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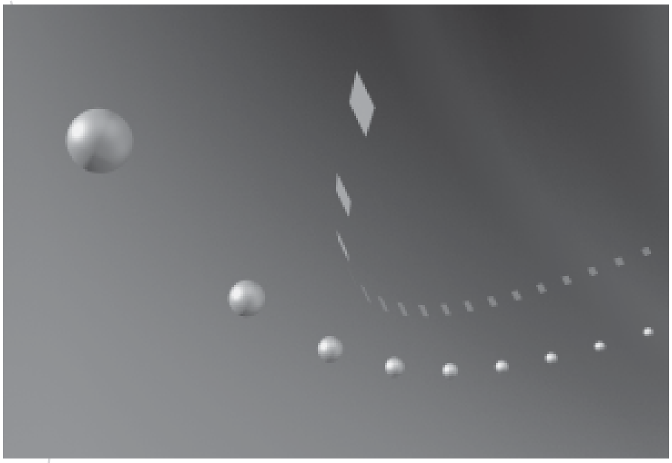

Representation of the Swedish transport and logistics system

(Logistics Model Version 2.00)

Inge Vierth
Nicklas Lord
John Mc Daniel

vti
FINDING A BETTER WAY

Preface

The Norwegian and Swedish transport agencies develop their national freight models in co-operation. The description of transport demand has been improved with a distinction between production-consumption (PC) flows and origin-destination (OD) flows. A Logistics Model has been developed to be able to take the logistic choices at the firm level into account. To accomplish this an aggregate-disaggregate-aggregate model approach has been chosen. The Logistics model calculates vehicle type specific matrices that can be assigned to networks. The Swedish model is documented in several reports, i.e. the Swedish Base Matrices Report (Edwards, Bates, Swahn, 2008) and the Method Report Logistics model (de Jong, Ben-Akiva, Baak, 2008).

This report gives an overview about how the Swedish transport and logistics system is represented in the Logistics Model Version 2. It describes the setup data (version 2009-01-19) that is needed to run the Version 2 model. Further validation and development is necessary. In order not to overload this report all input, output, control files, validation material etc. is included in a separate CD. The Swedish clients, the Samgods group, plan to produce a technical user manual and all such material is thus removed from the present report.

VTI:s work in the development of the national freight model has been funded by SIKA, on behalf of the Samgods group. Inge Vierth, Nicklas Lord and John Mc Daniel (now Ramböll) have written the report. Comments from the Samgods group on an earlier report version have been included.

Gunnar Lindberg
Research Director

Quality review

External peer review was performed 29 April 2009 by Henrik Swahn. Inge Vierth has made alterations to the final manuscript of the report. The research director of the project manager Gunnar Lindberg examined and approved the report for publication on 8 June 2009.

Kvalitetsgranskning

Extern peer review har genomförts 29 april 2009 av Henrik Swahn. Inge Vierth har genomfört justeringar av slutligt rapportmanus. Projektledarens närmaste chef, Gunnar Lindberg, har därefter granskat och godkänt publikationen för publicering 8 juni 2009.

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Representation of the Swedish transport and logistics system (Logistics Model Version 2.00)

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Summary

The aggregate-disaggregate-aggregate freight models that have been developed in Norway and Sweden take into account the logistic decisions at firm level. The Swedish model is documented in i.e. the Swedish Base Matrices Report (Edwards, Bates, Swahn, 2008) and the Method Report Logistics model (de Jong, Ben-Akiva, Baak, 2008). This report gives an overview about how the Swedish transport and logistics system is represented in the Logistics Model Version 2, which is a deterministic cost minimization model. Further validation and development is necessary in several aspects. The report describes the setup data (version 2009-01-19) that is needed to run the Version 2 model. In order not to overload the report all input, output, control files, validation material etc. is included on a separate CD.

The *35 commodity groups* used are based on the 24 groups in the European NST/R-nomenclature. Some commodities are further divided due to their importance for Swedish freight transport and varying logistic properties. Transport demand is described with commodity specific demand matrices for *464 administrative zones* inside and outside Sweden. Demand between sending zones (production, warehouse) and receiving zones (consumption) is described with the help of production warehouse consumption (PWC) matrices.

The commodity specific P, C or W zones are split into sub cells that include *firms*. The zone to zone flows are divided into up to three firm size categories at the PWC zones at the origin and at the destination zone. There is therefore a maximum of nine sub-cells per relation. A tenth cell is used for single firms' extremely large PC-flows and transit flows. All small, medium and large sized firms are assumed to base their logistic decisions on the same optimization principles. Some large firms are assumed to have direct access to the rail and/or sea network.

A range of *vehicle and vessel types* is used to reflect scale advantages in transport operations including loading and unloading. There are five vehicle/vessel types defined for road, eight for rail, 21 for sea including ferries and one freight aeroplane. In total 86 pre-defined *transport chains* are used. A distinction is made between container transports and non container transports.

Infrastructure networks are used to generate the level of service (LOS)-matrix data for each vehicle/vessel type providing transport time, distance and network related infrastructure charges. The LOS matrices supply information between all administrative PWC-zones and all terminals. There are a total of 150 LOS-matrices, consisting of 140 vehicle specific matrices (35 vehicle types * 4 cost/time matrices and ten frequency matrices that are used to determine wait time in terminals). Emme/2 has been used in order to produce the LOS-matrices, and a solution using CUBE-Voyager is also planned.

The *logistics costs* consist of transport costs (vehicle type specific link costs and node costs) and non transport costs (commodity specific order costs, storage costs and capital

costs in inventory as well as capital costs in transit). For each commodity it is assumed that either the overall logistics costs are optimized or that transport costs are minimized. *Consolidation* assumes that goods are only consolidated within a commodity group and that consolidation only takes place at terminals.

The model generates a huge amount of output at different levels. All output files that are generated are explained in the last chapter of this report.

Representation av det svenska godstransport- och logistiksystemet (Logistikmodell Version 2.00)

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Sammanfattning

De nationella aggregade-disaggregade-aggregade godsmodellerna som har utvecklats i Norge och Sverige tar hänsyn till logistiska beslut på företagsnivå. Den svenska modellen dokumenteras bl.a. i *Swedish Base Matrices Report (Edwards, Bates, Swahn, 2008)* och *Method Report Logistics model (de Jong, Ben-Akiva, Baak, 2008).* Denna rapport ger en överblick over hur det svenska transport- och logistiksystemet är representerat i logistikmodellen *Logistics Model* Version 2, som är en deterministisk kostnadsminimeringsmodell. Det krävs ytterligare validering och utveckling i flera avseenden. Rapporten beskriver input data (*setup data*) version 2009-01-19 som behövs för att köra Version 2 modellen. För att inte överbelasta rapporten finns alla filer (input, output, control files), valideringsmaterial m.m. i en separat CD.

De *35 varugrupperna* baseras på de 24 grupperna i den europeiska NST/R-nomen-klaturen. Några varugrupper delas upp ytterligare med hänsyn till betydelse för svenska godstransporter och varierande logistiska egenskaper. Godstransportefterfrågan beskrivs med hjälp av varugruppsspecifika efterfrågematriser för *464 administrativa zoner* i och utanför Sverige. Efterfrågan mellan avsändande zoner (production, warehouse) och mottagande zoner (consumption) beskrivs med hjälp av s.k. *production warehouse consumption (PWC) matrices.*

De varugruppsspecifika P, C och W zonerna delas i celler (sub cells) som innehåller företagen. Zon till zon flöden delas i upp till tre företagsstorlekskategorier i de avsändande resp. mottagande PWC-zonerna. Det finns således totalt max nio celler per relation. En tionde cell används för de enskilda företagens mycket stora PC-flöden och transitflöden. Det antas att alla små, mellanstora och stora företag fattar sina logistiska beslut utgående ifrån samma optimeringsprinciper. Några stora företag antas ha direkt tillång (*direct access*) till järnvägs- och eller sjötransportsystemet.

Flera olika fordons- och fartygstyper (*vehicle and vessel types)* används för att avbilda skalfördelar i transportoperationer inklusive lastning och lossning. I modellen ingår fem olika lastbilstyper, åtta tågtyper och 21 fartygstyper inklusive färjor. Sammanlagt 86 fördefinierade transportkedjor (*transport chains)* används. Containertransporter och icke containertransporter skiljs.

Infrastrukturnätverk används för att skapa s.k. (LOS)-matris data (*level of service*) för varje fordons- och fartygstyp; det beräknas transporttid, transportavstånd och nätverks-relaterade infrastrukturavgifter. LOS-matriserna levererar information mellan alla administrativa PWC-zoner och mellan alla terminaler. Det finns sammanlagt 150 LOS-matriser, bestående utav 140 fordonsspecifika matriser (35 fordonstyper * 4 kostnads/tid matriser och tio frekvensmatriser som används för att ange väntetiden i terminalerna). Emme/2 har använts för att tillverka LOS-matriserna, en lösning med CUBE-Voyager planeras också.

Logistikkostnaderna består av transportkostnader (fordonsspecifika länkkostnader och nod/terminalspecifika kostnader) och icke transportkostnader (varugruppspecifika

orderkostnader, lagerkostnader och kapitalkostnader i lager och under transporten). För varje varugrupp antas att antingen de totala logistikkostnaderna optimeras eller transportkostnaderna minimeras. Vad det gäller konsolidering (c*onsolidation)* antas att gods enbart samlastas inom en varugrupp och att konsolideringen alltid sker i terminalerna.

Logistikmodellen genererar en stor mängd resultatdata (*output files*) på olika nivåer. Alla typer av resultatdata som genereras förklaras i sista kapitlet av denna rapport.

1 Background

1.1 Logistics model

The aspect of logistics is crucial for understanding developments of the freight transport market, the modes of transport and the requirements on the infrastructure. Therefore it is important that the national freight model explicitly treats logistics choices. Examples of these choices are the selection of shipment sizes, consolidation of shipments or choice of road terminals. The logistics model should as realistically as possible define the likely number of shipments per year, terminal passages, handling technologies used and routes of shipments from a sending firm to a receiving firm.

The existing Swedish national freight model (STAN-model) is an aggregated model that does not include mode choice and route choice at the firm to firm level and does not treat logistics explicitly. The model is limited to the minimization of the transport costs and does not include inventory cost outside the transport process and order costs. Selection of shipment sizes, consolidation of shipments and use of road terminals are not modelled, though some ad hoc improvements have been performed to solve some of the drawbacks.

The development of the new Swedish national freight transport model system has been carried out in co-operation between the Norwegian and the Swedish transport agencies. [1] The Dutch consultancy *Significance* have specified and programmed the Norwegian and Swedish logistics models using the same aggregated-disaggregated-aggregated approach.[2] John Bates and Henrik Swahn have acted as the clients' advisors throughout the development process.

Parallel to the logistics model new concepts for the calculation of the matrices that describe transport demand has been developed. The Swedish base matrix report describes the generation of producer to consumer flows, values for the year 2004 as well as the disaggregation of the producer to consumer flows to firms to firm flows.[3]

For a given demand, expressed in tonnes between senders and receivers, the logistics model generates available transports chains (Buildchain) and chooses optimal shipments sizes and transport chains (Chainchoi) commodity by commodity. The model delivers a. o. flows, expressed in number of vehicles per vehicle type between senders, different types of terminals and receivers. The vehicle flows can than be assigned to the respective networks. The model delivers also cost information for individual transport chains.

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[1] The Swedish National Freight Model, A critical review and an outline of the way ahead, SAMPLAN 2004:1, by John Bates and Henrik Swahn.

[2] Gerard de Jong, Moshe Ben-Akiva, Jaap Baak (Significance), Method Report Logistics model in the Swedish National Freight transport model system, Deliverable 6B for the Samgods group, 2008, Gerard de Jong, Moshe Ben-Akiva, Jaap Baak (Significance), Method Report Logistics model in the Norwegian National Freight transport model system, Deliverable 6A for the NTP group, 2008.

[3] Henrik Edwards with assistance from John Bates and Henrik Swahn, Swedish Base Matrices Report, Estimates for 2004, estimation methodology, data, and procedures, Version 13 March 2008.

1.2 Purpose and structure of report

The purpose of this report is to give policy makers, researchers, consultants and users of the logistics model an overview of how the Swedish transport and logistics system is represented in the Logistics model Version 2. The report includes a description of all input data (setup data) that are necessary to run the Logistics Model Version 2.00. (The dashed line represents iteration process.)

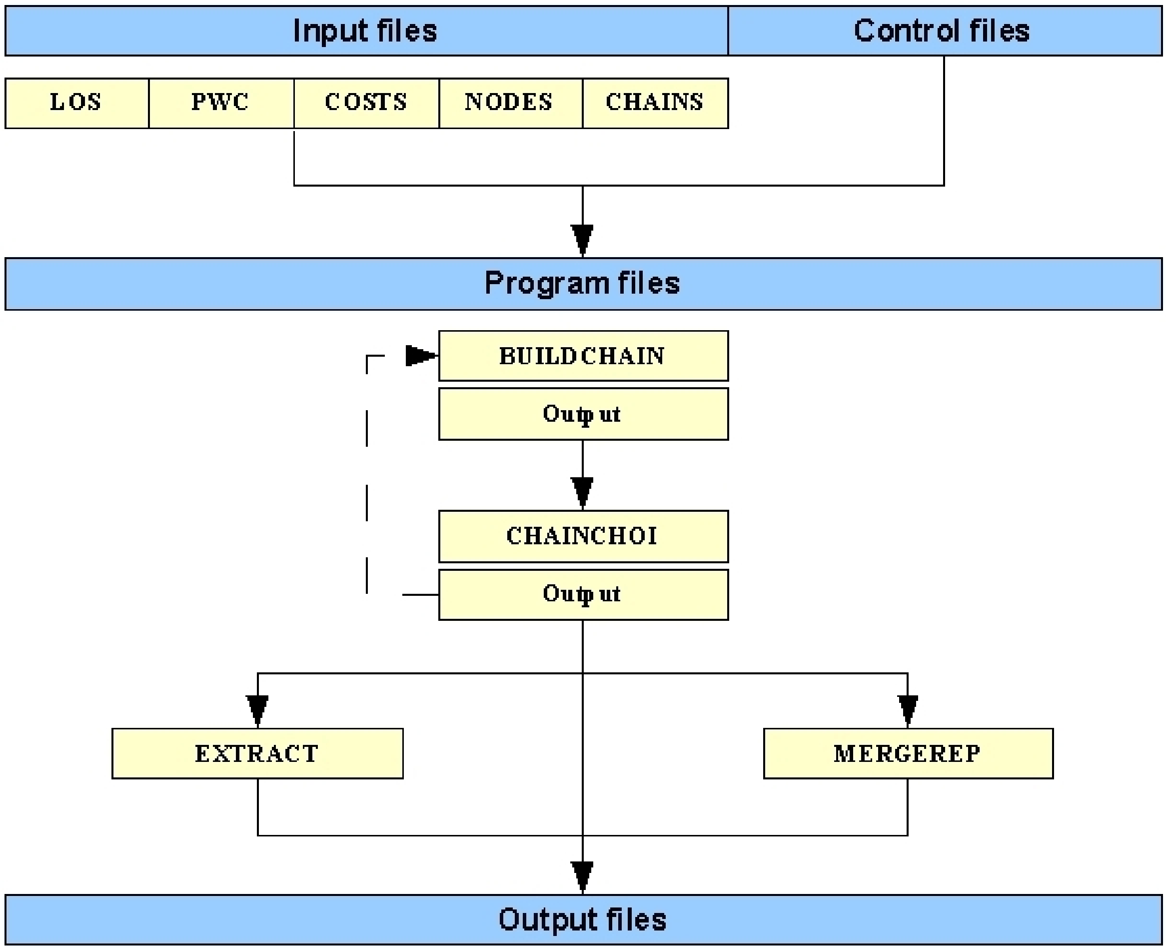

Figure 1.1 Overview of Logistics Model Version 2.00.

We distinguish between input files, control files and program files as well as output files. The input files are structured (in folders) as shown Figure 1.1 and described in chapter 3 (PWC matrices, production/wholesale consumption matrices to describe transport demand), chapter 4 (CHAINS, transport chain types), chapter 5 networks (LOS level of service matrixes to describe the infrastructure network) and chapter 6 (COSTS, logistics costs). Finally Chapter 7 describes the different output files.

In order not to overload the printed report, all input, control and output files, the Method Report for the Swedish Logistics model, the Base Matrices Report as well as information on the existing national freight model STAN, material used in cost calculation as well as validation material are included in the Appendix CD.

Both input and control files can be changed by the transport analyst. Access to the source code is needed to make changes in the program files. There are no hardcoded parameters in the source code which makes it easy for the analyst to try different changes. Control files are used to control the programs' runs e.g. where to look for input files and where to store output files.

Name conventions:

- New setup: This means that changes are done in input files and/or control files.
- New program version: This means that changes are done in the program files.
- Logistics Model 2.00: Collective name for input files, control files and program files. The version number is referred to in the program files.

This report describes the setup dated 2009-01-19 and the version 2 of the program files in the Logistics Model. In some of the setup files the user can give default values to be used by the program e.g. default frequencies.

This report document aims to ensure that the transport system (infrastructure network including costs functions) is described and structured in a way that the clients' analyses requirements can be dealt with and facilitated.

2 Commodity groups

2.1 Background

The logistics model Version 2 operates with aggregated commodity groups (commodities). The commodities are based on the standard NST/R[4] commodities used in European statistics. These commodities are reported in the statistical publications as 24 commodity groups with subdivisions making up a total of 30 commodities.[5] Four commodities are further divided due to their varying logistic properties as value and shipment size. The group paper and pulp is e.g. split into paper pulp and waste paper (Commodity 24), paper, paperboard and manufactures thereof (Commodity 33).

Commodity 30, mixed and part loads and miscellaneous articles, is not used in the Logistics Model Version 2. A commodity group for those goods that are transported by air freight (Commodity 35) is introduced by allocating fractions of certain commodities to group 35. The reason for this approach is that not even small shares of the 34 commodities would not go by air solely based on their logistics costs.[6]

2.2 Commodities used

All commodities are associated with an aggregate commodity type: dry bulk, liquid bulk or general cargo (which in turn defines e.g. which costs apply, see section 6.3) The values of the commodities (expressed in SEK/tonne excluding taxes in year 2004 prices) are derived in the base matrix project.[7] In the logistics model the same values are used for domestic transports, import, export and transit though separate values for some of these categories are available.[8]

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[4] Nomenclature**.** uniforme des merchandises pour les statistiques de transport.

[5] http://ec.europa.eu/dgs/energy_transport/figures/pocketbook/nomenclature_nst_en.htm., http://www.sika-institute.se/Templates/FileInfo.aspx?filepath=/Doclib/2008/Statistik/ss_2008_13.pdf.

[6] The commodity group air freight should be replaced in coming model versions.

[7] Henrik Edwards with assistance from John Bates and Henrik Swahn, Swedish Base Matrices Report, Estimates for 2004, estimation methodology, data, and procedures, Version 13 March 2008.

[8] The product mix varies between different types of transports. The model could be improved by using different commodity values for domestic transports, import, export and transit.

Table 2.1 Commodity classification incl aggregates and values.

