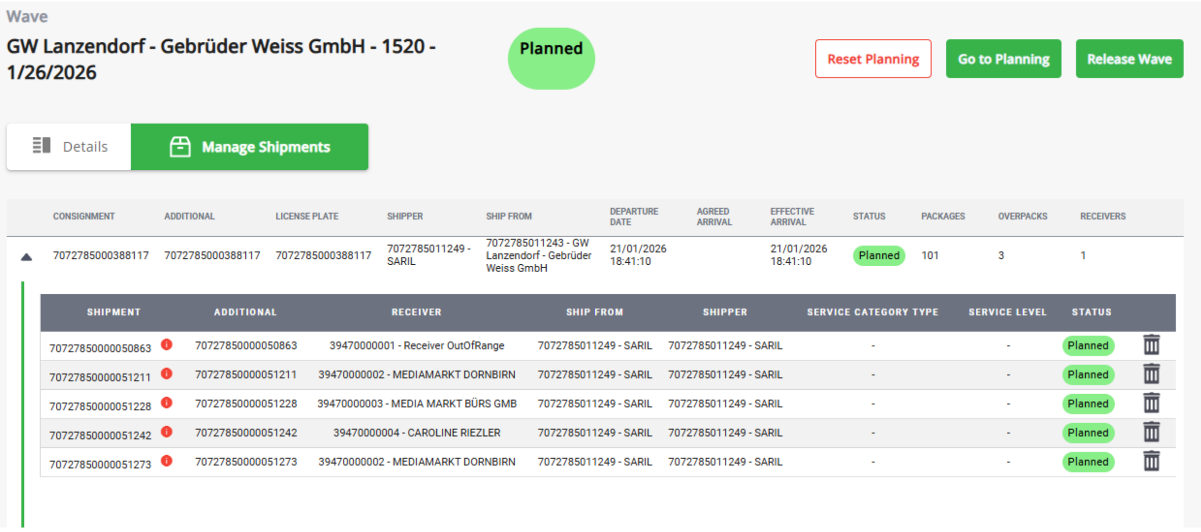


Figure 30: Manage shipment details.

Note that the shipment in line 1 states that "receiver is out of range", meaning that the post code in the address is outside the range covered by the decision rules.

Once the planning is completed, the list of planned waves is shown in a screen like the one in Figure 31

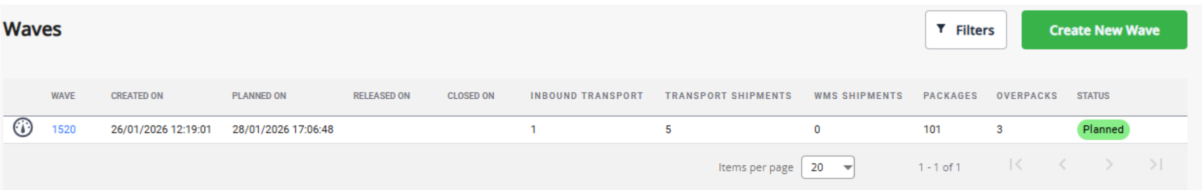


Figure 31: List of planned waves.

By pressing the "instrument" on the left side of the planned wave (no. 1519), the details are presented, as shown in Figure 32, which shows what to do with cargo in the pre-sort lanes.

GW Lanzendorf - Gebrüder Weiss GmbH - 1520 - 1/26/2026

Go to wave ↗

PRESORT LANE	RECONSTRUCTION TYPE	TASK TYPE	NR. TASKS	WEIGHT	VOLUME	TRADE ITEMS	PACKAGES	OVERPACKS
IN01	Pallet	98 - Reconstruct by Address (GLN) (A)	2	730	0	2	100	1
IN02	Pallet	98 - Reconstruct by Address (GLN) (A)	1	6096	0	2	1	1
IN03	Pallet	95 - Reconstruct by next HUB (H)	1	77	0	1	0	1
		GRAND TOTAL	4	6,903	0	5	101	3

Figure 32: Wave plan details.

The cargo in lane IN01 is reconstructed by address, so that the cargo going to the same address and can fill a truck is kept together.

The item weighing more than five tons (6 actually) is also reconstructed by address.

The rest are reconstructed "by next hub".

Figure 33 confirms that the appropriate cargo (weighing less than 5 tons and with post codes between 6700 and 6974 in Austria) is sent by groupage service to Passau, as requested.

