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MOVING FROM INTERMODAL TO SYNCHROMODAL TRANSPORT: A MATURITY MODEL APPLIED TO A CASE STUDY IN NORTHWESTERN EUROPE

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ABSTRACT
In order to meet emission targets for 2050 in Europe transport needs to be executed more efficiently. A promising way to make transport more efficient is synchromodal transport. When the service provider has more flexibility to arrange transport, the utilization and use of intermodal transport, such as rail, can be increased and emissions per unit transported are reduced. Synchromodal transport requires a large change in way of working for shippers and logistics service providers that may seem insurmountable. In this article a maturity model is developed for synchromodal transport that breaks this large change down into several stages that companies go through when developing synchromodal transport. In a case study, executed for several companies situated in Northwestern Europe the maturity model is applied in practice to identify enablers and inhibitors of synchromodal transport.

1. INTRODUCTION
Transport, and in particular the need to carry goods efficiently and effectively from origin to destination, is essential in the current global and continental economies. However, the efficiency of transport is continuously under pressure. Firstly, due to the increased traffic on the roads, causing traffic jams and unreliable travel times. As a result, companies adapt their processes in order to avoid traffic jams. Secondly, due to the (expected) rise of oil prices and the objectives to reduce greenhouse gas emissions. The European Union's objective is to reduce the transport sector's greenhouse gases by 60% in 2050 compared to the level of 1990 *(1)*. Therefore smart solutions are required that on the hand meet the increased demand for transport, and on the other hand reduce greenhouse gases, fuel consumption and, ultimately, costs.

Fuel consumption and/or greenhouse gas emissions from transport can be reduced by enhancing vehicles or by using the infrastructure and vehicles more efficiently. Solutions in the first area are use of electric vehicles, or improved aerodynamics. Solutions in the second area are initiatives to reduce empty returns and combining container transport loads. These solutions do not require large capital investments with long lead times and therefore can be implemented rather easily and reduce fuel and emissions at the same time. Synchromodality comes under the latter category and will be explained briefly below.

Synchromodal transport is structured, efficient, and makes synchronized use of multiple modalities *(2)*. Synchromodal transport is defined in *(3)* as: "Synchromodal transport is the transport of goods - without changing the loading unit - in which real-time changes can be made with regard to the flexible and sustainable use of different transport modes in a network, in this the logistics service provider is in control in order to offer optimized integrated solutions for all parties."

Synchromodal transport is often perceived as a big change for companies (shippers and logistics service providers), i.e. it is not always clear *how* to start using synchromodal transport. Although the scientific literature about synchromodality is increasing, little attention is paid to how to initiate and develop synchromodality. Therefore the goal of our paper is to present a maturity model which provides a step-by-step plan how to develop synchromodal transport. This model is applied in a case study in Northwestern Europe to identify enablers and inhibitors of synchromodal transport.

This article is structured as follows. First, Section 2 contains a literature review on synchromodal transport. In Section 3, the synchromodal maturity model is described. Section 4 contains findings from the case study. Finally, in Section 5 the conclusions are presented.

2. WHAT IS SYNCHROMODALITY: LITERATURE REVIEW
Synchromodal transport distinguishes itself from intermodal transport by having an integral planning of transport and by exploiting flexibility *(4)*. In intermodal transport, each party (shipper, logistics service provider, operational service provider) is focused on maximizing transport efficiency for themselves. Usually, this does not lead to the most efficient solution, seen from a supply chain management perspective, because parties, for instance, only have little volume and they have to operate within the tight time windows set by the other parties. Synchromodal transport or intermodal transport can be used in intercontinental flows as well as on continental corridors between hinterland terminals *(5)*.

Synchromodal transport can provides shippers benefits in shorter transport times, price reduction, and/or improved reliability. Shorter transport times can also be achieved by responding adequately to disruptions to increase reliability. Since transport services are used more efficiently, costs per shipped container will go down for both the operational service provider and the logistics service provider.

Compared to an intermodal transport network or environment, synchromodal transport has different requirements. When setting up and implementing a synchromodal network, decision problems *(4)* are as shown in FIGURE 1. *At strategic level*, there should be a network suitable to offer synchromodal transport. This requires both a suitable infrastructure and sufficient transport volume to make synchromodal transport cost-effective.

