PASSENGER AND FREIGHT TRANSPORT IN FLANDERS 2010-2040 UNDER THREE SCENARIOS

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1. INTRODUCTION

The Flanders Region in Belgium is preparing a new transport masterplan ('Mobiliteitsplan Vlaanderen'), which will be the basis for its long-term transport policies. Both passenger and freight transport, especially by road, have been growing rapidly since the 70ties and the new strategic policy should strike a balance between fostering economic growth and guaranteeing sustainability.

One of the inputs to the transport masterplan will come from a new scenario analysis, in which three scenarios for the period up to 2040 have been developed:

- Scenario 1: Standstill;
- Scenario 2: Work it out together ("Yes, we can");
- Scenario 3: Individuals in the queue.

The first scenario focusses on economic stagnation (GDP grows by 1% per year), the second on economic growth (2% per year, tapering off after 2030), coupled with government intervention, international coordination and technological change and the third on relatively high economic growth (2.5% per year, tapering off after 2030), technological change, free trade and *laissez faire*.

These scenarios have been used as input in three different transport models, to estimate the likely evolution of mobility and transport under each scenario. The three models are:

- For passenger transport by car, public transport and non-motorised modes: an application of the disaggregate Dutch National Model System (LMS) calibrated to Flanders;

- For freight transport: an application of the aggregate-disaggregate-aggregate (ADA) model, originally developed for Norway and Sweden (including a logistics module, see de Jong and Ben-Akiva, 2007) calibrated to Flanders;
- For passenger transport by airplane: a new elasticity-based air transport model for Flanders.

Model simulations have been carried out for the base year (2010), 2020, 2030 and 2040. The outputs consist of forecasts of the number of tours and passenger kilometres by mode and travel purpose, tonnes, tonne-kilometres, vehicles and vehicle-kilometres by mode and commodity class, modal split, road network flows and congestion.

Besides these scenario runs, the models have also been used in sensitivity analyses, focussing on the sensitivity of the model outcomes to changes in the future value of individual input variables (such as transport costs by mode and income).

Section 2 of this paper describes the development of the three scenarios and the specific scenario assumptions that are the inputs to the transport model simulations. The models used in the analysis are briefly presented in section 3, including the calibration of these models to Flanders. The mobility and transport outcomes for the scenarios are in section 4 and the results of the sensitivity analyses can be found in section 5. Finally, section 6 contains a summary and conclusions.

2. DESCRIPTION OF THE THREE SCENARIOS

A scenario provides an internally consistent picture of a possible future. By using multiple scenarios that are sufficiently different, policy makers can investigate which policies are robust in the sense that they are effective and efficient both in good times and in bad times.

The three scenarios have been developed in consultation with stakeholders (citizens, firms, public sector) and experts, that came together at various workshops. To some degree, the three scenarios are also based on scenarios developed for Europe (such as TRANSvisions, see Petersen et al., 2009) and The Netherlands (WLO, see CPB et al., 2006). Besides assumptions on economic growth, the scenarios also contain consistent sets of assumptions on employment, trade flows, sectoral developments, demography (e.g. greying of the population), attitudes and behaviour (e.g. teleworking), spatial distributions (e.g. urban sprawl), availability and price of energy and technological developments (e.g. in intelligent transport systems, vehicles and logistics). Some of the assumptions mean a continuation of trends from the previous decades. But especially the sharp increase in fuel cost per litre (by 50%-90%) marks a break from previous trends and represents impacts of expected oil shortages in the next decades.

The following table describes the main input assumptions of the three scenarios. We only present the scenario assumptions for 2040 here (relative to 2010). The values used for 2020 and 2030 are not always on the straight line between 2010 and 2040, but the assumptions for 2040 give a good idea of the differences between the three scenarios.

