REPORT

Transport Modelling
Overview and Best Practice

2007

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Part-financed by the European Union

Title: Transport Modelling Overview and Best Practise
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Publication 2007:WP5_REPORT
Publishing date: 2007
Publisher: Region Blekinge
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Layout: East West TC Secretariat
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1 Introduction

This report addresses tasks 5.8 and 5.9 in the East West Transport Corridor project "Development of a Sustainable, Efficient and Attractive Intermodal Transport Corridor". The activities have the following specifications.

5.8 Identification of the activity:
Overview on status of transport modelling in southern part of the Baltic Sea Region (BSR).
Purpose
To overview status of transport modelling in the southern part of the BSR and to clarify the main obstacles in developing and applying transport modelling along the corridor.

5.9 Identification of the activity:
Selection of best practice for different types of transport modelling.
Purpose
To select best practice for different types of transport modelling in the east part of the BSR.

We begin with an overview of freight transport modelling. Examples of models used in Europe are presented, with focus on the southern part of the BSR. In order to address their applicability for different purposes, the models are classified with respect to a number of characteristics. Best practice is mainly about choosing the right tools for the right problem (purpose) in this context. Further, some of the main obstacles in developing and applying transport modelling in the East West Transport Corridor are addressed.

2 Transport Modelling

Modelling in the area of transportation is much diversified. For instance, it differs with respect to:

- *Purpose* of the modelling and the associated analysis. The end-user of the results (typically the financer of the analysis) can be, e.g., public authorities or businesses.
- *Scope* is very different depending on the purpose as well as the available resources for performing the modelling.

Most often the purpose is to analyze future scenarios (today's behaviour we typically do not need to model, since it can be observed). However, models can also be used for analysing the current situation, for instance, in cases of incomplete information. Typically different scenarios are studied with respect to exogenous changes, for instance, different assumptions on trends concerning the level of transport demand, level of modal shift, etc. Often scenarios are studied to support decision making, e.g., public authorities may need help with decisions regarding:

- Management (traffic control, public passenger transportation, etc.)
- Infrastructure investments (terminals, roads, railways, etc)
- Control policies
    - o Regulative control policies. For instance, affecting the

ownership of vehicles, such as emission requirements on vehicles.

- Fiscal control policies. For instance, taxing the usage of infrastructure, such as kilometre taxation, road tolls etc.

With respect to the business perspective, models might for instance be used for evaluating new transport services or testing different set-up of operations (e.g. including warehouse allocation).

The scope of the model naturally depends on the purpose, but also on the available resources (including information) available for the analysis. The scope concerns among other things: level of detail, geographical area covered, complexity of the behaviour of the involved actors, type of costs (multi-objective), multi-period or single period, and dynamics (changes over time).

There are some differences between traffic modelling and transport modelling:

- In traffic modelling (often):
  - Both transportation of freight and people are modelled
  - The total “flow” on links (e.g. roads) is considered
  - Behaviours of people might be considered (often an difficult issue to model)
- In transport modelling (often)
  - Passengers are ignored (focus on freight transportation)
  - Total flows are ignored (only certain types of goods are considered).

In the East West Transport Corridor project there are multiple purposes of modelling. One major task is to facilitate sustainable business concepts through cooperation between different stakeholders, since the stakeholders include both public authorities and companies. It is therefore reasonable in the review to include both macro-level modelling, which is commonly used by public (state) authorities at strategic level, and micro-level modelling, which is commonly used by companies.

3 Overview of Transport Models

Most countries around the Baltic Sea perform some kind of transport modelling. On the national level most models are mainly focused upon the transport within the country and therefore normally only models volumes entering the country regardless of whether the volumes originate inside or outside the BSR. The methodological frameworks of the national models are however in most cases the same as for the international models.