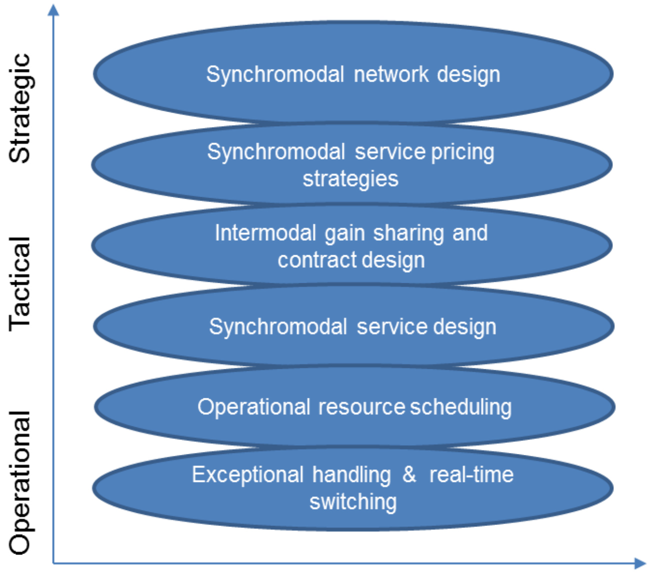


FIGURE 1 Decision problems in synchromodal network *(4)*.

At tactical level, it is important to organize the process determining the prices in such a way that it is attractive to all parties to choose synchromodal transport. This concerns the transport service price for shippers and the intermodal profit sharing between the different transport parties (operational service providers, logistics service providers and other parties). Also the design of the synchromodal services has to be developed. This concerns offered routes, modalities and capacity.

At operational level, the actual planning of synchromodal transport is made. This involves the allocation of containers to synchromodal services. The advantage of synchromodal transport is reflected in the flexibility to respond to disruptions. These disruptions may be caused by delays of containers, rail or inland shipping disruptions, etc. Because shippers make a-modal bookings, the logistics orchestrator is free to change modalities at the latest moment to minimize the effects of these disruptions.

Van Riessen, Negenborn, and Dekker *(6)* describe three steps needed for planning synchromodal transport for container networks in the hinterland. First, an integral network planning has to be made. The network needs an orchestrator who is in control of the transport flows and the available capacity to make the transport more efficient. Second, there must be a way to make a real-time network planning. To reduce the impact of the disruptions, the plan must be monitored continuously and adjusted when new information is available. Finally, there must be planning flexibility: shippers must allow for more flexibility in their planning horizons and time-windows for deliveries.

Compared to intermodal transport several additional characteristics are required for synchromodal transport. The most important characteristics are described next and are incorporated into the synchromodal maturity model.

Integral planning of transport on a corridor requires *cooperation* between the different parties (shippers, operational service providers, logistics service providers) and, in fact, both vertical cooperation and horizontal cooperation *(4)*. Cooperation in a chain is necessary to plan transport on a corridor integrally and benefit from a player taking on the *orchestrator's* role to match supply and demand *(7)*. To match demand and supply effectively flexibility is required in the supply chain. Three areas in which flexibility can be improved is in: booking capacity, determining the modality, including the route, and flexibility in arrival time.

Matching supply and demand occurs in the planning phase (well before the transport is carried out), but the matching is improved when supply and demand can be changed at the last moment (*flexibility in booking capacity*). Think, for instance, of adding rush orders that can still be transported by rail or water. If this can be included, fewer rush orders will be carried via road transport.

A-modal booking is a condition for making synchromodal transport successful. The logistics orchestrator determines to which modality and which vehicle the loads are allocated. The shippers' loads are then combined as efficiently as possible. The higher the flexibility, the longer the decision of allocating loads to a specific vehicle can be changed, taking into account current disruptions *(8)*. The effect of this booking method is that shippers go from a situation in which they specifically choose a modality to a situation in which they buy a transport service that is determined by price, time and reliability.

When the orchestrator also has the flexibility to determine the *arrival time of the goods*, based on actual inventory levels and agreed service levels, the flexibility is increased. This information can be used to plan the execution of the transport even more efficiently. This requires an even more intensive form of cooperation between shipper and logistics orchestrator and more trust of shippers in the orchestrator.

Compared to intermodal transport, the prices offered towards the shipper will have to change so that it is a better reflection of the actual costs, because the modality is not yet determined at the time of booking. The logistics service provider, therefore, will determine an *integral price,* independent of the modality. This does not mean, however, that no distinction can be made in the price. It is possible, for instance, to use different tariff classes on the basis of the lead time, ranging from a more expensive express service to a cheaper slow service *(9)*.

