

# TRANSPORTATION PLANNING FOR SUSTAINABLE DEVELOPMENT

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## 1 INTRODUCTION

Over many decades transportation and traffic have grown at a steady pace, and this trend is likely to continue because of a combination of various demand and supply factors [Grübler, 1993], especially in urban areas in both the industrialised and industrialising world. At the same time the negative impacts from transportation have become a global issue. They may be classified as impacts on air, water resources and land as well as impacts on biosystems (see for a detailed discussion on these impacts a/o [Whitelegg, 1997]).

Transportation planning theory traditionally relies a/o on the equilibration theory of Manheim [Manheim, 1979]. Here a transportation system is said to be tightly interrelated with the socio-economic system. The transportation system (*supply*) will affect the way in which the socio-economic system grows or changes (*demand*) and vice-versa the socio-economic system will call for changes in the transportation system.

Manheim's equilibrium theory has for long been modelled using 'predict – provide' models. Nowadays believe that no feasible road network is going to be able to cope with the forecasted levels of travel demand as well as the obvious fact that the limits of environmental burden have been crossed, initiated the search for new methods of transportation planning.

At the same time there is international agreement that sustainable development is a requirement for the planning and development of transportation systems. This has urged transportation engineers and planners to internalise the concept of sustainable development in their transportation planning methods and models.

This paper aims at giving a synthesis of initiatives on transportation planning techniques in relation to the concept of sustainable development. First the basic principles of sustainable development and transportation planning are discussed. Next these principles are confronted with each other in order to say something on the possibilities for transportation planning within the framework of sustainable development. Some initiatives of incorporating sustainable development idea in transportation planning are given and discussed.

## 2 SUSTAINABLE DEVELOPMENT AND TRANSPORTATION PLANNING

### 2.1 Sustainable development and transportation

Sustainable development has been the topic of many conferences and activities by transportation professionals and international agencies. As is widely known, the concept aims at launching a large-scale political, economic and cultural project, harmoniously linking environmental requirements with those of economic development, from a long-term point of view [Camagni, 1998].

The Bruntland Report of the World Commission on Environment and Development called Our Common Future [WCED, 1987] defined sustainable development as ‘a process of change in which the exploitation of resources, the direction of investments, the orientation of technological investment, and institutional change are all in harmony and enhance both current and future potential to meet human needs and aspirations<sup>1</sup>’. The most important elements being satisfaction of (basic) human needs and at the same time complying with available or affordable resources (e.g. environmental, financial and social) implying intergenerational justice.

Roughly spoken this Bruntland definition can be related to transportation as Black (2000) for example did by stating that a sustainable transportation system is ‘satisfying current transportation and mobility needs without compromising the ability of future generations to meet these needs’.

Black’s definition is more operationalised by Akinyemi and Zuidgeest (2000) who discuss a sustainably developed transportation system, i.e. a transportation system that meets the people’s needs, i.e. in terms of mobility, accessibility and safety within the limits of available or affordable environmental, financial and social resources. The available or affordable resources are determined conform an intergenerational objective. Sustainable transportation development is accordingly defined as a process of improving a transportation system towards a sustainably developed system.

For a more detailed discussion on the concept of sustainable development vs. transportation the reader is referred to another contribution to SATC 2000, [Zuidgeest *et al.*, 2000].

### 2.2 Transportation planning

In transportation planning traditionally a systems approach has been used (see for example [Manheim, 1979] or [Ortúzar and Willumsen, 1994]). Manheim sees the transportation system (of a region) as a single, multimodal system. Three basic variables are distinguished: (i) the transportation system and (ii) an activity system that equilibrate in (iii) traffic and transportation flows (see figure 1). Besides, a transportation system cannot be separated from the social, economic and political system. This assumption seems to invite the principles of sustainable development in systems planning via for example feedback mechanisms in the equilibrium calculation. However, he also states that it is feasible to separate the long-run shifts in the location and scale of socio-economic activity from the short-run behaviour of the market for transportation, implying that it is not necessary (or possible?) to incorporate the long-term principles of sustainable development in the short-term calculations of transportation planning.

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<sup>1</sup> Also referred to as ‘development that meets the needs of the present without compromising the ability of future generations to meet their own needs’.