3.1 Categorising freight models

In this section we categorise relevant freight models. We do it from a transport corridor perspective, which we believe implies that some logistical aspects need to be considered in order to encapsulate the business perspective. The aim is not to cover all existing freight models since there already exist freight model reviews, see for instance Department for Transport (2002) and Friesz (2000). Instead we intend to give some representative examples of different categories of models with a focus on models developed in the BSR. As a consequence, several models are left out in the categorisation since they resemble the included models. Moreover, models that include logistical aspects are in particular considered since we believe it is important to capture more detailed aspects of transportation when studying transport corridors. Categories of models that are included are national models, international models developed in EU-projects, commercial models and other interesting models. Many countries within the EU have their own national models. Such national models are exemplified with the Swedish SAMGODS model, the Dutch SMILE model, the Danish DTF SENEX and the Norwegian NEMO. Models that have been developed within EU-projects as international models include for example SLAM (which is a module in the SCENES model) and STEEDS. Further there exist a number of other international models: STREAM/SCENES, NEAC, STEMM, EUFRANET, and ASTRA. It is out of the scope of this report to produce an in-depth review of all the models as this can be found elsewhere, see RAND (2002). Commercial models that include a governmental perspective are exemplified with Cube Cargo. Other models that are interesting to review since they include logistical aspects are PACE-FORWARD, GoodTrip and TLUMIP. Furthermore, as the models mentioned above are mainly macro-level models, the micro-level model TAPAS (Transportation And Production Agent-based Simulator) is included in the comparison.

Some models mentioned above are classified according to a framework presented below and they are described in more detail in Appendix A. The majority of the models that are classified are rather course grained.

3.1.1 Framework for describing freight models

The reviewed models are described according to a framework. The macro-level freight models typically start out from converting trade flows into transport flows (usually in tonnes) using value to volume ratios, which are defined for a number of different commodity types between different origins and destinations. Finally the trade flows are assigned to the transport network using an assignment algorithm, and hence, the transport volumes on different links can be found. Hence they can satisfy a number of purposes but the low level of detail naturally prohibits their use when level of details needs to be fine, e.g. when considering timetables of ferries and trains. A purpose of this review is to identify potential limitations in macro-models when including some typical micro level issues, which are relevant when studying a transport corridor.

Some models are left out of the framework since they are rather similar to other models, e.g. NEMO, DTF – SENEX (national) and STREAM&SCENES, NEAC, STEMM, EUFRANET, ASTRA, and BMT (which is based on STAN as SAMGODS, although extended). The logistical factors are included in the framework together with other important characteristics that are important for analysing how well the models are suited for analysis. The following characteristics are included in the framework: geographical scale, transport mode, purpose, level, maturity, and input and output. Geographical scale and transport mode are brought up since they give a context in which the model functions. The level of the model (macro or micro) is crucial in this context since it describes whether the focus is on the behaviour of the population or the individuals. The maturity of the model is interesting to examine since this shows how far the work has proceeded. Finally, input and output of models are important since parameters that are included in the model, as well as whether these parameters function as input or output, describe important model characteristics. We focus on the input and output from the part of the model that models the transport movements. Below the framework is described.

Geographical scale It indicates which spatial level the model operates on. We have divided geographical scale into international, national, regional and urban.

Transport mode It indicates which modes that are modelled. The transport modes for freight transport that we consider are road, rail, air, waterborne and pipeline. Moreover, if several transport modes can be used we refer to this as multimodal.

Potential Purpose All reviewed models aim at performing forecasts in various settings. Some models have a societal perspective which implies that the societal aspects, such as sustainability and economic growth, are of interest to study. These models concern the evaluation of the effects of different governmental control policies. The models can function as decision support for governments when evaluating possible implementations of control policies. The model can be aimed at performing analysis of what the consequences would be for different scenarios where for instance governmental control policies are included. The model can also be directly aimed for governmental policy-making where control policies that are likely to be implemented are evaluated. We call such purposes governmental policy analysis.

Some models focus on transport chain issues. The main interest of transport chain actors is to maximize profit, i.e., increase income and reduce expenses (e.g., the transport cost). These models concern the evaluation of different strategies that can be implemented by transport chain actors. The strategies can for instance concern warehouse location or investments in new transport equipment, and the influence on transport cost, environmental load, etc. can be analysed with the model. We call such purposes transport chain strategy analysis.