An important role is reserved for information technology support in synchromodal transport. IT support is necessary for all three steps described by Van Riessen, et al. *(6)*. For integral planning, the orchestrator needs an overview of the transport flows and intermodal transport. As a result, the transport orders of the shippers, all transport capacity, and current utilization need to be visible in one location to enable the logistics service provider to make real-time changes: *real-time planning*. Flexible capacity is then created by using the latest information the match between demand and supply is improved to maximize utilization. Two examples of real-time planning approaches for container allocation in the harbor of Rotterdam are given in *(10)* and *(11)*.

For synchromodal transport one integral system is needed containing data from shippers, infrastructure managers and operational service providers for the orchestrator: a so-called *control tower*, as describe by Hofman *(12)*. The big difference between a control tower and a traditional transport management system lies in dealing with disruptions and processing real time data. Actual data are needed to make a real-time planning and this requires information from many different sources that are visible in a central system. It is a challenge to make all these data available in time and in the right format for the orchestrator, see for example *(13)*.

An important point in the design of a control tower is that it contains data of several or perhaps even many shippers and operational service providers. When designing a control tower, serious thought should be given to security, so that companies cannot have access to confidential information from competitors. Several synchromodal control towers have been developed in practice, see for example *(14)* and *(15)*.

In the past few years, scientific literature has been paying increasing attention to synchromodality. Originally in the Benelux in particular, but nowadays also elsewhere: in Austria *(16)*, in Greece *(14)*, and in Ghana *(17)*. Synchromodal transport is not often applied in practice yet. The reason for this is that there are a few issues that have to be dealt with when implementing synchromodal transport.

Rossi *(18)* describes four important organizational points of particular interest in synchromodal transport. First, coordination is necessary and an independent intermediary is needed to coordinate the shippers and operational service providers. In addition, a fair distribution of savings between parties is needed to guarantee trust, transparency and commitment of all parties. The distribution of risk between the different parties, too, must be described properly. How are delays and costs distributed across all actors? Finally, sharing of information and increased transparency are necessary but difficult in practice, due to a lack of transparency in the supply chain and a fear of sharing data with competitors.

Synchromodal transport offers advantages to all parties, but it is necessary to meet certain conditions. Pfoser, Treiblmaier, and Schauer *(19)* describe critical success factors for synchromodal transport. First, it is necessary for shippers to enter into long-term relationships with logistics service providers. This results in more insight into supply and demand of transport. A high degree of trust between shippers and service providers is key as well. For synchromodality it is required that a lot of data is shared and all parties must be convinced that these data are only used for the right purposes.

A-modal booking changes a lot for shippers and freight forwarders, since they hand over part of the control and have to rely on the logistics service provider making the right decisions for them. Synchromodal transport also requires changes in the field of legislation and liability. Finally, the physical infrastructure, integral planning, ICT technology and price policy are mentioned as success factors.

This article contributes to this field of literature by developing a maturity model that describes how synchromodal transport can be implemented and what is required from the different actors. Furthermore, a case study is performed to identify enablers and inhibitors of synchromodal transport linked to the levels of the maturity model.

3. SYNCHROMODAL MATURITY MODEL

Maturity models have been used to describe, or to benchmark, companies and processes. An important purpose of a maturity model is to give companies an indication on which levels improvements must be implemented to enable them to take the next step towards a mature process. A maturity model often consists of 5 different levels, as is described in *(20)*, *(21)*, *(22)*, and *(23)*. The synchromodal maturity model, therefore, also consists of 5 levels:

1. Ad hoc: Ad-hoc intermodal transport
2. Repeatable: Structural intermodal transport
3. Defined: Synchromodal transport
4. Integrated: Synchromodal transport with real-time planning and capacity
5. Extended: Extended synchromodal transport

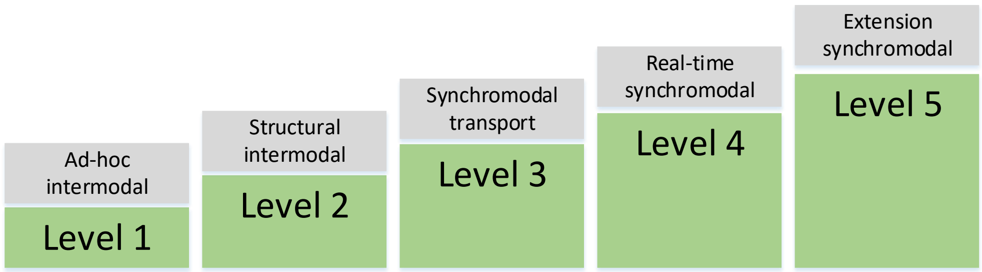
In addition to the levels, key process areas must be established that give a full description of each level and that show changes per level in a structured way *(24)*. The 7 key process areas for the synchromodal maturity model are:

