



World transport scenarios project

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World transport scenarios project

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Abstract:

The World Transport Scenarios Project (WTSP) has produced an Excel spreadsheet database on transport activity (passenger-kms and freight ton-kms by air, road, rail and water) and related CO₂ emissions. The database covers the “present day” (1995) and future years (2025, 2050 and 2100), with data for each future year being produced for a set of six scenarios reflecting different world development patterns. The principal use of this data is for input to the Tyndall Community Integrated Assessment Model (CIAM), and the scenario set has included four IPCC SRES scenarios (A1, A2, B1 and B2), as used by CIAM. Furthermore, CIAM requirements determined the regional specification of data: all data on transport activity and related CO₂ emissions was produced for twenty “CIAM regions” of the world. The essential process in WTSP has been to transfer scenario predictions on transport activity developed by the Stockholm Environmental Institute’s Global Scenario Group (GSG) to the SRES scenarios, which contain no predictions on mobility. However, there are many gaps in the GSG scenarios (from the point of view of CIAM requirements) and so a large amount of effort was required to fill such gaps. It is very much hoped that this data will be of use to the Tyndall CIAM in the short and medium term. However, the WTSP concluded that, for long term modelling purposes, a new “qualitative model of world transport” needs to be developed. A secondary aspect of the WTSP has been to produce some initial thinking on such a model.

Section 1 Overview of Project Work and Outcomes

Abstract

This report describes the World Transport Scenarios Project (WTSP). The project has produced an Excel spreadsheet database on transport activity (passenger-kms and freight ton-kms by air, road, rail and water) and related CO₂ emissions. The database covers the “present day” (1995) and future years (2025, 2050 and 2100), with data for each future year being produced for a set of six scenarios reflecting different world development patterns. The principal use of this data is for input to the Tyndall Community Integrated Assessment Model (CIAM), and the scenario set has included four IPCC SRES scenarios (A1, A2, B1 and B2), as used by CIAM. Furthermore, CIAM requirements determined the regional specification of data: all data on transport activity and related CO₂ emissions was produced for twenty “CIAM regions” of the world. The essential process in WTSP has been to transfer scenario predictions on transport activity developed by the Stockholm Environmental Institute’s Global Scenario Group (GSG) to the SRES scenarios, which contain no predictions on mobility. However, there are many gaps in the GSG scenarios (from the point of view of CIAM requirements) and so a large amount of effort was required to fill such gaps.

It is very much hoped that this data will be of use to the Tyndall CIAM in the short and medium term. However, the WTSP concluded that, for long term modelling purposes, a new “qualitative model of world transport” needs to be developed. A secondary aspect of the WTSP has been to produce some initial thinking on such a model.

Objectives

The objectives of the project were as follows:

- To provide quantitative input on “transport activity and emissions” to the Tyndall CIAM. This input was derived from an intelligent synthesis of quantitative estimates of transport activity estimated by other projects.
- To make a first attempt at developing a qualitative world transport model.

Work Undertaken

The research was carried out in the following steps:

1. Initial discussions with Tyndall HQ partners on requirements of the transport activity database, focussing upon the needs of the Tyndall CIAM
2. Review of relevant literature, focussing upon availability of data for both the “present year” and for a range of policy-dependent future scenarios
3. First specification of database and methodology for estimating data
4. Initial thinking about qualitative world transport model
5. Further discussions with Tyndall HQ partners on refinement of database and estimation methodology.
6. Formulation of detailed specification of database
7. Final discussions with Tyndall HQ partners, including agreement on a final regional specification that would be of most benefit to the CIAM
8. Production of database
9. Further thinking about qualitative world transport model
10. Production of Final Report

Results

It is considered that the objectives given above have been fully met. The project has produced an Excel spreadsheet database on transport activity (passenger-kms and freight ton-kms by air, road, rail and water) and related CO₂ emissions. The database covers the “present day” (1995) and future years (2025, 2050 and 2100), with data for each future year being produced for a set of six scenarios reflecting different world development patterns. These scenarios are the four IPCC SRES scenarios (A1, A2, B1 and B2) and two “GSG Scenarios” (Fortress World and Great Transitions). All data is disaggregated by the twenty regions used by CIAM, which are (in order of energy usage): USA, Japan, Germany, UK, France, Italy, “Rest of EU-15”, “EU-10”, Canada, Australia, “Rest of OECD”, Russian Federation, “Rest of Annex 1”, China, India, Mexico, Brazil, “NICs”, OPEC, and “Rest of World”.

The project has furthermore produced some initial thinking about a future qualitative world transport model. The main conclusion from this exercise is that the traditional “derived demand” paradigm (by which all travel is assumed to result from the demand to satisfy non-travel needs) is inappropriate for long-term transport forecasting. As a result, future transport activity cannot simply be estimated as a result of non-transport factors in exogenously-given scenarios (such as the SRES scenarios), since travel and transport will change the essential nature of these scenarios. Rather, there is a need to build free-standing “transport/travel scenarios” which represent the complex interdependencies between transport and non-transport activities.

Relevance to Tyndall Centre Research

The Tyndall Centre Research Strategy (Summary) under “Research Theme 1: Integrating Frameworks” includes the following text with respect to “Modelling for integrated assessment”:

A simulation system is required that assembles and couples key factors involved in the climate change problem. The system needs to be well-structured for convenient operation, flexible for addressing diverse issues, and harmonised for balanced treatment of natural and socio-economic processes. Models (e.g. agricultural production, transport, economics, and climate) and data sets have to be created, modified or accessed from other communities.

The WTSP provides precisely the type of data defined above with respect to transport.

Potential for further work

It is very much hoped that this data will be of use to the Tyndall CIAM in the short and medium term. However, the WTSP concluded that, for long term modelling purposes, a new “qualitative model of world transport” needs to be developed. A secondary aspect of the WTSP has been to produce some initial thinking on such a model. The justification for such a model is provided by the following logic:

1. IAG models for climate change assessment (such as CIAM) require quantitative transport input
2. This input needs to be provided by quantitative transport models
3. For long term prediction which goes beyond simplistic “demand extrapolation”, quantitative transport models need strong underlying qualitative transport models

4. Such qualitative models need, in turn, a strong behavioural basis with respect to an understanding of the inter-relationship between evolving social factors and travel/transport activity.

The development of such a qualitative model of world transport will require a large programme of work, probably funded by a variety of sources, and involving co-operation by a substantial group of international researchers.

Communication

The WTSP has been a relatively small project funded by Tyndall Centre round 3, and very much devoted to producing data for the CIAM. As such has not been directed to producing publications. However, it is hoped that the initial thinking about the qualitative world transport model will be incorporated in various future publications.

World Transport Scenario Project – Section 2 – Technical Report

1 Introduction

The World Transport Scenario Project (WTSP) was funded by the Tyndall Centre for Climate Change Research, the national UK centre for trans-disciplinary research on climate change. The project was undertaken by the Institute for Transport Studies (ITS) at the University of Leeds in partnership with Jonathan Köhler and Rachel Warren at Tyndall HQ, who are responsible for the Tyndall Community Integrated Assessment Model (CIAM).

The project had two interlinked aims:

1. To provide quantitative input on “transport activity and emissions” to the Tyndall CIAM. This input was derived from an intelligent synthesis of quantitative estimates of transport activity estimated by other projects.
2. To make a first attempt at developing a qualitative world transport model.

The data required by the CIAM on transport activity was specified by the project partners at Tyndall HQ. This specification included: the regions for which data was required; the periods of time for which values need to be provided (1995, 2025, 2050, and 2100); the scenarios which the project needed to use (the “IPCC SRES scenarios”, to be defined below in Section 3); and the inputs required for the CIAM for these scenarios (pass-kms, ton-kms and CO₂ emissions). The CIAM regions and their constituent countries are provided in Table 1: they are ordered by energy use.

