Sustainable Transport in the 21st Century

Background Paper for Comments

BACKGROUND. The Shell Foundation[1] has established a "Centre for Sustainable Transportation, Energy, and Environment". The Goal of this Centre is acceleration of implementation of policies and technologies that make transportation more environmentally sustainable, improved analysis of present trends as a means towards this goal, and assistance for capacity building of analytical capabilities, principally in developing regions of the World. A core grant of between USD 750K and USD 1500K for a minimum period of five years has been committed and a Centre leader identified. This note provides a summary of the proposed activities of the Centre, as well as background material to allow interested persons and institutions to comment on the thoughts underlying the creation of this Centre and its directions.

Under the direction of Dr. Lee Schipper, this Centre will focus on these key activities:

A. Observation and Analysis.

1. The City Programme and Regional Partnerships. The most pressing transport and environment problems today – congestion, air pollution, noise – manifest themselves at the city or regional level. At the core of the Centre's work programme, therefore, will be its leadership of a set of city-based initiatives designed to create the sort of data measurement and analysis systems and capacities they currently lack but which are needed if their transport problems are to be tackled effectively.

*The systems introduced and capacities created will build upon and incorporate the "ASIF" methodology developed by the International Energy Agency for the World Bank over the last 4 years. The ASIF approach is acknowledged as a simple yet elegant way of decomposing the multiplicative components of emissions into constituent parts (transport **A**ctivity, transport modal **S**tructure, transport fuel **I**ntensity, and **F**uel mix (or emissions per unit of fuel) thus allowing the minimum data needed for adequate analysis to be identified, collected then analysed within a context that is manageable by most developing countries[2]. Until cities and regions understand how some of these components (A, particularly the component in cars and two-wheelers) may be growing fast enough to undermine the progress in reducing emissions per kilometre or per vehicle.*

[1] Further details on the Shell Foundation can be found at www:Shellfoundation.org and through contacting Kurt Hoffman, Deputy Director, Shell Foundation, Shell Centre, London SE1; Tel: 44 – (0)207 934 – 4992;

[2] Developed in Schipper et al (2000) Examples of the kinds of specific questions that advisers, policy makers and planners tasked with designing cost effective interventions should have answers to include

- Measuring the particulate emissions from natural gas buses in comparison with ordinary or advanced diesel buses (the F term)
- Measuring the changes in overall transportation patterns from the imposition of a metro system, bus-ways, or other large scale transportation projects (A and S terms);
- Measuring change in car or two-wheeler use (the AS terms) arising from higher fuel prices, imposition of road pricing, changes in road availability, changes in parking prices, or other policies.
- Measuring changes in fuel economy of different passenger vehicles, as well as possible changes in vehicle use resulting from changes in vehicle operating costs (the so-called rebound effect).
- Measuring changes in carbon and other emissions from distinct modes of traffic after imposition of new fuel or emissions technologies or different fuels.

The core funding provided to the Centre will, for each of the partner cities/regions, allow it to fund a transport expert based in that city/region who will work in parallel with the Centre but on a work programme jointly designed with the city authorities. This work programme will be largely funded by the city (using its own or external funds) and will form the core of the city's own commitment to build and maintain the ASIF monitoring and analysis programme as part of its regular policy making and support infrastructure in the transport area.[3]

The value of the Centre's city-based initiatives will manifest at three levels – first, permanent systems and processes will be created in each city providing a sound analytical basis for policy and investment; second, the experience of building these capabilities and the evidence of their success in generating good policies will provide a template for rolling out the same approach in other cities through the various outreach elements of the Centre's work plan. Finally, the "solid science" approach will encourage real time experiments from both the public and private sectors, assuring good monitoring and evaluation and a fair interpretation of the results.

2. *<u>Broader transport studies</u>. Beyond the city-based programme, it is anticipated that Centre staff - directly on their account, through networks and via commissioned work - will engage in a range of broader applied studies that will answer key questions linked to society's need to understand and respond to the evolving relationship between transport, environment, energy and society. Among the likely topics would be:*

- *Key Indicators of energy and environment for transportation, such as compilation of sales-weighted fuel economy of new vehicles (from two-wheelers to large trucks), on-road fuel economy of each mode, and distances each kind of vehicle is driven each year. Despite their importance, these indicators are not compiled outside of major IEA countries;*
- *Simple projections showing what these trends mean for future environmental problems (including carbon emissions) connected to CO_2, i.e., what do baseline projections for ASI and F lead to in terms of emissions?*
- *Trends in transportation, energy, and environmental technologies, indicated by performance, costs, such as emissions characteristics of new vehicles, incremental costs of hybrid buses, or costs/kW of motor-vehicle fuel cells;*
- *Key policies related to transport, energy, and environment, particularly those in one region that may affect technologies or policies elsewhere (as has been the case for California for decades), such as tailpipe emissions standards.*
- *How do large companies, NGOs and the multi-national lender face the particular problems of urban areas related to the global and national problems? Do commonalties lead to solutions offered by the private sectors?*

Such work will be carried out to the highest standards of scholarship and it is expected that there will be a powerful and invaluable synergy between this broader sweep of studies and the knowledge gained from the applied activities inherent in the City Programme. Together these activities will generate the intellectual capital and practical experience upon which the rest of the Centre's work programme will be based.