No	Commodity	NSTR	Aggregate commodity type]	Value [SEK/tonne]
1	Cereals	10	Dry bulk	1350
2	Potatoes, other vegetables, fresh or frozen, fresh fruit	20	Dry bulk	3 631
3	Live animals	31	Dry bulk	8 224
4	Sugar beet	32	Dry bulk	427
5	Timber for paper industry (pulpwood)	41	Dry bulk	289
6	Wood roughly squared or sawn lengthwise	42	Dry bulk	6 352
7	Wood chips and wood waste	43	Dry bulk	592
8	Other wood or cork	44	Dry bulk	452
9	Textiles, textile articles and manmade fibres	50	General cargo	158 131
10	Foodstuff and animal fodder	60	General cargo	19 558
11	Oil seeds and oleaginous fruits and fats	70	Liquid bulk	2576
12	Solid mineral fuels	80	Liquid bulk	713
13	Crude petroleum	90	Liquid bulk	2 597
14	Petroleum products	100	Liquid bulk	3 309
15	Iron ore, iron and steel waste and blast-furnace dust	110	Dry bulk	496
16	Non-ferrous ores and waste	120	Dry bulk	7 444
17	Metal products	130	General cargo	9 762
18	Cement, lime, manufactured building materials	140	Dry bulk	2 169
19	Earth, sand and gravel	151	Dry bulk	74
20	Other crude and manufactured minerals	152	Dry bulk	1 114
21	Natural and chemical fertilizers	160	Dry bulk	2 020
22	Coal chemicals	170	Liquid bulk	1 210 937
23	Chemicals other than coal chemicals and tar	180	Dry bulk	15 959
24	Paper pulp and waste paper	190	Dry bulk	2 155
25	Transport equipment, whether or not assembled, parts	200	General cargo	70 281
26	Manufactures of metal	210	General cargo	21 041
27	Glass, glassware, ceramic products	220	General cargo	15 183
28	Paper, paperboard; not manufactures	231	Dry bulk	4 637
29	Leather textile, clothing, other manufactured articles	232	General cargo	24 920
30	Mixed and part loads, miscellaneous articles [9]	240	General cargo	19 521
31	Timber for sawmill	45	Dry bulk	356
32	Machinery, apparatus, engines, parts thereof	201	General cargo	47 132
33	Paper, paperboard and manufactures thereof	233	General cargo	15 894
34	Wrapping material, used	250	Dry bulk	2 250
35	Air freight (Logistics Model Version 2)		General cargo	561 026

[9] No PWC flow for this commodity.

3 Zones, firms and their access to infrastructure

3.1 PWC-matrices and disaggregation to firms

The transport demand between sending zones (production) and receiving zones (consumption) is described with the help of production consumption (PWC) matrices. Wholesale (W) is treated separately because of the fact that wholesalers' logistics requirements differ from producers' requirements. There is only a special treatment of wholesale at the sender as the classification at the receiver side is not known from the Commodity Flow Survey.[10] In total there are 34 commodity group specific demand matrices for 638 administrative zones. The base matrices for the year 2004 (version 2007-12-13) that are described in the base matrix report have been used in this report.[11]

The logistics model runs at a virtual firm level. The commodity specific P, C or W zones are split into sub cells that include firms. The method applied to generate firm to firm flows from zone to zone flows, is to divide it into up to three firm size categories at the origin zone (P or W) and destination zone (C). There is a maximum of nine sub-cells per relation. A tenth cell (No 0) is used for so called singular flows and transit flows. Singular flows are single firms' extremely large PC-flows. Transit flows start and end outside Sweden and go on land on Swedish territory. Table 3.1 illustrates that that 13 % of the transported volume (in tonnes) is transported in large singular flows and transit flows in 900 out of about 19 million relations.

Table 3.1 Distribution of transport volume and relations per sub cell.

Sub cell	Explanation	Transport volume (in tonnes)	No of relations	Share (tonnes)	Share (relations)
0	Singular flows and transit flows	47 515 029	900	13%	0%
1	small firm to small firm	50 153 231	5 059 379	14%	26%
2	small firm to medium firm	41 095 630	2 288 722	11%	12%
3	small firm to large firm	20 490 971	857 305	6%	4%
4	Medium firm to small firm	35 596 372	5 162 860	10%	26%
5	Medium firm to medium firm	60 173 447	2 239 539	16%	11%
6	Medium firm to large firm	33 936 956	813 819	9%	4%
7	Large firm to small firm	16 618 207	2 120 126	5%	11%
8	Large firm to medium firm	46 142 302	829 249	13%	4%
9	Large firm to large firm	17 209 980	277 390	5%	1%
Total		368 932 126	19 649 289	100%	100%

All small, medium seized and large firms are assumed to base their logistic decisions on the same optimization principles (see 6.4). Logistic decisions such as the choice of transport chains, differ though due to the firm's annual transport volume and number of

[10] The distinction between W and C will probably be possible based on coming commodity flow surveys.

[11] The agencies have plans to update the base matrices Version 2007-12-13 before calibrating the logistics model. There are also plans to use another format than the actual one that is based on EMME2.

firm to firm relations. It is assumed that some large firms have direct access to the rail and/or sea network.[12,13]

3.2 Firms' access to infrastructure

Inside Europe

In the Logistics model Version 2 it is assumed that all sending and receiving firms have direct access to the road network and via the road network to the other modes (rail, sea and air). This means that goods flows from firms located at the centroid that describes the business centre of a zone, start with a road link. In some cases industrial producers and/or consumers have – via industrial tracks – direct access to the rail network or are located in ports. One example is the iron-ore produced in the mines of Kiruna. Similarly crude oil is transferred from vessel to the oil terminal within ports and not unloaded and again loaded for further transport to the business centre.

As mentioned above, in Model Version 2 it is assumed that only the large firms (sub-cells 0, 3, 6, 7, 8, 9 in Table 3.1) have direct access to rail or sea. Inside Sweden direct access to system trains and sea is specified per commodity while all commodities may use feeder and wagon load trains. (See separate sheets for feeder train, wagonload train, system train and sea in the input file nodes_all.xls.) The model does not include any direct access for air transport in Europe. This is because airports are not assumed to be the end location of any goods flow (at PWC level) which means that it is necessary to first transport the goods by lorry to and from the airport.

Table 3.2 Direct access for rail and sea.

	Commodity specific	Number of locations in Sweden	Number of locations in Europe outside Sweden	Total number of locations in Europe
DirectFeederTrain	No	148	0	148
DirectWagonLoad	No	0	28	28
DirectSystemTrain	Yes	56	0	56
DirectSea	Yes	41	25	66

Outside Europe

Outside Europe we do not explicitly model land-based networks, but assume that all transports (for all sub cells and all commodities) start/end in a port or airport that is connected via a virtual link without distance and costs to the zone centroid. Direct access to sea and air is assumed for all node numbers above 97 500, i.e. all zones outside Europe, in order to ensure network connectivity and therefore that LOS-matrices can be built. One difference between air and sea is that direct sea has to be specified in

[12] The assumption that only large firms have access to rail and sea should be relaxed in coming model versions, especially for sea there are probably smaller firms that are located in ports and can therefore have e sea link as first/last link.

[13] There is one exception, for crude petroleum transports direct access is assumed for all sub cells. It should be followed up if this exception is necessary when the final base matrices (incl disaggregation to firm to firm) have been implemented.

the input files (nodes_all.xls) while direct access to air is always assumed for airborne flows outside Europe.

3.3 Administrative zones

3.3.1 Domestic zones

There are a total of 464 regional administrative zones for the Swedish base matrix and logistics model – as in the existing STAN-model. Of these, 290 are domestic municipalities and 174 foreign zones. The input file “nodes” includes a full list of the individual administrative zones. Figure 3.1 shows the administrative zones in Sweden and the neighbouring countries.

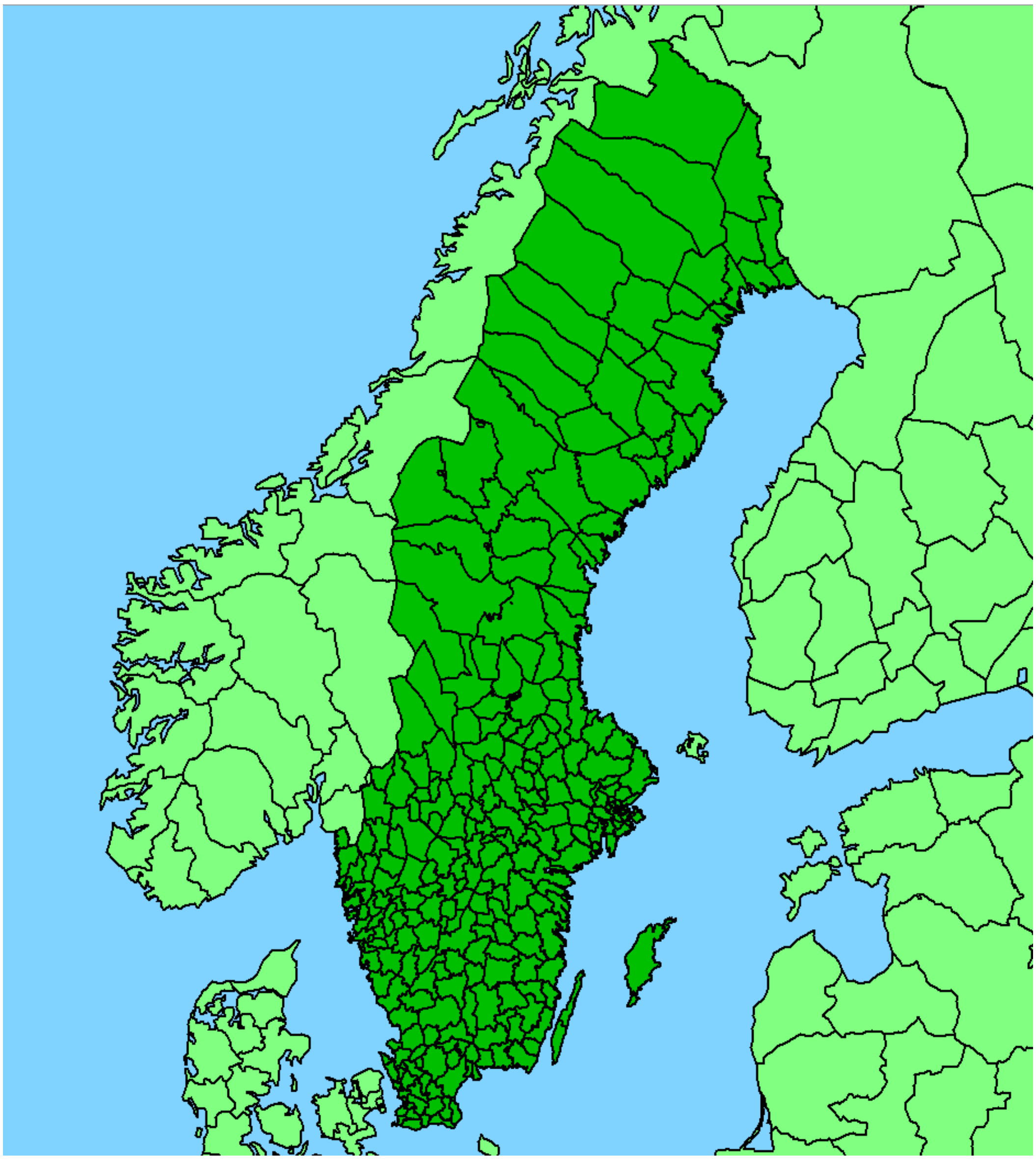

Figure 3.1 Administrative zones in Sweden and the neighbouring countries.

The domestic zones have the same zone numbers as in the previous STAN-model, which are based on the official municipality numbers used by Statistics Sweden. All domestic administrative zones finish with 00 and are in the range 711400-958400.

Table 3.3 Number of administrative zones per county in Sweden.

County	Number of zones
Stockholm	26
Uppsala	7
Södermanland	9
Östergötland	13
Jönköping	13
Kronoberg	8
Kalmar	12
Gotland	1
Blekinge	5
Skåne	33
Halland	6
Västragötaland	49
Värmland	16
Örebro	12
Västmanland	11
Dalarna	15
Gävleborg	10
Västernorrland	7
Jämtland	8
Västerbotten	15
Norrbotten	14
Total	**290**

3.3.2 International zones

For the zones outside Sweden a new numbering system has been developed so that the foreign zones come after the Swedish zones when sorted numerically. Zones outside Sweden also finish with two zeros and are in the number range 960100-977400. Further from Sweden, but within Europe, there are relatively fewer zones per country. Outside Europe some counties with significant trade with Sweden are separately defined whereas others are aggregated.

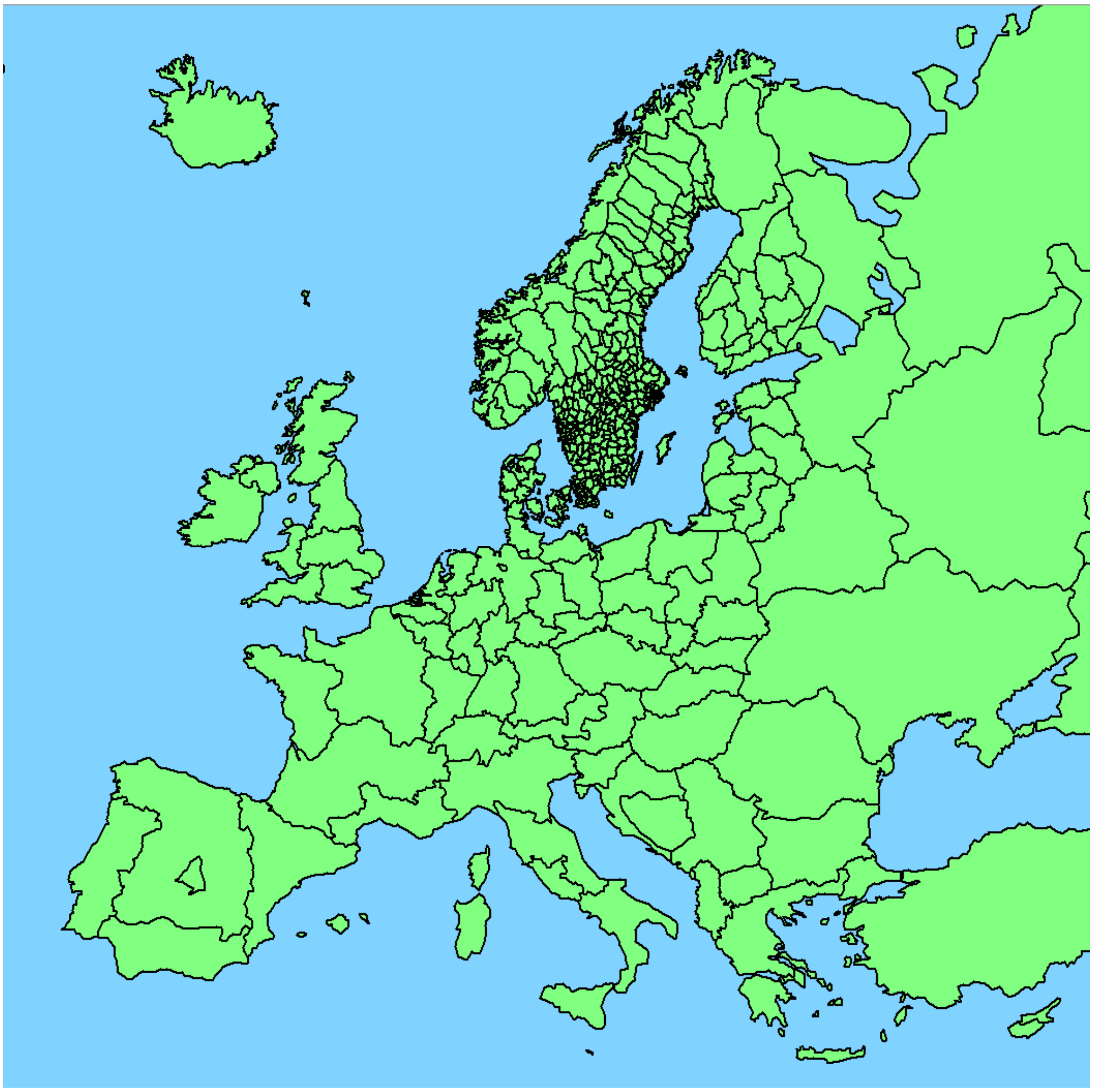

Figure 3.2 Administrative zones in Europe.

The 25 administrative zones outside Europe represent all countries outside Europe where countries with significant trade with Sweden have been defined as individual administrative zones. Other countries with smaller trade flows have then been aggregated into a single administrative zone within each continent. This definition was carried over from the STAN-model.[14]

[14] In order to produce decent geographical diagrams only the zones for Europe have real coordinates. The zones outside Europe have been given virtual coordinates on the western boundary of Europe. The data, particularly distances however use the proper distances and not the distances to the virtual locations.

The following table shows the geographical break-down of the zones outside Sweden.

Table 3.4 Number of zones per country/region outside Sweden.

	Country	**Number of zones**
Neighbouring countries	Norway	18
	Finland	19
	Denmark	15
	Germany	16
Within Europe	Albania	1
	Austria	2
	Belgium/Luxemburg	2
	Belorussia	1
	Bosnia	1
	Bulgaria	1
	Cyprus	3
	Estonia	6
	France	1
	Faroe Islands	3
	Greece	1
	Greenland	1
	Hungary	1
	Ireland	1
	Iceland	5
	Italy	1
	Serbia	1
	Croatia	3
	Lithuania	3
	Latvia	1
	Macedonia	1
	Malta	2
	Netherlands	2
	Poland	8
	Portugal	2
	Romania	1
	Russia	10
	Switzerland	1
	Slovakia	1
	Slovenia	1
	Spain	5
	United Kingdom	6
	Czech Rep	1
	Turkey	1
	Ukraine	1
Outside Europe	North America	2
	Central and South America	3
	Near Asia	2
	Far Asia	12
	Africa	3
	Oceania	3
	Total	**174**

4 Vehicles/vessels, cargo units and transport chains

4.1 Vehicles/vessels

4.1.1 Requirements for classification

Goods to be transported

When it comes to the vehicle/vessel classification there are several requirements. Vehicles and vessels often have to be adapted to the goods that are transported. Liquid products require tanks; hazardous goods require damage protection etc. Since the goods to be transported are only defined in broad terms as for both type of commodity (see Table 2.1) and shipment size it would hardly be realistic, considering the low precision of input data, to try to define in great detail what exact vehicle/vessel types will be used. The categories used are as broad as possible while still fulfilling the requirement to reflect scale advantages and infrastructure requirements sufficiently well.

Some of the products require special handling equipment for loading and unloading and/or specific vehicles. Liquid matters require i.e. tank lorries, wagons and vessels as well as pumps. Because of these product related differences it might seem natural to differentiate vehicle types also by product. The combined classification would thus be vehicle size and type of commodity to be transported. However, such product related additions to the vehicle classification should only be made if the product related differences have a significant influence on the costs for any given vehicle size or if the relevant range as well as classes of vehicle sizes differ significantly for different products. The commodity based approach chosen in the Logistics Model Version 2 works with few vehicle types and focuses on scale advantages. Following the approach it is best to have as few product related exceptions for the vehicle types as possible.[15]

Economies of scale at the vehicle level

For each mode of transport a range of vehicle types is used in order mainly to reflect scale advantages in transport operations including loading and unloading. Per provided capacity unit, using larger vehicles/vessels leads to lower costs. Given a good capacity utilisation for the vehicles/vessels employed, there are scale economies with increased vehicle size for all modes. For rail there exist scale advantages both for wagons (axle loads etc) and trains (number of wagons).