Table 1 CIAM Regions and the countries that constitute these regions

Group Number	Name	Constituent Countries (for regions that are not single countries)
1	USA	
2	Japan	
3	Germany	
4	UK	
5	France	
6	Italy	
7	Rest EU-15	Austria, Belgium, Denmark, Finland, Greece, Ireland, Luxembourg, Netherlands, Portugal, Spain, Sweden
8	EU-10	Czech Republic, Estonia, Cyprus, Latvia, Lithuania, Hungary, Malta, Poland, Slovenia, Slovakia,
9	Canada	
10	Australia	
11	Rest of OECD	Iceland, New Zealand, Norway, Switzerland, Turkey
12	Russian Federation	
13	Rest of Annex 1	Belarus, Bulgaria, Croatia, Romania, Ukraine
14	China	Including Hong Kong
15	India	
16	Mexico	
17	Brazil	
18	NICs	S Korea, Malaysia, Philippines, Singapore, Taiwan, Thailand
19	OPEC	Algeria, Indonesia, Iran, Iraq, Kuwait, Libya, Nigeria, Qatar, Saudi Arabia, UAE, Venezuela
20	Rest of World	South Africa, North Korea, Argentina, Kazakhstan, Pakistan, Uzbekistan, Egypt, Israel, Bangladesh, Vietnam, Columbia

This report will firstly cover, in Section 2, the transport model that was developed to provide the inputs to the CIAM model, and will discuss the initial data collection that was required to populate the transport model for the base year (1995). Section 3 will then discuss how the transport scenarios were developed for the years beyond 1995. Section 4 will describe the outputs produced from the model, with examples of such outputs being provided in Section 5. Section 6 gives an overview of progress made in thinking about a qualitative world transport model. The report concludes in Section 7 with suggestions for further work.

2 Model Description

As stated above, the CIAM model requires input on transport activity and CO₂ emissions for the years 1995, 2025, 2050 and 2100. To be able to provide this input an Excel spreadsheet model was constructed: this section provides an overview of this model.

The model was designed so that future changes in pass-kms (passenger transport), ton-kms (freight transport) and fuel efficiency (MJ/activity-km) could be entered to determine how CO₂ levels would change under different scenarios. The initial stages of the design involved determining which modes of transport would be included in the model. The selection of modes was influenced by data availability for the base year (1995): selected modes are shown in Table 2.

For each category of transport, the WTSP database provides information on passenger kms and ton-kms (for freight transport) for each of the CIAM regions for the year 1995. The sources used for this data are described below. Fuel efficiency is taken into account through values of MJ/pass-km (for passenger transport) and MJ/ton-km (for freight transport) for each of the regions and modes of transport (in Table 2) for 1995.

Table 2 Modes of transport for passenger and freight transport

Passenger transport		Freight Transport	
Mode category	Sub-category	Mode category	Sub-category
Air	Regional	Air	Regional
	Inter Regional		Inter regional
Road	Bus	Road	Regional
	Car	Rail	Regional
	Bus + Car	Water	Inland waterway
Rail	Regional		Shipping

Data acquisition for 1995

Various “compilations” of data were considered in order to identify their use in building the 1995 database, since there are obvious advantages of using results produced by other projects. In particular, the project considered compilations produced by: the World Business Council for Sustainable Development (WBCSD, 2001); Schafer (1998); and the International Energy Agency (Landwehr and Marie-Lilliu, 2002). However, two general problems quickly emerged. Firstly, the results of these studies were not available in a form easily transferable to the Excel spreadsheet format required. Secondly the regional definitions were not consistent with the definitions for the CIAM regions given in Table 1. Therefore it was decided that it would be necessary to use data “more at source”.

The key sources used for the 1995 database were:

- International Road Federation (2001) World Road Statistics 2001 (data 1995 to 1999). This source provided information on a country by country basis for road freight-kms and road passenger-kms for 1995.

- World Bank Group Railway Database.
<http://www.worldbank.org/transport/rail/rdb.htm> This source provided rail passenger-kms and freight kms on a country by country basis.
- ICAO (1999) This source provided passenger-kms and freight kms for air travel on a country by country basis for the year 1995.

Additional specific sources were used for the 1995 database for countries where information was sparse. It was not possible to find data that covered all vehicle categories for all regions (e.g. Brazil and Mexico lacked relevant data).

The IEA study (Landwehr and Marie-Lilliu, 2002) was used to check the 1995 data in terms of passenger and freight kms and fuel intensity for the OECD regions.

The 1995 data provides the basis for the WTSP model. The next stage in its design was to use this data to make future estimates of transport activity covering the next 105 years. Information is now given on how this was done, distinguishing between passenger and freight transport.

Passenger transport

As can be seen from Table 2, the passenger transport model involved the following modes of transport: air (split into regional and inter regional); road (split into bus, car and bus + car); and rail (regional). The required inputs for this model in order to calculate estimates for future years are:

- % change in passenger-km per year (by category and region) for the periods 1995-2025, 2025-2050 and 2050-2100.
- % change in MJ/pass-km per year (by category and region) for the periods 1995-2025, 2025-2050 and 2050-2100.
- Fuel Types used by each category for the periods 1995-2025, 2025-2050 and 2050-2100.
- Conversion factors for CO₂ emission

The basic structure of the model using the base year data for 1995 and the inputs listed above involves the completion for each of the passenger categories and regions:

1. Passenger-kms (year n)* % change in pass-kms (for year n+1) =
Total Pass-kms in year n+1 (complete for all years)
2. MJ/pass-km (year n) * % change in MJ/pass-km (year n+1) =
Total MJ/pass-km in year n+1(complete for all years)
3. Passenger –kms (year n, n+1, n+ 2 etc...) *MJ/pass-km (year n, n+1, n+2 etc...) =
Total MJ (year n, n+1, n+2 etc...) (complete for all years)
4. Total MJ (for each year) converted into KWh (= MJ/3.6)
5. Total KWh (per year) split in fuel type used¹ and then converted using the relevant conversion factor² (for the fuel type) into CO₂ emissions.

¹ Fuel types used in the model are presented in Appendix 1

² Conversion factors were taken from DEFRA Environmental Reporting
www.thecarbontrust.co.uk/energy/pages/page_87.asp

Freight Transport

As can be seen from Table 2, the freight transport model involved the following modes: air (split into regional and inter regional); road (regional); rail (regional); and water (inland water and shipping). The required inputs for this model for each of the modes of transport and sub categories are:

- % change in Ton-km per year (by category and region) for the periods 1995-2025, 2025-2050 and 2050 -2100.
- % change in MJ/ton-km per year (by category and region) for the periods 1995-2025, 2025-2050 and 2050-2100.
- Fuel Types used by each category for the periods 1995-2025, 2025-2050 and 2050-2100.
- Conversion factors for CO₂ emission

The method of calculating future year estimates is analogous to the method described above for passenger transport.

Acquisition of estimates for future years

As stated above, WTSP required estimates from other sources on transport activity for future years. In researching the data availability a number of potential sources were considered, in particular: Schafer and Victor (2000), work conducted for the IEA (Landwehr and Marie-Lilliu, 2002), and the work of the Global Scenario Group (GSG) (Kemp-Benedict et al, 2002). All of these sources had interesting aspects. However, the first two were inappropriate for our use. In the case of the Schafer and Victor research, which predicted passenger transport levels for 11 world regions up to 2050, “all [the] main results reported” were for a “reference scenario” (though “sensitivity analysis” was carried out for a high growth scenario). This approach was not consistent with the CIAM approach that seeks to define a number of alternative scenarios without specifying one that is more likely than the others. In particular, the CIAM approach attempts to capture the concept that future transport activity is dependent upon international/national government policy, so that scenarios differ to the extent that governments apply environmentally-friendly policies. This dimension is not captured in the Schafer and Victor work.