<u>B. Evaluation and Lesson Learning.</u> *The Centre will use a portion of its core resources to fund a rigorous and comparable set of evaluations of on-going transport interventions around the world. This effort will also build base-lines that are needed by local, regional, or national governments for many tasks related to transport planning, energy policy, and policies towards air pollution and restraining carbon emissions as well. As noted*

[3] Further details on the potential city partners and the strategy for putting this partnership into practice will be forthcoming. However, we have held preliminary discussions with Rio de Janeiro, Sao Paulo, Mexico City, Jakarta, Delhi, and Bangalore, and officials and experts in each city have shown interest in this effort.

earlier there are many such interventions planned or under way, most designed on an individual basis with no attention to extracting broader lessons and very little links to other initiatives. By linking basic data (or assisting local experts to develop such data) with a variety of projects, a consistent measure of the transport-environment link is obtained.

By conducting such an evaluation programme, the Centre will build up an understanding of experiences elsewhere that will feed back into the other work of the Centre (under its Guidance and Brokering elements). In addition by communicating widely the results, this activity will be a valuable contribution to the field in its own right via the creation of a mechanism that maximises the rigour, scope and rate of horizontal learning between the huge array of ad-hoc interventions (and their clients, funding and implementing agents) under way or planned.

C. Guidance: *Currently the private sector and multi-national lenders turn to short-term consultants (and occasionally academia) for guidance and analysis on what is happening in transportation. Both sectors also support various projects and programmes in North American and European Universities. Most of these programmes have good academic qualifications but tend to focus on a relatively narrow range of important transportation problems, and there are too few in the Third World. The Centre will compensate for this gap by focusing its advisory work on those cross-cutting features of the transport-environment context that are often missed by the more narrow, in-depth academic studies but whose understanding is critical in designing effective policies*

The Centre is conceived to develop a high profile as a reliable source of rigorous analyses integrating the various elements of transport, energy, and environment in a way particularly relevant to the planning and decision-making requirements of the major multi-lateral donors such as the World Bank as well as major private sector actors and investors and other players who are in position to make major investments in the sector in response to sound and robust recommendations.

D. Brokering and Umpiring, *We envisage that the Centre will, through its own and commissioned projects as well through its established networks and contacts (see below), frequently find itself in a position to offer advice on various policy, intervention and investment options being considered by different stakeholders. The Centre will also assist in raising funds and substantive in-kind support for good projects involving transport planning, planning experiments, alternative fuels, non-motorised transport, as well as competence building among public and private authorities.*

In some cases, this may be in the passive guise of an umpire or facilitator brought in by outside parties to oversee an exchange of views between stakeholders holding different perspectives. In this context, the Centre would maintain policy-neutrality as a way of playing an umpire's role in bringing together stakeholders with clearly different opinions who nevertheless wish to address important transport.[4] Alternatively, the Centre may be invited to give clear opinions on proposed policies or interventions, which it will render without prejudice or advocacy. [5] Alternatively, for example, the Centre could provide technical

[4] A good current example of controversy is the issue of diesel vs. compressed natural gas buses. Many regions believe that converting to natural gas will lower many pollution levels, particularly those of soot and fine particulates. In New York and Los Angeles, transit authorities have focused much of their new bus procurement on natural gas, a trend that is seen elsewhere in the US and Europe. In India, the Indian Supreme Court has ordered public buses in Delhi to convert to natural gas by April 1, 2001, but as of May. 2001, only a few hundred have complied. What is not clear is the real costs and benefits of conversions or procurements of new natural gas buses vs. improvements of existing and new diesel buses and improvements in the quality of diesel fuels. Not surprisingly, there are strong positions staked out on both sides, but little work has been done to balance these positions.

[5] A key issue is the costs and benefits of advanced vehicles and alternative, from two-wheelers to large city buses. How have hybrid buses or CNG taxis (three- and four-wheeled) or electric motorbikes performed? Do such technologies make good investments for public authorities or private individuals and companies? Exhaustive, unbiased post-hoc evaluation is lacking

services to authorities undertaking major feasibility studies, such as is currently planned for bus systems in El Salvador or already carried out for bus lanes in Bangalore, India.