Infrastructure requirements

Another reason for keeping record of different vehicle types and sizes is that different vehicles/vessels have different infrastructure requirements. Different vehicle types, i.e. size of system trains, influence wear and tear of infrastructure differently. This implies

[15] In this aspect the Norwegian and Swedish vehicle classifications differ. For the Swedish model it was a natural starting point is to test a classification only by size by assuming that, for all modes a limited set of vehicle sizes could adequately reflect scale advantages and that this set would suffice for all commodities. Then the result could be examined and possible product related exceptions to the general pattern identified. On the assumption that the simplest structure of a universal set of vehicles could be used for each mode there is no need to define allowable combinations of vehicle types forming a transport chain, other than those implied by the carrying capacity required by the shipments, which is anyway part of the logistics model as such.

that the sizes of the vehicles should be expressed in dimensions that are relevant for the infrastructure holders.

Classifications used in official statistics and other models

The vehicle/vessel classification should if possible take into account nomenclatures used in official statistics, tax regulations etc. The classification should if possible also take into account the vehicle classifications used in other calculation models. One example is the European ARTEMIS model that is used to calculate of emissions from transport.[16]

4.1.2 Vehicles/vessels used

The logistics model uses 35 vehicle/vessel types covering:

- road (vehicle number 101–105),
- rail (number 201–209, no 203 is not used in Logistics Model Version 2),
- sea (number 301–321, the medium sized and large road ferries no 319 and 320 are not used in Logistics Model Version 2) and
- air (number 401).

Table 4.1 includes information about the vehicle type name and capacity expressed in tonnes/vehicle.[17] (See files vhcls_drybulk.xls, vhcls_liqbulk.xls and vhcls_gencargo.xls). When it comes to rail, trains – and not single wagons – are used as vehicle units. The capacities, expressed in tonnes per vehicle have to be seen as maximum values. For many bulky products the volume (expressed in m^3) is the limiting factor. Lower capacities, expressed in tonnes per vehicle, should be studied based on empirical data.

[16] The ARTEMIS model has been used for the road transport, it is planned to extend it to the other modes.

[17] Besides the distinction between modes at the highest level (road, rail, sea, ferry, air) more detailed sub-modes (e.g. light lorry,) are used (see Table 4.4) as intermediate level, between modes and vehicle types.

Table 4.1 Vehicle/vessel classification.

Mode	Vehicle number	Vehicle name	Capacity (tonnes per vehicle)
Road	101	Lorry light LGV, ≤ 3,5 ton	2
	102	Lorry medium ≤ 16 ton	9
	103	Lorry medium ≤ 24 ton	15
	104	Lorry HGV ≤ 40 ton	28
	105	Lorry HGV ≤ 60 ton	47
Rail	201	Kombi train	594
	202	Feeder/shunt train	450
	204	System train STAX 22,5	750
	205	System train STAX 25	833
	206	System train STAX 30	6000
	207	Wagon load train (short)	550
	208	Wagon load train (medium)	750
	209	Wagon load train (long)	950
Sea	301	Container vessel 5 300 dwt	5300
	302	Container vessel 16 000 dwt	16000
	303	Container vessel 27 200 dwt	27200
	304	Container vessel 100 000 dwt	100000
	305	Other vessel 1 000 dwt	1000
	306	Other vessel 2 500 dwt	2500
	307	Other vessel 3 500 dwt	3500
	308	Other vessel 5 000 dwt	5000
	309	Other vessel 10 000 dwt	10000
	310	Other vessel 20 000 dwt	20000
	311	Other vessel 40 000 dwt	40000
	312	Other vessel 80 000 dwt	80000
	313	Other vessel 100 000 dwt	100000
	314	Other vessel 250 000 dwt	250000
	315	Ro/ro vessel 3 600 dwt	3600
	316	Ro/ro vessel 6 300 dwt	6300
	317	Ro/ro vessel 10 000 dwt	10000
(Ferry)	318	Road ferry 2 500 dwt	2500
	319	Road ferry 5 000 dwt	3000
	320	Road ferry 7 500 dwt	4500
	321	Rail ferry 5 000 dwt	5000
Air	401	Freight aeroplane	50

4.1.3 Road

Five typical road vehicles represent lorries (with or without trailer) of various sizes:

- a light lorry under 3.5 tonnes total weight (total weight includes lorry and goods)
- two medium sized lorries with 16 tonnes resp. 24 tonnes total weight and
- two heavy duty lorries with 40 tonnes resp. 60 tonnes total weight. The 40 tonnes lorry is the standard vehicle in most EU-countries whereas the 60 tonnes lorry is common in Sweden and Finland.

4.1.4 Rail

In the Logistics Model Version 2 there are a total of eight train types. The use of different vehicle types is driven by the existence of different production systems for rail transport:

- Combined trains (combi trains) require unitised cargo units like containers (see below). These trains combine road resp. sea with rail. Only one typical combi train is modelled.[18]
- There are four wagonload trains, one acting as a feeder or shunt train between industrial locations and marshalling yards and the other, with three different lengths, as long-distance train between marshalling yards. The wagon load system is used for goods with different destinations with fixed frequencies between marshalling yards.
- System trains are block trains normally for one commodity that go with fixed frequency from one industrial location to another industrial location. There are three sizes of system trains depending on the maximum permissible axle weight (STAX). These are ≤ 22.5 tonnes, ≤ 25 tonnes and ≤ 30 tonnes per axle.[19] The system trains with 25 tons and 30 tons maximum axle load are available for a limited part of the rail network and only for certain products.

In the Logistic Model Version 2 economies of scale at the train level are modelled for wagon load trains.However, this approach should be improved and extended to combi trains and system trains. Additionally there is a need to model economies of scale at the wagon level.

Different types of freight trains display certain speed differences. Speed does though differ more according to infrastructure characteristics than to train types and the train speeds therefore are coded universally for all train types per link in the network. (See chapter 5.)

4.1.5 Sea

The sea mode includes both different types of vessels and road and rail ferries. For vessels the economies of scale aspect is taken care of by way of defining the vessel's

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[18] In later versions it is planned to differentiate also kombi trains according to different lengths to take into account economies of scale.

[19] Certain products are – due to their density – transported in vehicles that require (much) more bearing capacity than conventional trains. In addition different system trains of different length could be modelled in coming versions.

capacity in dead-weight (dwt), e.g. the approximate cargo carrying capacity in weight terms in tons. Vessels with similar dwt-capacity tend to have similar draught, although there are differences in draught for the same dwt between various vessel categories (tankers, bulk carriers, container vessels etc) due to different "lines" in the ship design. Sea vessels, as opposed to most land-based vehicles, differ significantly in size and therefore cost. The sea vessels as defined in Model Version 2 vary from as little as 1 000 tonnes dwt to a maximum of 250 000 tonnes dwt. In the model a total of 17 different vessels are defined. (It is taken into account that certain products/commodities due to their density are transported in vehicles that require (much) more depth than average vessels.):

- four container vessels
- three roro vessels and
- ten "other vessels".

are defined. The category "other vessel" includes all non container and non-roro vessels that carry different commodities, mainly dry bulk and liquid bulk (tankers)

Ferries are in a way part of the road or rail network (they could be replaced by bridges or tunnels). Ferry capacity is normally shared by different firms and commodities. Economies of scale are less relevant as for ferries than for vessels; when increasing size the decrease in unit costs is larger for vessels than for ferries. In Version 2 three road ferries (but only the smallest road ferry is used) and one rail ferry are defined.[20]

There are speed differences between certain types of vehicles/vessels within each mode. Notable examples are between container vessels (30–39 km/h), ro-ro vessels (30 km/h) and other vessels (22–30 km/h).

4.1.6 Air

In the Logistics Model Version 2 one cargo-specific aircraft (freighter) with a maximum freight capacity of 50 tonnes is defined. This means that freight transports in passenger air planes, so called pax belly transports, are not included.

4.2 Cargo units

Inter modal transports use unitised cargo types and at least two modes of transport. These transports are interesting as they combine the comparative advantages of the different modes. From an analysis perspective it is also important to know the potential for inter modal transports.[21] Conventional freight models use commodity classifications and vehicle classifications but it is much less common to categorize cargo types.[22] There is little experience when it comes to the modelling of cargo units.[23]

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[20] In the short term development it could be taken into account which road ferry, in terms of seize, is used in which relations. The long term development could include the choice of ferry size.

[21] It should be modelled how firms (senders, receivers, forwarders and carriers) behave today and when conditions change i.e. due to the introduction of policy measures or change in market conditions. It should be possible to present the contribution of different factors to changes in logistic decisions, modal split, transport flows etc.

[22] Unitised cargo has characteristics of both commodities and vehicles. Port statistics describe how many containers are handled, without specifying which commodities are stored in the units. The Swedish

In Version 2 the modelling of unitised transports is limited to container transports in contrast to conventional load on/load off transports. Further, the assumption is made that containers can be transported on nearly all vehicle and vessel types. Exceptions are the light and medium sized lorries, system trains and airplanes. On the other hand, combi trains and container vessels are assumed to be used for container transports only. It is also assumed that the container is carried the entire transport chain from the sender to the receiver. It is not possible stuff or strip a container along the transport, which, however, occurs in real life for example in ports.[24]

4.3 Transport chains

Table 4.2 describes the modes, sub-modes and vehicle/vessel types that are assumed in the model to be available. The modes are given separately for container transports and non-container transports in Version 2. The sub modes define for each mode a typical vehicle/vessel. These are used to reduce the number of predefined transport chains in the *Buildchain* step. It has to be stressed that the Buildchain step is used to specify the transfer points. It is though possible for the model algorithm in the *Chainchoi* step to choose other vehicles types than those assumed in the the Buildchain step. When it comes to sea transports, a distinction between direct sea and feeder/long haul transports is made. Direct transports include only one sea link while feeder and long haul transports build sea/sea links. It is assumed that small feeder vessels (i.e. the smallest container vessel with 5 300 dwt) "feed" large long haul vessels that go overseas (i.e. the largest container vessel with 100 000 dwt).

In the Version 2 the following 86 pre-defined transport chains, presented in an alphabetic order in Table 4.3 are used. The chains are divided in those for container transports and those for conventional (non container) transports. The pre-defined chains can be changed via the input files. The typical vehicles/vessels used in BuildChain for each commodity are given in Table 4.4.

Commodity Flow Survey (CFS) uses a. o. the following conventional cargo types (liquid bulk, solid bulk, palletised, pre slung goods) and unitised cargo types (containers, self propelled and other mobile units). There are containers of different sizes, the most common are 20 foot containers (corresponding 1 TEU) and 40 foot containers.

[23] The use of international sea containers has been modelled in the 2005 version of the STAN-model See SIKA Rapport 2005:2, Modellanalyser av godsflöden i Östra Mellansverige.

[24] The assumption that stuffing and stripping only takes place at the sender or receiver should be relaxed in coming model versions.

Table 4.2 Predefined transport chains.

No	Chain	Explanation	Container transport
1	A	Direct transport by road	*Yes*
2	ADA	road – rail	*Yes*
3	ADJA	road – rail – sea – road	*Yes*
4	ADJDA	road – rail – sea – rail – road	*Yes*
5	ADKL	road – rail – sea – sea	*Yes*
6	AJ	road – sea	*Yes*
7	AJA	road – sea – road	*Yes*
8	AJDA	road – sea – rail – road	*Yes*
9	AKL	road – sea – sea	*Yes*
10	APA	road – ferry – road	*Yes*
11	B	Direct transport by road	No
12	BR	road – air	No
13	BRB	road – air – road	No
14	BS	road – road	No
15	BSB	road – road – road	No
16	C	Direct transport by road	No
17	CGH	road – rail – rail	No
18	CGHC	road – rail – rail – road	No
19	CGHM	road – rail – rail – sea	No
20	CGHNO	road – rail – rail – sea – sea	No
21	CGHQC	road – rail – rail – ferry – road	No
22	CH	road – rail	No
23	CHG	road – rail – rail	No
24	CHGC	road – rail – rail – road	No
25	CM	road – sea	No
26	CMC	road – sea – road	No
27	CMI	road – sea – rail	No
28	CMT	road – sea – rail	No
29	CMU	road – sea – rail	No
30	CNO	road – sea – sea	No
31	CPC	road – ferry – road	No
32	CQGH	road – ferry – rail – rail	No
33	CQHG	road – ferry – rail – rail	No
34	CQHGC	road – ferry – rail – rail – road	No
35	GH	rail – rail	No
36	GHC	rail – rail – road	No
37	GHG	rail – rail – rail	No
38	GHM	rail – rail – sea	No
39	GHMI	rail – rail – sea – rail	No
40	GHMT	rail – rail – sea – rail	No
41	GHMU	rail – rail – sea – rail	No
42	GHNO	rail – rail – sea – sea	No
43	GHQC	rail – rail – ferry – road	No

No	Chain	Explanation	Container transport
44	GHQH	rail – rail – ferry – rail	No
45	HC	rail – road	No
46	HG	rail – rail	No
47	HGC	rail – rail – road	No
48	HQKG	rail – ferry – sea – rail	No
49	I	Direct transport by rail	No
50	IM	rail – sea	No
51	IMC	rail – sea – road	No
52	IMHG	rail – sea – rail – rail	No
53	INO	rail – sea – sea	No
54	J	Direct transport by sea	Yes
55	JA	sea – road	Yes
56	KL	sea – sea	Yes
57	LK	sea – sea	Yes
58	LKA	sea – sea – road	Yes
59	LKDA	sea – sea – rail – road	Yes
60	M	Direct transport by sea	No
61	MC	sea – road	No
62	MHG	sea – rail – rail	No
63	MHGC	sea – rail – rail – road	No
64	MI	sea – rail	No
65	MT	sea – rail	No
66	MU	sea – rail	No
67	NO	sea – sea	No
68	ON	sea – sea	No
69	ONC	sea – sea – road	No
70	ONHG	sea – sea – rail – rail	No
71	ONHGC	sea – sea – rail – rail – road	No
72	ONI	sea – sea – rail	No
73	ONT	sea – sea – rail	No
74	ONU	sea – sea – rail	No
75	RB	air – road	No
76	SB	road – road	No
77	T	Direct transport by rail	No
78	TM	rail – sea	No
79	TMC	rail – sea – road	No
80	TMGH	rail – sea – rail – rail	No
81	TNO	rail – sea – sea	No
82	U	Direct transport by rail	No
83	UM	rail – sea	No
84	UMC	rail – sea – road	No
85	UMGH	rail – sea – rail – rail	No
86	UNO	rail – sea – sea	No

Table 4.3 Modes, sub-modes and vehicle types.

				Container	Non container
Mode	**Sub mode**	**Vehicle No**	**Vehicle name**	**Mode**	**Mode**
Road	Light lorry	101	LGV, ≤ 3,5 ton		B
	Light lorry	102	MGV max 16 ton		B
	Light lorry	103	MGV max 34 ton		B
	Heavy lorry	104	HGV max 40 ton	A	B, C, S
	Heavy lorry	105	HGV max 60 ton	A	B, C, S
Rail	Kombi train	201		D	
	Feeder train	202	Feeder train	E	G
	System train	204	STAX 22,5		I
	System train	205	STAX 25		T
	System train	206	STAX 30		U
	Wagon load	207	Short train	F	H
	Wagon load	208	Medium train	F	H
	Wagon load	209	Long train	F	H
Sea	Direct + feeder	301	Container, 300 dwt	J, K	
	Direct	302	Cont, 16 000 dwt	J	
	Direct + long haul	303	Cont, 27 200 dwt	J, L	
	Direct + long haul	304	Cont, 100 000 dwt	J, L	
	Direct	305	Other, 1 000 dwt	J	M
	Direct	306	Other, 2 500 dwt	J	M
	Direct	307	Other, 3 500 dwt	J	M
	Direct	308	Other, 5 000 dwt	J	M
	Direct	309	Other, 10 000 dwt	J	M
	Direct	310	Other, 20 000 dwt	J	M
	Direct	311	Other, 40 000 dwt	J	M
	Direct	312	Other, 80 000 dwt	J	M
	Direct	313	Other, 100 000 dwt	J	M
	Direct	314	Other, 250 000 dwt	J	M
	Direct + feeder	315	Ro/ro 3 600 dwt	J, K	M, N
	Direct + feeder	316	Ro/ro 6 300 dwt	J, K	M, N
	Direct + long haul	317	Ro/ro 10 000 dwt	J, L	M, O
(Ferry)		318	Road ferry 2 500 dwt	P	P
		319	Road ferry 5 000 dwt	P	P
		320	Road ferry 7 500 dwt	P	P
		321	Rail ferry 5 000 dwt	Q	Q
Air		401	Freight aeroplane		R

Table 4.4 Vehicle type in BuildChain for each sub-mode by commodity type.

(See Table 2.1 for commodity group numbers and Table 4.2 for vehicle numbers and mode)

Commodity	A	D	E	F	J	K	L	B	C	G	H	I	M	N	O	P	Q	R	T	U
1	104	201	202	208	-	-	-	102	104	202	208	204	310	315	317	319	321	401	205	206
2	104	201	202	208	-	-	-	102	104	202	208	204	310	315	317	319	321	401	205	206
3	104	201	202	208	-	-	-	102	104	202	208	204	310	315	317	319	321	401	205	206
4	104	201	202	208	-	-	-	102	104	202	208	204	310	315	317	319	321	401	205	206
5	104	201	202	208	303	301	303	102	104	202	208	204	310	315	317	319	321	401	205	206
6	104	201	202	208	303	301	303	102	104	202	208	204	310	315	317	319	321	401	205	206
7	104	201	202	208	303	301	303	102	104	202	208	204	310	315	317	319	321	401	205	206
8	104	201	202	208	-	-	-	102	104	202	208	204	310	315	317	319	321	401	205	206
9	104	201	202	208	-	-	-	101	104	202	208	204	310	315	317	319	321	401	205	206
10	104	201	202	208	303	301	303	101	104	202	208	204	310	315	317	319	321	401	205	206
11	104	201	202	208	-	-	-	102	104	202	208	204	310	315	317	319	321	401	205	206
12	104	201	202	208	303	301	303	102	104	202	208	204	310	315	317	319	321	401	205	206
13	104	201	202	208	-	-	-	102	104	202	208	204	310	315	317	319	321	401	205	206
14	104	201	202	208	303	301	303	102	104	202	208	204	310	315	317	319	321	401	205	206
15	104	201	202	208	303	301	303	102	104	202	208	204	310	315	317	319	321	401	205	206
16	104	201	202	208	303	301	303	102	104	202	208	204	310	315	317	319	321	401	205	206
17	104	201	202	208	303	301	303	101	104	202	208	204	310	315	317	319	321	401	205	206
18	104	201	202	208	303	301	303	102	104	202	208	204	310	315	317	319	321	401	205	206
19	104	201	202	208	303	301	303	102	104	202	208	204	310	315	317	319	321	401	205	206

Table 4.4 Vehicle type in Build Chain for each sub-mode by commodity type.