GW Lanzendorf - Gebrüder Weiss GmbH - 1520 - 1/26/2026

Go to wave ↗

PRESORT LANE	RECONSTRUCTION TYPE	TASK TYPE	NR. TASKS	WEIGHT	VOLUME	TRADE ITEMS	PACKAGES	OVERPACKS
IN01	Pallet	98 - Reconstruct by Address (GLN) (A)	2	730	0	2	100	1
IN02	Pallet	98 - Reconstruct by Address (GLN) (A)	1	6096	0	2	1	1
IN03	Pallet	95 - Reconstruct by next HUB (H)	1	77	0	1	0	1

LOCATION	TASK	ROUTING	SERVICE AGREEMENT	TASK GROUP DESCRIPTION	SHIPMENTS	PACKAGES	OVERPACKS	TRADE ITEMS	WEIGHT	VOLUME	DG	DG LQ	H S
1	NO_GINC		Groupage service between Lanzendorf and Passau	7072785011244 - GW Passau - Gebrüder Weiss GmbH, Passau - Spedition für Landverkehr Industriestraße 14B 94036 Passau DE	1	0	1	1	77	0	No	No	N

			NR. TASKS	WEIGHT	VOLUME	TRADE ITEMS	PACKAGES	OVERPACKS
		GRAND TOTAL	4	6,903	0	5	101	3

Figure 33: Confirmation that the appropriate cargo is sent by groupage service to Passau.

6.4.7 There is a Disruption in Passau

Information is received about problems in and around the hub in Passau. It is therefore necessary to redirect the cargo vis Salzburg.

This information may arrive prior to cargo arriving and the Lanzendorf hub, or it may be arriving in the middle of the planning process.

The decision rules must be changed. The rule sending cargo to Passau must be disabled and the rule sending cargo to Salzburg must be enabled.

The former is illustrated in Figure 34. A similar process is used to enable the rule sending cargo via Salzburg (rule no. 61).

The new configuration of rules is illustrated in Figure 35, where now rule 58 is disabled (the one that was used above) and rule 61 is enabled.

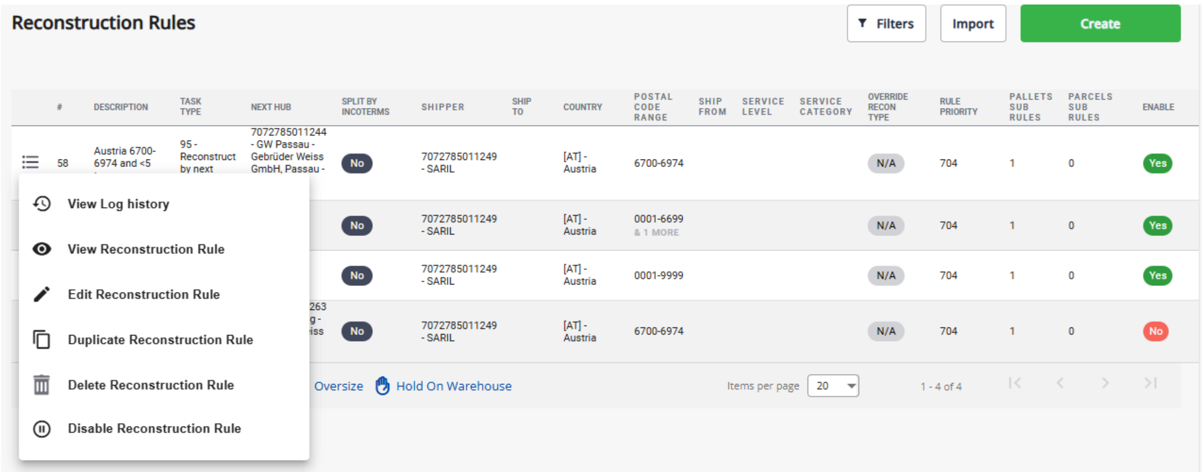


Figure 34: Disabling the rule that sends the cargo via Passau.