Landwehr and Marie-Lilliu (2002) have made transport projections, for both passenger and freight transport, up to the year 2020 for the OECD countries. The report does capture the idea of alternative policy-differing scenarios, distinguishing between “a base case without policy action”, a scenario with “enacted measures”, and a scenario with “additional measures”. However, since the forecasts only apply to OECD countries up to 2020, they were of limited benefit in our project.

On the other hand, the third source mentioned above, involving the GSG scenarios, was highly appropriate. Kemp-Benedict et al (2002) provide estimates up to the year 2050 for each of four scenarios in terms of pass-km, ton-kms and MJ/activity-kms. These scenarios will be described further below in Section 3. However, it is worth pointing out here that two of the GSG scenarios are similar to two of the SRES scenarios that form the basis of the CIAM work. Furthermore, data was available for the GSG scenarios through the internet in a highly transferable form. For this reason, the GSG scenarios were chosen as the basis for constructing the SRES transport scenarios required by CIAM.

At a relatively late stage in WTSP (i.e. July 2004), the WBCSD published “Mobility 2030: Meeting the challenges to sustainability” (WBCSD, 2004). This report provides projections

up to the year 2030 for transport activity for 11 world regions and further extrapolations of these results to 2050. The report is very detailed in its consideration of the potential impacts on transport and the technologies that could be involved between 2000 and 2030. The main limitation of the report for our research is that quantitative predictions are provided for one single “Reference Case” (though qualitative descriptions are provided for three alternative scenarios: “The Price is Right”, “The Global Citizen” and “We’ll Do It Our Way”). Furthermore, the projections are generally presented graphically so that there are practical problems of data transferability.

GSG scenario regions

As stated above, the GSG scenarios were chosen as the basis of forming transport activity predictions for the CIAM. One difference between the requirements for the CIAM model and the values provided by the GSG scenarios concerned the classification of the regions used. Table 3 shows the GSG classification, along with CIAM regions. In general (and in particular for the high fuel-use regions), each GSG region is a discrete aggregation of one or more CIAM regions. However, in some cases (such as “Rest of OCED”), CIAM regions do not straightforwardly on to GSG Regions and so “best estimates of equivalence” have been required.

Table 3: GSG and CIAM Regions

	GSG Regions	CIAM Regions (see Table 1 for explanation)
Group 1	North America	USA
		Canada
Group 2	Western Europe	Germany
		UK
		France
		Italy
		EU-15
		Rest of OECD
Group 3	Eastern Europe	EU-10
		Rest of Annex 1
Group 4	FSU	Russian Federation
Group 5	South Asia	India
		NICS
Group 6	China+	China+
Group 7	Pacific OECD	Australia
		Japan
Group 8	Latin America	México
		Brazil
Group 9	Middle East	OPEC
Group 10	Developing	Rest of the world

Essentially, the method used to make our predictions involved applying appropriate regional annual scale factors (growth or decline), taken from GSG, to the original estimates of 1995 transport activity, based upon the CIAM regions. For example, estimates of transport activity in the USA and Canada CIAM regions are increased/decreased year-by-year using data derived from the GSG scenarios for the North American Region. Thus only one set of annual scale factors for the two CIAM regions is required (though clearly there are different data sets for the USA and Canada for 1995).

A simplification was designed into the model to reduce the number of values that were required for annual scale factors. This was achieved by defining three time periods (within

the overall time horizon of 1995-2100) and assuming fixed annual scale factors for each time period. These periods were:

- 1995-2025
- 2025-2050
- 2050-2100

For each of these time periods the fixed annual change per year is input for: Passenger-kms; Ton-kms; MJ/activity-km; and proportion of fuel types. An example of the inputs required for passenger-kms is provided in Table 4. It shows that, for example, for all years between 1995 and 2025 air travel is declining in Scenario B2 (to be defined in Section 3) by approximately 3.5% per year.

Table 4 Passenger-km inputs example for Scenario B2

Annual Scale factors				
		1995-2025	2025-2050	2050-2100
Group 1	North America			
Air	Regional	0.9652083	0.975646	0.9851439
	Inter regional	0.9652083	0.975646	0.9851439
Road	Bus	1.0198338	1.013884	1.008469
	Car	1.0198338	1.013884	1.008469
	Bus + Car	1.0099169	1.006942	1.0042345
Rail	Regional	1	1	1

Thus for each scenario there are four input sheets to fill in: two for passenger transport (change in Pass-kms and change in MJ/pass-kms) and two for freight transport (change in ton-kms and change in MJ/ton-kms). The model then calculates total pass-kms, ton-kms and CO₂ emissions for the 20 CIAM regions.

An example of the data produced is presented in Table 5.

Table 5 Pass-kms and CO₂ output example

Passenger transport				Freight Transport			
		Pass-kms	CO ₂ emissions			Ton-kms	CO ₂ Emissions
Air	Regional			Air	Regional		
	Inter Regional				Inter regional		
Road	Bus			Road	Regional		
	Car			Rail	Regional		
	Bus + Car			Water	Inland waterway		
Rail	Regional		Shipping				

3 Scenarios

Near the start of WTSP the scenarios that were to be used to estimate future transport activity were specified. Two groups of scenarios have been used and will be described in this section:

- SRES scenarios (A1, A2, B1, B2)
- GSG scenarios (Market Forces, Policy Reform, Fortress World, Great Transitions)

Essentially, the CIAM model is based upon the SRES scenarios, and so any set of transport activity scenarios created by WTSP needed to include the four SRES scenarios as a minimum.

3.1 Scenario Descriptions

SRES Scenarios

The SRES scenarios were developed by the Intergovernmental Panel on Climate Change (IPCC, 2000) from 1996 onwards, as a set of emission scenarios. A large number of scenarios were developed under four scenario families (A1, A2, B1 and B2): it is these four scenario families that are being used in this research. Each scenario family involves a storyline and a number of quantifications, including estimates on population estimates and GDP. The high level storylines for these scenario families are provided in Figure 1.

Figure 1 SRES family storylines

The **A1 storyline** and scenario family describes a future world of very rapid economic growth, low population growth, and the rapid introduction of new and more efficient technologies. Major underlying themes are convergence among regions, capacity building and increased cultural and social interactions, with a substantial reduction in regional differences in per capita income. The A1 scenario family develops into four groups that describe alternative directions of technological change in the energy system.

The **A2 storyline** and scenario family describes a very heterogeneous world. The underlying theme is self-reliance and preservation of local identities. Fertility patterns across regions converge very slowly, which results in high population growth. Economic development is primarily regionally oriented and per capita economic growth and technological change is more fragmented and slower than in other storylines.

The **B1 storyline** and scenario family describes a convergent world with the same low population growth as in the A1 storyline, but with rapid changes in economic structures toward a service and information economy, with reductions in material intensity, and the introduction of clean and resource-efficient technologies. The emphasis is on global solutions to economic, social, and environmental sustainability, including improved equity, but without additional climate initiatives.

The **B2 storyline** and scenario family describes a world in which the emphasis is on local solutions to economic, social, and environmental sustainability. It is a world with moderate population growth, intermediate levels of economic development, and less rapid and more diverse technological change than in the B1 and A1 storylines. While the scenario is also oriented toward environmental protection and social equity, it focuses on local and regional levels.

Source: IPCC (2000)

Although various emission-related factors are predicted in each of the SRES scenarios, they do not include estimates of transport activity. It is this lack of data that led to the establishment of the WTSP project.

GSG Scenarios

The Stockholm Environment Institute started the Global Scenario Group (GSG) in 1995. The GSG has developed four scenarios, based upon three future visions: Conventional Worlds, Barbarization and Great Transitions. Each vision leads to one or two scenarios: Market Forces and Policy Reform Scenarios (Conventional Worlds vision); Fortress World Scenario (Barbarization vision); and Great Transition Scenario (Great Transition vision). A high level description of these visions and scenarios is given in Figure 2.