Commodity	A	D	E	F	J	K	L	B	C	G	H	I	M	N	O	P	Q	R	T	U
20	104	201	202	208	-	-	-	102	104	202	208	204	310	315	317	319	321	401	205	206
21	104	201	202	208	-	-	-	102	104	202	208	204	310	315	317	319	321	401	205	206
22	104	201	202	208	-	-	-	102	104	202	208	204	310	315	317	319	321	401	205	206
23	104	201	202	208	303	301	303	102	104	202	208	204	310	315	317	319	321	401	205	206
24	104	201	202	208	303	301	303	102	104	202	208	204	310	315	317	319	321	401	205	206
25	104	201	202	208	303	301	303	101	104	202	208	204	317	315	317	319	321	401	205	206
26	104	201	202	208	-	-	-	101	104	202	208	204	310	315	317	319	321	401	205	206
27	104	201	202	208	303	301	303	101	104	202	208	204	310	315	317	319	321	401	205	206
28	104	201	202	208	303	301	303	102	104	202	208	204	317	315	317	319	321	401	205	206
29	104	201	202	208	303	301	303	101	104	202	208	204	310	315	317	319	321	401	205	206
30	104	201	202	208	303	301	303	101	104	202	208	204	317	315	317	319	321	401	205	206
31	104	201	202	208	303	301	303	102	104	202	208	204	310	315	317	319	321	401	205	206
32	104	201	202	208	303	301	303	101	104	202	208	204	317	315	317	319	321	401	205	206
33	104	201	202	208	303	301	303	101	104	202	208	204	317	315	317	319	321	401	205	206
34	104	201	202	208	303	301	303	102	104	202	208	204	317	315	317	319	321	401	205	206
35	-	-	-	-	-	-	-	101	-	-	-	-	-	-	-	-	-	401		

The Build Chain program is used to generate the available transport chains, including the optimal transfer locations between OD legs. This program step requires pre-set of typical shipment sizes as input parameters – as starting point. The Version 2 model used the average shipment sizes per commodity from the Commodity Flow Survey 2004/5.

Table 4.5 Typical shipment sizes used in BuildChain.

No	Commodity	Typical shipment size (tonnes/shipment)
1	Cereals	41.0
2	Potatoes, other vegetables, fresh or frozen, fresh fruit	3.8
3	Live animals	3.8
4	Sugar beet	0.3
5	Timber for paper industry (pulpwood)	41.2
6	Wood roughly squared or sawn lengthwise	9.2
7	Wood chips and wood waste	122.8
8	Other wood or cork	43.4
9	Textiles, textile articles and manmade fibres	0.2
10	Foodstuff and animal fodder	1.8
11	Oil seeds and oleaginous fruits and fats	14.1
12	Solid mineral fuels	164.5
13	Crude petroleum	19 739.1
14	Petroleum products	103.1
15	Iron ore, iron and steel waste and blast-furnace dust	4212.2
16	Non-ferrous ores and waste	135.9
17	Metal products	12.9
18	Cement, lime, manufactured building materials	7.2
19	Earth, sand and gravel	20.5
20	Other crude and manufactured minerals	29.1
21	Natural and chemical fertilizers	55.6
22	Coal chemicals	3.2
23	Chemicals other than coal chemicals and tar	3.1
24	Paper pulp and waste paper	173.9
25	Transport equipment, whether or not assembled, parts	1.7
26	Manufactures of metal	0.9
27	Glass, glassware, ceramic products	1.1
28	Paper, paperboard; not manufactures	23.3
29	Leather textile, clothing, other manufactured articles	0.6
30	Mixed and part loads, miscellaneous articles	No PWC flow for this commodity
31	Timber for sawmill	40.9
32	Machinery, apparatus, engines, parts thereof	18.2
33	Paper, paperboard and manufactures thereof	0.3
34	Wrapping material, used	0.6
35	Air freight (Logistics Model Version 2)	2.9

5 Networks and LOS-matrices

5.1 Background

In order to produce the LOS-matrices separate vehicle type specific networks have been modelled using Emme/2. A solution using CUBE-Voyager is planned to in order to make it easier to carry out analyses that require changes in the network. The main reason for using the Emme/2 software is that there is a vast amount of experience within the transport agencies.[25] The Emme/2 assignment macro used to generate the cost and time LOS-matrices uses a matrix with .0001 vehicles for each OD-pair. (A value is needed to create the relation between zones.) The idea of this is to allow all possible OD-pairs to be connected and LOS-data generated but without effects of congestion on the network for the LOS-generation, but still allowing the same network model to be used for the later assignment of the vehicle OD-matrices calculated by the Logistics model. The LOS-matrix generation process thus does not take congestion into account. In order to produce a net of LOS-matrices, a set of Emme/2 macros is run as follows:

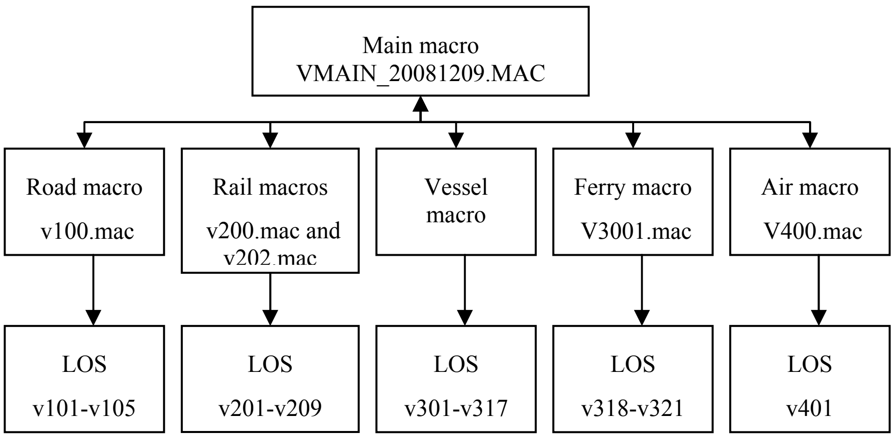

Figure 5.1 Structure of Emme/2 macros to generate LOS-matrices.

One main macro is run per main mode – i.e. road, rail, sea, ferry and air. These can then easily be combined into a singular main macro. The LOS-matrices produced are in standard Emme/2 format which the logistics model is prepared for as outlined below:

```
c EMME/2 Module:  3.14(v9.05)  Date: 08-12-12 14:30   User: E061/SIKA.......jm
c Project:      Samgods
t matrices
a matrix=mf08  dist      0 distance
718021 718121:379.440 718221:16.0700 718821:213.260 719221:231.720
 718021 731921:301.160 738221:210.980 748121:300.950 758121:354.700
```

Where the first four rows are the header needed for Emme/2 (ignored by the logistics model). The next row begins with the starting node (718021), the destination zone (718121), a colon and then the value (379.440). The row then continues with the second

[25] The STAN software is restricted to 32 000 links whereby it is not possible to import the entire road network from the national passenger model Sampers. The network requirements in the logistics model approach put a lower burden on the freight transport modelling aspects which are specific to the STAN software.

destination and the second value. If there are no further destinations from the same start zone a new start zone and row is started.

In order to generate a set of vehicle type-specific level-of-service-matrices (LOS matrices) not only the administrative zones but also the possible transfer locations between vehicles need to be defined as zones. Therefore terminal locations such as ports, airports, lorry terminals, combi terminals, marshalling yards have been defined as additional zones. Including terminal locations the model consists of 1 171 zones, including 464 administrative zones (discussed above) and 707 terminal zones inside and outside Sweden. The base matrices use the same zonal numbering system as the new (domestic and international) networks.

The "terminals" where it is possible to transfer between different vehicle types are defined in the network (LOS matrices) as well as in the input file nodes_all.xls. The terminals are numbered according to the municipality that they are geographically located within, but with the difference that the last two digits are not "00" as with the administrative zones but in the range 01–99. In this way it is possible to see which administrative zone every terminal zone is a part of.

Table 5.1 Terminal zone numbering system by main mode.

	Last two digits
Road terminal zone	01-10, 51-59[26]
Rail terminal zone	11-20
Port terminal zone	21-30
Ferry terminal zone	31-40
Airport terminal zone	41-50

5.2 LOS-matrix generation

The infrastructure networks are used for several purposes. One is to generate the level of service (LOS)-matrix data for each vehicle type providing *the vehicle transport time, distance and network related infrastructure charges and fees*. The LOS matrices supply information between all zones (administrative PWC-zones and terminal zones). Vehicle type specific LOS-matrices have been extracted:

– Total distance matrix (km) dist
– Domestic-only distance matrices (km) ddist
– Pure time matrix (h) time
– Infrastructure charges/fees matrix (kr) xkr
– Frequency matrices freq

There are a total of 150 LOS-matrices, consisting of 140 vehicle specific matrices

[26] Initially numbers 01–10 were allocated to road terminals (maximum of 10 road terminals per administrative zone). A later project by the National Road Administration defined a larger set of road terminals and these were then allocated the range 51–59. In the future it could be possible to re-define e.g. all road terminals to the range 51–69.

(35 vehicle types * 4 cost/time matrices, (see section 5.2) and ten frequency matrices (see section 5.4) The domestic-only distance matrices are needed for the calculation of tonkm for road rail and sea on Swedish territory, that is presented in official statistics (See section 7.3) Concerning infrastructure charges and fees, Table 5.1 summarises which infrastructure fees are included and how they are implemented. Infrastructure fees for air transport are not included in the Version 2 model.[27]

Table 5.2 Implementation of infrastructure charges and fees.

Mode		**Vehicle type**	**Distance/time based**
Road	Tolls (bridges)	per lorry type	per link (passage)
	Km tax	per lorry type	per link (km)
Rail	Rail infrastructure charges	per train type	per link (km)
	Tolls (bridge)	per train type	per link (passage)
Sea	Fairway dues Sweden)	per vessel type	per node (port)
	Pilot fees (Sweden)	per vessel type	per port and link (km/hour)
	Kiel canal fee	per vessel type	per link (passage)
Air	En route fees	per vehicle type	per (link) km
	Start-/landing fees	per vehicle type	per node (air port)

Another role for the network beside providing LOS-matrices is to describe restrictions that are link-based, such as the restriction that STAX 30 system trains can only use parts of the rail network that have sufficient bearing capacity. All non-link-based or node-based restrictions are dealt with in the input files via very high costs to prevent vehicle use or restrictions in nodes (in costs reps nodes file).

The diagram below illustrates how administrative and terminal zones are connected to the network.

[27] The collection process for air infrastructure fees has been started.

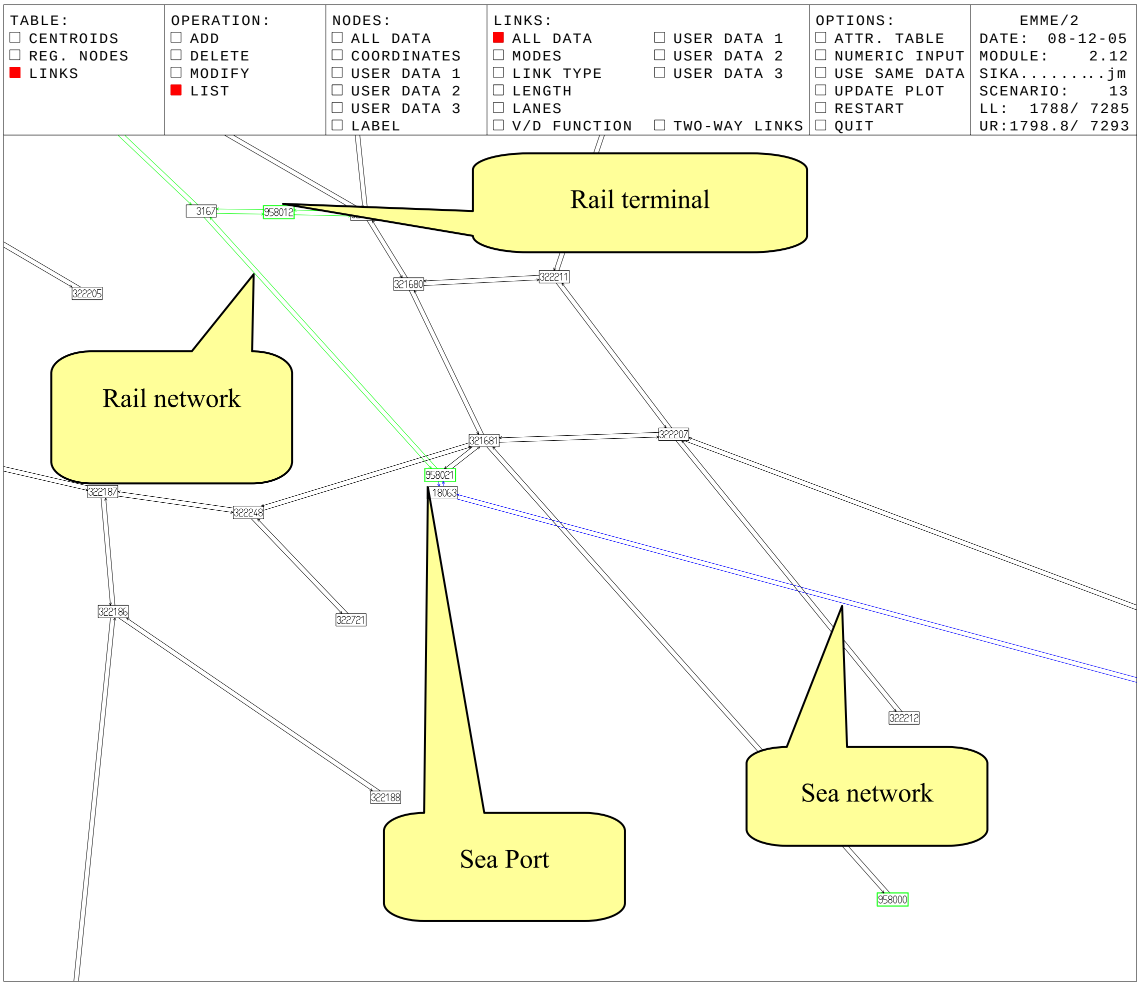

Figure 5.2 Administrative zones, road network and centroid connector.

5.3 Links

All network information above has been provided by the Swedish National Road Administration, Swedish National Rail Administration, Swedish National Maritime Administration and Swedish Civil Aviation (now: Swedish Transport Agency) during the development of the STAN-model. The domestic road network has been extended according to the requirements of the Road Administration in order to be able to use the same Emme/2 road network for passenger and freight transports. (The classifications specified in Table 5.3 are relevant to Emme/2.) The term “mode” is used for road, rail, air, sea or ferry. Link type is a way of classifying links. This has not direct relevance to the assignment calculation as such but is used in the LOS-calculation as a way of defining which group of links are to be included. For example to add an extra charge on Swedish rail links but not on rail links outside Sweden.

Table 5.3 Network link characteristics.

	Mode	Link type	Speed (km/h)	Number of links
Within Sweden				
Main road links	Road	1-69	50-111	62 181
Rail links	Rail	70-79	20-86	786
Sea links	Sea	80-99	7.4-30	260
Ferry links	Ferry	90-99	25	76
Road links – centroid connectors	Road	110	50	580
Dummy road connection links	Road	111-119	50	156
Road connection links to/from terminals	Road	201	50	798
Extra rail links to terminal zones	Rail	211	50	646
Extra sea links to port zones	Sea	221	50	112
Extra ferry links to terminal zones	Ferry	231	50	34
Total within Sweden				65 629
Outside Sweden				
Main road links	Road	501-504	70-110	2 722
Sea links – inland waterways	Sea	540	5	126
Extra air links to airport terminals	Air	560	600	476
Rail links	Rail	570-579	40	1 952
Sea links – Kiel canal	Sea	580	30	2
Sea links	Sea	581-599	25-30	648
Road connection to/from terminals	Road	601	50	282
Extra rail links to terminal zones	Rail	602	50-70	226
Extra ferry links to terminal zones	Ferry	604	25	56
Road links – centroid connectors	Road	610	50	276
Road connection links	Road	611-669	50	902
Rail links – centroid connectors	Rail	670-999	50	342
Total outside Sweden				8 010
Total inside and outside Sweden				73 639

The link categories are "model related". This means that centroid connectors (which connect the zone-centroid to the main network) are defined separately from the "real" infrastructure networks. In the same way the "dummy connection links" are links which connect the "real" infrastructure networks to terminals via virtual links. Additional virtual links were required in order to connect the additional terminal zones to the networks. These were given new link type classes in order to differentiate from the original STAN-link types.[28] Link speeds in open water are defined by vessel type in the network model and used to determine the values in the time-dependent LOS matrices, which is then passed to the logistics model.

[28] We have a mixture of the old STAN- link types/categories and the new Emme/2-Samgods link types. This should ideally be cleaned-up in the future.

5.3.1 Road network

Road network in Sweden

The domestic road network has been created from the National Sampers model (in Emme/2 format).[29] The network representation corresponds to the main road network (statlig huvudvägnät) for the year 2004. Road ferry links have been removed from the Sampers application as these are modelled as separate networks. We now have a road network including over 67 000 links and nearly 23 000 nodes. Once the road network was converted the following data characteristics were copied from the Sampers application: link length (km), number of lanes and volume delay function (VD function). This makes it possible to assign the vehicle specific OD-matrices calculated by the logistics model.

Road network outside Sweden

The STAN road network outside Sweden for the year 2001 was added to the domestic network and mismatches between the new domestic and foreign networks were corrected. The road network in Europe is the main road network. No official definition exists as these are sometimes motorways, but in other cases, where no motorways exist, major roads are used instead. The network model can be used also for restrictive purposes such as with 60 tonne lorries (vehicle type 105) which are in the default base model allowed only in Sweden and Finland, and not in the rest of Europe according to infrastructure restrictions and regulations.[30]. If alternations to this standard restriction are to be tested then this can be done by adjusting the mode selection for a set of specified network links.

Road terminals

171 road terminals are defined in Sweden. (See Table 5.12). As Figure 5.3 shows, these terminals are concentrated to the Southern and Central Sweden. In version 2 no road terminals outside Sweden are defined (which is unfortunate since this may be forcing perhaps longer transport with the incorrect lorry size).[31]

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[29] Some node numbering issues were resolved by the Road Administration, this was because a small number of node numbers in the Sampers model were not within the "standard" numbering convention and had numbers corresponding to the number classification for Samgods as rail nodes (i.e. 1000-9999).

[30] This can though be changed in the LOS-files, for example in order to take into account the ongoing trials with longer lorries in Denmark.

[31] The model does only include Swedish goods, and it should be necessary to assume a preload factor to take into account the foreign goods. This approach is used for the large container ports in Europe. See below.