- Execution of transport: the way in which transport is executed
- Transport planning: the way in which transport is planned
- Data exchange: the data requirements for correct execution of the planning
- Decision-making power: which stakeholder can make which decisions about how and when the transport is executed.
- Type of relationship: to which extent there is horizontal and vertical collaboration in the chain
- Pricing: how the tariffs are set and how payment takes place
- Key performance indicators: the way in which feedback is given about the performance of the operational process.

The synchromodal maturity model has been developed based on literature and validated in nine interviews with experts from academia and practice, and adjusted accordingly.

A summary of the important changes between the different levels of the maturity model is given in FIGURE 2. A full description of the maturity model is given by the authors *(25)*. The following transitions to a higher level are distinguished:

1. The switch from ad-hoc intermodal transport to structural intermodal transport is characterized by a more intensive cooperation between shippers and logistics service providers, and by making structural use of intermodal transport. Achieving this requires a limited form of cooperation, e.g., by sharing a forecast enabling capacity to be reserved and/or purchased in advance.
2. The switch from structural intermodal transport to synchromodal transport is characterized by a-modal booking. This also makes reliability per modality a major KPI, since the shipper transfers this decision to the logistics orchestrator.
3. The switch from synchromodal transport to flexible synchromodal transport is characterized by the fact that transport is approached integrally on the route: in terms of price and reliability. There is an intensive cooperation via a logistics data platform which creates more flexibility in booking and planning transport in order to enhance the utilization rate. The idea behind it is, that in case of disruptions and/or events, real time switching to other modalities and/or routes is possible.
4. The switch from flexible synchromodal transport to the extension of synchromodal services is characterized by the fact that the logistics orchestrator determines the transport delivery moments on the basis of service level agreements. The logistics service provider has then the flexibility to choose the modality, the route to be taken, and the delivery moment. In this way, optimal use can be made of the different options in the synchromodal network.



Execution of transport	Truck	**Train or barge**	Train or barge	Train or barge	Train or barge
Transport planning	Ad-hoc	Upfront reservation	Upfront reservation	**Real time**	**Real time and stock**
Data exchange	Per container	Forecast per customer	Forecast per customer	**Control tower**	Control tower
Key performance indicators	Price and time	Price and time per modality	Price, time, reliability	Price, time, reliability and utilization degree	Price, time, reliability, utilization degree and service level
Decision making power	Shipper	Shipper	**Logistics orchestrator (a modal booking)**	Logistics orchestrator	Logistics orchestrator
Type of relationship	Transactional	**Limited vertical**	Intensive vertical, limited horizontal	Intensive vertical and horizontal	**Intensive vertical and horizontal**
Pricing	Spot market	Alignment on tariff (tender)	**Tariff per modality**	**Integral tariff**	Integral tariff

FIGURE 2 Development Of Synchromodality.

The changes in the maturity model do not always impact all parties in synchromodal networks. TABLE 1 describes the changes for the three important stakeholders: operational service providers, shippers and logistics service providers. It can be seen that for logistics service providers not only most changes occur but also with the most impact. For the higher levels of the model, the logistics service provider is given more responsibility and freedom, which, of course, also requires other competencies from the staff. For shippers changes occur in data sharing and transport contracts with logistics service providers.

TABLE 1 Changes Per Party

	Operational service provider	Shipper	Logistics service provider
Level 1	Transport orders through contracts and/or chartered vehicles	Transactional relation: ad-hoc intermodal transport	Ad-hoc intermodal transport, short-term planning, payment afterwards.
Level 1 to 2		Structural intermodal transport, exchange forecast with LSP. Determine capacity per modality.	Structural medium-term capacity reservation, beforehand tariff per modality
Level 2 to 3		Communicate the quantity of goods beforehand, including logistical conditions. Tariff per modality.	A-modal booking: logistical orchestrator has the freedom to determine the modality and reserve capacity. Payment afterwards based on actual distribution of modalities.
Level 3 to 4	Offer more insight (full visibility in available capacity) for real-time planning when multiple parties use capacity of a train or barge.	Determine integral tariff together with logistical orchestrator	Plan transport optimally taking into account real time events and insight in capacity utilization to maximize share of intermodal transport. A control tower is available to synchronize data from all relevant parties.
Level 4 to 5		Transport is planned by orchestrator based on required service level.	Freedom to plan transport, including delivery times, as long as the service levels of the shippers are met.