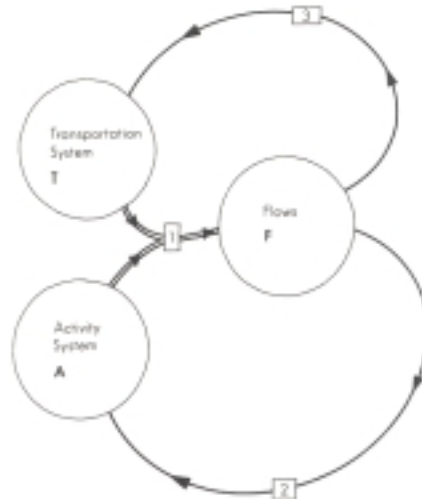


Figure 1 Basic relations of transport systems analysis [Manheim, 1979]

This traditional approach may be typified by three main categories, i.e. (i) the ad-hoc approach; (ii) the accounting approach; and (iii) the scenario approach [Deen, 1995]. The ad-hoc approach involves the discussion and analysis of a/o environmental impacts of transportation systems and how to investigate them. This is basically the traditional predict – provide – manage approach with its major critique to it shown in figures 2<sup>a</sup> and 2<sup>b</sup>.

The accounting approach involves: (i) identification of desirable limits to transportation related impacts a/o on the environment; and (ii) setting of standards for design and operation of transportation facilities and vehicles. The combination of the ad-hoc and accounting approaches seems to be the approach of most transportation agencies in many countries.

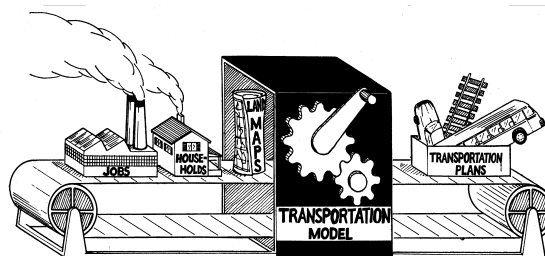


Figure 2<sup>a</sup> The standard predict – provide – manage approach [Beimborn *et al.*, 1996]

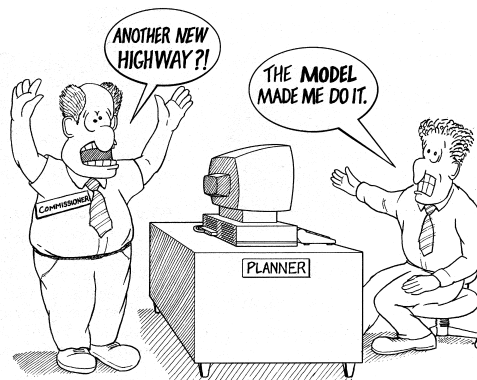


Figure 2<sup>b</sup> Major critique to traditional travel demand models [Beimborn *et al.*, 1996]

Finally Deen mentions the scenario approach that involves: (i) definition of some sustainability criteria; (ii) prediction of the expected future transportation demand scenario; and (iii) specification of a transportation system that will meet the sustainability criteria as well as the expected travel demand.

In these approaches it is unclear whether a sustainable transportation system is equivalent to a system that is compatible with the ideas of sustainable development. A transportation system that meets sustainability criteria is not necessarily the same as one that satisfies the travel-related needs of people.

### 3 SUSTAINABLE DEVELOPMENT VS. TRANSPORTATION PLANNING

As is stated before sustainable development basically involves a process of improving well-being and prosperity of the people (communal and economic) and at the same time taking care for available resources (mostly ecological) implying care for present and future generations. Illustrating this with transportation systems the bipartite character of sustainable development becomes clear. Undoubtedly, transportation and transportation systems are a prerequisite for (economic) development, and therefore for an improved well-being and prosperity, but at the same time this same transportation system can be a threat for this same development especially for future generations by the negative consequences of transportation, like air pollution, noise pollution, congestion etc.

Tools for transportation systems planning are often used for forecasting future travel demand, which is converted to traffic flows in a study-area. The different modal flows are subsequently translated into traffic related problems as pollution and congestion.