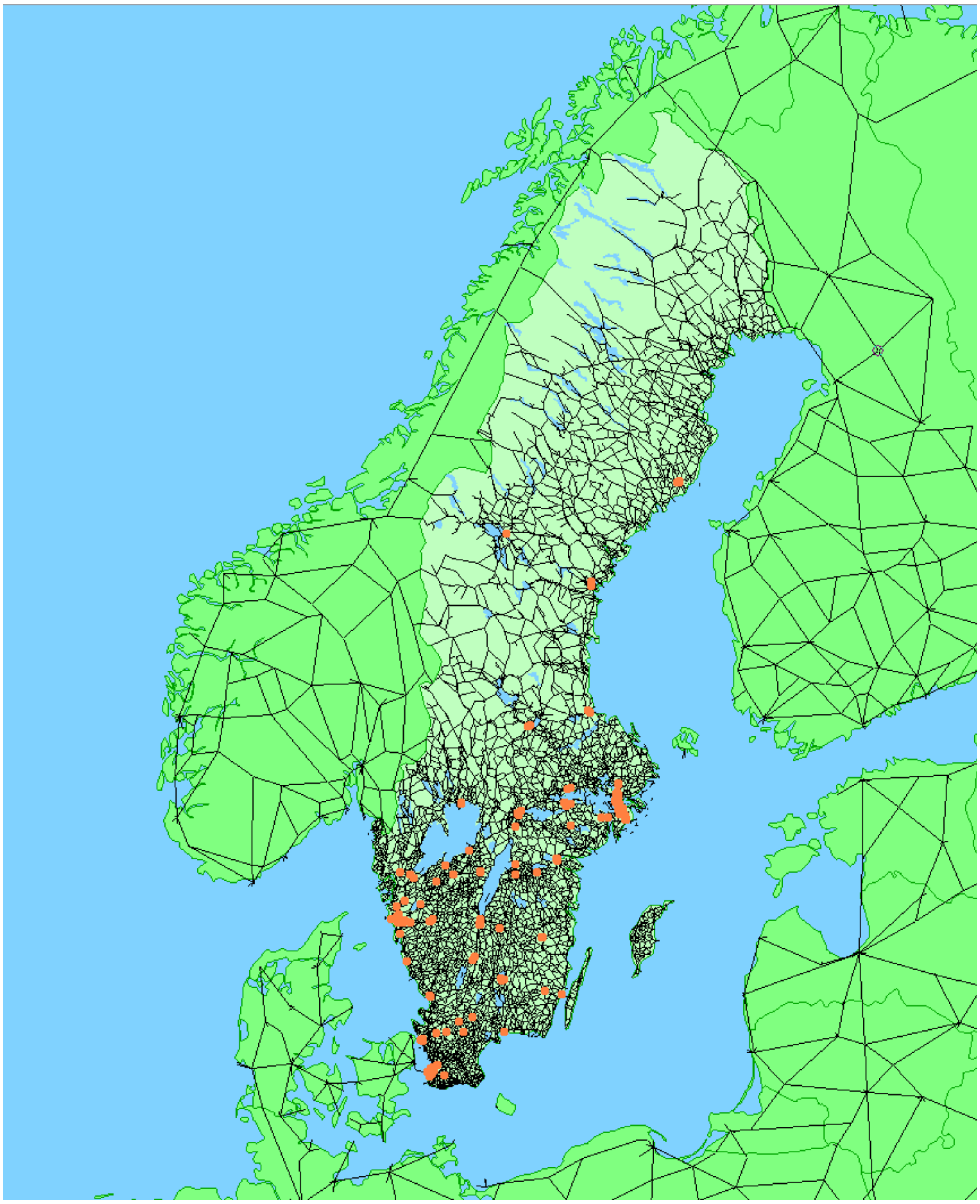

Figure 5.3 Road network and road terminals.

The LOS-matrices for road are generated as follows:

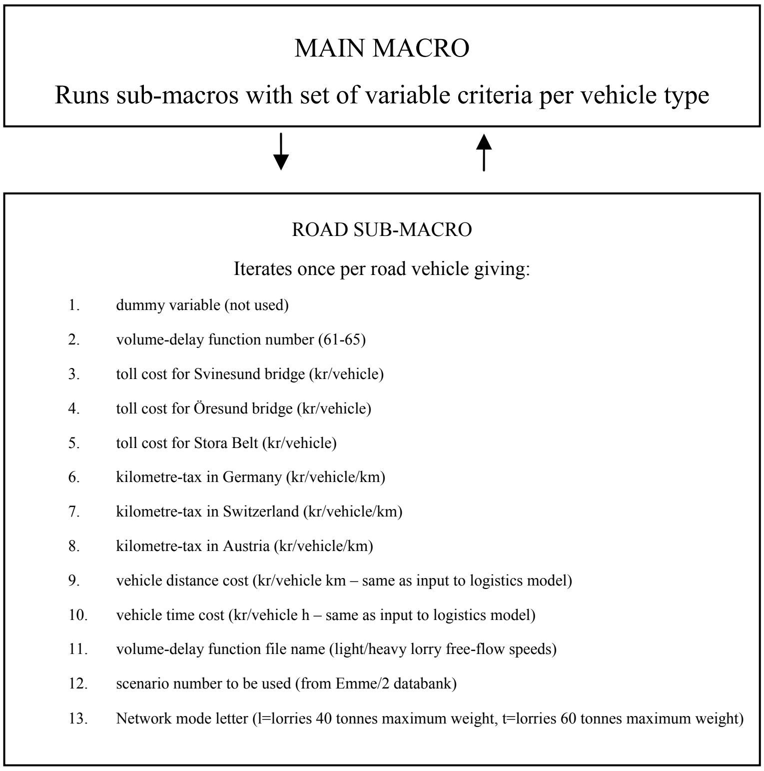

Figure 5.4 Generation of LOS-matrices for road vehicles.

The Emme/2 model uses two different networks. One that covers the entire road network in Sweden as well as abroad is coded as mode “l”. This mode is used for Vehicle No 101–104 (vehicles up to a maximum of 40 tonnes). The other mode is “t” and is only used for vehicle No 105 which has a maximum weight of 60 tonnes. Vehicles 104 and 105 can be used between zones covering the areas of Sweden and Finland.

Associated with the modes l and t are two sets of free flow speeds with volume-delay functions. The functions for light lorries (Vehicle No 101) assume passenger car expressions from the Sampers model and the highest speeds are found on high standard motorways with a free-flow speed of 108 km/h. The functions for the medium and heavy lorries (Vehicle No 102-105) use lorry functions from the Sampers model where the equivalent speed on a high standard motorways is 85 km/h.[32] A full set of volume-delay expressions can be found in the files v101.414 and v102.414 found as inputs to the LOS-building step of the model.

[32] It should be noted that the column with scenario number is used in the macros to define which scenario network version is the relevant one (at the time of writing scenario 14). Several values are built into the Emme/2 macros but are not used, because there have been a number of changes to the macro process during the development phase but that these have not then been cleaned-up.

Table 5.4 Road vehicle specific values in Emme/2 macro.

Vehicle type	No	VDF number (#2)	VDF file (#11)	Scenario (#12)	Mode (#13)
Lorry ≤ 3,5 ton	101	61	V101.414	14	l
Lorry ≤ 16 ton	102	62	V102.414	14	l
Lorry ≤ 24 ton	103	63	V102.414	14	l
Lorry ≤ 40 ton	104	64	V102.414	14	l
Lorry ≤ 60 ton	105	65	V102.414	14	t

Vehicle type specific infrastructure charges and fees (based on information for the year 2008) are included for the Svinesund bridge, the Öresund bridge and Stora Belt bridge.[33] Also kilometre taxes for heavy lorries in Germany, Switzerland and Austria are modelled in the Infrastructure charges/fees matrix[34,35] The 60 tonnes lorries are not allowed in most European countries.

Table 5.5 Toll charges per lorry and passage, km-tax outside Sweden.

		Charge per lorry and passage			Km-tax outside Sweden		
Vehicle type	No.	Svinesund	Öresund	Stora Belt	Germany	Switzerland	Austria
		(SEK/vehicle passage)			(SEK/vehicle km)		
Lorry ≤ 3,5 ton	101	20	650	650			
Lorry ≤ 16 ton	102	100	960	985	3.692	1.953	2.127
Lorry ≤ 24 ton	103	100	960	985	3.692	2.9295	2.6778
Lorry ≤ 40 ton	104	100	960	985	6.039	2.9295	3.7794
Lorry ≤ 60 ton	105						

5.3.2 Rail network

Rail network in Sweden

The rail networks have been taken from the STAN network and adapted to Emme/2-format. Additional connection links to the extra terminal zones have been coded. The following rail modes have been coded:

- The combi network covers a total of 51 000 kilometres and has access to 103 locations, 33 of which are rail terminals and ports in Sweden and 70 outside Sweden.
- There are three wagonload networks: one for transports between marshalling yards and another with feeder trains to the yards divided by direction.

[33] http://www.vv.se, http://www.storebaelt.dk, http://www.oresundsbron.com/prices.

[34] http://www.bmvbs.de, http://de.wikipedia.org/wiki/Schwerverkehrsabgabe_(Schweiz), http://de.wikipedia.org/wiki/Lkw-Maut_in_%C3%96sterreich.

[35] The present set up has no kilometre tax in Sweden. The macro will need adjusting in order to take into account such costs, as will alternative charging systems in countries other than the default setting.

– System trains are modelled as three modes in Emme/2 with different network coverage facilitating different maximum axle-weight capacities (STAX), different costs as well as different rail infrastructure fees. Basically the STAX 30 mode covers the rail track between Kiruna and Luleå. The STAX 25 mode is more widespread and covers the iron-ore rail track in northern Sweden as well as parts of central and western Sweden. STAX 22.5 is available throughout most of Sweden.

Limited rail track capacity, measured in number of trains, is another infrastructure restriction. Currently such capacity limits are disregarded in the Logistics model. It is planned to check the track capacity used against capacity available (after the assignment).[36] Width of track, length of meeting points, profile/height are also relevant infrastructure characteristics that should be modelled in coming model versions.

Rail network outside Sweden

Outside Sweden a rail network has been produced for Europe. As for the road network, no rail network is explicitly modelled outside Europe. The rail network within Europe has been coded manually using a map. The network coverage for each rail mode was taken from the STAN-model which assumed the following:

– feeder-wagonload trains are not modelled outside Sweden, here wagonload trains are directly connected to the zones.

– combi rail exists to a limited number of European zones.

– no system trains exist outside Sweden, other than the iron-ore corridor Kiruna–Riksgränsen–Narvik. Additional corridors can be added, as necessary, to the model by adding additional links to the system train network and/or adjusting the list of zones in the Nodes.xls file thus allowing direct access for system trains in more locations. Note also that the LOS-matrices will need to be recalculated.

[36] The VD-function used in STAN to model limited track capacity is not longer used. The inclusion of shipment sizes in the logistics model (compared to the STAN model) makes the model more realistic in that way, that it is from a cost point of view only interesting to use rail for transport large volumes (from single firms or consolidated flows).

Rail terminals

Figure 5.5 includes also the different types of rail terminals and transfer points (number 2, 3, 7–11 in Table 5.12) that are defined in Sweden and the neighbouring countries.

Figure 5.5 Rail network and terminals and transfer points in Sweden and neighbouring countries.

The LOS-matrices for rail are generated according to the following:

RAIL SUB-MACRO

Iterates once per rail vehicle giving:

1. dummy variable (not used)
2. volume-delay function number (66-71)
3. mode
4. mode 2 (used only for aggregating both direction local wagonload train modes)
5. kilometre track-fees in Sweden (kr/vehicle/km)
6. kilometre track-fee factor outside Sweden
7. vehicle distance cost (kr/vehicle km – same as input to logistics model)
8. vehicle time cost (kr/vehicle h – same as input to logistics model)
9. toll cost for Öresund bridge (kr/vehicle)
10. toll cost for Stora Belt (kr/vehicle)
11. scenario number to be used (from Emme/2 databank)

Figure 5.6 Generation of LOS-matrices for rail.

The Emme/2 network model uses seven different modal networks. Mode "k" is used for combined rail which connects combined rail terminals, ports where combined rail terminal functions are possible and ports where the transfer between combined rail and sea is possible. It is used for calculation of the LOS-matrices for vehicle 201. Two modes are used for feeder wagonload trains, "r" and "q".[37] These two modes are produced separately and aggregated into a single set of feeder wagonload LOS-matrices as 202. The 202 network only exists in Sweden. Mode "j" represents the wagonload trains in and outside Sweden. This mode generates LOS-data for wagon load (vehicles 207, 208 and 209). Then there are three different modes for system trains (modes "y" "z" and "u" which are subsequently vehicles 204, 205 and 206).

Table 5.6 Rail vehicle specific values in Emme/2 macro.

Vehicle type		**VDF number (#2)**	**Mode (#3)**	**Scenario (#11)**
Kombi train	201	66	K	14
Feeder/shunt train	202	67	r and q	14
System train STAX 22,5	204	69	Y	14
System train STAX 25	205	70	Z	14
System train STAX 30	206	71	U	14
Wagon load train (short)	207	68	J	14
Wagon load train (medium)	208	68	J	14
Wagon load train (long)	209	68	J	14

When it comes to infrastructure charges the fees for crossing the Öresund bridge and the Stora Belt bridge are included as well as rail infrastructure fees. The Swedish rail infrastructure fees (banavgifter) that are paid based on gross tonkm, trainkm and litre

[37] This is a legacy of the previous STAN-model where explicit modelling of directional feeder modes was implemented in order to stop unrealistically short transport directly between neighbouring zones – in reality even transport between adjoining zones are transported via a regional marshalling yard.

diesel[38] are "translated" to a fee per trainkm. It is possible to specify the fee per train type and passage, at the moment the fee does not differ between different train types. Table 5.7 includes the rail infrastructure charges per passage resp. per train km for 2005.[39]

Table 5.7 Rail infrastructure charges.

Vehicle type	No	Öresund bridge	Stora Belt Bridge	Rail infrastructure fee in Sweden
		SEK/train passage		SEK/train km
Kombi train	201	5388	6584	4.47
Feeder/shunt train	202	5388	6584	2.68
System train STAX 22,5	204	5388	6584	4.47
System train STAX 25	205	5388	6584	5.20
System train STAX 30	206	5388	6584	24.39
Wagon load train (short)	207	5388	6584	3.26
Wagon load train (medium)	208	5388	6584	4.47
Wagon load train (long)	209	5388	6584	5.63

The Swedish rail infrastructure fees are assumed in all European countries. This implies – due to the relatively low rail infrastructure fees in Sweden an underestimation in most other countries.[40]

5.3.3 Sea network

Sea network inside Europe

The sea network basically consists of a single sea mode connecting all ports in the Emme/2 network (instead of the various sea modes previously coded in the STAN model). This mode connects both domestic and foreign ports allowing all port-to-port combinations. The Kiel Canal in Northern Germany has infrastructure restrictions that do not allow very large vessels. In order to model this, a separate mode has been created where the Kiel Canal is missing. This means that those vessels that cannot use the Canal are forced to use the longer route over the Northern part of Denmark. Each vessel type, except certain categories and sizes, can either use the LOS-matrices which allow use of the Kiel Canal, or the LOS-matrices that cannot use the Kiel Canal.

The infrastructure restrictions in the Öresund and/or Baltic Sea are not modelled explicitly in (the links of) the network but taken account of at the port level. The input files nodes_all.xls show the assumed infrastructure restrictions per port. The restrictions

[38] Banverket, Rapport 2006-12-19, Underlag till kapitel 6, Avgifter i Banverkets Järnvägsnätsbeskrivning 2008.

[39] VTI notat 56-2005, Bertil Hylén, Banavgifter i Europa, En kunskapsöversikt. (It is assumed that 1 DKK corresponds 1,25 SEK.)

[40] A "rail infrastructure factor" has been defined for a number of countries based on VTI notat 56-2005 but this has to be implemented in the model. The large number of country-specific values complicates the macro (maximum width of 72 columns in text file main macro file.).

have been provided by the Maritime Administration. A high value i.e. 9 999 999 assumes unlimited access to a port, a value of 100 000 that only vessels less-than 100 000 tonnes dead-weight (dwt) can access the port. The most significant restrictions, according to the Maritime Administration, are in the Swedish inland lakes (Lake Vänern and Lake Mälaren) where e.g. no vessels over 40 000 tonnes dwt are permitted

In real world shipping companies adjust their routes to the infrastructure restrictions in that way that they use fairways and call ports with restrictions with partly loaded vessels. This optimizing strategy is not modelled in the actual logistics model neither is taken into account that vessels collect and distribute goods along the route (slingor). See section 6.4.2.

Sea network outside Europe

Unlike road and rail, we explicitly model sea links outside Europe. For purposes of convenience we do not show the entire distances in the geographic map but the links between Europe and the destinations outside Europe have real distances and are connected to non-European zones.

Ports

A total of about 300 transfer points land/sea are defined inside and outside Sweden (see Table 5.12) and presented in Figure 5.7. The transfer sea/sea is assumed to be possible onlyin the large ports in central Europe, namely Hamburg, Bremerhaven, Rotterdam, Antwerp.

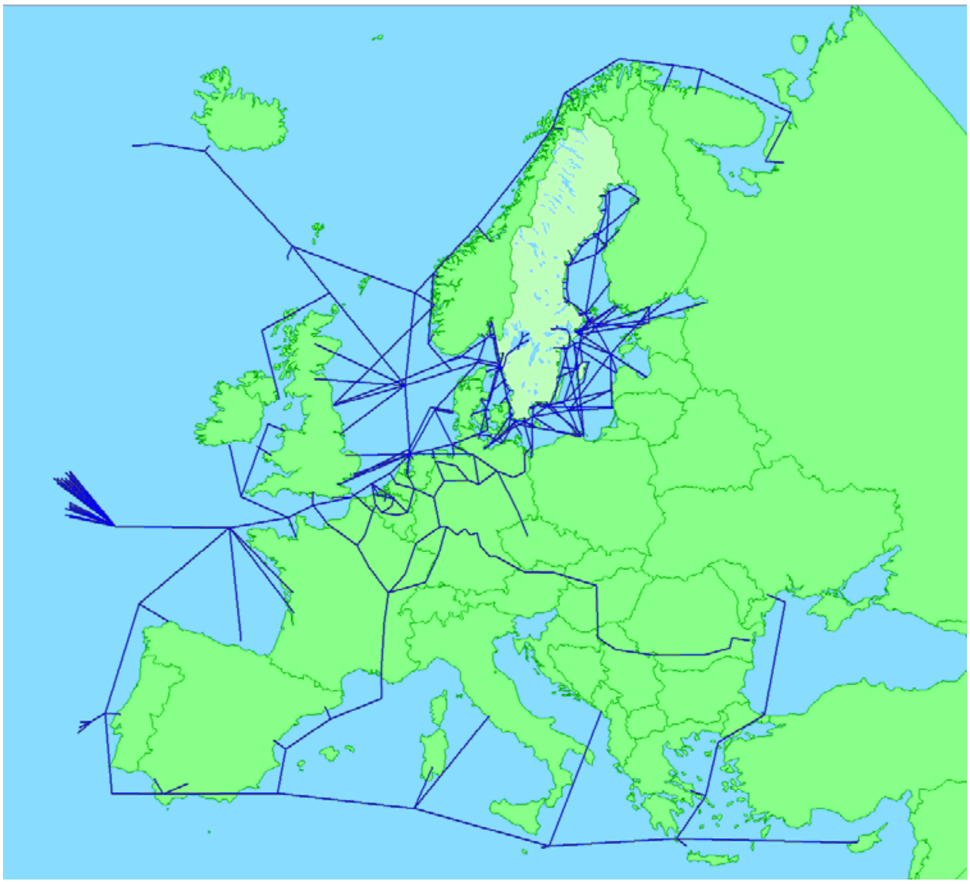

Figure 5.7 Sea network inside and outside Sweden.

LOS-matrices for sea are generated separately for vessels and ferries. The LOS-matrices for vessels are generated as follows:

SEA SUB-MACRO

Iterates once per sea vessel giving:

1. dummy variable (not used)
2. vessel speed in open water
3. volume-delay function number (72-88)
4. vehicle distance cost (kr/vehicle km – same as input to logistics model)
5. mode of vessel
6. vehicle time cost (kr/vehicle h – same as input to logistics model)
7. Kiel canal fee
8. scenario number to be used (from Emme/2 databank)

Figure 5.8 Generation of LOS-matrices for vessels.

The Emme/2 network model uses two modes for sea transport. Mode “s” covers the entire sea network whereas mode “e” covers the entire sea network except the Kiel canal. For sea there are two different categories of speeds. Those classified as “open water" use the vessel default values in the macro, whereas those classified as "not open water" are fixed in the network model. These are specific links, e.g. enclosed waterways (e.g. Mälaren, Vänern) or canals such as the Kiel Canal.