Table 1. Key scenario developments 2010-2040

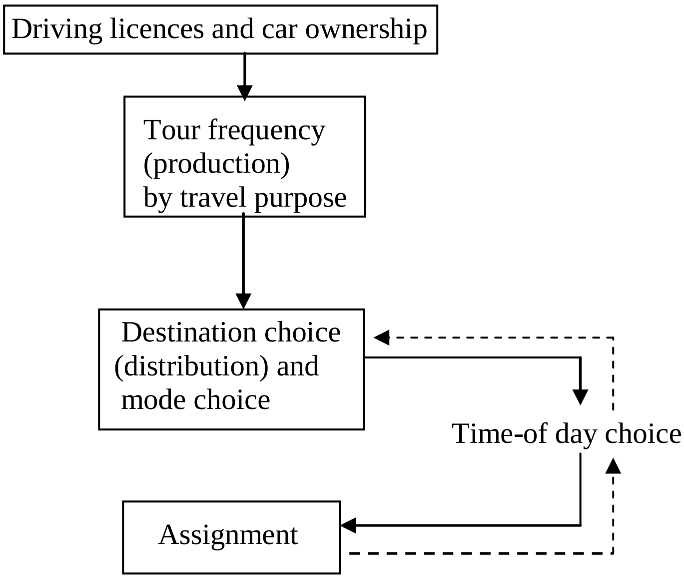
	Standstill	Together	Individuals
GDP	+35%	+65%	+84%
Population	+12.5%	+12.5%	+15%
Cars	+15%	+25%	+40%
Fuel cost per litre (road)	+50%	+70%	+90%
Fuel efficiency cars	+15%	+25%	+20%
Road user charging	No	4.5 cent/kilometre on all roads	No
ICT, e.g. teleworking	No changes	Commuting tours -5% Shopping tours -10% Business tours -7.5% Education tours -2.5%	No changes
Road network	Limited expansion of network and link capacity	Large expansion of network and very large for link capacity	Very large expansion of network and large for link capacity
Public transport networks	Limited expansion of network	Large expansion of network	Very large expansion of network
Public transport fares	+10%	+0%	+20%
Cost heavy road freight transport	+6%	+7.2%	+11.6%
Cost light road freight transport	+6%	+7.2%	+11.6%
Cost rail freight	+5%	-5%	+0%
Cost inland waterways transport	-2%	-5%	-10%
Tonnes/ vehicle	-5%	+5%	-10%

3. THE TRANSPORT MODELS USED

3.1 The LMS passenger transport model

The passenger transport model (not including air travel) used in the simulations for The Flanders transport masterplan is an application of the Dutch National Model System LMS (version 7.0) that was developed for The Netherlands Ministry of Transport, Public Works and Water Management (see for instance Gunn, 1999, Daly and Sillaparcharn, 2008). This model contains discrete choice models (by travel purpose) for the choices by individuals on tour frequency, mode and destination and travel time period on an average working day, as well as a capacity-dependent iterative assignment of road vehicles to the networks. A tour is a round-trip (usually beginning and ending at home).

Figure 1. Structure of the LMS



The application to Flanders uses a zoning system with 2386 zones in the study area (consisting of Flanders and Brussels), whereas the original application to The Netherlands uses 1308 zones. The LMS was calibrated to the situation in Flanders by adding constants to match observed mode and distance band shares by travel purpose. All the other (behavioural) model coefficients were kept the same as in The Netherlands (these are based on estimation on the Dutch national travel survey). This model transfer method is similar to the way the national passenger model results are transferred to various regions in The Netherlands. Models for Flanders that would fully be based on local data (e.g. all model coefficients estimated on the Flanders mobility survey 2007-2008) would lead to more appropriate traffic models, and this is recommended for detailed traffic studies, such as cost-benefit analyses of specific transport projects. However, the above model transfer is a cost-efficient method to obtain a strategic model, that is sensitive to a large number of input variables, and that can be used for scenario-analysis. For a review of model transfer methods and results, see Gunn et al. (1985) and Gunn and Fox (2005).

Both in calibration and application, these models use attributes of zones and networks in the study area (e.g. employment by sector, population characteristics, travel time and cost by travel mode). The passenger car and lorry flows are assigned to the road network simultaneously, by inserting lorry OD matrices from the ADA freight model into the LMS.