Table 1 gives an overview (which is not necessarily complete) with some aspects that might complicate internalising sustainable development in transportation planning.

Table 1 Comparison between transportation planning and sustainable development

<i>Aspect</i>	<i>Transportation planning</i>	<i>Sustainable development</i>
<i>Time scale</i>	10 to 15 years	Intergeneration (>30 years)
<i>Time</i>	Static in time (snapshot)	Dynamic in time (process)
<i>Spatial</i>	Local problems, local solutions	Think global, act local
<i>Hierarchy</i>	Local, regional, national, ...	Global, continental, regional, ...
<i>Disciplinarily</i>	Sectoral	Integral (holistic)
<i>Data</i>	Quantitative (model output)	Quantitative and qualitative (indicators)
<i>Approach</i>	Reactive, Predict – provide (- manage)	Proactive (precautionary principle), Predict – prevent Provide – predict

- Transportation planning studies normally have a time horizon of 10 up to 15 years, whereas sustainable development implies intergenerational justice that at least takes up 30 years.

- Transport models give a ‘snapshot’ of the situation in an area at a certain time  $t$ , whereas in sustainable development models the process is important implying time-dependent models.

- As transportation models only have limited exogenous inputs, sustainability studies can always be seen in the light of a larger, global, system.

- The same applies to hierarchy; transportation studies are mostly conducted at a local level and to a lesser extent regional, national etc., whereas sustainability studies initially focussed on a world scale, although nowadays more regional and also local studies are initiated. Lindquist (1998) justifies using sustainable development at local transportation planning level by stating that most politics is done at the same local level, although the enormity of problems is far beyond the scope of local planning, or global.

- Transportation models are typically sectoral models. Travel demand is calculated for a given static, fixed land-use pattern. More recently dynamic transportation – land-use interaction models have been developed, but these models have not been widely commercialised (yet). Sustainable development models are multi-sectoral, integral, although often limited to a few sectors.

- In transportation models impacts of alternative plans are calculated and evaluated using performance variables like total vehicle kilometres or total emissions, whereas in sustainability studies researchers often work with indicators that can be qualitative as well as quantitative.

- As stated before transportation models typically are predict – provide models and therefore reactive. Sustainability studies try to adapt the precautionary principle of predict – prevent, or more theoretically try to design (provide) a ‘world’ that complies to the requirements of sustainability.

## **4 SUSTAINABLE DEVELOPMENT IN TRANSPORTATION PLANNING**

### **4.1 Examples of applications of sustainable development in transportation planning**

Several aspects of use of sustainable development idea in transportation planning have been discussed. Some transportation planning studies adapted principles of sustainability and are subsequently described and shortly discussed.

#### *4.1.1 Sustainable transportation system for Sweden 2040*

In a recent study Steen *et al.* (1999) relate sustainable development to energy use and the emission of carbon dioxide CO<sub>2</sub>, which cause an enhanced greenhouse effect. The net emissions from fossil fuels seem to be the critical factor in reaching sustainable development, but admitting that other emissions like nitrogen oxides NO<sub>x</sub> are also important.

In their study total emissions are predicted for current and future travel demands assuming advances in vehicle technology as well as transportation system technology. It is concluded that even with improved technologies the trend in traffic volume growth must be broken. Sustainability goals are set in terms of target quantities of energy use and compared for different energy scenarios (figure 3). The two different energy levels indicate the uncertainties of what sustainable energy use is expected to be. The first alternative relying completely on renewable energy, whereas the second alternative permits some fossil fuel use based on a stabilisation of CO<sub>2</sub> content in the atmosphere.

In this study a very long time scale has been used (45 years) on a national scale. Sustainable development is merely seen from an environmental point of view, i.e. one single indicator for sustainability in terms of total CO<sub>2</sub> emissions and therefore ignores many other aspects of sustainable development. The emphasis is on sustainability rather than on development. The method tries to spot problems more than that it tries to derive solutions. Development is seen from a predict – prevent point of view. They suggest that much commuting can be (has to be) replaced by for example telecommuting from teleoffices and by teleshopping. Sustainable development has therefore not been internalised in this approach.