In other cases, the Centre may find opportunities to use its independent status and expertise to take a more pro-active brokering role in the pursuit of pragmatic solutions to specific problems – perhaps by negotiating agreements for action between different stakeholders or more specifically by introducing vetted sources of technology, services and finance to public authorities ready to act. Additionally, the Centre can actively solicit partners for a transport project getting started: pairing a clean fuel supplier with a vehicle manufacturer, bringing in bilateral assistance for evaluation of a new pollution reduction project, finding a sponsor for competence- building in transport planning, say to fund a major daily travel survey or fuel-use diary project.

E. ***A Vital Link to Other Efforts.*** *Underpinning all of the other elements of the Centre's work will be a deliberate strategy to provide a "real-time"/pro-active learning and information exchange link among key national and regional transport authorities of non-OECD countries, major companies in the transportation and fuels sectors, international agencies such as the IEA, researchers and policy analysts, the European Council of Ministers of Transport, Regional Energy Centres (such as OLADE), multi-national and national Lenders, and NGOs active in energy, environment, and transportation. All of these groups are all too often constrained by time and resources today to carry out proper analysis of many of the issues confronting them let alone exchange views, experiences and lessons learned.*

*For example, the Centre will work closely with the IEA's Energy Indicators Effort (*http://www.iea.org*) and similar efforts at the European Environmental Agency (Transport and Environment Indicators), the UN Commission on Sustainable Development (see* http://www.un.org/esa/sustdev/gite.gite.htm*) and UNDP (Environmental Indicators), the OECD (*http://www.oecd.org/env/ccst/est*), the World Bank (*http://www.wordbank.org/html/fpd.transport*, etc. The Centre will also work with the Transportation Information-Pool recently funded in Latin America by the German Trust fund, and with the various Clean Air Initiatives launched by the World Bank.*

The Centre will maintain strong ties to the motor vehicle and fuel community and first steps in this direction were taken at the Roundtable on vehicles and transportation held at the Bank in October 1998 (www.back-to-work.com/clearingtheair.html). A second step was taken with the convening of a meeting at the IEA in May of 2000 to promote the Information Pool. A third will be to form a close working relationship with the WBCSD Sustainable Transport Programme that is just beginning.

These links will also insure that the Centre approaches the most relevant problems with the best background and most potent intellectual tools, experience. This combination yields an important element missing from many views of the future – precision, not so much in forecasting as in pinpointing the blindside possibilities, future trouble spots and key uncertainties.

in most locations where these technologies have been tried, hindering the spread of good ones and – perhaps equally – permitting the proliferation of counterproductive ones.

1. The Transport Conundrum

Transportation brings people and goods to people, returning enormous benefits to economies. But transportation also brings significant undesirable side effects or externalities, particularly in urban areas and on the global environment via CO_2 emissions. While its undesirable side effects have long been recognised, state efforts to tackle the transport problem have been limited because of its inherent complexity and the costs, disruptions and long lead times involved – all of which have militated against politicians initiating substantive interventions.[6]

However, society's benign neglect of the transport dilemma cannot be allowed to continue as transportation externalities – safety, air and other pollution, carbon emissions, congestion and noise, sprawl, and other side effects - are creeping pervasively into the daily lives of ever more millions of people each year.

The situation is becoming problematic in developing countries who are experiencing rapid growth in motorised transport. In China and India growth rates in automobile and two-wheeler ownership often exceeded 10%/year in recent years. There is evidence everywhere one looks in Third World cities of transport's negative impact on local populations, (particularly the poor) and the local environment, as well as of the way pollution and congestion act as a brake on local, national and regional economic growth.[7] At the same time, experience shows that the longer the pervasive creep of transport externalities is left unaddressed, the harder it becomes to halt and then reverse this process through policy interventions.[8]

The size of these transportation externalities is surprising. The World Bank estimates that air pollution and traffic congestion lead to enormous losses in health, time, and ultimately economic growth (3). These problems are visible today in virtually every sizeable city in the Developing world. A rising number of programmes at the national, Local, and multinational (i.e. World Bank) level have taken aim at these problems. There are some successes, such as the phase out of leaded fuel in most developing countries. Yet smogs and particulate fogs as well as grid-locked traffic remain the rule in most places, in part because the growth in vehicle use is often faster than the reduction in emissions per kilometre driven.