4. FINDINGS

This maturity model was developed within the framework of the SYN-ERGIE project. To apply the maturity model semi-structured interviews were set up. The involved companies perform intermodal transport services in Northwestern Europe. After an exploratory interview, 10 companies showed interest to participate: 5 logistics service providers, 2 operators, and 3 shippers. The goal of the interviews was to identify the level of maturity for each company based on the key process areas of the model. Moreover, the factors that facilitate the current level and factors that prohibit improvement to the next level have been discussed.

Based on the 10 interviews it can be stated that most interviewed companies have already adopted intermodal transport in some way. The majority of transport is at level 2, structural intermodal transport. Next to that, it is noticeable that all companies excel in one or more key process areas. It is observed that synchromodal transport is easier to implement in continental transport because there is no dependence on the intercontinental ports that can be a large source of time deviation.

What logistics service providers often said, is that they differentiate in services between customers. They could offer synchromodal services to their biggest customers, but not each customer is already at a specific organizational level that they could work together in synchromodal transport. The synchromodal supply chain is as strong as the weakest link. Many logistics service providers on the corridor are already excelling in transport planning and monitoring of inventory levels in practice.

Two of the seven key process areas require most attention: data exchange and horizontal collaboration. Data exchange between shippers and logistics service providers is often not the problem, if both parties trust each other. However, sharing data between different logistics service providers or between logistics service providers and operational service provider is not common practice. Most service provider are not willing to cooperate with their competitors. This also means that data exchange is very hard.

The shippers are willing to seek for higher levels of synchromodality and many companies are already applying a-modal booking. Most shippers are mainly concerned with their goods being delivered on time. The route, modality and sometimes even the duration are less important, as long as it gets delivered on time. Reliability is the most important KPI. An important side note is that sometimes the agreed lead time is too short and only allows for direct trucking.

The data exchange between the operators and the logistics service providers is minimal. Real-time sharing of information on expected arrival times is a first requirement. Real-time information on capacity utilization is a second requirement. Currently only manual requests for available capacity can be made and are responded with an approval or denial, since operational service providers are reluctant to share the required data.

The impact of freight forwarders and their related price focus cannot be underestimated. Most freight forwarders benefit from the lack of data sharing, since that is an important part of their business model. This has a major inhibiting effect on data exchange and results in ad-hoc short term planning and limited transport possibilities.

Looking at the maturity model, development from level 2 to level 3 is often hard to realize, because extra and simplified data exchange is needed. The introduction of real-time planning and horizontal collaboration are impediments to develop from level 3 to level 4.

Considering the success factor categories mentioned in the article of Pfoser, et al. *(19)* horizontal cooperation between service providers is a major hurdle in developing synchromodal transport. Consequently, the data exchange seems to be a hurdle as well. The ICT/ITS technologies are available, but they require data from many parties. This also has to do with the required mental shift to embrace cooperation. On certain routes the physical infrastructure, or the availability of reliable capacity is also an issue. Lastly, regarding price and service, most shippers are willing to use a-modal booking.

5. CONCLUSION AND DISCUSSION

A maturity model has been drawn up for synchromodal transport. This model is based on scientific literature in the field of maturity models and synchromodal transport. The maturity model has been applied to a case study in Northwestern Europe. It has been observed that the relation between shippers and logistics service providers is strong and a-modal shipping is often applied. Issues arise in the field of horizontal collaboration between logistics service providers and operators. Especially data sharing is an issue due to unwillingness to share the data, rather than technical incompatibilities..

The maturity model has proven its value by clearly showing the current state of synchromodal transport between the three different stakeholders, identifying the clarifying factors for the current state and showing directions for improvement to increase supply chain integration through synchromodality. The authors will extend this research to a larger number of companies using a questionnaire to assess the maturity level of companies and investigate success factors to draw more generalizable conclusions.

In the project SYN-ERGIE one of the goals is to inform and educate potential implementers of synchromodal transport using a serious game to encourage horizontal collaboration between partners. Moreover, a demonstration tool is created for implementers to experience real-time planning through a platform to enhance data sharing.

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