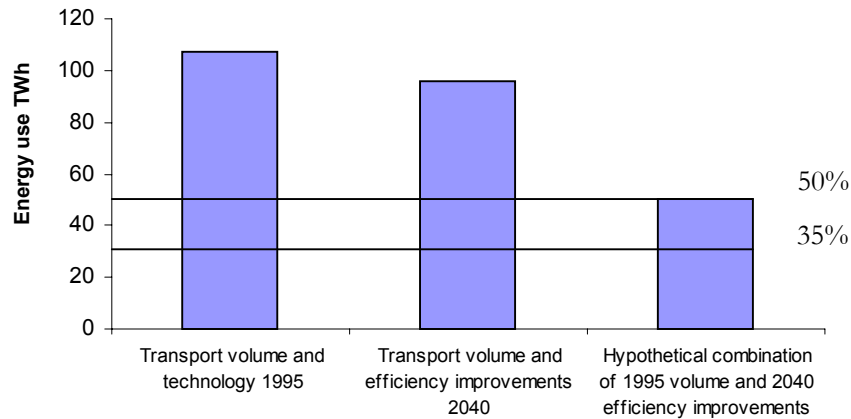


Figure 3 Energy use in the transportation sector. 1<sup>st</sup> present-day energy use, 2<sup>nd</sup> forecasts of expected increases in traffic volume in combination with realisation of the estimated technology potential. 3<sup>rd</sup> traffic volumes of 1995 in combination with hypothetical realisation of technology potential. Two target for energy use are set, 35% and 50% [Steen *et al.*, 1999].

#### 4.1.2 Trendbreach scenario 2010

The trendbreach scenario [Novem, 1989] has been used to calculate implications for current volumes of vehicle traffic (based on a do nothing scenario) if target figures for emissions, energy consumption and land-take are strictly taken into account (figure 4<sup>a</sup>). By doing this inverse transformation, the necessary shift (a trendbreach) in modal split has been calculated, which led to quite ‘heavy’ figures for a required modal change (figure 4<sup>b</sup>).

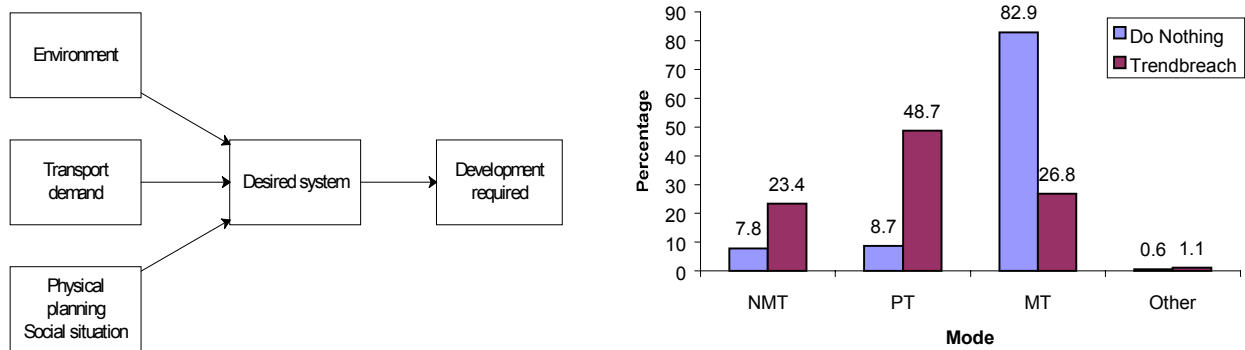


Figure 4<sup>a</sup> Research scheme for the so-called “Travelling clean” approach [Novem, 1989]

Figure 4<sup>b</sup> Mode split in ‘do nothing’ scenario vs. necessary split in ‘trendbreach’ scenario [Novem, 1989]

This trendbreach scenario has also been used for long-term predictions, i.e. 20 years for the whole of the Netherlands. The method is a snapshot approach where at one point in time the transportation system is required to change in order to cope with the (mainly ecological) sustainability targets. The study relies on sustainability targets as a exogenous variable, omitting the development aspect. It has also predict – prevent character. It spots problems more than that it solves them.