Perhaps the costliest externality of all in the very long term, however, is not visible locally but arises from the absolute size and relentless rise in the sector's share of total CO_2 emissions. These grew from 19.3% to 22.7% in the 1990s and are forecast to expand over the next two decades to 26% of total emissions (or 4.73 Gtonnes) – some 43% higher than the 1997 level. As a consequence of this, the need to take urgent, effective and concerted action to tackle the energy-environment-transport conundrum is now shooting rapidly up the environmental agenda of the international community.[9] While few Developing Countries are expected to impose significant policy changes on transportation only for CO_2 emissions, many seek to exploit the hidden links between improvements in the transport system and

[6] The Dutch government repeatedly backed away from ambitious plans for intercity road pricing; the government of Stockholm, which had worked out a detailed transportation package in the early 1990s, saw its work fall through because of political differences

[7] The World Bank has threaded environment, economy ,and equity into their important book, *Sustainable Transport: Priorities for Policy Reform*. Washington, DC, The World Bank. 1996.

[8] A recent World Bank/IEA hosted Roundtable (http://www.back-to-work.com/clearingtheair.html documented this phenomena in New Delhi and Mexico City – where policies designed to address years of neglect of the transport challenge either had the opposite effect (leading to increases in traffic and emissions) or took so long to implement that any benefit was overwhelmed by problems elsewhere. valuable years were lost. This is a subtle but terribly important reason why urgent action is needed - once the problems (and failed solutions) get out of hand, trends are even harder to break.

[9] **IEA, 2000. World Energy Outlook**. Indeed, the IEA presents a case of intervention for OECD countries in which the growth in emissions from transport is brought to near zero after 2010.

local pollution and carbon emission restraint[10] And few countries are keeping score on the changes within the transportation system that underling growing emissions of all kinds.

2. Awareness is rising of the need for action

Rising volumes of air pollution and traffic congestion have gained the attention of authorities in virtually every major city of the world. Growing recognition that "something needs to be done" about transport is at last being translated into action of a sort. Notable, but least effective, are the rising tide of pronouncements by politicians, under pressure from their constituents to tackle the chaos on the roads and its side effects[11] In some cases, words are being replaced by action and recently, a small number of new policies and programmes.

National and International Transport Policy Reform Positions

The EU issued its green paper on transportation in 1995[12] which was followed by a similar study of transport pricing by the European Council for Ministers of Transport in 1998[13] The U.S. National Research Council's Transportation Research Board released its own assessment of "Transport for a Sustainable Environment[14] What each recognised that certain key externalities – safety, air pollution, congestion, noise, etc. --- represented enormous costs to society. These costs were borne not just by drivers but by non-drivers, particularly pedestrians and cyclists. The studies recognise that reducing the problems are represents both challenges to technology and to behaviour, both that of individuals and governance, i.e., collective behaviour. What many see as "unsustainable" is the growth in transportation activity – vehicle acquisition and use – that proceeds much more rapidly without internalisation of costs or tough regulations to stem some of the worst problems.

The IEA studied the way certain member countries have approached the CO_2 problem[15]. It was found that four of the five European countries studied had begun to strengthen price signals, either through fuel taxes or other forms of taxation that favoured cleaner fuels and vehicles and in one way or another discouraged vehicle use. The initiatives in Europe echo the thoughts of the World Bank.

All of the aforementioned studies recognised the importance pricing and of regulations. While no one argues that pricing alone will achieve all of the goals of clean transport, most agree that few private actors (i.e., vehicle and fuel companies, private vehicle users) will change technologies or behaviour without both price signals <u>and</u> regulation. But it is widely recognised that charging for use of the transport infrastructure and for the externalities imposed on others is politically difficult.

The problems are now recognised in the Developing World. Even before the World Bank's "Sustainable Transport" in 1996 broadened the topic to embrace most of the developing world, local and international studies of Mexico City, Santiago, Beijing, and other large metropolises recognised the real costs of both air pollution and congestion on health and

[10] This is the principal recommendation of Schipper, Marie, and Gorham 2000, **Flexing the Link between Carbon Emissions and Transportation** (World Bank). See also *www.iea.org/flexing.html*. A more complete version is available as Schipper and Lilliu-Marie, 1999. *Transportation and CO2 Emissions: Flexing the Link – a Path for the World Bank*. Paper No. 69. Washington: World Bank Environment Division.

[11] Former Vice President Al Gore made many statements about urban sprawl, for example during the 2000 Presidential Campaign in the US.

[12] CEC (Commission of the European Communities), 1995a. *Towards Fair and Efficient Pricing in Transport – Policy Options for Internalising the External Costs of Transport in the European Union*, Green Paper COM(95) 691 final, Brussels, Belgium.

[13] ECMT, 1998. *Efficient Transport for Europe: Policies for Internalisation of External Costs*. Paris, France: OECD

[14] NRC (National Research Council, National Academy of Sciences), 1997. *Transportation for a Sustainable Environment. Report of the Transportation Research Board* (in press). Washington, DC.