Level In the simulation literature, simulation models can be divided into macro-level models (e.g., equation-based models) and micro-level models (e.g., agent-based models). Micro-level models include detailed information of individual transports and are therefore fine-grained. In micro-level models specific behaviours of specific individuals as well as the interactions between the individuals are modelled. In macro-level models the characteristics of a population are modelled. The characteristics are averaged together, and the model attempts to simulate changes in these averaged characteristics for the whole population. Since macro-level models mainly focus on higher-level properties, and not particularly on individual companies and transports, the level of detail is not high. These models are therefore course-grained. Since the data in macro-level models is aggregated, i.e., gathered together and averaged, specific properties of individual data are therefore not available. Aggregated data is often used to distinguish general characteristics, because the data can be generalized more easily than in micro-level models. The data can also be disaggregated, i.e., divided into smaller parts.

Maturity Models can have varying degree of maturity, see for instance Parunak (2000) for a classification of the maturity of models. We choose to describe the maturity of the models as laboratory experiment or deployed system. Laboratory experiment is the level which indicates that the model has been tested in a simulation environment. The most mature models are deployed, i.e., the model has been implemented and used for analyses of the real world. If the model has been involved in real world contexts, we call it deployed.

Input and output In the classification of the models it is indicated which parameters that are input versus output. Logistical factors are included in the framework to be able to draw conclusions from the appearance of the logistical factors in the models. Geographical location of the customer appears in transport flow between actors. Product characteristics are further elaborated in product group characteristics where more parameters are added. Available transport infrastructure is included in transport mode described above. Besides the logistical factors, more parameters are added to better describe the models.

The input and output are described in the following way:

- Governmental control policies
  - Fiscal, e.g., vehicle taxes, road fees
  - Regulatory, e.g., load regulations of vehicles, emission standards
  - Infrastructure investments, e.g., new transport infrastructure and improvements

- Product demand
    - Aggregated, i.e., averaged data between for instance zones
    - Individual, i.e., demand from individual consumers
- Product group characteristics
    - Logistical aspects, e.g., value density, packing density, perishability, delivery time, shipment size, demand frequency
    - Possible transport modes and vehicle types, e.g., based on shipment size, perishability
- Transport flow
    - Between geographical zones
    - Between transport chain actors
- Available resources
    - Production resources
    - Storage facilities
    - Transport resources
- Logistical operation planning, which concerns the operational or tactical planning of the time window for certain product quantities to be handled
    - Production planning
    - Inventory planning
    - Transport planning
- Transport choice
    - Transport mode, i.e., the assignment of transport movements to transport modes
    - Vehicle type, i.e., the assignment of transport movements to vehicle types
    - Fuel type, which is needed to calculate environmental performance
- Vehicle utilization
    - Vehicle load factor
    - Frequency of the transports
    - Load consolidation
    - Backloading
- Effects
    - Revenues to the government.
    - Transport work, measured in ton kilometre
    - Traffic work, measured in vehicle kilometre
    - Emissions, e.g., carbon dioxide, nitrogen oxide, particles, carbon monoxide, sulphur dioxide
    - Environmental impact of emissions, e.g., in terms of global warming
    - Reliability of time of delivery and product quality
    - Costs
        - External costs, e.g., emission cost, congestion cost
        - Internal costs, e.g., capital cost, fuel cost, labour cost, maintenance cost, time cost

3.2 Analysis of existing models

Table 1 and Table 2 show the classification of some relevant freight models and include our perception of how the models should be classified. If the information available is unclear with respect to a certain model parameter, this is indicated with a question mark.