#### 4.1.3 Berlin Mobility plan

Principles of sustainable development have recently been used to set up a local mobility plan for Berlin, Germany. Targets of sustainability have been internalised in a traditional travel demand model [Bluemel, 1999], in a so-called backcasting method. Economic growth, land-use and travel demand are (as usual) regarded input to the transportation model. Modelling results are compared with a set of sustainability targets (specified by the European Union). In an iterative process a sustainable transportation system will be modelled (figure 5). The sustainable level of environment and urban compatibility is then defined on the basis of a modal split alike the trendbreach scenario, i.e. the journeys covered using public and individual means of transport and the measures necessary here.

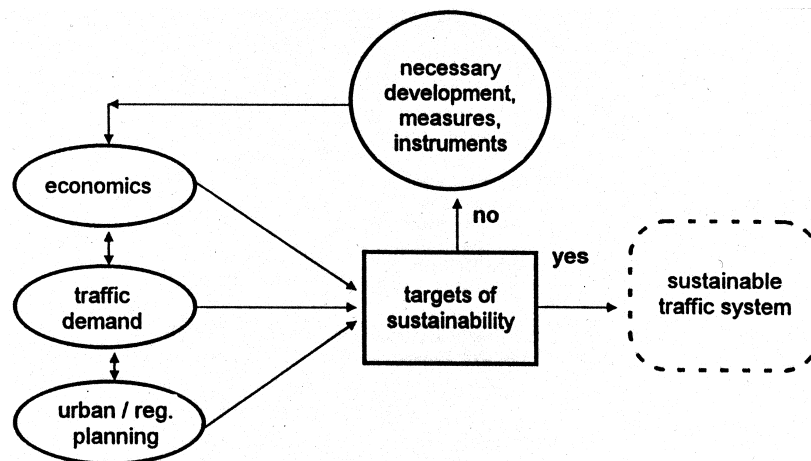


Figure 5 The backcasting method used for the Berlin mobility plan [Bluemel, 1999]

In this approach, better than in the previously discussed cases, sustainability is internalised (but still as target values for merely environmental variables) in the modelling process, in an integral way (interaction with land-use is also taken into account for example). This approach derives solutions to the problems via a feedback loop, instead of merely spotting them. Alike the other methods this method relies on sustainability, whereas it's not discussing development aspects of the system, i.e. in terms of for example accessibility or mobility.

## 4.2 Sustainably developed transportation systems

According to Akinyemi and Zuidgeest (2000) and Akinyemi (1998) the focus should more be on a sustainably developed transportation system. This, as defined earlier, is a transportation system that meets the people's needs, i.e. in terms of mobility, accessibility and safety, within the available or affordable environmental, financial and social resources. This implies that the problem that is to be addressed is how to move towards such a system, that is, how to develop a transportation system, that will maximise the levels of essential mobility, cost and safety of travel by people in an area without exceeding the available or affordable scarce resources of that area. The approach proposed for addressing this problem is summarised in figure 6.