[15] IEA, 2000. *The Road from Kyoto: Current Co2 and Transport Policies in the IEA*. Paris: Int'l Energy Agency.

human activity, and pointed to the rapidity with which the pollution from transportation often become dominant over that from stationary sources. A forthcoming review led by Prof. D. Sperling of the Univ. of California, Davis organised thoughtful reviews by local experts of Delhi, Shanghai, Capetown, and Santiago points to solutions, but also shows the challenges to technology, individual behaviour, and governance that any solution brings. The World Bank is now reviewing its entire urban transport strategy, with a great deal of attention paid to environment (see http://www.worldbank.org/html/fpd/transport/ut_over.htm).

A Broader Perspective: "Sustainable Transportation"

This topic became popular after the Brundtland Commission report of 1987. Not surprisingly, it has been addressed in many of the aforementioned transport studies and dozens more, as can be seen by searching the web on "Sustainable Transport". In an early definition, "Sustainable transport means users and beneficiaries paying their full costs, including those imposed on the future" (Schipper, Sperling and Deakin 1996)[16]. Yet making transport sustainable – however defined – is no simple matter.

The reasons for the difficulties can be seen in the World Bank's description of sustainablity with three characteristics:

- Economic and Financial Sustainability. "To be economically and financially sustainable, transport must be cost-effective and continuously responsive to changing demands".
- Environmental Sustainability: "Transport has significant effects on the environment that should be addressed explicitly in the design of programs (*and systems in general [our addition]).* Making better use of readily available and cost-effective technology is necessary, but not in itself sufficient. More strategic action is also required in the form of better-directed planning of land use and stricter management o demand, including the use of pollution and congestion charges to correct the relative prices of private and public transport."
- Social Sustainability, i.e. equity. "Transport Strategies can be designed to provide the poor with better physical access to employment, education, and health services."

What is the problem with these otherwise lofty ideals is that they lead to conflicts in the sphere we would call "governance sustainability". Few local or national governments can impose the regulations and pricing and land-use controls which, taken together, might provide a balanced and equitable set of underpinnings. This is there are immediate apparent losers – private vehicle owners and transit riders who face higher costs or more inconvenience– and apparent losers in the longer term – transport operators, vehicle and fuel manufacturers, all of whom must adjust their business practices. In IEA countries we see the unsustainable element of governance in many forms:

- Continual changes in the rules of the California Zero Emissions Vehicle rules (for better or worse), recently sued by General Motors Corporation
- Challenges to European governments over fuel taxation in the fall of 2000 as a falling Euro and rising prices of crude oil stimulated truckers to demonstrate for lower road taxes, particularly environmental ones;
- Powerful resistance in the U.S. to proposed new rules for low-sulphur diesel fuel, even as political pressures are forcing many large bus authorities to switch to CNG-fuelled buses.
- Softening in many key areas of the original plans of European nations to deal with CO_2 in transportation, between the early conceptions of policies in the beginnings of the 1990s to what was on the books by 2000 (IEA 2000[13]).

[16] Presented at the OECD Workshop on Sustainable Transport, Vancouver BC, Canada, and published by the OECD, Paris. See http://www.ecoplan.org/vancouvr/enhome.htm

- The abrupt reversal by President George W. Bush of the United States' "commitment" to restraining carbon emissions.

The same problems plague the developing world in many more critical ways. If one works the first sustainability principal through economically healthy transport, whether public or private, will fight higher costs imposed by the second principal, environmental sustainability. With fares for public transit barely covering costs, few operators want to improve their vehicles or fuels and risk not covering the incremental costs. And manufacturers of vehicles for individual personal or freight transport fight regulations on pollution or safety for the same reason: higher first costs threaten sales. In a few IEA countries, these problems are mitigated by differential taxation, such as lowering the acquisition or yearly fees on vehicles that are very low emission or low fuel users. But these countries already charge wealthy users high enough taxes to have room for such adjustments. By contrast, raising diesel taxes in India in 1998 and 1999 was met with wide-spread protest. Indeed, few developing countries even passed on the full force of crude oil price hikes in 2000, and those that are oil producers often sell road fuels at less than world market prices.

Transportation is complicated by the third principal, social equity. The new Metro in Calcutta is too expensive to be used by the poor, and it is already heavily subsidised (World Bank 1996 [3]). Studies of Delhi India point to the negative social impact of higher bus fares --- very poor are shut out of motorised transport, while middle class users often switch to scooters, increasing pollution and congestion. The same concern is raised in Latin America when aim is taken at semi-legal paratransit (mini buses and vans): those riders would revert to cars or have no other way of getting around except with long walks to the trunk lines of "normal", i.e., poorly operated and inefficient public transit. Matching people to jobs and free time in an affordable way is what equity strives at, yet the spatial distribution of habitat, workplace, and play is confounding. We suspect the reasons are political will – governance – and a lack of both public and private resources to adapt to new boundary conditions – social and economic sustainability.