		SAMGODS	SMILE v.1	SLAM	STEEDS	Cube Cargo	GoodTrip	PACE-FORWARD	TLUMIP	TAPAS
Geographical scale	International			x	x	x				x
	National	x	x	x	x	x		x		x
	Regional					x			x	x
	Urban					x	x			
Transport mode	Road	x	x	x	x	x	x	x	x	x
	Rail	x	x	x	x	x		x		x
	Waterborne	x	x	x	x	x		x		x
	Air	x	x	x	x					
	Pipeline		x	x			x	x		
	Multimodal	x	x	x	x	x	x	x		x
Potential Purposes	Governmental policy analysis	x	x	x	x	x	x	x	x	x
	Transport chain policy analysis		x	x		x	x	x	x	x
Level	Macro	x	x	x	x	x	x	x	x	
	Micro									x
Maturity	Laboratory experiments			x	x	x	x	x	x	x
	Deployed system	x	x							

Table 1 Characteristics of the reviewed models. An x indicates that the property is included in the model.

Input/Output		SAMGODS	SMILE v.1	SLAM	STEEDS	Cube Cargo	GoodTrip	PACE-FOR.	TLUMIP	TAPAS
Governmental control policy	fiscal	i	i	i	i	i		i	i	i
	regulatory	i	i	i	i			i		i
	infrastructure investments	i	i	i	i	i	i	i	i	i
Product demand	aggregated	i	i	i	i	i	i	i	i	
	individual									i
Product group characteristics	logistical aspects		i	i			i			i/o
	modes and vehicles	i	i	i		i	i		i	i
	production pattern									i
Transport flow	between zones	o	o	o	o	o	o	o		
	between actors								o	o
Available resources	production		i	i		i	i		i	i
	storage facilities		o	o		i	i	i	i	i
	transport				i	i			i	i
Logistical operations planning	production									o
	inventory									o
	transport								o	o
Transport choice	transport mode	o	o	o	o	o	o	o	o	o
	vehicle type	o		o	o	o	o	o	o	o
	fuel type	i		i	i	i	i	i		o
Vehicle utilization	vehicle load factor			i	i	i	i	i	i	o
	frequency of transports		i	i		i	i			o
	load consolidation					i?		i	o	i/o
	backloading		i			o			o	o
Effects	governmental revenues	o	o	o				o		o
	transport work	o	o	o	i	o		o	o	o
	traffic work	o	o		o	o	o	o	o	o
	emissions	o	o	o	o	o	o	o		o
	environmental impact				o					
	reliability		o				o	o		o
	internal costs	o	o	o	o	o	o	o	o	o
	external costs	o	o							o

Table 2 The input (i) and output (o)in the reviewed models.

Different conclusions can be drawn from Table 1 and Table 2. TLUMIP include some micro-level characteristics, for instance, the transport movements are assigned to vehicle routes between individual transport chain actors. The data that is used in TLUMIP is originally aggregated, therefore it is not a pure micro-level model. SMILE, GoodTrip, SLAM, Cube Cargo, PACE-FORWARD and TLUMIP include some detailed aspects of transportation, such as different ways of designing the transport chain and planning the usage of storage facilities, for instance by centralization. Still these aspects are simulated based on aggregated data, such as the goods flow of a whole country, so the decisions made by the individual transport chain actors cannot be simulated. In SMILE, GoodTrip and SLAM the product types are grouped into product groups with similar logistical characteristics to make the simulations more realistic and detailed. Some of the other models also include product group characteristics, but these groups are only based on possible transport modes, and are therefore not as detailed.

SMILE, GoodTrip, PACE-FORWARD, Cube Cargo, SLAM and TLUMIP have an explicit purpose to be able to perform transport chain strategy analysis. Therefore these models also include more details than more traditional macro-level models.

In some models production resources are included in the models. In these models production chains are included, i.e., product types are connected to the geographical location of the product plant, and possible connections between product plants are included. In none of these models (except for TAPAS) is the actual production planning included.

Only one of the reviewed models includes logistical operation planning. TLUMIP includes transport planning, i.e., the planned shipment time is connected to a certain quantity of goods. TLUMIP is also the model that includes most micro-level characteristics (except for TAPAS).