Figure 2 GSG scenario general descriptions

<p>The Conventional Worlds vision scenarios envision the global system evolving without any major surprises, sharp discontinuities or fundamental transformations in the basis for human civilization. Dominant values and institutions shape the future, the world economy grows rapidly and developing countries gradually converge towards the norms set of highly industrial countries.</p> <ul style="list-style-type: none">• The Market Forces Scenario incorporates mid-range population and development projections and typical technology change assumptions. The problem of resolving the social and environmental stress arising from global population and economic growth is left to the self correcting logic of competitive markets.• The Policy Reform Scenario adds strong comprehensive and coordinated government action to achieve greater social equity and environmental protection. The political will evolves for strengthening management systems and rapidly diffusing environmentally friendly technology in the context of the proactive pursuit of sustainability, as a strategic priority <p>The Barbarization vision considers the possibility that social economic and moral underpinnings of civilization deteriorate.</p> <ul style="list-style-type: none">• The Fortress World Scenario features an authoritarian response to the threat of breakdown. Ensclosed in protected enclaves, elites safeguard their privilege by controlling an impoverished majority and managing critical natural resources, whilst outside the fortress there is repression, environmental destruction and misery. <p>The Great Transition vision explores solutions to the sustainability challenge, including new socioeconomic arrangements and fundamental changes in values. They depict a transition to a society that preserves natural systems, provides high levels of welfare through material sufficiency and equitable distribution and enjoys a strong sense of social solidarity. Population levels are stabilized at moderate levels and material flows through the economy are radically reduced through lower consumerism and massive use of green technologies.</p> <ul style="list-style-type: none">• The Great Transition Scenario
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Source: Adapted from the GSG website (2004)

Unlike the SRES scenarios, the GSG scenarios consider the future implications of the scenarios for mobility. Kemp-Benedict et al (2002) provide estimates of pass-kms, ton-kms and MJ/activity-kms for the years 1995, 2025 and 2050, for the main modes of transport, and for a set of 10 regions (see Table 3 above).

Comparison of SRES and GSG Scenarios

A comparison of the SRES and GSG Scenarios shows that the SRES A1 Scenario is similar to the GSG Market Forces Scenario, and the SRES B1 Scenario is similar to the GSG Policy Reform Scenario. Thus our project has considered six scenarios:

- A1 / Market Forces (assumed to be equivalent)
- A2
- B1 / Policy Reform (assumed to be equivalent)
- B2
- Fortress World
- Great Transition

3.2 Scenario and transport matrix

Combining the scenario descriptions given above with knowledge about transport activity resulted in the matrix provided in Table 6. It shows that each of the scenarios differ in a number of respects. For example, population growth starts to decline after 2050 in scenario A1/MF, B1/PR and GT, but is still increasing in all others. When considering CO₂ emissions, technology change is important as this provides an idea as to whether the efficiency of fuel use is improving over time. It can be seen that the two scenarios that are considering future sustainability (B1/PR and GT) both have rapid diffusion of “clean” technology in their scenario. In the case of B1/PR this allows the global nature of the scenario to continue at a reduced expense to the environment. Under A1 /MF the very high economic growth rate has a different effect on fuel consumption and efficiency. Under this scenario technology has been used to find more fuel, so there is no restriction on the fuel used by the economy and so less need to reduce the negative side effects of using this fuel.

The scenario descriptions provide a good indication as to how transport activity will differ between the scenarios. For instance under the A1/MF and B1/PR scenarios air travel is likely to increase, due to the nature of the global market in the case of B1/PR and the emphasis on increased mobility in A1/MF. Mobility is likely to be least (for fuel intensive vehicles) under B2 and GT, as both are looking for sustainable solutions in their worlds. Under Fortress World the use of fuel is likely to be the most inefficient, with the elite controlling the fuel use. While population is due to increase under this scenario mobility levels will not increase at the same level as investment declines and incomes are reduced.

By considering the different factors that influence each of the scenarios it is possible to see that a range of factors work together to influence transport activity. These scenario descriptions provide the first step of the development of the qualitative predictive transport model to be described further in Section 6, and have been used to develop the inputs required for the quantitative transport activity model for the years 1995 – 2100. By investigating these scenarios in this way it is possible to consider what might possibly happen in the future and provide some information to plan for this.

The next section will discuss the data used to populate the model from 1995-2100 for each of the scenario perspectives.

Table 6: Matrix of scenarios and critical factors

	A1/MF(Market Forces)	A2	B1/PR(Policy Reform)	B2	GT(Great Transitions)	FW(Fortress World)
Population 1995 = 5 (i.e. world population in 1995 was 5 billion)	Medium 2050 = 8.7 2100 = 7.1	Very high 2050 = 10 2100 = 15	Medium 2050 = 8.7 2100 = 7.1	High 2050 = 9.4 2100 = 10.4	(Lowest GSG) 2050 = 7.9 2100 = Lower than B1	Higher than all GSG 2050 = 10.6 2100 = Highest scenario
Age groups	Ageing and declining after 2050	Large population	Ageing population Declining after 2050	Population high in certain areas	Small population Ageing due to low fertility and mortality rates	Large population majority poor
Economic Growth	Very High	Medium	High	Medium	Lower than PR	Lowest
Freight Transport	<ul style="list-style-type: none"> Increased international mobility 	<ul style="list-style-type: none"> Large increases Lower trade flows between regions Regional development 	<ul style="list-style-type: none"> Service and information economy Decrease in material intensity Decline between 2050 and 2100 in population 	<ul style="list-style-type: none"> Use of local products leads to a decline in Ton-kms More inclined to switch to environmentally friendly modes 	<ul style="list-style-type: none"> Move to a service and information economy 	
Passenger Transport	<ul style="list-style-type: none"> Increased international mobility Increased social and cultural interactions Abundance of 	<ul style="list-style-type: none"> People are less mobile Less international focus High car ownership in 	<ul style="list-style-type: none"> Service and information economy Global Focus Invests in social welfare to reduce 	<ul style="list-style-type: none"> Local solutions lead to reduced distances Urban and transport infrastructure is focused on 	Sustainable travel is key	Breakdown of transport system. Elite increase travel

	<p>energy</p> <ul style="list-style-type: none"> • High incomes high car use and air travel • Sprawling suburbia 	rich areas	<p>exclusion</p> <ul style="list-style-type: none"> • Cities are compact and designed for PT and walking • High regional connections 	community innovation leads to a decrease in sprawl and a decreased dependence on the car		
Type of Scenario	Towards global convergence	Heterogeneous	Convergent	Local solutions	Convergent Key word Sustainability	Elite have the wealth Moving away from convergence
Income levels	Reductions in regional differences High incomes	No narrowing of incomes	Policy of income redistribution Incomes 1/3 less than A1	No narrowing of incomes	Narrowing of incomes the highest	Narrowing of incomes among the poor
Use of Technology	Rapid technological progress leads to plenty of energy resources	People and ideas are less mobile Technology diffuses slowly (rapidly in some areas)	Rapid diffusion of cleaner technology	Less rapid technological change than in B1 and A1 as local solutions are used	Rapid diffusion of cleaner technology	People and ideas are less mobile Technology diffuses slowly (rapidly in some areas)
Equity	2 nd least equitable of the GSG	No narrowing of incomes	2 nd most equitable of the GSG	No narrowing of incomes	Most equitable of the GSG Move to social solidarity	Least equitable Small number of elites manage impoverished majority
Migration	Large migrations	Limited migration	People migrate to jobs	Limited migration		Limited migration except among elites

4 Data for the model (1995-2100)

The data requirements for the quantitative values for the model (as discussed earlier) are:

- % change in pass-kms (1995-2025, 2025-2050, 2050-2100)
- % change in MJ/pass-km (1995-2025, 2025-2050, 2050-2100)
- % change in ton-kms (1995-2025, 2025-2050, 2050-2100)
- % change in MJ/ton-km (1995-2025, 2025-2050, 2050-2100)

This section discusses the data that was available for these periods of time, and outstanding data that needed to be estimated.