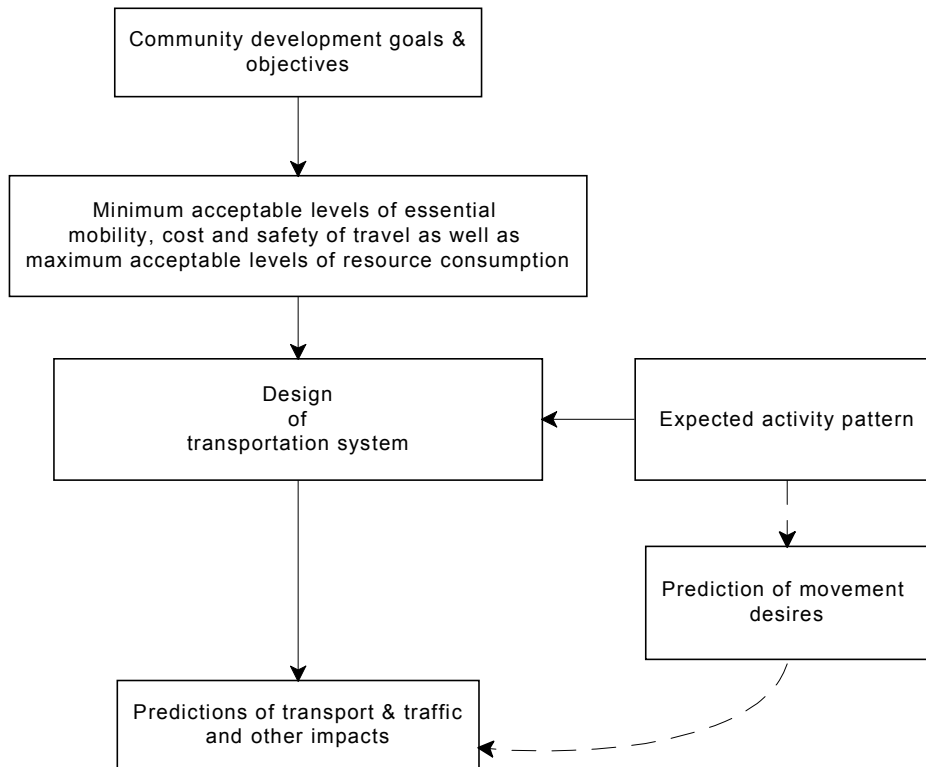


Figure 6 Proposed approach to transportation system planning for sustainable development

In this approach, which still needs elaboration, emphasis is put on the bipartite character of sustainable development, implying care for both the travel related needs of people in an area and at the same time complying with the available or affordable use of resources (in the light of intergenerational justice). Here, the communal goals and objectives for development (welfare as well as prosperity for the short- and long-term) are translated into requirements for transportation systems in an area in terms of needs and resources use. These requirements will have to be related to the existing and expected land-uses, and therefore activity pattern of the people in an area.

The transportation system design problem is then basically a mathematical problem, with the scarce resources as optimisation constraints and a combination of for example essential mobility, cost and safety of travel as an optimisation function. Now, transportation systems can be developed that maximise levels of accessibility and mobility in an area without exceeding the environmental, financial and social capacities.

By doing so sustainable development ideas are internalised in the transportation planning process. The requirement for intergenerational justice is operationalised in constraints. People's travel related needs are integrated in supply-type transportation system characteristics as accessibility. In this method we still have a sectoral approach to the problem with a snapshot character. Next, this method has to be integrated with land-use dynamics conform Manheim's equilibrium theory.



## 5 CONCLUSIONS AND RECOMMENDATIONS

The analysis in this paper has shown that sustainable transportation development should be regarded as a process of harmonising sustainability and development requirements for transportation. This process is currently not adequately addressed in transportation planning practice. Most existing approaches fail in deriving an 'optimal' transportation system within the framework of sustainable development. These approaches seem to be more compatible with the existing economic and other conditions in society, rather than improving those conditions.

Internalising the concept of sustainable development in transportation planning will be complicated by some fundamental differences in their approaches. Sustainable development focuses on intergeneration from an integral viewpoint and is dynamic in its character, whereas transportation planning is mostly locally used, on a rather short time span and is static in its character (as in a snapshot). Besides, transportation planning is typically characterised by its predict – provide – manage approach, whereas in sustainable development one tries to provide a 'world' that complies to the requirements of sustainability. From this a maximum sustainable capacity/yield can be predicted, meaning a provide – predict approach.

A newly developed modelling technique should be able to integrate (local) transportation planning with the concept of (global) sustainable development. The planning, design and redesign of urban transportation systems will be a time-dependent process in which the systems performance improves towards one which may be called a sustainable optimal state of the system. The model should have as its main output system characteristics that are compatible with the available or allowable resources. These can subsequently be used for the planning, design or redesign of urban transportation systems.

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### **Short Curriculum Vitae – Ir. Mark H.P. Zuidgeest**

Ir. M.H.P. Zuidgeest (1974) is currently Ph.D. – candidate in the department of Transportation Engineering and Management within the faculty of Technology and Management, University of Twente, Enschede, the Netherlands. He is responsible for research and some training in sustainable development and transportation planning. His main interest is in transportation system design for industrializing countries within the framework of sustainable development. Before joining the University of Twente Mark Zuidgeest worked as a lecturer for an international training institute, also based in the Netherlands. Field-experience is gained while working on projects in Kenya and Tanzania for this institute.