Why do people move around so much? Many studies point to the pivotal role of land use: "If people could just live near work (our reading, "want to live or afford to live near work") then transport distances would be reduced. Unfortunately, very few communities have solved the land use regulation problem because doing so would destabilise governance. Robert Cervero, in "The Transit Metropolis", reviews the relatively modest successes of a number of cities around the world. The two notable highlights, Singapore in Asia[17] and Curitiba in Brazil[18], are justly held up as models for transportation planning, yet neither has been replicated elsewhere. Other cities he cites – Zuerich, Ottawa, -- each made progress combining both good public transportation and land use rules, but both are still overwhelmingly dominated by cars for most trips.

There is one final element of this conundrum that makes action difficult, In its most narrow form, sustainability means not leaving unpaid cost for future generations to pay. The US NRC study identified only a limited number of externalities as truly intergenerational in this sense: CO_2 and disruption of natural habitat. To this may be added the long-term damages to human health and ecosystems of pollution. Additionally, one could argue that the fixed infrastructure laid down in any era is very difficult to change short of war and natural catastrophe. And rarely after such events do planners pause to ask how to improve the infrastructure just destroyed. In short, decisions and actions whose consequences are largely irreversible are closely related to effects that are unsustainable.

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[17] Ang, B. W., and Tan, K. C. 2001. Why Singapore's land transportation energy consumption is relatively low. *Natural Resources Forum* 25 (2) 2001

[18] Rabinowitch, J., and Leitman, J. 1993. *Environmental Innovation and Management in Curitiba, Brasil.* Washington DC:UNCP/UNCHS World Bank Urban Management Programme, Working Paper #1.

Now add the arrow of time. Economic growth usually means more cars and more transport activity in an irreversible spiral: How many metropolises find it impossible to restrict car use or impose land-use controls once cars are widespread, in contrast to Curitiba and Singapore, which acted relatively early on[19]. Normally, it is impossible to move homes, jobs, i.e. buildings, and roads and guide-ways overnight to a new configuration that would reduce travel; moving them piecemeal takes decades, during which other forces are likely to intervene to sideswipe the plan, although the reverse – building suburbs connected by superhighways – has managed to transform most cities in N. America and Europe in two or three decades. While few oppose reducing congestion now ("getting the other guy off the road") or pollution ("get rid of his black smoke"), real action still faces the classic commons problem, where the collective benefits are not felt by the individual who has to make the investment to reduce the pollution or incur the cost of not driving. And few individuals behave in a way that reflects concern for problems that face their descendants. Hence some elements of the transport conundrum echo face the usual problem of the commons or the lack of real concern for damages that accrue to the future. Politicians can make some inroads against the first set of concerns, but it is more difficult to convince individuals to make sacrifices on behalf of others not yet born.

3. The Framework for Developing Responses: AS IF ~~Data~~ Keeping Score on Transport Developments Mattered[20]

In order to develop sensible, sustainable plans and policies in transport, it is first necessary to understand where one stands and where one is heading. This issue -- keeping score on transportation and environment -- is not simply one of counting accurately (bottom-up statistics). It also rests on untangling the components of changes over time and across the population and the vehicles they use (top-down decomposition). It is vital to both allocating political credit for success and for fixing blame and fixing the problem when a policy or technology does not yield the intended benefits.

The IEA has developed the **ASIF** equation, expanding the IPAT equation to cover transport impacts in a more general (and thus complete) way (Schipper and Lilliu 1999):

$$\mathbf{G = A * S_{\mathit{i}} * I_{\mathit{i}} * F_{\mathit{i,j}}} \qquad \textbf{(1)}$$

where **G** is the emission of any pollutant summed over sources (modes) *i;* **A** is total travel activity, in passenger kilometers (or ton-km for freight), across all modes. **S** converts from total passenger (or freight) travel to vehicle travel by mode. **I** is the energy intensity of each mode (in fuel/passenger or tonne-km), and is related to the inverse of the actual efficiency of the vehicle, but it also depends on vehicle weight, power, and of course driver behaviour and traffic. (Details are given in the appendix.)

[19] There is an interesting counter example in Stockholm, Sweden. "Slussen" the elaborate set of ramps that is one of only two connections between Northern Stockholm, Gamla Stan (the old town) and Soedermalm (the southern part of Stockholm) was built in 1936 when Sweden still used the left side of the road for driving. The authorities at the time realised that the had to build a symmetrical set of ramps or forever face the spectre of huge costs should they decide to switch to right-hand drive, which they did in 1967. By contrast, did the authorities of Los Angeles think about reversibility when they removed the "Key System" trolley lines, or did the authorities of Paris worry when they took away the rail that originally went around Paris? Instead both cities had to re-invest billions of dollars decades later to try to reverse some of the impacts of these decisions, much of which went to rebuilding parallel structures!