Table 5.8 Vessel specfic values in Emme/2 macro.

Vehicle type	No	Speed in open water (km/h) (#2)	VDF no (#3)	Mode (#5)	Scenario (#8)
Container vessel 5 300 dwt	301	30	72	E	14
Container vessel 16 000 dwt	302	32	73	S	14
Container vessel 27 200 dwt	303	39	74	E	14
Container vessel 100 000 dwt	304	39	75	E	14
Other vessel 1 000 dwt	305	22	76	S	14
Other vessel 2 500 dwt	306	26	77	S	14
Other vessel 3 500 dwt	307	26	78	S	14
Other vessel 5 000 dwt	308	28	79	S	14
Other vessel 10 000 dwt	309	30	80	S	14
Other vessel 20 000 dwt	310	30	81	S	14
Other vessel 40 000 dwt	311	30	82	E	14
Other vessel 80 000 dwt	312	30	83	E	14
Other vessel 100 000 dwt	313	30	84	E	14
Other vessel 250 000 dwt	314	30	85	E	14
Ro/ro vessel 3 600 dwt	315	30	86	S	14
Ro/ro vessel 6 300 dwt	316	30	87	S	14
Ro/ro vessel 10 000 dwt	317	30	88	S	14

The fee that has to be paid when using the Kiel Canal is included in the network related infrastructure charges. In a medium or longer time perspective it should be useful to collect more information about the infrastructure charges and fees outside Sweden. For fairway dues (farledsavgifter), pilot fees (lotsavgifter) and port fees (hamnavgifter) see section 6.3.

Table 5.9 Kiel Canal charges per vessel and passage.

Vehicle type	**No**	**Kiel canal fee SEK/vessel passage**[41]
Container vessel 5 300 dwt	301	33358
Container vessel 16 000 dwt	302	50346
Container vessel 27 200 dwt	303	62094
Container vessel 100 000 dwt	304	117166
Other vessel 1 000 dwt	305	9264
Other vessel 2 500 dwt	306	14536
Other vessel 3 500 dwt	307	25414
Other vessel 5 000 dwt	308	28830
Other vessel 10 000 dwt	309	37623
Other vessel 20 000 dwt	310	49078
Other vessel 40 000 dwt	311	64253
Other vessel 80 000 dwt	312	90715
Other vessel 100 000 dwt	313	108772
Other vessel 250 000 dwt	314	171201
Ro/ro vessel 3 600 dwt	315	33683
Ro/ro vessel 6 300 dwt	316	45368
Ro/ro vessel 10 000 dwt	317	53700

The LOS-matrices for ferries are generated according the following:

FERRY SUB-MACRO

Iterates once per vessel giving:

1. dummy variable (not used)
2. dummy variable (not used)
3. volume-delay function number (89-92)
4. vehicle distance cost (kr/vehicle km – same as input to logistics model)
5. mode of vessel
6. vehicle time cost (kr/vehicle h – same as input to logistics model)
7. scenario number to be used (from Emme/2 databank)

Figure 5.9 Generation of LOS-matrices for ferries.

The Emme/2 network model uses two modes for ferry transport: mode “m” for road ferry and mode “i” for rail ferry.

[41] http://www.kiel-canal.org/.

Table 5.10 Ferry specific values in Emme/2 macro.

Vehicle type	No	VDF number (#3)	Mode (#5)	Scenario (#8)
Road ferry 2 500 dwt	318	89	m	14
Road ferry 5 000 dwt	319	90	m	14
Road ferry 7 500 dwt	320	91	m	14
Rail ferry 5 000 dwt	321	92	i	14

5.3.4 Air network

A single air mode has been coded into Emme/2 based on the definition coded in the STAN-model. There are five Swedish freight airports, namely Arlanda, Skavsta, Landvetter, Sturup and Örebro). There are no significant amounts of air freight transported *within Sweden*, therefore no air network (and LOS-matrices) exist between Swedish airports.

There are also a further 80 airports throughout Europe that are either connected directly to Sweden or via a European hub. Direct services between Swedish and European airports have been included using data collected on air routes by The Civil Aviation. This means that LOS-matrices are calculated for transport between the five Swedish air freight airports and the European air freight hubs, via the hubs in Frankfurt, Copenhagen etc., as well as transport to/from all other air freight destinations in Europe or outside Europe. See Figure 5.10. Similarly to sea transport all non-European zones are connected using real distances to the European network.

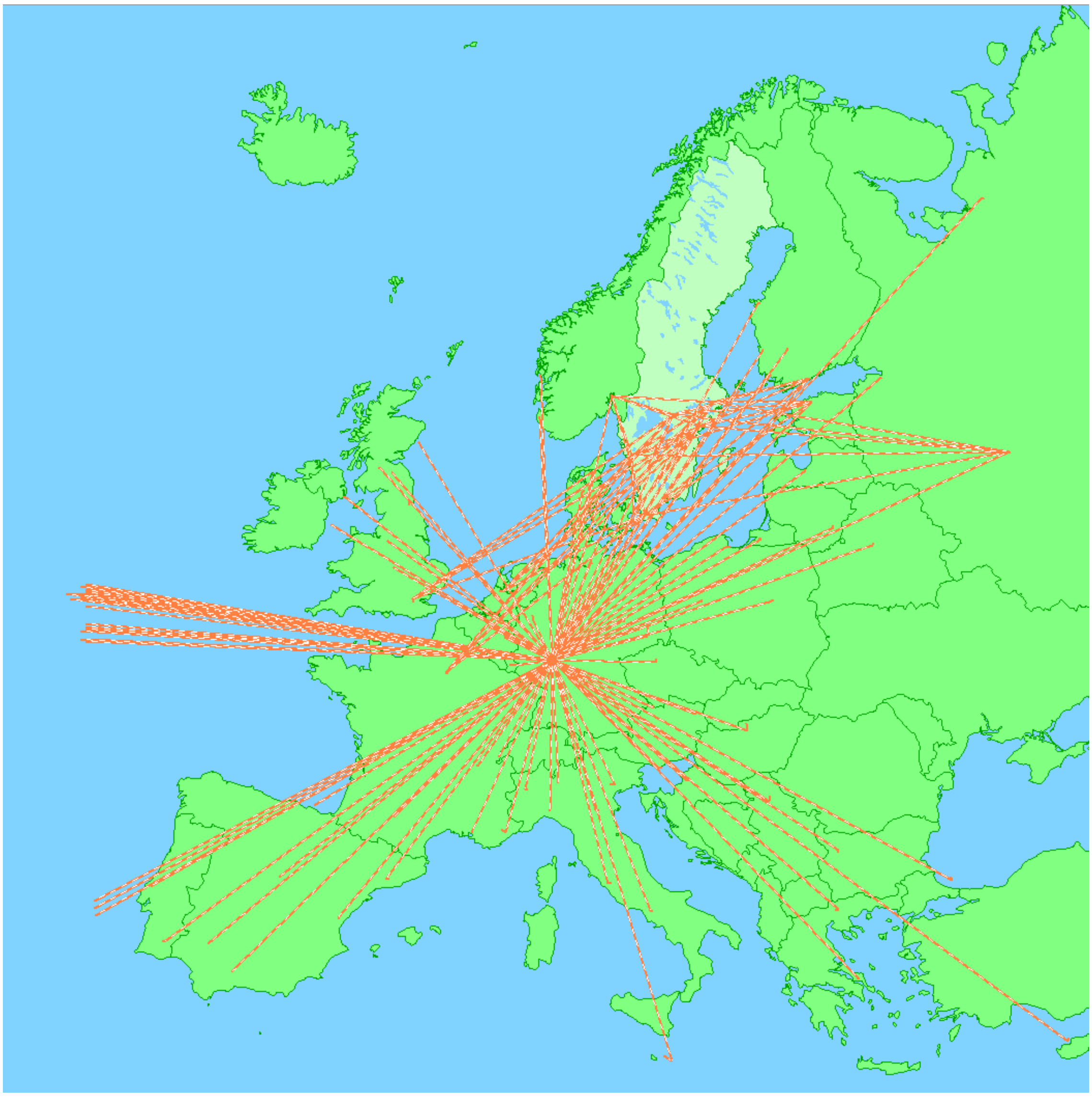

Figure 5.1 Air network to/from Sweden.

The LOS-matrices for air are generated according:

AIR SUB-MACRO Iterates once per sea vessel giving:

1. dummy variable (not used)
2. vehicle distance cost (kr/vehicle km – same as input to logistics model)
3. volume-delay function file nnumber
4. vehicle time cost (kr/vehicle h – same as input to logistics model)
5. scenario number to be used (from Emme/2 databank)

Figure 5.11 Generation of LOS-matrices for aircraft.

The Emme/2 network model uses one mode "f" for air.

Table 5.11 Air plane specific values in Emme/2 macro.

Vehicle type	No	VDF number (#3)	Mode (#5)	Scenario (#8)
Freight airplane	401	93	F	14

5.4 Nodes

5.4.1 Transfer at terminals

Transfers between modes or vehicle types of different size take place in terminals, (transfer zones, see Table 5.12). The terminals' location and their corresponding numbers are defined in the network. (See file nodes_all.xls.) Feasible combinations of vehicle types and commodities in any terminal are determined by two independent sets of restrictions on infrastructure (vehicle types) and commodities. The present set up allows the transfer of all commodities at all terminals. One exception is that the port in Brofjorden only handles the transfer sea/road for the commodities Crude petroleum and Petroleum products.

It is also specified which terminals can handle containers. In Version 2 it is assumed that containers can be handled at 162 terminals, thereof 47 in Sweden. The information is stored in the file nodes_all.xls.

Table 5.12 Transfers between different vehicle types /modes.

	Terminal/explanation		Number of transfer zones
1	Road terminals in Sweden	TransferRoadRoad	171
2	Combi terminals or ports	TransferRoadCombi	67
3	Marshalling yards, transfer road /wagonload	TransferRoadTrain	80
4	Ports, transfer road/vessel	TransferRoadSea	125
5	Ferry ports, transfer road/road ferry	TransferRoadRoadFerry	46
6	Air ports, transfer road/air	TransferRoadAir	85
7	Ports, transfer combi trains/vessel	TransferCombiSea	36
8	Marshalling yards, feeder/wagonload in Sweden	TransferFeederTrainWagonload	31
9	Ports, transfer wagonload/vessel	TransferWagonloadSea	86
10	Ferry ports, transfer rail/rail ferry	TransferWagonloadRailFerry	7
11	Ports, transfer system train/vessel	TransferSystemTrainSea	13
12	Ports, transfer between vessels of different size	TransferSeaSea	4
	Total		751

5.4.2 LOS service frequencies

The service frequency of different vehicle types is used to determine wait time in the different types of terminals. The wait time, calculated as half-headway, has an impact on the capital costs of the goods in transit. In the actual setup the LOS frequency matrices are not unique by vehicle type but by categories of vehicle types. [42] Service frequencies are defined for lorry (vehicle types No 104 and 105), for combi (No 201), wagonload (No 202, 207–209), system trains (No 204–206), container vessels (No 301-304), other vessels (No 305–314), roro vessels (No 315–317), road ferries (No 318–320), rail ferries (No 321) and airplane (No 401).

The LOS-service frequency matrices (FreqLorry.314, FreqCombi.314 etc.) are specified in Emme/2-format In the LOS-frequency matrices a zero means that the particular OD-relation is not permitted. In the current setup the following frequencies per week are assumed.

[42] Variation by vehicle type is possible but requires more input data.

Table 5.13 Assumed frequencies per week.

		Departures per week	Source
Specified in LOS –matrices			
Lorry	between road terminals	168	Assumption[43]
Combi	between combi terminals and/or ports	5	Assumption, co-ordinated with Gerhard Troche, KTH
Wagon load	between marshalling yards	5	Assumption, co-ordinated with Gerhard Troche, KTH
System train	between enders/receivers and/or ports	5	Assumption, co-ordinated with Gerhard Troche, KTH
Container vessel	between major ports		based on Seglingslista[44]
	between minor ports	0,1	Assumption
RoRo vessel	between major ports		based on Seglingslista
	between minor ports	0,1	Default
Road ferry	between ferry ports		Time tables / Swedish Maritime Administration
Rail ferry	between ferry ports		Time tables/ Swedish Maritime Administration
Air	between air ports	5	Assumption
Specified in input files (vehicles)			
To Lorry	transfer **to** lorry	84	Assumption
Other vessel	Tramp traffic (non liner)	0,1	Assumption

In version 2 of the Logistics model there is an exception for other vessels (vehicle type No 305 to 314) where a positioning cost is calculated instead of a service frequency. This is done in order to take into account that these vessels (mainly transporting bulk products) normally do go in tramp traffic and not in liner traffic. Positioning costs and default frequencies are specified in the files vhcls_drybulk.xls, vhcls_liqbulk.xls and vhcls_gencargo.xls.

Transfers to lorry/road (vehicle type No 101–105) from another, non-road mode do not have specific LOS-based service frequency files but default values. 84 departures per week are assumed when transferring between non-road and road vehicles.

[43] Differences between lorry terminals should be taken into account. According to information for Southern Sweden frequencies per week in lorry terminals vary between about 25 and 400 lorries per week. See Vägverket Konsult, Göran Forssén, Anders Karlsson, Transportflöden med lastbil via terminaler i Skåne, 2008-09-27.

[44] Svensk Sjöfartstidning, 6 Mars 2007, Seglingslista, Europalinjer.

6 Logistics costs

6.1 Approach

Using the aggeragate-dissaggregate-aggregate modelling approach the logistics model operates at the firm and shipment level.[45] The choice of shipment size and logistic chain is decided on the basis of the firms' total annual logistic costs for each firm to firm flow. The Logistics Model Version 2 is a deterministic cost minimization model. Therefore it is essential that the cost elements of feasible logistic alternatives are calculated with sufficient precision i.e. a precision that is reasonably compatible with other data. The logistics costs consist of transport costs and non transport costs (order costs, storage costs and capital costs in inventory as well as capital costs in transit). The logistics model aims to describe the trade offs between the different costs components, e.g. transport costs and other non transport costs.

It is assumed that the firms' transport demand is fulfilled by the transport system. The firms optimize their logistics, including transport solutions, based on the prices they meet. In most cases we do not have access to prices for logistics and transport services, therefore we calculate prices based on the carriers and forwarders costs which are easier to get. We say implicitly that the prices the senders and receivers pay in the long run are not too different from these costs.[46] The underlying assumption that operators' costs are the same as shippers' prices does though only hold in the case of perfect competition. In reality there exist imperfections in several market segments. Market conditions between countries are i.e. not harmonized in all aspects.

The logistics costs are presented in 2005 years prices except for vessels where the hour costs are based on historical market prices. All costs are expressed excluding value added tax. The costs presented in this chapter include vehicle taxes and fuel taxes. Network specific infrastructure fees are partly described below (for fairway dues and pilot fees) and partly in section 5.3.

Total annual logistic costs

Let G denote the total annual logistics costs of commodity k transported between firm m in production zone r and firm n in consumption zone s of shipment size q using logistic chain l: The basic costs, as a function of shipment size q, can be written:

$$G_{rskmnql} = O_{kq} + T_{rskql} + Y_{rskl} + I_{kq} + K_{kq} \qquad (1)$$

Where:

G: total annual logistics costs

[45] while the STAN-model uses zones and tons.

[46] The relative cost is what is determining the optimal solutions. The relationship between cost and price in relevant segments of the transport market needs further thoughts, as well as the question to what extent taxes/dues and charges could be expected to be absorbed by buyers and sellers of the transport markets. There may be hard competition on the carrier market but limited competition on the forwarder market. When it comes to transfer costs in ports, terminals etc. there may exist lower costs than the calculated due to sunk costs. Monopolies may exist.

O: order costs (or order setup costs)

T: transport costs

Y: capital costs of goods during transit

I: storage costs (floor space costs or other holding costs)

K: capital costs of inventory[47]

The transport costs are calculated per shipment and should be multiplied by annual shipment frequency to get the annual total that can be compared with the other logistics costs items.

Equation (1) can be further worked out:

$$G_{rskmnql} = o_{k.}(Q_{mnk} / q_{mnk}) + T_{rskql} + (i * t_{rsl} * v_k * Q_{mnk}) / (365 * 24) + (w_k + (i * v_k)) * (q_{mnk} / 2) \quad (2)$$

Where:

o: the unit cost per order

Q: the annual demand (tonnes per year)

q: the average shipment size

i: the interest rate

v: the value of the goods (in SEK per tonne)

t: the average transport time (in hours).

w: the storage costs (in SEK per tonne per year).

6.2 Non transport costs

6.2.1 Order costs

The order costs $O^{kmn}{}_q$ are assumed to be a function of frequency only, so that

$$O^{kmn}{}_q = o_k * (Q^k{}_{mn} / q^k{}_{mn}) \quad (3)$$

[47] Cost of deterioration and damage during transit (D) and stock out costs (Z) are not used in version 2 of the Swedish logistics model. These could be implemented in coming versions. In the Norwegian model cost of deterioration and damage during transit is included.

where:

o: the constant unit cost per order

Q: the annual demand (tons per year)

q: the average shipment size.

This assumes that orders are placed regularly, with a frequency

$$f^{k}_{mn} = Q^{k}_{mn} / q^{k}_{mn} \qquad (4)$$

The key trade off, which underlies the concept of the economic order quantity (EOQ), is that between the cost of placing the orders (which, for a given total demand Q, will increase if a smaller consignment q is ordered), and the costs of holding stock in inventory (which will increase if the consignment size goes up).

Parameters for unit order cost could be obtained from practice and textbooks, from special surveys that are carried out for this purpose. We use data from the Commodity Flow Survey (CFS) to set up observation for the basic EOQ-model.[48] The order costs are expressed in SEK per shipment and commodity in the input file cargo.xls.

6.2.2 Inventory costs

The inventory (inventory holding) costs I^{k}_{q} consist of the storage costs and the capital costs of inventory.

Storage costs

The storage costs w^{k} depend on the commodity type. The storage costs are expressed per ton and commodity though they in practice are not so much dependent on the weight of the goods but on their volume. The total annual storage costs depend on the level of the inventory and therefore on the shipment size q. On average, half the shipment size is stored at any time over the year, assuming constant shipment rates over time.

$$I^{kmn}_{q} = w^{k} * (q^{kmn} / 2) \qquad (5)$$

Other storage costs are equal to the sum of cost for spaces (depending on cargo's requirements: closed warehouse, open space, tank facilities, bulk storage and the cost per square meter for rental of a given sort of facilities) plus cost for equipment and manpower in the storage site. Also other costs like insurance, energy costs etc. should be included in the calculation of this cost item. Depending on the type of product the inventory holding cost vary considerable. The reason for this is obvious as the resources needed to physically store a product only to a limited extent is depending on the products value, but more on its physical properties.

[48] See Henrik Edwards with assistance from John Bates and Henrik Swahn, Swedish Base Matrices Report, Estimates for 2004, estimation methodology, data, and procedures, Version 13 March 2008.

Capital costs of inventory

The capital costs of inventory K^k_q are defined as the capital costs of the goods during the time the goods are stocked. These are the interest costs on the capital that is tied up in storage, which depend on the average level and value of the inventory (and therefore on shipment size q and commodity type k).

$$K^{kmn}_q = i * v^k * (q^{kmn} / 2) \qquad (6)$$

In version 2 of the Logistics model an interest rate of 10 %.is assumed.[49] (See control file.) The storage costs are calculated using the information about the relation between the capital costs of the inventory and other non transport costs presented in a report published by the Finish Ministry of Transport and Communications.[50] The inventory costs (sum of storage costs and capital costs of inventory expressed in SEK/year, tonne, Table 6.1) are presented the input file cargo.xls.[51] Further validation is necessary.