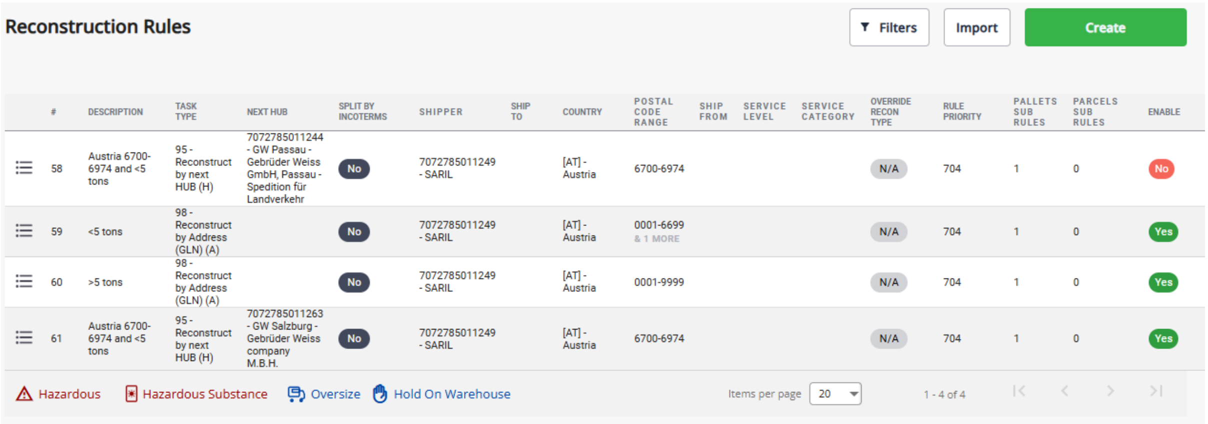


Figure 35: Revised decision rules.

By repeating the planning process, the new plan is as shown in Figure 36.

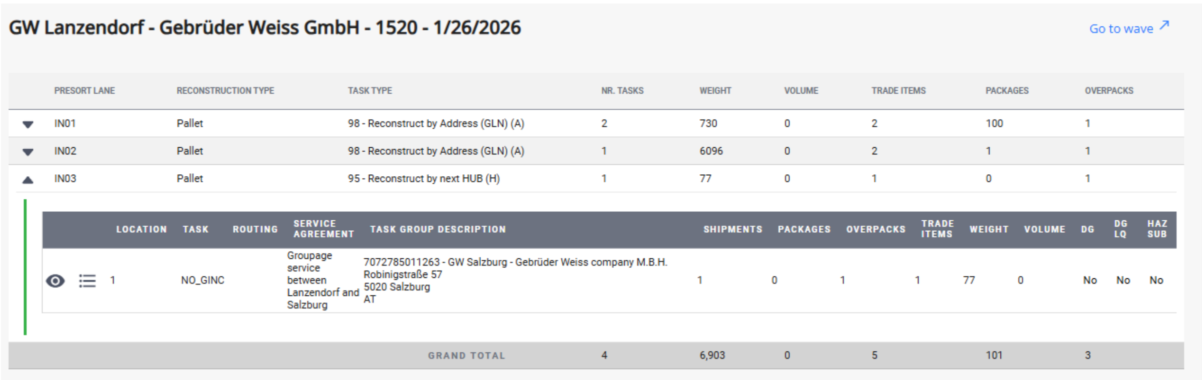


Figure 36: The new plan.

This shows that the cargo in lane IN03 is now sent via Salzburg and not Passau.

When things are normalising in Passau, the decision rules may be changed back to support the preferred operation.

7 Conclusions

This report has outlined how synchromodal logistics principles can be applied to strengthen both the sustainability and resilience of modern transport networks. Originating from efforts to reduce inefficiencies in hinterland operations, synchromodality emphasises delayed planning, real-time decision-making, and the delegation of routing choices to logistics nodes. When combined with fully digitalised cargo management and uniquely identifiable logistics units—from parcels to containers—this approach enables smarter use of transport modes, higher load factors, and rapid adaptation to disruptions.

In line with the objectives of SARIL, the transition from traditional linear logistics chains to flexible logistics networks offers clear advantages. Network-based operations facilitate optimal matching of cargo with available transport services, even under uncertain conditions, while supporting the ambitions of the ALICE zero-emission roadmap through more efficient use of fleets, assets, and lower-emission transport options.

The demonstration carried out with Gebrüder Weiss illustrates these principles in practice. By modelling a segment of their groupage network and applying dynamic decision rules within the MIXMOVE X-Dock system, it has been shown that cargo flows can be rapidly redirected in response to disruptions. A simple rule change—implemented within minutes—allows the network to bypass affected hubs and maintain service continuity. This exemplifies how digital tools, decision-rule based operations, and network-oriented planning can together deliver robust, sustainable logistics performance.

Overall, the findings highlight that resilience and sustainability are not competing objectives but mutually reinforcing. Through synchromodal logistics, digital integration, and adaptive network design, SARIL demonstrates a viable pathway toward a more efficient, low-emission, and disruption-resistant European logistics system.

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