[20] This discussion is taken from Schipper, L. and Fulton, L. 2001, "Driving a Bargain? Using Indicators to Keep Score on the Transport-Environment-Greenhouse Gas Linkages". Presented at the 75th Annual Transpiration Research Board Meeting, Washington, January 2001. Washington, DC: Transportation Research Board, National Research Council.

Box. Decomposition or Factoral Analysis

"Decomposition" or "factoral analysis" was the subject of a 1097 US National Academy of Sciences Symposium. The arithmetic falls back on the "*IPAT*" equation set out by Ehrlich and Holdren in the early 1970s.[21] Those authors symbolically related an environmental impact I to the product of population *P*, per capita activity *A* related to that impact (say car driving), and the characteristics of technology *T* that consumes a given amount of fuel and produces a given amount of pollution per unit of activity.

Key points made by those authors include:

- The factors multiply to give the result, thus relative changes are as important as absolute size. For example, a small change in a small population with a high per-capita activity may be as important as a small change in a large population with low per-capita activity.
- Factors are not necessarily all independent of each other.
- Small changes in each factor can multiply together to give large changes in the result

Indeed, the most important facet of the IPAT equation is that it is an oversimplified but useful representation of how a chain of factors interact to produce a given result or output. The approach is especially useful for showing the relative importance of factors that multiply to give a result, such as how the components of transport impact fuel use or emissions.

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What matters for transport and environment is that each of these components be exposed to transport policies as well as feedback from other components. Not all components respond the same to a given stimulus, say a fuel tax increase or a kilometre road-use fee. And not all actors, ie., vehicle operators, travelers, or shippers, will respond to the same stimuli in the same way, either. The key purpose of the **ASIF** identity is to show policy makers how the components of transport and emissions fit together, and make sure that the potential –and actual – impacts of their actions on each component are noted. In the end ASIF is only an identity, but it has a powerful effect identifying underlying factors and rates of change.

4. Where Can Interventions Take Place? Where Should they Take Place?

The ASIF framework affords a way of linking policy and technologies to particular problems that are associated with any of the ASIF components or their interactions. The following matrix was proposed by Schipper and Lilliu-Marie (1999). Shown below is the part for passenger transportation as it relates to carbon emissions, but very similar matrices could be drawn for other pollutants or for freight transportation.

[21] Ehrlich, Paul R., and Holdren, John P., 1971. Impact of population growth, *Science*, vol. 171, pp. 1212-1217, 26 March.

Table 1: Interaction Matrix:
Which Policies Affect Which Components of Travel Related Emissions?
(source: Schipper and Lilliu- Marie 1999)

Component/ Option	**A** (Activity)	**S**(Modal Share)	**I** (veh. Intensity, characteristics, load factor)	**F** (Fuel Mix)
Vehicle Fuel Economy Technology	None except through rebound	Slightly encourage modes with lower running costs	All	Affected by fuel (e.g. diesel has lower fuel intensity)
Alternative Vehicle Technology (2, 3 wheelers)	Decrease for car users, increase for the un-motorized	Shifts from other modes	Reduce fuel intensity of 2, 3 wheelers	Depends on fuel: electricity has great potential
Overall Fuel Taxation	Slight restraint, elasticity low	Favors modes with low fuel intensities	Encourages improvement in all comps.	Neutral
Carbon Taxation	Slight restraint`	Favors low carbon modes	Same as above	Favors lower carbon fuels
Km Pricing (including congestion pricing, etc.)	Significant restraint. Depends on extent, costs, time of day, etc.	Favors modes with small footprints per passenger (i.e., bus, rail)	Little effect unless permits small vehicles selectively	Little effect unless cleaner fuels exempt
Fuel Quality Improvements	Small impact if fuel prices rise	Small impact away from most fuel intensive modes, but potentially important when affecting fuels used in vehicles used by lower income people such as buses or two-wheelers	Usually small improvement in engine performance.	Can improve the attractiveness of otherwise "dirty" fuels (e.g., diesel or gasoline) over alternative fuels (natural gas or alcohol).
Alternative Fuels: development, pricing	Little effect unless price of fuel forced up	Little unless "clean fuel " modes given priority	Little, unless clean fuel more efficient	Potentially large (subsidies, taxes on dirty fuels)
Transit Development	Increases activity among low income, distance for all	Encourages its own use if supported by policies	Could take some hi-occupancy car	Could be developed to use nat. gas, electricity
Non-Motorized Transport Initiatives	Increases among those w low activity	Reduce other shares	None	None
Land use Planning	Supposedly would reduce total activity	Could increase transit share	Little	Little

A key interaction to guard against is a rebound effect, by which changes in one term of ASIF lead to changes in the opposite sense in another term. The most common of these, increased car usage with lower fuel costs (or indeed increased usage of any mode if costs fall), is small in high-income countries but can be very important in lower income countries. Perhaps the most perverse of these effects can arise when an alternative "clean" fuel is available at substantially lower variable costs than the traditional fuel, for example, LPG or CNG for cars and taxis or even diesel in place of gasoline.