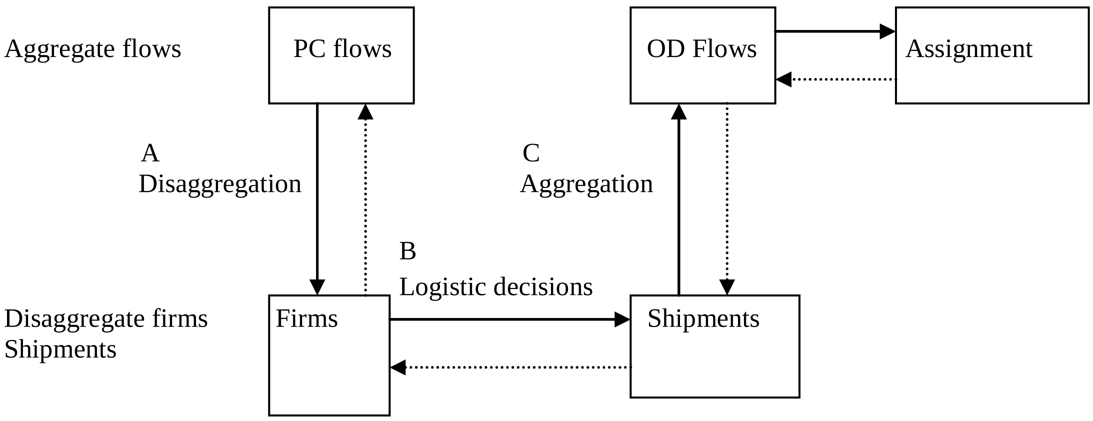
3.2 The ADA freight transport model

The freight model is an application of the ADA (aggregate-disaggregate-aggregate) model concept that was originally developed for the national transport authorities in Sweden and Norway for freight transport forecasting at the national level (de Jong and Ben-Akiva, 2007; Ben-Akiva and de Jong, 2008).

The ADA model uses 309 zones in Flanders and Brussels and 23 in the Walloon region and outside Belgium, which is similar to the number of zones used in Norway or Sweden. The ADA model was calibrated to Flanders by adding constants to match observed mode shares for the study area, distinguishing between export, import and domestic transport.

Figure 2 is a schematic representation of the structure of the freight model system. The boxes indicate model components. The top level of Figure 2 displays the aggregate models. Disaggregate models are at the bottom level. So in the ADA model system, we first have an aggregate model for the determination of production-consumption (PC) flows, then a disaggregate “logistics” model, and finally another aggregate model for network assignment.

Figure 2. Structure of the ADA Model



PC matrices contain commodity flows all the way from the production zone to the consumption zone (i.e. trade flows). These flows may consist of several OD flows (i.e. transport flows). This is because a transport chain may be used with multiple modes and/or vehicle types as well as one or more transhipments along the route.

The model system starts with the determination of flows of goods between production (P) zones and consumption (C) zones (being retail for final consumption; and further processing of goods for intermediate consumption). The PC flows in this study were prepared using the existing PLANET model (Desmet et al., 2008), that covers interregional and international trade for the study area.

A relatively novel phenomenon of the ADA model is the inclusion of a logistics model that on the basis of PC flows produces OD flows for network assignment. The logistics model consists of three steps:

A. Disaggregation to allocate the flows to individual firms at the P and C end;

B. Models for the logistics decisions by the firms (e.g., shipment size, use of consolidation and distribution centres, number of legs in the transport chain, modes for each leg of the chain);
C. Aggregation of the information per shipment to origin-destination (OD) flows for network assignment.

This way, the logistics choices are modelled at the level of the individual decision-maker. The logistics decisions in step B are derived from minimisation of the full logistics and transport costs, using cost functions for Flanders.

The assignment of the road transport OD flows (by heavy and light goods vehicles, HGVs and LGVs) takes place using the LMS assignment routines, simultaneously with the car OD flows.

3.3 Air travel model

For passenger transport by airplane from airports in the study area we use a simple elasticity-based forecasting model with population, income and price elasticities based on the literature.