6.2.3 Capital costs of goods during transit

The capital cost of the goods during transit is notated Y^{rsk}. These costs depend on the transport time compared to a full year and on the value of the goods:

$$Y^{rskmn} = [i * t_{rs} (q^k_{mn}) * v^k * Q^k_{mn}] / 365 \qquad (7)$$

We use the same interest rate of 10% for capital costs in transit as for capital costs in inventory. The capital costs of the goods in transit Y are calculated using commodity group specific average monetary values (SEK/tonne/hour) that are multiplied by the total transport time. The total transport time consists of link time, and loading/unloading time at the sender/receiver and transfer time and waiting at the terminal. The time elements are provided by the time on links on the network *(*LOS-matrices, see section 5.2), the time for loading/unloading (see vehicle files) and time for transfer in terminals (see file nodes:all.xls) and waiting time at sender or in terminal (LOS matrices, see vehicle files).

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[49] It might be considered if the interest rate should be increased to better reflect the required profitability in the companies. As the required return on capital employed will vary between companies, one approach might choose different values like for example 20 % in a sensitivity analysis unless we have data supporting other values.

[50] Finish Ministry of Transport and Communications, Finland, State of Logistics 2006.

[51] The inclusion of an extra column in the input file cargo.xls in order to be able to separate storage costs and the capital costs of inventory which may be desirable in a future model version.

Table 6.1 Inventory costs and order costs.

No	Commodity	Value (SEK/ton)	Inventory costs (capital costs + storage costs) [SEK/(year,tonne)]	OrderCosts SEK per shipment
1	Cereals	1350	466	1829
2	Potatoes, vegetables, ffruit	3631	1253	203
3	Live animals	8224	2837	406
4	Sugar beet	427	147	2665
5	Timber for paper industry (	289	100	12
6	Wood roughly squared/sawn	6352	2191	654
7	Wood chips and wood waste	592	204	7671
8	Other wood or cork	452	156	999
9	Textiles, textile articles	158131	44277	435
10	Foodstuff and animal fodder	19558	9388	6327
11	Oil seeds,oleaginous fruits	2576	889	9589
12	Solid mineral fuels	713	269	155
13	Crude petroleum	2597	762	3258
14	Petroleum products	3309	794	1063
15	Iron ore, iron and steel waste	496	101	4467
16	Non-ferrous ores and waste	7444	1310	5734
17	Metal products	9762	3221	138
18	Cement, lime,	2169	824	129
19	Earth, sand and gravel	74	21	37
20	Other minerals	1114	254	265
21	Natural/chemical fertilizers	2020	1030	249
22	Coal chemicals	1210937	617578	634
23	Chemicals other than coal	15959	8139	115
24	Paper pulp and waste paper	2155	905	1349
25	Transport equipment	70281	29518	1189
26	Manufactures of metal	21041	6944	845
27	Glass, glassware,	15183	5010	79
28	Paper, not manufactures	4637	1948	936
29	Leather textile, clothing,	24920	10466	130
30	Mixed and part loads[52]	19521	5856	999
31	Timber for sawmill	356	123	776
32	Machinery, apparatuss	47132	31107	224
33	Paper, manufactures	15894	6993	88
34	Wrapping material, used	2250	675	232
35	Air freight (2006 model)	561026	168308	10000

[52] No PWC flow for this commodity.

6.3 Transport costs

6.3.1 Approach

The cost functions give transport cost for all different vehicle/vessel types. The transport costs include link costs (vehicle operating costs) and node costs (costs for loading the goods at the sender and unloading at the receiver) and transferring the goods between vehicles (if several vehicles are involved in a transport chain). The approach to the transports costs is a. o. based on the following assumptions:

Movement of goods

There are economies of scale in the pure movement of goods. Larger volumes will allow larger transport units to be used for which costs do not rise proportionally to volume. However, a prerequisite for reaping scale advantages is that the utilisation rate is reasonably high, which implies that sufficient volumes of goods have to be available. Large ships or lorries are not to be used profitably for short distances since the fixed cost for positioning the respective unit for loading/unloading would be too high in relation to the impact of the lower transport cost for a short distance trip. In reality these "volume restrictions" can be more important than physical infrastructure requirements. The costs presented below are assumed to include return transports for vehicles and containers.

Loading/unloading

There are economies of scale in many transferring operations. Such economies of scale of loading/unloading can be exhausted at different levels. Operation at terminals generally includes also other types of activities such as re-grouping of shipments sometimes involving consolidation, intermediate storage services, protecting the goods etc. Up to a limit there are also economies of scale in the terminal operations related to handling and storing of goods. However, a component of major importance for economies of scale is the network effect or hub effect. By reducing the number of terminals the scope of economies of scale in transport and handling is extended to more relations. Since loading, unloading and repositioning of a larger vehicle/vessel is more costly per time unit as well as often requiring more time such "set up" occasions have to be kept as low as possible. The implication is that the available goods volumes must be loaded and unloaded at a rather limited number of places.

The transport costs and times have been calculated, starting from the costs used in the STAN-model. Adoptions were necessary a. o. to include more and different vehicle types and to get from costs per tonkm and tonhour (assuming an average load factor) to costs per vehiclekm and vehicle hour.

6.3.2 Link costs

Link costs (or vehicle operating costs) are the average company cost per time or distance unit of operating the vehicle/vessel. The costs consist mainly of fuel costs, driver salaries, wear and tear of the vehicle and depreciation. One part of the costs is related to time and another part to distance:

- *distance-based costs* given in the cost functions as cost per kilometre for each vehicle/vessel type. The parameters (cost/vehicle unit km, cost/vehicle unit hour) are multiplied by distance and time values calculated from the networks

(LOS-matrices, see section 5.2) to give the vehicle operating costs (pure transport costs).

- *time-based costs* given in the cost functions as cost per hour per vehicle/vessel for all the vehicle/vessel types based on network input for transport time. These are the time costs of the vehicle. Waiting time in the terminals is used for the calculation of capital costs in inventory and transit.

See vehicle type specific hour costs and km costs in the files vhcls_drybulk, vhcls_liqbulk.xls and vhcls_gencargo.xls. The costs can be differentiated by the commodity aggregates. This option is not used in Version 2.

Road

The calculation of the link costs for road are based on the Swedish Haulier Association:s tariff calculation program SÅCALC (Sveriges Åkeriföretag). The program is used as one base among others to calculate the hauliers' vehicle operating costs.[53]

The vehicle operating costs calculated with help of the SÅCALC-program have been compared with the costs used in other studies.[54] There is only a limited number of studies that estimate the vehicle operating costs for heavy lorries. Table 6.2 summarises in the upper part an overview from Winter and Hirschhausen (2005) and in the lower part the parameters used in the Swedish logistics model.[55] The Swedish vehicle operating costs are both in absolute level and in relation between value of time and distance similar to Winter and Hirschhausen (2005). The 60 tonnes lorries are not included in the comparison because within Europe they are only used in Sweden and Finland.

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[53] Petter Hill, Förklaringar, beräkning av indatakostnader för lastbil i modellen, 25 april 2008. Draft.

[54] In the Heavy Route application both the absolute level of the vehicle operating costs and the relation between distance based and time based costs are important. The relation between Value of Time based costs and Value of Distance based costs will in the simulation system determine the weight put on the choice of the fastest path or shortest path. In addition, as Heavy Route will include additional cost components in the routing algorithm, e.g. environmental cost, the level of operator cost in relation to these additional costs is important.

[55] based on an exchange rate of 9 SEK/€.

Table 6.2 Lorry operating costs compared to other studies.

	Time based lorry operating costs (€/h)	Distance based lorry operating costs (€/km)	Time/distance based Lorry operating costs
Rothengatter et.al (2002)	45.0	0.520	86.5
Troyer (2002)	23.4	0.335	69.9
DfT (2001)	12.4	0.900	13.7
Winter and Hirschhausen (2005)	28.0	0.400	70.0
Lorry light LGV, ≤ 3,5 ton (No 101)	25.1	0.137	183
Lorry medium ≤ 16 ton (No 102)	27.6	0.236	117
Lorry medium ≤ 24 ton (No 103)	29.1	0.298	98
Lorry HGV ≤ 40 ton (no 104)	32.0	0.420	76

The same vehicle operating costs for road are used all over Europe. This is assumed to be acceptable due to the relatively uniform conditions in the different countries.

Rail

The logistics model uses maximum capacities per train expressed in tonnes (see Table 4.1 and files vhcls_drybulk, vhcls_liqbulk.xls and vhcls_gencargo.xls). The same approach is chosen for lorries, vessels and air planes. The number of wagons is assumed to be high (about 30 wagons per kombi train, compared to 20 wagons on average, and even more for long haul wagon load trains[56]). Also the maximum number of tons per wagons is assumed to be high in the data setup used in Version 2. Ideally the maximum number of tons per wagon should be lower for bulky commodities.[57] The logistics model calculates how the maximum capacity is used.

In the actual setup the costs per train hour are relatively low and the costs per train km are relatively high. The assumptions and outcomes of the model have to be validated a.o. against the cost calculations that the Railway group at the Royal Institute of Technology has been carried out based on business cases.[58] These costs are, as the Rail Administration's costs for 2001[59], based on average capacities per wagon, an average number of wagons per train and average capacities per train. In the costs calculated by the Royal Institute of Technology the relation between link costs for combined transport trains and wagon load trains has been corrected.[60] After the correction the costs for combined transport trains are higher than for wagon load trains. During the development of the logistics model different improvements of the rail modelling have

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[56] The number wagons per feeder train is demand driven and therefore more spread (in reality).

[57] This is true for all modes and the capacities should be differentiated by commodity group (See *Table 2.1*) or at least the aggregated commodities dry bulk, liquid bulk and general cargo for all vehicle types.

[58] Gerhard Troche, Järnvägskostnader till nya SAMGODS-modellen, Uppdaterad 2007-12-07.

[59] Banverket BVH 706, Beräkningshandledning.

[60] The obvious mistake was observed in VTI rapport 592, Modellanalyser som underlag till Kombiterminalutredningen.

been discussed.[61] The same vehicle operating costs for rail are assumed all over Europe. In reality the rail production systems differ between different countries. This should be taken into account in coming model versions.

Sea

The link costs for vessels have been calculated based on the Norwegian data and a currency rate of 1,2 SEK/NOK. [62] The time based cost element is the time charter (TC) rate that differs for various vessel types and sizes.[63] The distance based cost element includes only fuel costs. The link costs for road ferries and rail ferries are based on calculations by Henrik Swahn.[64] The cost of moving a vehicle onto and off a ferry is dependent on both the size of the ferry and the type of vehicle that is used. [65] See on ferry hour costs and on ferry km costs in the vehicle files vhcls_drybulk.xls. vhcls_liqbulk.xls and vhcls_gencargo.xls.

The Swedish fairway dues are implemented per vessel type and aggregated commodites: dry bulk, liquid bulk and general cargo. The Swedish pilot fees are specified per port and vessel type in the file pilotfees.xls in the input for costs. Information on fairway dues and pilot fees has been provided by the National Maritime Administration. The fees have been calculated based on the Administration's revenues. Maritime infrastructure fees outside Sweden are not included in the Version 2 model except for the Kiel Canal fee (see Table 5.9).

Port fees – inside and outside Sweden – are assumed to be paid for as services in the ports and are assumed to be a part of the transfer costs.

Air

The link costs for the freight airplane are based on the calculations made in 2002 that have subsequently been amended.[66] The largest change from the 2002 calculations came in the distance based costs per km, due to the increase in fuel prices which has taken place.

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[61] Gerhard Troche, Förbättringsmöjligheter vid modelleringen av järnvägstransporter i Samgodsmodellen, 2008-10-26, uppdaterat 2008-12-14.

[62] Stein Erik Grønland: Working paper: Cost models for Norwegian and Swedish freight transport. To be used in the Logistics model developed by Rand for NTP transportanalyser and Samgods/SIKA. Oslo 5.12.05 – included in RAND's deliverable 4.

[63] This is a price component.

[64] Henrik Swahn, Note on road and rail ferry link cost for the Swedish model, 2008-09-11.

[65] It has also been discussed to take into account the "lower costs" when lorry drivers make use of the rest time regulations by using ferries.

[66] SIKA 2002:15 Kostnader i godstrafik.

6.3.3 Node costs

Additionally to the link costs there are loading/unloading costs at the sender/receiver of the goods. The same loading/unloading costs at sender and receiver are used though different technologies are used in some cases i.e. for timber that is delivered to the paper and pulp industry.

If the goods go via one or several transfer points there are also transfer costs. We use the same transfer costs per ton independent of direction. The transfer costs depend also on the aggregate commodity (dry bulk, liquid bulk and general cargo) and vary with respect to the type/size of vehicles used and the facilities available at the transfer points.

The transfer costs are the sum of the loading/unloading costs for the vehicles that are involved in the transfer. [67] It is also assumed that also the time for the first and the second vehicle that are involved in the transfer are added, i.e. there is no overlap between loading and unloading in the transfer. A minimum transfer cost equivalent to the cost for 1 tonne is assumed. (The transfer cost of 1 tonne and 10 kg are the same.) The minimum of one ton is specified in the control file and is thus a parameter that could be adjusted by the user. The loading/unloading and transfer costs are expressed per ton and listed in the files vhcls_drybulk.xls, vhcls_liqbulk.xls and vhcl_gencargo.xls. The costs are also specified for "conventional transports" (non container) transports and container transports.

Conventional transferss

For a conventional transfer (between two vehicles), the cost is calculated as:

$$(\text{Transfer cost})_{v1,v2} = ((\text{Unloading cost})_{v1} + (\text{Loading cost})_{v2}) * \text{techno factor per terminal} \qquad (8)$$

The costs have been calculated based on the Norwegian data and a currency rate of 1,2 SEK/NOK and assumptions on the compatibility between Norwegian and Swedish vehicle types.[68]

[67] When it comes to the process of loading and unloading of goods onto vessels (also to some extent other vehicles such as lorries, trains, and aircraft) alternative basic technologies are used. Sometimes such technologies require adaptation of the vehicle/vessels as well as the terminal environment. This is the case for ro-ro (which e.g. requires ramps) versus lo-lo which requires lifting equipment. Loading and unloading operation could be a self-contained function carried out by the vehicle/vessel (and its crew) without assistance from external resources e.g. at a terminal or any other specific location. Self-contained loading and unloading has been very important in an historic perspective but its importance has declined somewhat over time. The scale and capacity of the vehicle's own loading and unloading equipment could generally be assumed to be balanced to suit the capacity of the vehicle/vessel as well as the type of service in which the vehicle/vessel is operated. Alternatively, loading and unloading could be an operation that is entirely external to the vehicle or vessel and that is carried out entirely by external resources that are made available at the point of loading or unloading. Support from the crew of the vehicle/vessel could be very small in these cases.

[68] The loading/unloading costs are based on direct calculations based on methods used, time used by workers, trucks, cranes and other equipment etc. Relevant sources for the assumptions behind are from Virum and Foss. Norsk Petroleumsinstitutt as well as from some unpublished direct case studies. The calculated costs have been compared with published prices, among others from several Norwegian ports. The loading/unloading costs to/from rail have been checked by Gerhard Troche at the Royal Institute of

Container transfers

The logistics model takes into account the trade off between higher *costs for stuffing and stripping* (putting the goods into the container and taking it out of the container) and lower transfer costs (for transferring the container) in kombi terminals and ports. The use of containers increases the loading and unloading costs at the sender and receiver and reduces the transfer costs (between the modes) in the terminals. Also the transfer time i.e. in ports differs between conventional and container transports.(See container load time and non container load time in files vhcl_drybulk.xls. vhcl_liqbulk.xls and vhcl_gencargo.xls in the input for costs) This means that intermodal transports are more attractive than conventional transports for specific commodities, shipment sizes and/or relations.

If the goods are transported in a container the loading/unloading costs are the costs for stuffing/stripping the goods into the container <u>and</u> the costs for lifting the container onto/into the vehicle. The costs for stuffing at the sender and stripping at the receiver are assumed to be the same. The costs for stuffing/stripping and costs for loading/unloading the container (incl time estimates) costs are based on estimates made by the Railway group at the Royal Institute. The costs for stuffing and stripping are specified in the control file. Forty foot containers are modelled as "prototype" which gives a risk for underestimating the costs for loading/unloading/transfer. Assuming the same lift costs for 20 foot containers and 40 foot containers means higher transfer costs per ton for smaller containers.[69]

"Technology factor"

Technical development has gradually increased productivity of transport as well as loading and unloading operations and different types of terminal operations. There is probably no reason to assume that this development has come to an end.[70] The transfer costs can be multiplied by a terminal specific technology factor for loading costs. There is also a terminal specific technology factor for loading time. With the help of these factor(s) it is possible to differentiate the transfer costs by commodity aggregate, vehicle type and terminal. Both technology factors are assumed to be 1 in Version 2.

Technology. The loading/unloading costs for dry bulk and liquid bulk are of about the same size as the costs in the STAN-model. We reduced the (Norwegian) loading/unloading costs for general cargo. The reason is that these costs are very much higher than the costs that we use in the STAN model. Further input and analysis of the cost structure for loading/unloading and transfer costs is needed.

[69] In coming model versions both 20 foot containers 40 foot containers could be handled separately or the distribution between 20 and 40 feet containers within the transport system could be used. Other dimensions as well as piggy backs (lorries on rail wagons) could also be modelled. It could also taken into account that different containers are used for different products there are e.g. containers for liquids, dry bulk, general cargo and thermo containers. It could further be modelled that special small air containers are used for air transports. The transport of empty cargo units is not addressed in the model version 2. In a longer time perspective the approach should include separate modelling of empty flows for vehicles that carry containers as opposed to vehicles that do not.

[70] Sensitivity tests with and without the technology factors in ports should be carried out.

7 Results and output summaries

The users of the logistics model and their clients are interested in different topics, aspects and parts of the results. The model generates a huge amount of output at different levels. There are standard output files at the overall level (for all commodities) as well on the commodity level. Tonkm is presented for the Swedish territory as well as for the whole world. Information on frequency/shipment size, distance, costs, time etc is available at the transport chain level. Information, e.g. on the transfers at a port can be taken for consistency checks etc. In the following we explain the output files that are generated by the program.

7.1 Overview of output files

In Table 7.1 all created output files are listed. They are grouped into output from the buildchain step, from the chainchoi step, from the aggregation over commodities (merge) and in form of tonnes and vehicles at the OD-level (extract)

Table 7.1 Overview: Output files.

BuildChain	**Search path**
Chains<commodity>.dat	/BUILDCHAIN/OUTPUT
BuildChain<commodity>.log	/BUILDCHAIN/OUTPUT
Connection<commodity>.lst	/BUILDCHAIN/OUTPUT
ChainChoi	**Search path**
Chainchoi<commodity>.out	/CHAINCHOI/OUTPUT
Chainchoi<commodity>.log	/CHAINCHOI/OUTPUT
Chainchoi<commodity>.fac	/CHAINCHOI/OUTPUT
Chainchoi<commodity>.cst	/CHAINCHOI/OUTPUT
Chainchoi<commodity>.rep	/CHAINCHOI/OUTPUT
consol_<commodity>_<mode>.314	/CHAINCHOI/OUTPUT
volume_<commodity>_<mode>.314	/CHAINCHOI/OUTPUT
MergeRep	**Search path**
Chainchoi.rep	/MERGEREP/OUTPUT
Extract	**Search path**
od_tonnes<vehicletype>.314	/EXTRACT/OUTPUT
od_vhcl<vehicletype>.314	/EXTRACT/OUTPUT

The specific files are explained in the following sections.