4.1 Data available for the period 1995 - 2100

Data is available for pass-kms, ton-kms and MJ/activity-km from the “GSG Technical Notes” (Kemp-Benedict et al, 2002) for the following scenarios/periods:

- A1/MF (1995-2025 and 2025-2050)
- B1/PR (1995-2025 and 2025 – 2050)
- FW (1995-2025 and 2025 – 2050)
- GT (1995-2025 and 2025-2050)

This data was converted into percentage changes for each of the periods for each of the main mode categories described in Table 2.

An example of the data for the scenario A1/MF and B1/PR is provided in Table 7 (ton-kms for road and air). Table 7 shows that, as expected, the growth in freight ton-kms is greater over the period of 1995 – 2050 for the A1/MF scenario than the B1/PR scenario. It also shows that there are some very distinct differences in how the different regions develop. The B1/PR scenario assumes convergence in mobility levels across regions, so those countries who previously had high mobility levels grow at a slower rate than those who previously had lower mobility levels.

Table 7: Example data for A1/MF and B1/PR. Freight Transport (billions of tonne-kms)

	Road			Air		
	1995	2050 MF	2050 PR	1995	2050 MF	2050 PR
North America	1766	5880	3290	29	95	53
Pacific OECD	372	775	540	27	56	39
Western Europe	1282	2934	2108	32	73	52
FSU	78	388	334	3	16	14
Eastern Europe	131	297	240	0	1	1
China+	317	1715	1154	2	11	8
Latin America	441	1757	1720	4	16	16
Middle East	673	3483	3352	6	30	29
South Asia	29	349	175	1	17	9

Due to lack of data from GSG, the following periods and scenarios had to be estimated using the scenario descriptions:

- A1/MF (2050-2100)
- A2 (1995-2025, 2025-2050 and 2050-2100)
- B1/PR (2050-2100)
- B2 (1995-2025, 2025-2050 and 2050-2100)
- FW (2050-2100)
- GT (2050-2100)

This next section will discuss the process used to estimate the unknown data.

4.2 Estimation of the passenger-km and freight-km data

1995-2050

The first set of data that required estimation was for scenarios A2 and B2 for the period 1995-2050. It was decided to use the A1 scenario as the base line for making these estimates. Essentially the method involved adjusting the annual change factors for passenger-kms and ton-kms in A1, using comparative information from A1, A2 and B2. This comparative information was taken from the SRES report (IPCC, 2000) and is shown in Table 8. The most important items of comparative information were the economic growth rates (% per annum) for the different scenarios. These are shown in Table 9 and are categorised into four “SRES” regions: OECD90, REF (“Reform countries”); ASIA; and ALM (Africa and Latin America). The GSG regions (listed in Table 3) needed to be mapped on to these SRES regions. For nine of the GSG regions this exercise was unambiguous, so that we have the following mapping:

- OECD90: North America, Western Europe and Pacific OECD
- REF: FSU and Eastern Europe
- ASIA: South Asia, China+ and Middle East
- ALM: Latin America

However, the GSG Region “Developing” cannot be mapped unambiguously on to one of OECD90, REF, ASIA or ALM. Thus judgement was required to estimate appropriate economic growth factors for this region.

Table 8: Key factors for Scenarios A1, A2 and B2 (1995-2100)

Scenarios	Population Size (billions)	Economic growth	Passenger transport	Freight Transport
A1	1995 – 5 2050 – 8.7 2100 – 7.1	Very High	Increased mobility	Increased mobility
A2	1995 - 5 2050 - 10 2100 – 15	Medium	People are less mobile	High regional flows
B2	1995 – 5 2050 – 9.4 2100 – 10.4	Medium	Local solutions and reduced distances	Decline due to use of local products

Source: adapted from IPCC (2000)

Table 9: Economic Growth rates (% per annum)

Region	1990- 2050				1990 - 2100			
	A1	A2	B1	B2	A1	A2	B1	B2
OECD90	2.0	1.6	1.8	1.4	1.8	1.6	1.5	1.1
REF	4.1	2.3	3.1	3.0	3.1	2.5	2.7	2.3
ASIA	6.2	3.9	5.5	5.5	4.5	3.3	3.9	3.8
ALM	5.5	3.8	5.0	4.1	4.1	3.2	3.7	3.2

Source: IPCC (2000)

The process is given in the following steps for creating annual change factors for passenger-kms in Scenario A2 for the years 1995-2025:

1. Let x_{A1} be the annual change factor for passenger-kms for A1, and x_{A2} be the annual change factor for passenger-kms for A2 (with x_{A1} being calculated from GSG data)
2. Let $r_{A2:A1}$ be the relative annual economic growth rate factor between A2 and A1, so that $r_{A2:A1} = (\text{annual economic growth rate for A2}) / (\text{annual economic growth rate for A1})$, with values taken from Table 9
3. Then x_{A2} is calculated according to the following formula:

$$x_{A2} = 1 + r_{A2:A1} * (x_{A1} - 1) \quad (1)$$

The following examples help illustrate the process:

- If there were no economic growth at all for Scenario A2, then $r_{A2:A1}$ would be 0, and x_{A2} would thus be 1; i.e. there would be no change in passenger-kms attributable to economic growth
- If the economic growth rate for A2 were the same as for A1, then $r_{A2:A1}$ would be 1, and x_{A2} would thus be the same as x_{A1} ; i.e. the growth in passenger-kms in A2 would be the same as in A1.
- In the OECD90 regions the annual economic growth rate for A1 is 2.0 (according to Table 9), whilst the annual economic growth rate for A2 is 1.6. $r_{A2:A1}$ is thus 0.8, and $x_{A2} = 0.8 * x_{A1} + 0.2$.

Analogous computations are made for Scenario B2 and for freight transport.

The project also took into consideration the population trends shown in Table 8 for the different scenarios. However, given the similarity in estimates of population for 2050, it was decided not to use this factor in the 1995-2050 estimates.

2050-2100

The method to calculate estimates for annual scale factors for all scenarios for the years 2050-2100 was analogous to that used to calculate annual scale factors for A2 and B2 for 1995-2050.

1. Let $x_{2025-2050}$ be the annual change factor between 2025 and 2050 for passenger-kms for Scenario S, and $x_{2025-2050}$ be the annual change factor between 2050 and 2100.
2. Let $r_{2025-2050:2050-2100}$ be the relative annual economic growth rate factor (for Scenario S) for the periods 2025-2050 and 2050-2100, so that $r_{2025-2050:2050-2100} = (\text{annual$

economic growth rate for 2050-2100) / (annual economic growth rate for 2025-2050), with values taken from Table 9

3. Then $x_{2050-2100}$ is calculated according to the following formula:

$$x_{2050-2100} = 1 + r_{2025-2050:2050-2100} * (x_{2025-2050} - 1) \quad (2)$$

However, since, as can be seen in Table 8, the estimated population difference between Scenario A2 and Scenario A1 for 2100 is large, an extra factoring was made to passenger-kms in Scenario A2. Table 10 shows the differences in population estimates for five of the GSG regions: as can be seen, the population changes are not evenly distributed throughout the world. For example, in the case of the China+ region the A1 population change was estimated to be a 40% reduction and the A2 population change was estimated to be a 40% increase. The proportional increase in the A2 population estimate over the A1 estimate is shown in the right hand column of Table 10. These factors are applied to the passenger-km estimates for their respective regions in A2.