4. MOBILITY AND TRANSPORT OUTCOMES FOR THE THREE SCENARIOS

4.1 LMS outcomes

The LMS outcomes for the three scenarios in 2040 (relative to the base year 2010) are in Tables 2 (tours) and 3 (passenger kilometres).

The first thing to observe is that total mobility is not predicted to grow as fast as it has been growing in the past decades. According to the model, the total number of tours will increase by between 10% and 18% in the next 30 years (roughly in line with population growth), and the number of passenger kilometres (not including air travel) will stay more or less the same as it is now.

We think that it makes sense to expect only a modest growth of passenger travel, even if incomes would grow substantially in real terms. The number of jobs is predicted to increase only slightly, and the number of school-going children and students will even decrease. This limits the need for an increase in the number of tours for commuting and education. Furthermore, car ownership will grow at a slower rate than in the past, though there won't be saturation in this respect. Travel costs will increase for all motorised modes in all scenarios, especially car cost (fuel costs per litre go up by 90% in the 'Individuals in the queue' scenario). At the same time, there will be no significant change in the speed of the modes. So, the time budget constraint for travel will not be relaxed and the money budget constraint will be tightened. The 'Work it out together' scenario also has substitution of physical tours by electronic communication (more teleworking, teleshopping, teleconferencing, e-learning) and road user charging. Similar patterns result from the STEPs project, that also looked at the impact of substantial fuel cost increases (Fiorello et al., 2006).

Table 2. Outcomes from LMS for person tours by mode for the three scenarios in 2040

Outcomes for person tours (2010=100)			
	Standstill	Together	Individuals
Car driver	112	114	132
Car passenger	100	94	103
Train/bus/tram/metro	120	120	116
Non-motorised	117	111	105
Total	**112**	**110**	**118**

Table 3. Outcomes from LMS for passenger kilometres by mode for the three scenarios in 2040

Outcomes for passenger kilometres (2010=100)			
	Standstill	Together	Individuals
Car driver	98	94	112
Car passenger	92	83	87
Train/bus/tram/metro	132	149	159
Non-motorised	114	108	102
Total	**104**	**103**	**115**

Another noticeable feature is that passenger kilometres do not increase as much as tours. Average tour distance will decline. What we see here is that travellers respond to the increased cost of mobility by reducing not only the number of trips, but especially by choosing more nearby destinations. This occurs in particular for shopping and social/recreational tours.

Finally a comment on the modal split. Especially for the longer distances, there is a shift from car, which becomes very expensive, to public transport, which becomes more expensive than now, but the fare increase stays far below the fuel cost increase. For the shorter distances there is some shift to the non-motorised modes (particularly in Standstill), where there are no price increases. The car occupancy will decline.

4.2 ADA model outcomes

Results for freight for the three scenarios in 2040 (relative to 2010) can be found in Tables 4 and 5.

Table 4 gives the number of tonne-kilometres. To some degree these are determined by the PC matrices from the PLANET model, but the allocation of the zone-to-zone flows to transport chains with different modes (vehicle types) is done in the ADA model. Freight transport in all three scenarios grows much faster than passenger transport. On the one hand people can't travel much more in their daily trips if the travel speeds do not go up, but people (in Flanders and abroad) can consume more goods than they do now, and the PLANET model says that with increasing incomes

Table 4. ADA model outcomes for tonne-kilometres for three scenarios for 2040

Outcomes for freight transport (2010=100)			
	Standstill	Together	Individuals
Domestic	167	234	279
Import	169	233	281
Export	174	243	294

that is what will happen. The growth in freight transport tonne-kilometres is biggest in the scenario with the highest GDP growth (Individuals) and smallest in the low growth scenario (Standstill). Import and export grow usually slightly faster than domestic flows, testifying of a further internationalisation of trade and transport.