Model characteristics can be defined from the parameters used for input and output in the models. This is especially interesting for parameters that in some models are input parameters, and in others are output parameters. An example of such a parameter is vehicle utilization. For instance, in the models that include frequency of transports and vehicle load factor, these parameters are input parameters. Load consolidation and backloading both appear as input and output in the models. If parameters concerning vehicle utilization appear as input, it implies that it is not possible to study the effects of governmental control policies on these parameters. Such effects are possible to study in micro-level models since these parameters typically serve as output.

Available storage facilities are input parameters in some of the models and output parameters in some of the models. In SMILE and SLAM is the location of storage facilities calculated in the model based on the attractiveness of locations of storage facilities. In the other models that include storage facilities, the location of storage facilities is given.

The transport mode assignment for all models is classified as output. The mode assignment typically depends on the amount of transport and the cost parameters (i.e., both internal and external costs) associated to these volumes, as well as the available transport infrastructure. The cost parameters are values that most often are calculated and averaged for different product groups, and the assignment is based on a minimization of the total costs. The number of product groups differs between the models. For instance, SAMGODS includes fewer product groups (12), while for instance SMILE includes more product groups (50). The more product groups that are included, the more detailed information influences the mode assignment, because the mode assignment can get more precise. The vehicle assignment is carried out in a similar way as the transport mode assignment.

In some models, such as SAMGODS and SMILE, the governmental revenue is calculated. This indicates that the purpose of the models mainly is to perform transport analyses for the government, for instance how control policies can achieve governmental goals and what the effects will be for the governmental economy. These models also have a more explicit purpose to function as a decision support for governmental policy-making. SAMGODS and SMILE have been involved in real world evaluations of policies that are likely to be implemented, and the final policy-making has also been influenced by the simulation results. The other models have been used for performing laboratory experiments for the evaluation of the effects of governmental control policies.

TLUMIP does not include the environmental effects of governmental control policies, but the ambition is to include environmental effects of transportation in TLUMIP in the future. In some of the other models, such as SLAM and Cube Cargo, the calculation of emissions is not explicitly done in the actual freight model. However, since there are calculation tools closely coupled to the model, it is indicated in Table 2 that emission calculations can be done in these models.

4 Main Modelling Obstacles

This section clarifies some of the more general obstacles in developing and applying transport modelling which naturally also applies to the East West Transport Corridor. We have identified the following areas where problems may arise:

- OD data
- Network data
- Flow data
- Model availability
- Micro-level-specific issues
- Competence

4.1 OD data

The typical foundation for modelling transport flows at a macro level is a matrix describing the origin (O) and destination (D) for the goods that need to be transported. This is normally referred to as an OD-matrix. The ideal unit of the information within the OD-matrix is e.g. ton or some kind of transport unit like e.g. number of containers, trucks or TEU. Unfortunately this kind of information is extremely seldom available. Due to historical reason (taxation) governments and nations have been more focused upon the value of the trade than the volume. The national and international interest in trade however makes this kind of information fairly easy accessible and often free of charge although the quality of the data can vary greatly.

So in most cases what is available is a more or less incomplete and inconsistent OD-matrix of the value of trade for different groups of commodities. This is the data foundation for almost all international transport models. The first step of modelling is to transform the monetary values into volumes. This is mostly done by using more or less empirical value-to-volumes ratios. This use of empirical methods adds value (in the form of knowledge and know-how) to the OD-matrix thereby making it less available to outside users.

4.2 Network data

The next step in traditional 4-step transport macro modelling is to combine the OD-matrix with a transportation network. Nowadays most networks used have a spatial reference and are handled within some kind of geographical information system. Some of the major GIS manufacture (like e.g. ESRI) provides free topographical digital networks covering almost all of Europe for road, rail and sea links on an aggregated level. These can be used free of charge and are especially useful for strategic (macro) modelling. There are however still some limitations with regards

to transport modelling. Normally there are not many (if any) attributes describing the network links included.
When modelling on a micro level, the links considered are fewer but typically there are more information needed e.g. ferry line time tables. Networks for railway lines, ro-ro lines and intermodal terminals are of less demand and therefore not so easy accessible. These kinds of networks often have to be more or less manually generated, updated and linked to the road network. As for the OD-matrix that adds value to the network and that again makes it less available for outside users.