Table 10: Changes in population according to Scenarios A1 and A2

Region	A1 Population change (2050-2100)	A2 Population change (2050-2100)	A2 Population / A1 Population
China	40% reduction	40% increase	2.3
FSU	17% reduction	47% increase	1.8
Pacific OECD	13% reduction	13% increase	1.3
Middle East	9% reduction	47% increase	1.6
Latin America	17% reduction	57% increase	1.9

4.3 Estimation of the MJ/activity-km input values

Following the estimate of pass-kms and ton-kms, the next stage was to estimate the MJ/activity-km inputs which provide the data on fuel efficiency. It was agreed at the start of the project that the emphasis should be upon estimating activity-kms rather than fuel efficiency, and the methodology described in this section is quite simplistic (especially for estimates of MJ/activity-km between 2050 and 2100).

Data is available for MJ/activity-km from the “GSG Technical Notes” (Kemp–Benedict et al, 2002) for the following scenarios/periods:

- A1/MF (1995-2025 and 2025-2050)
- B1/PR (1995-2025 and 2025 – 2050)
- FW (1995-2025 and 2025 – 2050)
- GT (1995-2025 and 2025-2050)

As with activity-km estimates, MJ estimates thus need to be made for the following scenarios and periods:

- A1/MF (2050-2100)
- A2 (1995-2025, 2025-2050 and 2050-2100)
- B1/PR (2050-2100)
- B2 (1995-2025, 2025-2050 and 2050-2100)
- FW (2050-2100)
- GT (2050-2100)

In general, these estimates are made using scenario information shown in Table 11, which shows: technology changes; economic growth; equity; and type of scenario in terms of global convergency/divergency. Technology change provides in particular a useful indication as to whether improvements are being made in the fuel and vehicles used in transport. The convergency/divergency indicator shows whether such improvements are being shared around the world, or whether there are only pockets of improvements.

Table 11: Key factors in scenarios key factors for calculating MJ data

Scenario	Technology Changes	Economic Growth	Equity (1= most equitable 6= least equitable)	Type of scenario in terms of global convergency / divergency	Income per capita (\$PPP/capita) 1= highest, 6 = lowest
A1/MF	Rapid technological progress leads to plenty of energy resources	Very High	4	Towards convergent	3
A2	Technology diffuses slowly Rapidly in some areas	Medium	5	Heterogeneous	5
B1/PR	Rapid diffusion of cleaner technology	High	2	Convergent	2
B2	Local solutions used so less rapid diffusion than B1 and A1	Medium	3	Local Solutions	4
FW	Technology diffuses very slowly	Low	6	Divergent	6
GT	Rapid diffusion of cleaner technology	High/medium	1	Convergent	1

1995 – 2050

Scenario A2

From Table 11, it can be seen that A2 is most closely aligned with the Fortress World scenario: both scenarios are divergent and have slow diffusion of technology. The MJ/activity-km estimates for Fortress World are thus used as the basis for making estimates for A2. Furthermore, these estimates take into account income (\$PPP/capita) data by region, so that vehicle/fuel efficiency for A2 becomes greater than for Fortress World as the income is higher. The calculation is:

$$\text{Increase in efficiency of A2 relative to FW} = \frac{\text{Income (\$PPP/capita) of A2 (1995-2050)}}{\text{Income (\$PPP/capita) of FW (1995-2050)}}$$

Scenario B2

From Table 11, it can be seen that Scenario B2 is most closely aligned with the B1/PR scenario. Thus estimates of MJ/activity-km for B2 are based upon estimates for B1/PR, applying an income adjustment factor analogous to that used above to estimate MJ/activity-km for A2.

2050 - 2100

As mentioned above, the estimates of MJ/activity-km for 2050-2100 are highly simplistic. Essentially, the approach taken is based upon the observation from Table 11 that the Fortress World scenario is both the least efficient in terms of technology change as well as having the lowest projected income per capita.

It is assumed that Fortress World has no improvement in vehicle/fuel efficiency between 2050 and 2100, i.e. MJ/activity-km values stay fixed at 2050 levels. Other scenarios have an improvement in MJ/activity-km based upon the difference in their projected income per capita with that of Fortress World.

5 Output from the model

The main output from this work is an Excel spreadsheet model that provides input on transport activity to the Tyndall CIAM. These inputs are:

- Pass-kms (per year, per scenario, per CIAM region, mode of transport)
- Freight kms (per year, per scenario, per CIAM region, mode of transport)
- MJ/Pass-km (per year, per scenario, per CIAM region, mode of transport)
- MJ/Freight-km (per year, per scenario, per CIAM region, mode of transport)
- CO₂ Emissions for passenger transport (per year, per scenario, per CIAM region, mode of transport)
- CO₂ Emissions for freight (per year, per scenario, per CIAM region, mode of transport)

In this section the CIAM region “UK” is used to provide an example of the outputs from our model. The values for the UK for pass-kms are presented in Table 12. The results show there will be the largest increase in pass-kms in Scenario A1/MF. The least amount of travel will take place in the Fortress World Scenario, as the transport system would break down and only the elites be able to travel long distances. Due to the lack of efficiency gains in the Fortress World scenario this decline in travel will not be mirrored by a similar decline in CO₂ emissions. Scenarios where efficiency gains will be at their greatest will be the Great Transitions and Policy Reform scenarios.

Table 12: Passenger-kms and annual changes for the UK

	Passenger kms (million)				Annual changes		
	1995 (base year)	2025	2050	2100	1995-2025	2025-2050	2050-2100
A1/MF							
Air	5760	13274	21740	52885	1.0282	1.0199	1.0179
Road	646000	1344597	1930847	3705374	1.0247	1.0146	1.0131
Rail	37000	38913	36875	33473	1.0017	0.9979	0.9981
A2							
Air	5760	10358	14601	15196	1.0198	1.0138	1.0008
Road	646000	1114665	1539504	2285069	1.0184	1.0130	1.0079
Rail	37000	38329	39127	40123	1.0012	1.0008	1.0005
B1/PR							
Air	5760	10896	13826	19771	1.0215	1.0096	1.0072

Road	646000	1020311	1167878	1430391	1.0154	1.0054	1.0041
Rail	37000	96455	136870	231569	1.0325	1.0141	1.0106
B2							
Air	5760	5325	5103	4845	0.9974	0.9983	0.9990
Road	646000	1069011	1405462	850313	1.0169	1.0110	0.9900
Rail	37000	38137	38767	39550	1.0010	1.0007	1.0004
GT							
Air	5760	5777	5471	5182	1.0001	0.9978	0.9989
Road	646000	824496	702226	598243	1.0082	0.9936	0.9968
Rail	37000	79257	76814	74446	1.0257	0.9987	0.9994
FW							
Air	5760	7376	4897	4897	1.0084	0.9825	1.0000
Road	646000	830074	533803	533803	1.0084	0.9825	1.0000
Rail	37000	34922	20157	20157	0.9981	0.9783	1.0000

The information in this table can also be viewed using a number of graphs. to represent the modes. These are presented in Figures 3, 4 and 5. They show that the scenarios that are aiming to reduce their CO₂ emissions, such as the Policy Reform (B1), scenario have increased pass-kms in rail.

The next section will discuss the second objective of the project, which was to make a first attempt at developing a qualitative world transport model.