In Table 5 on the modal split, one can see that heavy lorry is loosing market share in all three scenarios, but especially in the Individuals scenario, which has the highest increase in the road transport cost. Rail becomes cheaper in real terms in Together and inland waterways in all three scenarios. In Standstill however, rail becomes more expensive. In the results for the market shares, we see an increase for rail in Together and a decrease in Standstill (for export and import). Inland waterways wins in all three scenarios, but especially in Individuals, where its price dropped most. The modal split in freight transport turns out to be quite sensitive to changes in the transport cost per mode in this mode (also see the sensitivity analysis in the next chapter).

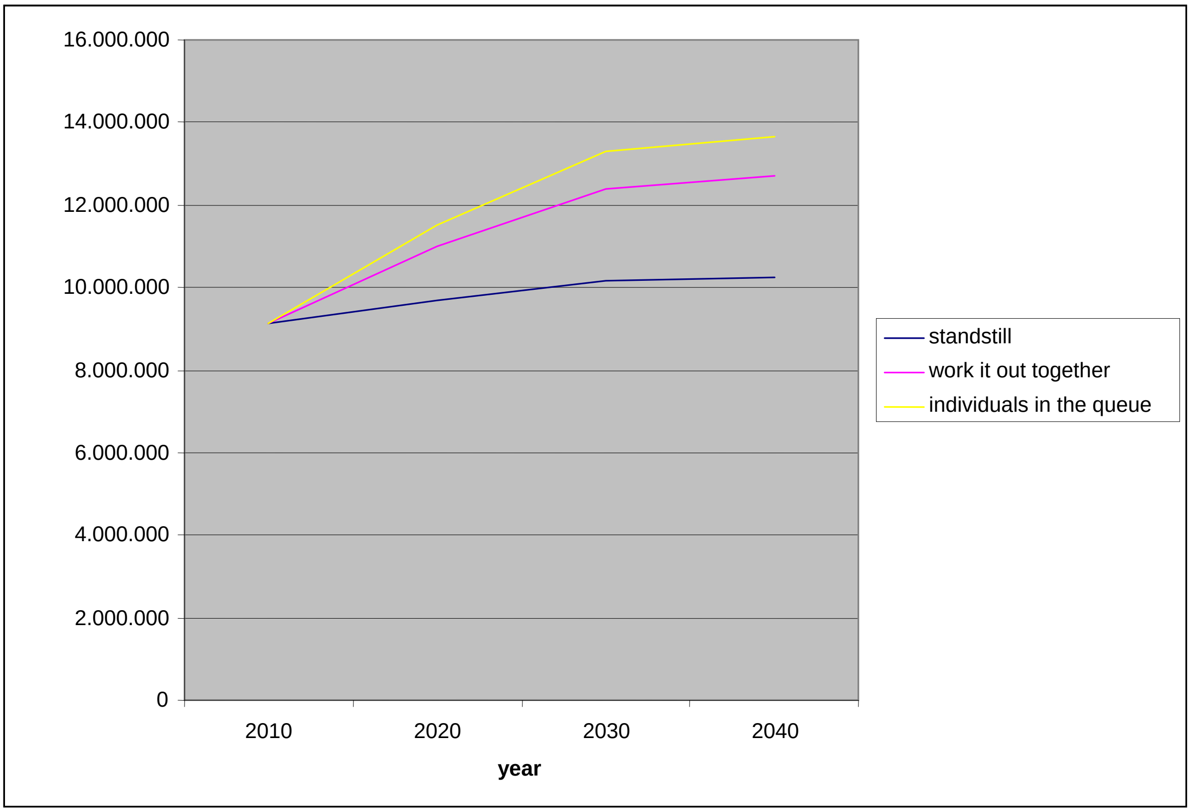
Table 5. ADA model outcomes for modal shares in tonne-kilometres for three scenarios for 2040

	2010	2040 Standstill	2040 Together	2040 Individuals
Domestic				
Light lorry	12%	9%	9%	8%
Heavy lorry	70%	67%	64%	62%
Rail	6%	6%	9%	7%
Inland waterways	12%	18%	18%	24%
Import				
Heavy lorry	12%	7%	5%	3%
Sea	57%	59%	58%	56%
Rail	11%	10%	15%	9%
Inland waterways	20%	25%	23%	31%
Export				
Heavy lorry	16%	9%	7%	6%
Sea	51%	58%	59%	58%
Rail	14%	12%	17%	12%
Inland waterways	18%	21%	17%	25%