4.3 Flow data

Flow data is mainly used to calibrate and verify the transport model. In most cases flow data are freely available. The main problem is that the information is scattered out across an extreme number of different sources. These sources include both infrastructure providers (e.g. regional/national road and rail administrations, toll bridges, ports etc.) and operators (like e.g. national and private train operators, shipping companies etc.). The collection, verification and relation of this data to the specific links within the transport network involve a lot of manual work. This again adds quite large value to the model resulting in making it even less accessible for outside users.

4.4 Model availability

Whereas the previous sections were related to the data side of freight transport modelling, this section is more related to the modelling side. There exists quite a variety of different freight transport models reflecting different theoretical approaches as illustrated in this report. Almost every country, university and company has their own "favourite" model. Even if they use the same tool (like e.g. STAN) they develop their own methods and add-on applications to suite their specific purpose. It goes without saying that an extreme amount of knowledge and know-how are put into these models. This has the obvious consequence that is almost impossible to get free access to these models. Most of the models are however accessible at the right price and that price often reflects the amount of knowledge that has been put into the model.

4.5 Micro-level-specific issues

When applying a micro-level model perspective there is no established standard way of pursuing a modelling project or which standard type of information (e.g. OD data) is used. However, one of course can point out the problem of finding data of transport links, resources, and their characteristics and the transport demand. Particularly the lack of information on costs is an issue; maybe greater than in the macro-level case since here realistic values of the different costs for individual actors are needed. Cost information on individual actors' service is sometimes sensitive (unless tariffs are published) since it is only stated within the contract between two (or a few) actors.

4.6 Competence

There are a number of pitfalls in modelling, i.e. selecting right model, finding and interpret data etc. Hence, there is a need of competence for pursuing a modelling project, which should not be underestimated.

5 Conclusions

There are a number of macro-level models available (and used) for modelling of freight transports. These can serve some of the objectives of the East West Transport Corridor projects (e.g. transport flow analysis). They are, however, less suitable for business development where individual actors may need to be considered and the level of detail needs to be high, for instance when considering time table issues (synchronization).

Since individual entities are not possible to model in macro-level models, it is obvious that the behaviour of the individual transport chain actors can not be modelled explicitly using macro-level models. However, it is possible to include a number of micro level issues (at least implicitly) also using macro-level model, such as, BMT (see Appendix for details) by refining/extending the traditional macro-level models.

Micro-level models are of course suitable for modelling explicit transport characteristics which are of interest for individual transport chain actors (see Appendix for a review of micro-level models). It is however difficult to generalise their results. However, we argue that it also is possible to consider some macro level-issues (e.g. governmental control policies).

The attempts to use a micro-level approach are promising. According to the Department for Transport (2002), TLUMIP (which assigns the transport flow to individual vehicle tours) performs better than the more traditional and less detailed models. However, micro-level models demand detailed input data which often is problematic to gather. The simulation results therefore depend on the reliability of the provided data.

We can conclude that both types of models macro- and micro-level approaches are relevant for achieving the purpose of the East West Transport Corridor project.

6. Literature

BMO 2006, Baltic Maritime Outlook 2006 – Goods flows and maritime infrastructure in the Baltic Sea Region, Annex A2

Bergkvist, M., Davidsson, P., Persson, J.A. and Ramstedt, L. (2005) A Hybrid Micro-Simulator for Determining the Effects of Governmental Control Policies on Transport Chains, *Multi-Agent and Multi-Agent Based Simulation*, LNAI series Vol. 3415, Springer.

Bürckert, H-J, Funk, P. and Vierke, G. (2000) *An intercompany Dispatch Support System for Intermodal Transport Chains*, Proceedings if the 33rd Hawaii International Conference on System Sciences.