Figure 3: Air pass-kms (UK)

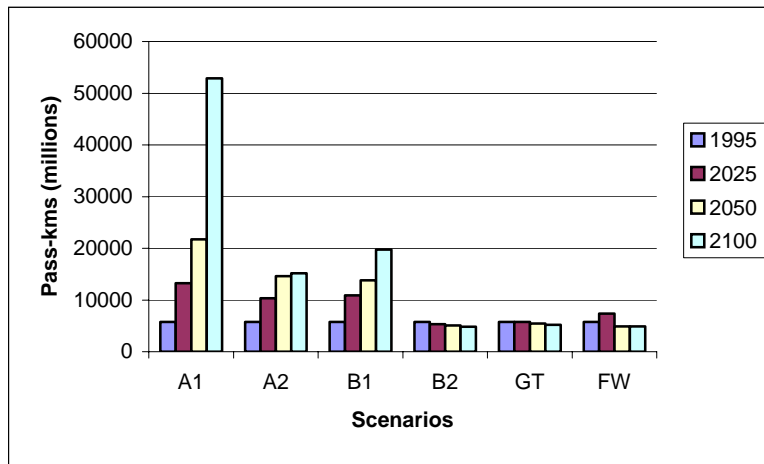


Figure 4: Road Pass-kms (UK)

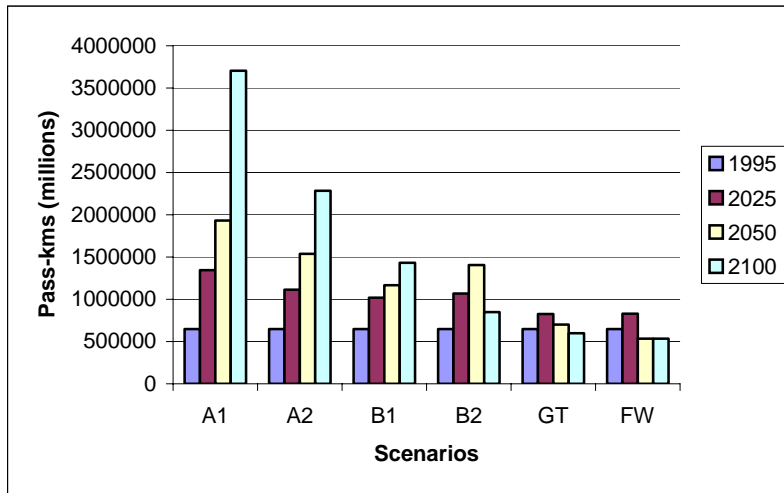
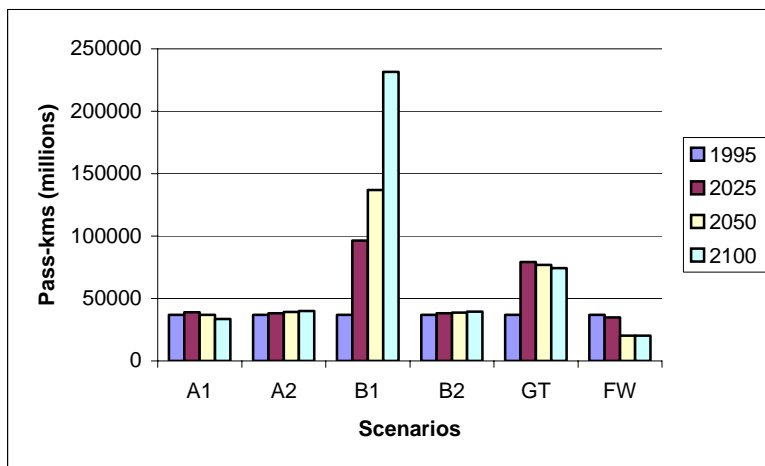


Figure 5: Rail Pass-kms (UK)



6 Qualitative Transport Model

As stated above, one of the project aims was to make a first attempt at thinking about a qualitative world transport model, in which mobility is treated as an important driving concept in its own right, as opposed to a traditional approach in which transport is always considered as a “derived demand”. First indications of this effort have been included in the transport activity scenario descriptions given in Section 4. This section describes further results for this effort. The logic is that firstly a qualitative understanding of “present-day” travel needs to be developed: this is described in Section 6.1. The next step is to consider how such understanding might help us in making predictions of the future: this is done in Section 6.2.

6.1 Present day travel

Traditionally travel behaviour has been explained as a behaviour always resulting from the demand to satisfy other needs. However this understanding of travel as a 'derived demand' is problematic. It tends to emphasise the disutility of travel and has the potential danger that travel is thought of as divorced from culture. The 'derived demand' approach neglects the social and cultural meanings of travel; the importance or place of travel in social relations; the 'pleasure' of travel; and the interdependencies that exist between travel and social structures and culture. In developing an alternative model of travel we intend to explore those factors that have hitherto been ignored.

Any understanding of travel needs to pay attention to the interdependencies between travel and society, put simply travel is not only shaped by society and culture it also influences society and culture. Travel is an intrinsic part of everyday life and has a fundamental influence on how people live their lives. In the developed world the ability to travel and the way in which travel is done is embodied in cultural notions of choice, flexibility and time.

The technologies available to people to travel, for example the car, bus, aeroplane and bicycle, can be seen to affect the very activities that people engage in and to actually change what are considered to be the ‘normal activities’. In the developed world this can be seen in that ‘touring’ that is, going for a drive, has become an activity in itself.

This picture is further complicated when we consider the interaction between communications technologies and travel technologies. Both technologies enable communication between people, one face to face and the other at a remove. It is becoming increasingly clear that communication technologies do not necessarily substitute for journeys but do have quite complex impacts on travel, for example mobile phones can have the effect of making journeys much more changeable while they are being undertaken, as people change destinations or meeting times. Thus traditional thinking which divorces the ‘why’ of travel from the ‘how’ of travel and implies a sequential decision-making process to the journey decision no longer seems to be appropriate.

There are a wide range of different influences on mobility ranging from the physiology and psychology of the individual; social structures and trends; cultural meanings and symbolism; organisational (including business) operations and culture; state policies and provision; economic structures and operations and international relations and world economic position. All of these influences will take on different intensities and effects and dependencies and relations to each other according to specific cultures and societies across the world. This qualitative model of world transport will identify some of the most important influences for explaining travel and particularly those relating to culture and societal structures and trends.

Specific social influences

One of the most neglected aspects of travel today is that of the 'pleasure' of travel (Mokhtarian, Salomon and Redmond, 2001). There are pleasures relating to feeling the body move such as when walking or cycling, pleasures associated with the speed felt in motorised vehicles and with cars there is the particular pleasure associated with being in control of a large machine. In aeroplanes there is pleasure associated with the mastery of the elements. There is also the pleasure, particularly associated with cars of feeling cocooned and safe in your own space. In addition to the pleasure associated with the actual experience of movement involved in travelling, there is also the pleasure associated with seeing and experiencing different places as you travel to a particular destination.

Recent research into women's travel highlighted another aspect of travel that made it pleasurable. Researchers working in the developed world found that some women valued the journey to and from the home and work for the time it gave them to relax 'between worlds'. Journeys were found to give the opportunity to relax and have time alone between the demands of fulfilling the role of worker at the workplace and mother and partner in the home. Although this research focussed on women's travel it may also be an aspect of travelling that men find pleasurable.

It is our contention that mobilities, that is, travel and communication technologies, and the interactions between them are crucial to understanding the dynamic character of social networks, social capital and significant to the understanding of the contested nature of 'community' and 'neighbourhood' and the transformation of places. To date, despite the numerous and contested definitions of social networks (Grootaert *et al*, 2004, Putnam 2000, Granovetter 1973), there is agreement that social networks are characterised by dynamism, relations, trust, reciprocity, communication and flows. There is also an increasing body of work which suggests that social capital can have positive outcomes on health, the economy and feelings of societal inclusion. It is the fluidity and connectivity between people that makes mobilities (transport, travel and communications) key to the understanding of the nature of social networks; because social networks require communication (passive and active), including travelling to be in another's proximity or communication through electronic or paper means or word of mouth or simply 'being seen', travelling becomes integral to the nature of social networks.