4.3 Air transport model outcomes

The results from the LMS are about an average working day and do not include passenger transport by airplane. These results come from a separate model. The

Figure 3. Air transport model outcomes for the scenarios (number of passengers departing from airport in study area, 2010=100)



outcomes for the three scenarios are in Figure 3. This figure clearly shows that air travel is expected to grow substantially (Standstill scenario) or very substantially (the other two scenarios), in all three cases much more than the land-based modes (that are the in the LMS). The major driver of this growth is income growth. If time becomes a major limiting factor for transport demand, than a more than average growth of the fastest mode (air) becomes very likely (see Schafer and Victor, 2000). Also we can expect more (international) business interaction (leading to more business trips by plane) and more leisure time for large groups of the population (leading to more leisure trips by plane).

5. OUTCOMES OF THE SENSITIVITY ANALYSES

A large number of sensitivity analyses was carried out, each time changing only one or a few of the input variables (either autonomous of policy variables). The most important outcomes, expressed as elasticities are in Table 6.

Again we see that the reaction of passenger transport by land-based modes to GDP growth is only modest, whereas freights transport has GDP elasticities of around 1.

Table 6. Main outcomes of the sensitivity analyses

Input that was varied	Output variable	Elasticity
Gross domestic product	Tours (passenger transport)	0.1
	Car tours	0.2
	Traveller kilometres	0.1
	Car kilometres	0.2
	Tonnes (freight transport)	1.0
	Tonne-kilometres	1.1
	Vehicle-kilometres	0.7
Fuel cost (cars)	Car tours	-0.05
	Car kilometres	-0.22
Public transport fares	Public transport tours	-0.36
	Public transport passenger kilometres	-0.40
Transport costs by road	Road transport tonnes	-0.2
	Road transport tonne-kilometres	-0.8
	Road transport vehicle-kilometres	-0.7
Number of cars	Car tours	0.3
	Car kilometres	0.3
		% impact on output variable
Road user charging (4.5 cent/kilometre on all roads)	Car tours	-4%
	Car kilometres	-10%

The fuel cost elasticity of car kilometres is -0.22 (which is in line with the literature, see PBL and CE Delft, 2010). Public transport is somewhat more price elastic than car travel. The tonne-kilometre price elasticity of road transport tonne-kilometres is -0.8 (which also conforms with the literature, see Significance and CE Delft, 2010). Car ownership influences car use (but the elasticity is well below 1) and road pricing (flat rate on all roads) can reduce the number of car kilometres.

6. SUMMARY AND CONCLUSIONS

By transferring model concepts that have been applied in The Netherlands and Scandinavia, a passenger and a freight transport model for Flanders were developed in a relatively cost-efficient way. The models were calibrated to Flemish data (zoning system, network, population, costs) by adding a limited set of mode and distance band-specific constants. They contain a lot of detail in the socio-economic segments and response mechanisms in passenger and freight transport that they handle. Therefore, the resulting models are sensitive to many scenario variables and very suited for scenario analysis. For detailed cost-benefit analysis of specific infrastructure schemes, more spatially detailed models that have been fully estimated on local data are recommended.

The transferred models were used to analyse three scenarios for Flanders up to the year 2040 for the Flanders transport masterplan. Passenger transport by airplane was treated in a separate new model, with coefficients based on the literature. In all three scenarios, freight transport will grow much more than passenger transport. The numbers of tours and passenger kilometres per person will remain more or less stable because transport will become considerably more expensive in real terms, whereas speeds will not change much. If in the next three decades new means of travel would be introduced that would speed up travel, the outcomes for passenger transport might be very different (or if travel would become cheaper), but this was not included in the scenarios. Car and lorry transport will see the highest price increases and according to the models will loose market share. Within passenger transport, air travel will be growing fastest.

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