7.2 Optimisation principles

7.2.1 Logistcs decisions

Within the logistics model different stereotypes of logistic decision making and modelling can be assumed for different commodity groups. For each commodity it is assumed that either the overall logistics costs are optimized or that the transport costs are minimized.[71] In the actual setup joint transport and inventory optimisation is used for all commodity groups except for Commodities No 3 Live animals, No 4 Sugar beet and No 11 Oil seeds and oleaginous fruits and fats. For these commodities cost minimisation for transport is assumed. No difference is made between senders that are producers or wholesale firms.[72]

7.2.2 Consolidation

When it comes to consolidation, it is assumed in the version 2 model that goods are only consolidated within a commodity group. This assumption is made for both conventional transports and container transports. In reality nearly all commodities can be transported e.g. in the same container vessel or the same combi train. In the Norwegian model alternative consolidation routines are tested, a. o. consolidation over specific groups of commodities. In the long run it is desirable also for the Swedish model to relax the assumption that only gods within one commodity can be consolidated.

Version 2 of the logistics model assumes that goods can only be consolidated in terminals. In reality though, forwarders and carriers make use of the possibility to consolidate along the route. The so called "consolidation along the route" is implemented for road transport in the Norwegian logistics model; it has also been discussed to develop "consolidation along the route" for sea transports. The possibility to include "consolidation along the route" has so far been postponed for the Swedish model.

7.2.3 Empty transports

The BuildChain step and ChainChoice step give vehicle flows for loaded transports. The empty vehicles (that are needed for the assignment) are calculated using the information on the loaded vehicle flows (as return flows, some of which will be empty). Results have been taken out for empty transports with all vehicle types but they have not been studied in depth. Further studies of the empty vehicle module are recommended.

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[71] The importance of constraints for i.e. total transport time (e. g for fresh food) or shipment size within the optimizations logics could be included in coming versions.

[72] We might distinguish between transports between producer and consumers (PC-relations) and are houses and consumers (WC-relations) in future model versions.

Table 7.2 Optimisation logic per commodity type.

Category:	Optimisation logic
1. Cereals	Joint transport and inventory optimisation
2. Potatoes, other vegetables fresh or frozen	Joint transport and inventory optimisation
3. Live animals	Cost minimisation for transport
4. Sugar beet	Cost minimisation for transport
5. Timber for paper industry (pulpwood)	Joint transport and inventory optimisation
6. Wood roughly squared or sawn lengthwise, sliced or peeled	Joint transport and inventory optimisation
7. Wood chips or wood waste	Joint transport and inventory optimisation
8. Other wood or cork	Joint transport and inventory optimisation
9. Textiles, textile articles and manmade fibres, other raw and animal and vegetable materials	Joint transport and inventory optimisation
10. Foodstuff and animal fodder	Joint transport and inventory optimisation
11. Oil seeds and oleaginous fruits and fats	Cost minimisation for transport
12. Solid mineral fuels (coal etc)	Joint transport and inventory optimisation
13. Crude petroleum	Joint transport and inventory optimisation
14. Petroleum products	Joint transport and inventory optimisation
15. Iron ore, iron and steel waste and blast-furnace dust	Joint transport and inventory optimisation
16. Non-ferrous ores and waste	Joint transport and inventory optimisation
17. Metal products	Joint transport and inventory optimisation
18. Cement, lime, manufactured building materials	Joint transport and inventory optimisation
19. Earth, sand and gravel	Joint transport and inventory optimisation
20. Other crude and manufactured minerals	Joint transport and inventory optimisation
21. Natural and chemical fertilizers	Joint transport and inventory optimisation
22. Coal chemicals	Joint transport and inventory optimisation
23. Chemicals other than coal chemicals and tar	Joint transport and inventory optimisation
24. Paper pulp and waste paper	Joint transport and inventory optimisation
25. Transport equipment, whether or not assembled, and parts thereof	Joint transport and inventory optimisation
26. Manufactures of metal	Joint transport and inventory optimisation
27. Glass, glassware, ceramic products	Joint transport and inventory optimisation
28. Paper, paperboards; not manufactured	Joint transport and inventory optimisation
29. Leather textile, clothing, other manufactured articles than 28	Joint transport and inventory optimisation
30. Mixed and part loads, misc. articles[73]	Joint transport and inventory optimisation
31. Timber for sawmill	Joint transport and inventory optimisation
32. Machinery, apparatus, engines	Joint transport and inventory optimisation
33. Paper, paperboard and manufactured thereof	Joint transport and inventory optimisation
34. Packaging materials, used	Joint transport and inventory optimisation

[73] No PWC flow for this commodity.

7.3 Buildchain

In the following the output files generated by the BuildChain procedure are listed. The OUTPUT folder **Buildchain** contains the results from buildchain.exe.

a) Chains<commodity>.dat

The ***Chains<commodity>.dat*** files are used as input to the ChainChoice procedure. One file per commodity group is created e.g. for commodity 8 the file name is Chains8.dat. The file contains a list of available chains per OD pair.

Table 7.3 Overview of columns in the file Chains<commodity>.dat.

Column	Attribute	Unit	Comment
1	FromZone		The shipment origin zone
2	ToZone		The shipment destination zone
3	NrOfChains		Number of available chains from the origin zone to the destination zone
4	ChainType		For each of the available chain the chain type is given
5	FromNode		Origin of respective leg in the chain
6	ToNode		Destination of respective leg in the chain
8	FromIndex		Index of FromNode in nodes file (first node in file has index 0)
9	ToIndex		Index of ToNode in nodes file (first node in file has index 0)
10	Freq	Per week	Service frequency per week
11	ConsolFac		Consolidation Factor used for this leg

b) BuildChain<commodity>.log

The ***BuildChain<commodity>.log*** file with reports of BuildChain process for each commodity is created e.g. for commodity 8 the file name is Chains8.log.

Table 7.4 Overview of columns in the file BuildChain<commodity>.log.

Column	Attribute	Unit	Comment
1	Message		Example messages: - Connection discarded - Using default frequency
2	Origin		
3	Destination		
4	Mode		
5	Time	Hours	
6	Distance	Km	
7	Frequency	Per week	Service frequency per week

The example messages below illustrate that connections are discarded when time and/or frequency is zero. There is also a message when the default frequency – in this case for transfer to road (B) is used.

Example messages:

Connection discarded: Orig=719141; Dest=719141; Mode=R; Time=0; Dist=0; Freq=5

Connection discarded: Orig=719141; Dest=966700; Mode=R; Time=7.04733; Dist=4228.4; Freq=0

Using default frequency: Orig=974941; Dest=974900; Mode=B; Time=0.4834; Dist=24.17; Freq=84

Using default frequency: Orig=974941; Dest=974911; Mode=B; Time=0.3308; Dist=16.54; Freq=84

c) Connection<commodity>.lst

Connection<commodity>.lst contains a list of connections that depart from each node. This file can be used for consistency checks etc. It is not needed for any other calculations and can be turned on and off in the control files for Buildchain.

To get the file; use the commands "CONNLST=connection<commodity>.lst" and "SELECT=Select.dat" in the control file. In the Select.dat file it can be specified which nodes that should be printed into the connection<commodity>.lst file. The filename for commodity 8 will be connection8.lst.

Table 7.5 Overview of columns in the file Connection.lst.

Column	Attribute	Unit	Comment
1	Origin		Origin node for the leg in the chain
2	Mode		Vehicle mode that is available from origin node to destination node
3	Destination		Destination node for the leg in the chain

7.4 Chainchoi

The OUTPUT folder **Chainchoi** contains the results from chainchoi.exe

a) chainchoi<commodity>.out

The chainchoi<commodity>.out file contains the best chain (route, costs) per pwc-subcell. One file per commodity is created and for commodity 8 the file name will be chainchoi8.out. This file is not needed for any other calculations and can be turned on and off in the control files for ChainChoi. To get the file; use the command "OUT=OUTPUT\ChainChoi<commodity>.out" in the control file.

Table 7.6 Overview of columns in the file chainchoi<commodity>.out.

Column	Attribute	Unit	Comment
1	NRelations	Number of relations	Number of firm to firm relations within this sub-cell of the basismatrix
2	AnnualVolume	Tonnes per year	Annual volume per firm to firm relation within this sub-cell of the basismatrix
3	ShipmentFreq	Number of shipments per year	Shipment frequency for a firm to firm relation within this sub-cell of the basismatrix
4	TransportCosts	SEK	
5	AllCosts	SEK	Sum of transport, order and holding costs
6	ChainType		Modes used e.g. CGHC
7	Orig		Origin zone
8	Dest		Destination zone
9	VhclType1	Vehicle Type 1	Vehicle used in leg 1 (from Orig to Orig2)
10	NrVhcls1	Number of Vehicles 1	Number of vehicles used in leg 1 (from Orig to Orig2)
11	Orig2		Origin 2
12	VhclType2	Vehicle Type 2	Vehicle used in leg 2 (from Orig2 to Orig3)
13	NrVhcls2	Number of Vehicles 2	Number of vehicles used in leg 2 (from Orig2 to Orig3)
14	Orig3		Origin 3
15	VhclType3	Vehicle Type 3	Vehicle used in leg 3 (from Orig3 to Orig4)
16	NrVhcls3	Number of Vehicles 3	Number of vehicles used in leg 3 (from Orig3 to Orig4)
17	Orig4		Origin 4
18	VhclType4	Vehicle Type 3	Vehicle used in leg 4 (from Orig4 to Orig5)
19	NrVhcls4	Number of Vehicles 3	Number of vehicles used in leg 4 (from Orig4 to Orig5 or Dest)
And so on			

b) chainchoi<commodity>.log

Log file with reports of ChainChoi process for each commodity is created e.g. for commodity 8 the file name is ChainChoi8.log. In the present model the log file is limited to give a list of pwc-relations without available chain.

Table 7.7 Overview of columns in the file chainchoi<commodity>.log.

Column	Attribute	Unit	Comment
1	Message		Example messages: - No transport chain available
2	Origin		Origin zone
3	Destination		Destination zone
4	SubCell		
5	Volume	Tonnes	Annual volume within this sub-cell of the basismatrix

Example messages:

No transport chain available: Orig=718000; Dest=966700; SubCell=5; Volume=0.0137

No transport chain available: Orig=718000; Dest=967200; SubCell=2; Volume=1.0487

No transport chain available: Orig=718000; Dest=967200; SubCell=5; Volume=2.0774

c) chainchoi<commodity>.fac

The files ***chainchoi<commodity>.fac*** contains information about total tonnes, total number of vehicles and load factor per origin, destination and vehicle type. This file is not needed for any other calculations and can be turned on and off in the control files for ChainChoi. To get the file; use the command "LOADFAC=OUTPUT\ChainChoi<commodity>.fac" in the control file. The filename for commodity 8 will be ChainChoi8.fac.

Table 7.8 Overview of columns in the file chainchoi<commodity>.fac.

Column	Attribute	Unit	Comment
1	Orig		Origin
2	Dest		Destination
3	VhclType		Vehicle Type
4	TotalTonnes	Tonnes	Total Annual Tonnes
5	TotalVhcls		Total annual number of Vehicles
6	LoadFac		Load Factor = TotalVolume / (TotalVhcls*Capacity)

d) chainchoi<commodity>.cst

The file ***chainchoi<commodity>.cst*** contains a detailed cost log per commodity. This file is not needed for any other calculations and can be turned on and off in the control files for ChainChoi. To get the file; use the commands "COST=OUTPUT\chainchoi<commodity>.cst" and "SELECT=Select.dat" in the control file. In the Select.dat file it can be specified which relations that should be printed into the chainchoi<commodity>.cst file. The filename for commodity 8 will be chainchoi8.cst.

Table 7.9 (part 1) Overview of columns in the file chainchoi<commodity>.cst.

Column	Attribute	Unit	Comment
1	TotalCost	SEK	Total annual Cost
2	TotalDist	Km	Total Distance
3	TotalTime	Hour	Total vehicle Time (loading and wait time not included)
4	TotalWaitTime	Hour	Total Wait Time
5	ChainType		Modes used e.g. CGHC
6	Commodity		Commodity
7	Orig		Origin zone
8	Dest		Destination zone
9	SenderType		Sender Type
10	SubCell		Sub Cell
11	Tonnes		Annual volume on a firm to firm relation within this sub cell of the basismatrix
12	Freq	Per year	Shipment frequency per year
13	ShipmentSize	Tonnes	Shipment Size
14	OrderCost	SEK	Annual order Cost
15	HoldingCost	SEK	Annual holding Cost
16	TransportCost	SEK	Annual Transport Cost

Table 7.10 (part 2) Overview of columns in the file chainchoi<commodity>.cst.

Columns below repeats for each mode specified in the ChainType column. Costs are per firm to firm shipment.			
17	LegNr		Leg Number
18	Mode		Mode
19	Orig		Origin node
20	Dest		Destination node
21	Dist	Km	Distance
22	Time	Hour	
23	VhclType		Vehicle Type
24	NrVhcls		Number of Vehicles
25	ConsolVolume	Tonnes	Volume available for consolidation
26	TransportCostShare		TransportCostShare = Tonnes/ConsolVolume
27	ConsolFactor		Consol Factor
28	LoadFactor		Load Factor
29	WaitTime	Hour	Wait Time
30	TimeCost	SEK	Time Cost
31	DistCost	SEK	Distance Cost
32	InfraCost	SEK	Infrastructure Cost
33	LoadingCost	SEK	Loading Cost
34	PositioningCost	SEK	Positioning Cost
35	FairwayDues	SEK	Fairway Dues
36	PilotFees	SEK	Pilot Fees

e) chainchoi<commodity>.rep

The file ***chainchoi<commodity>.rep*** contains a summary report per commodity with information accordance to the table below. This file is not needed for any other calculations and can be turned on and off in the control files for ChainChoi. (If you want to use MergeRep then the file for each commodity is needed.) To get the file; use the command “REP=OUTPUT\ChainChoi<commodity>.rep” in the control file. The filename for commodity 8 will be ChainChoi8rep.

Table 7.11 Overview of columns in the file chainchoi<commodity>.rep.

Column	Attribute	Unit	Comment
First part:			
1	OD_coverage VehicleType		Vehicle Type
2	DNShipments		Number Shipments
3	DNVehicles		Number Vehicles
4	DKm	Km	
5	DTonnes	Tonnes	
6	DTonneKm	Tonne Km	
7	DAvLoadFac		Average Load Factor = (Tonnes / (NVehicles * Capacity)) [The capacity is taken from the file and location: \Input\GENERAL\averageVehicleCapacity.txt Where the capacity is the average capacity from these three files: \Input\Cost\vhcls_dry_bulk.txt \Input\Cost\vhcls_liq_bulk.txt \Input\Cost\vhcls_gen_cargo.txt]
8	DAvDist (Km)	Km	Average distance = Km/NVehicles
9	DTotalNShipments		Number Shipments
10	DTotalNVehicles		Number Vehicles
11	DTotalKm	Km	
12	DTotalTonnes	Tonnes	
13	DTotalTonneKm	Tonne Km	
14	DTotalAvLoadFac		Average Load Factor
15	DTotalAvDist (Km)	Km	Averange distance
16	INShipments		Number Shipments
17	INVehicles		Number Vehicles
18	IKm	Km	
19	ITonnes	Tonnes	
20	ITonneKm	Tonne Km	
21	IAvLoadFac		Average Load Factor
22	IAvDist (Km)	Km	Averange distance

Column	Attribute	Unit	Comment
Second part:			
1	OD_coverageChainType		All available mode chains listed, (from the location and file \Input\chaintype.lis).
2	DNShipments		
3	DCosts (SEK)	SEK	
4	DKm	Km	
5	DTonnes	Tonnes	
6	DTonneKm	Tonne Km	
7	DTotalNShipments		
8	DTotalCosts (SEK)	SEK	
9	DTotalKm	Km	
10	DTotalTonnes	Tonnes	
11	DTotalTonneKm	Tonne Km	
12	INShipments		
13	ICosts (SEK)	SEK	
14	IKm	Km	
15	ITonnes	Tonnes	
16	ITonneKm	Tonne Km	

Explanation of the difference between D, DTotal and I:

- D (Domestic transport that has its start and end on Swedish territory.)
- DTotal (All transports that are performed on Swedish territory. Domestic transports and domestic part of international transports.)
- I (International transports on foreign territory)
- To calculate the total kms or tonne kms you should add DTotal and I.
- To calculate the total NShipments, NVehicles, Costs, Tonnes you add D and I.

The ***consol_<commodity>_<mode>.314*** *files* are OD-matrices with consolidation factors (output of ranking). One file per commodity group and mode is created e.g. for commodity 8 and mode C the file name is consol_8_C.314.

Table 7.12 Overview of columns in the file consol_<commodity>_<mode>.314.

Column	Attribute	Unit	Comment
1	Origin		Origin Node
2	Destination		Destination Node
3	ConsolFactor		Consolidation factor

g) volume_<commodity>_<mode>.314

OD-matrix with tonnes

These files ***volume_<commodity>_<mode>.314*** are used as input to the BuildChain procedure. The files are OD-matrices with tonnes. One file per commodity group and mode is created e.g. for commodity 8 and mode C the file name is volume_8_C.314.

Table 7.13 Overview of columns in file volume_<commodity>_<mode>.314

Column	Attribute	Unit	Comment
1	Origin		Origin Node
2	Destination		Destination Node
3	Weight	Tonnes	

7.5 MergeRep

The OUTPUT folder MERGEREP contains the results from MergeRep.exe The MERGEREP program is used to merge the commodity specific outputs. The need for this program was identified when taking out results and comparing to official statistics, the program is not (yet) described in the Method report.

chainchoi.rep

This file contains the results from merging all .rep files per commodity.

Contents in the file are equal to the table in section chainchoi<commodity>.rep.

7.6 Extract

The OUTPUT folder **EXTRACT** contains the results from extract.exe. (The EXTRACT program used to extract costs output for specific relations and to extract OD matrices). The program generates tonnes and vehicle matrices for each vehicle type. In the control file for the program it is possible to choose if the generated matrices should contain empty vehicles or not.

a) od_tonnes<vehicletype>.314

OD-matrix with tonnes for each vehicle type.

The file name for vehicle 104 will be od_tonnes104.314.

Table 7.14 Overview of columns in the file od_tonnes<vehicletype>.314.

Column	Attribute	Unit	Comment
1	Origin		Origin Node
2	Destination		Destination Node
3	Weight	Tonnes	

b) od_vhcl<vehicletype>.314

OD-matrix with vehicles for each vehicle type.
The file name for vehicle 104 will be od_vhcl 104.314.

Table 7.15 Overview of columns in the file od_vhcl<vehicletype>.314.

Column	Attribute	Unit	Comment
1	Origin		Origin Node
2	Destination		Destination Node
3	Volume	Number of vehicles	

References

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Appendix CD (Contents)

Logistics Model Version 2.00 (Input files and control files)

Appendices

1. Gerard de Jong, Moshe Ben-Akiva, Jaap Baak (Significance), Method Report Logistics model in the Swedish National Freight transport model system, 2008.
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3. STAN model.
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