The connectivity of networks and localities are to some extent determined by the opportunities to travel offered by the transportation system as well as the individual's inclination to travel. A general aim of transport planning has been to make localities more connected thereby giving those localities more access to markets, goods, finance, labour and other services. However, without the understanding of the relationship between mobilities and social networks much of the transport system is designed, implemented and operated in such a way as to favour those with cars and to continue patterns of exclusion within society. However there is limited research in this area. What research there is suggests that transport infrastructure favouring those with cars will lead to a locality being more porous, with the effect that higher quality human capital enters and mobile human and financial capital leaves (Grieco, 1994). This is to the further detriment of those who are socially disadvantaged and immobile.

One important aspect of travel today is the extent to which travel and the manner in which it is done has become important to peoples identity. This is particularly the case in the developed world rather than in the developing world because there is a more highly developed culture of consumption and more opportunity for consumption because of higher average income levels and levels of disposable income. In this context the choice of goods has become important in the formation and assertion of a persons identity and status. The choice of goods enables a person to say who they are and to make distinctions, particularly

between those groups that people wish to be associated with and those others they do not. For example within the developed world in cities outside the capital bus travel has the reputation of being the 'mode for poor people'. As well as the choice of vehicle the vehicle itself can be a space within which people can assert their own individuality using decoration or customising the bodywork and the engine, for example the highly decorated freight trucks of India or the taxi cabs of Jamaica or the stretch Sports Utility Vehicles of the hip hop music artists in America. (Maxwell 2001)

Within the developed world mobility is intrinsic to cultural ideas of time, flexibility, choice, freedom and independence. Private car travel in particular is valued for the flexibility, freedom and choice that it is seen to offer people whereas public transport is seen as inflexible and not offering the choices of car travel. Life styles and changes in time use and the way that we value time have an impact on the values and perceptions of travel and different modes. Cultural values have a decisive impact on travel behaviour and offer an understanding of the aspirations of different groups within a particular society. The values and symbolism embodied in travel and in different modes of travel need to be taken into account in any understanding travel.

There is increasing evidence of differences between men and women experiences of travel (Hamilton, Hodgson and Turner, 2004; Fernando and Porter, 2002). Women and men's experience of travel differ largely because of the different roles that men and women are expected to perform in society. So for example in certain societies women are expected to be accompanied by a family member when travelling. Throughout the world women are expected not to travel alone during night-time. There is evidence that women's role as mothers means that they take on the greater share of travel escorting children. In many parts of the developing world girl children do not go to school beyond the age of eleven whereas boys might continue to attend school thus giving rise to different travel patterns. Little is known about the differences in men and women's migration and work patterns. It is our contention that future analyses of travel should be gendered.

Other specific social influences include population trends. In particular the numbers of people and gender split but also the impact of the age profile of the population on mobility.

Migration patterns are another specific social influence. Continued inequalities between the developed and the developing world will ensure that there is migration from the developed world to the developing world. This coupled with population decline and an increasingly older population in the developed countries will mean that more people will migrate to the developed countries.

In recent years mobility has been affected through issues of security and threat with events such as September 11 and the Bali bomb increasing the fear and security associated with travel. It is difficult to predict what impact terrorism will have on people's future mobility levels, but following from September it was clear that events such as these had an impact in that people stopped flying and cut down their travel at least in the short term.

6.2 Future travel/transport activity

The development of a predictive qualitative transport model for the world will need to project the present-day insights on travel from Section 6.1 into the future. Given the rejection of the "derived demand" paradigm, it is not sufficient simply to try to interpret exogenously given scenarios (such as those of SRES) in terms of their travel and transport characteristics (as we have attempted to do in this small piece of research), since transport and travel will have an impact on changing the essential natures of these scenarios.

Clearly we are outlining a large programme of work here. However we would contend that this programme is justified in the area of assessing the effects of long term policies concerning climate change. The logic for this justification is as follows:

1. IAG models for climate change assessment (such as CIAM) require quantitative transport input
2. This input needs to be provided by quantitative transport models
3. For long term prediction which goes beyond simplistic “demand extrapolation”, quantitative transport models need strong underlying qualitative transport models
4. Such qualitative models need, in turn, a strong behavioural basis with respect to an understanding of the inter-relationship between evolving social factors and travel/transport activity.

7. Summary and suggestions for further work

This report has described the World Transport Scenarios Project (WTSP). The project has produced an Excel spreadsheet model to create a database on transport activity (passenger-kms and freight ton-kms by air, road, rail and water) and related CO₂ emissions. The database covers the “present day” (1995) and future years (2025, 2050 and 2100), with data for each future year being produced for a set of six scenarios reflecting different world development patterns. The principal use of this data is for input to the Tyndall CIAM, and the scenario set has included four IPCC SRES scenarios (A1, A2, B1 and B2), as used by CIAM. Furthermore, CIAM requirements determined the regional specification of data: all data on transport activity and related CO₂ emissions was produced for twenty “CIAM regions” of the world. The essential process in WTSP has been to apply scenario predictions on transport activity developed by the Stockholm Environmental Institute’s Global Scenario Group (GSG) to the SRES scenarios, which contain no predictions on mobility. However, there are many gaps in the GSG scenarios (from the point of view of the needs of the CIAM) and so a large amount of effort was required to fill such gaps.

It is very much hoped that this data will be of use to the Tyndall CIAM in the short and medium term. However, the WTSP concluded that, for long term modelling purposes, a new “qualitative model of world transport” needs to be developed. A secondary aspect of the WTSP has been to produce some initial thinking on such a model. The justification for such a model is provided by the following logic:

1. IAG models for climate change assessment (such as CIAM) require quantitative transport input
2. This input needs to be provided by quantitative transport models
3. For long term prediction which goes beyond simplistic “demand extrapolation”, quantitative transport models need strong underlying qualitative transport models
4. Such qualitative models need, in turn, a strong behavioural basis with respect to an understanding of the inter-relationship between evolving social factors and travel/transport activity.

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Appendix 1 Fuel Types used in the model and conversion factors

The tables below show fuel types used for each mode and conversion factors from KWh to Kg CO₂. As stated in the main text, it was agreed early in WTSP that the emphasis should be on estimating transport activity rather than the CO₂ outputs from this activity. Therefore the assumptions used about fuel types are relatively simplistic. However, the database has been constructed in a way to make it straightforward to replace these simplistic assumptions with more complex assumptions.

Passenger Transport fuel shares and conversion factors																
	Road (bus)					Road (car)					Rail		Air		Water	
Fuel Type	Petrol	Diesel	Hydrogen	Electric	Other	Petrol	Diesel	Hydrogen	Electric	Other	Diesel	Electric	Jet Fuel	Other	Diesel	Other
% fuel share per mode for each scenario	100	0	0	0	0	100	0	0	0	0	100	0	100	0	100	0
Conversion factors from KWh to Kg CO ₂	0.24	0.25	0	0.43	0	0.24	0.25	0	0.43	0	0.25	0.43	0.24	0	0.25	0

The conversion factors were taken from the carbon trust website (www.thecarbontrust.co.uk/energy/pages/page87.asp).

Freight Transport fuel shares and conversion factors													
	Road (freight)					Rail (freight)		Air (freight)		Water (freight)		Water(shipping)	
Fuel Type	Petrol	Diesel	Hydrogen	Electric	Other	Diesel	Electric	Jet Fuel	Other	Diesel	Other	Diesel	Other
% fuel share per mode for each scenario	100	0	0	0	0	100	0	100	0	100	0	100	0
Conversion factors from KWh TO Kg CO ₂	0.24	0.25	0	0.43	0	0.25	0.43	0.24	0	0.25	0	0.25	0

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The Tyndall Centre is named after the 19th century UK scientist John Tyndall, who was the first to prove the Earth's natural greenhouse effect and suggested that slight changes in atmospheric composition could bring about climate variations. In addition, he was committed to improving the quality of science education and knowledge.

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