Davidsson, P., Henesey, L., Ramstedt, L., Törnquist, J. and Wernstedt, F. (2005) An Analysis of Agent-Based Approaches to Logistics, *Transportation Research Part C: Emerging Technologies*, **13**(4), 255-271.

Department for Transport, *Review of Models in Continental Europe and Elsewhere*, Report B2, UK, 2002.

DFT 2005, *En national godstrafikmodel – Metodestudie*, Notat 5 2003

De JONG et al. 2004, *National and International Freight Transport Models:An Overview and Ideas for Future Development*, Transport Reviews, Vol. 24, No. 1, 103–124, January 2004

Fischer, K., Chaib-draa, B., Müller, J.P., Pischel, M. and Gerber, C. (1999) A Simulation Approach Based on Negotiation and Cooperation Between Agents: A Case Study, *IEEE Transactions on Systems, Man, and Cybernetics – Part C: Applications and Reviews*, **29**(4), 531-545.

Friesz, T.L., Strategic Freight Network Planning Models, *Handbook of Transport Modelling*, Henscher, D.A., Button, K.J. (eds.), Elsevier Science Ltd., Oxford, UK, 2000.

Kwon, O., Im, G. and Chang Lee, K. (2005) MACE-SCM: An Effective Supply Chain Decision-making APproach based on Multi-agent and Case-base Reasoning, *Proceedings if the 38th Hawaii International Conference on System Sciences.*

Parunak, H.V.D., Savit R., Riolo R.L., Agent-Based Modeling vs. Equation-Based Modeling: A Case Study and Users' Guide, *Multi-Agent Systems and Agent-Based Simulation*, Sichman, J.S., Conte, R., Gilbert, N. (eds.), pp. 10-26, Springer, 1998.

Ramstedt, L. and Woxenius, J. (2006) "Modelling approaches to operational decision-making in freight transport chains", NOFOMA 2006, 2006.

RAND 2002, DfT Integrated Transport and Economic Appraisal, Review of Freight Modelling Report B2 – Review of Models in Continental Europe and Elsewhere

SRLog 2004, SRLOG: Railway-oriented Logistics and Locations as a Base for Developing SMEs in the STIMENT Regions, Work Package 2 Freight flows and SRLog-regions FINAL REPORT, Draft 6th June 2005, INTERREG IIIC

SIKA 2004, *SAMPERS OCH SAMGODS - Nationella modeller för prognoser och analyser inom transportsektorn*, STATENS INSTITUT FÖR KOMMUNIKATIONSANALYS 2004.

Strader, T.J., Lin, F.R. and Shaw, M. (1998) Simulation of Order Fulfillment in Divergent Assembly Supply Chains, *Journal of Artificial Societies and Social Simulation*, **1**(2).

Swaminathan, J., Smith, S. and Sadeh, N. (1998) Modeling Supply Chain Dynamics: A Multi-agent Approach, *Decision Sciences Journal,* **29**(3), 607-632.

Terzi, S., Cavalieri, S., Simulation in the supply chain context: a survey, *Computers in Industry*, Vol. 53, pp. 3-16, Elsevier, 2004.

TØI 2002, *Rapport 581/2002*, Forfattere: Arild Vold, Jardar Andersen, Inger Beate Hovi, Olga Ivanova, Viggo Jean-Hansen, Lone-Eirin Lervåg, Solveig Meland og Ragnhild Wahl Oslo 2002, 97 sider

van der Zee, D.J, and van der Vorst, J.G.A.J. (2005) A Modelling Framework for Supply Chain Simulation: Opportunities for Improved Decision-making, *Decision Sciences*, **36**(1), 65-95.

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Municipality of Klaipeda
Municipality of Sölvesborgs
Municipality of Ronneby
Port of Esbjerg
Port of Karlshamn
Railion
Railog
Region Blekinge
Region Skåne
Region Sealand
SC Lithuanian Rail Administration
South West Business Development
Swedish National Maritime Administration
Swedish National Rail Administration
Swedish Road Administration Skåne
Swedish Road Administration South East
University of Southern Denmark
Vilnius Gediminas Technical University
Vinnova