Equally important is to think about the stakeholders who are concerned about possible initiatives. Their relative strengths vary from region to region, and their responses may vary too. The ability to balance these stakeholders and develop strong policies is the key element of governance required for dealing with transport problems.

(show table from Flexing the Link)

Table 2: The Governance Matrix:
Who Cares about Each Policy?
(source: Schipper and Liliu-Marie 1999)

Actor/ Option	Nat/Local Govt.	Vehicle Makers	Consumers, taxi drivers, etc,	Stakeholders and Lobbies
Vehicle Fuel Economy	Local: No influence except through procurement. Nat influence through fuel prices, standards, taxes	Hold the technologies	Choose vehicles and how to drive them.	Mainly Car industry opposing regulations to encourage or mandate. Less opposition to taxation
Fuel Taxation	Set by national or state governments	Mixed position; accept if alternative to regulation, but often defend status quo, especially through their industry associations.	Oppose!	Opposed in past by many groups
Registration, yearly, or Special Fees	Set by national or local governments	Oppose when aimed at new vehicles	Oppose	Opposed: by principal transport industries (e.g., airlines opposed landing fees, etc.)
Km Pricing (including congestion pricing, etc.)	Local and national favor for different reasons	Few have thought through what significantly lower utilization/year would mean for sales and planning!	Would oppose unless congestion benefits clear	Probably opposed, particularly by truckers and other transport professionals
Cleaner Fuels	Set Standards	Usually accept because of beneficial impacts on vehicles	Mixed, depending on costs	Often opposed by national oil companies and refiners, or transporters who have to pay the extra costs
Alternative Fuels: development, pricing	R&D, testing, pricing, introduction into market	Mixed reaction. Could favor	Suspicious unless price differential	Lobbies for fuels develop quickly
Transit Development	Crucial for planning, financing, running (?)	Some taking proactive stand (Volvo)	Urban interested; suburban not	All sides of issue
Land use Planning	Local Gov. implements, but can be based on national laws	No view	Take both sides	Usually real-estate interest, property owners organize to oppose

The table suggests that there are important groups who would be opposed to fiscal or regulatory measures. Vehicle manufacturers are not opposed to improved fuel economy *per se*, but, because of fears about market acceptance, are reluctant to commit themselves or their products to significant improvements. The challenge for analyst is to anticipate political opposition, economic difficulties, and other unforeseen problems and incorporate them into sensitivity analysis to gauge the real costs of any development. For developing countries, an additional political issue arises if a policy encourages use of a technology or product that must be imported. Conversely, the fact that some vehicle technologies are poor or old and outmoded in some countries may have more to do with trade and industrial policies than with any problems of local technical competence. India, where older models of British and Japanese cars were produced for many years, even decades, comes to mind immediately, as do the former Soviet bloc countries. Whether such policies are simply protectionist or a result of perception that newer technologies are too expensive, they cannot be put aside easily to make way for progress. Thus the Table suggests many profound positions that must be understood on a local level and met squarely in the political sphere, i.e., with political sustainability.

5. What is in the Way?

There are many kinds of factors in the way that run deeper than the problems indicated in the previous Table. Addressing them will take a long term commitment to fuse transportation issues with progress on other social fronts, i.e., improving all four of the elements of transport sustainability.

Serious inadequacies in the existing analytical and advisory policy-making infrastructure.

Lack of good data is of course no excuse for inaction, but it is a good reason to move carefully. But recent experience in many of the worst cities of the world revealed amazing inadequacies of even the most elementary data:

- The number of vehicles in use by type and fuel is not known in many countries. In India, for example vehicles are counted once, when they are first registered, but not through any yearly fees or census.
- Distances driven are also generally not known, nor is the total traffic by vehicle type.
- Hence, there are almost no real figures on fuel economy of each vehicle
- Emissions tests are rare, so emissions inventories are from simulations or norms, not from real measurements that reflect fuel quality, traffic, driver behaviour, and ageing of vehicles.

These uncertainties may seem academic, yet they form the basis for the ASIF breakdown. Without such information, authorities cannot discern good news from bad. Not knowing existing pollution per km or total km, one cannot evaluate the benefits of an improvement in pollution/km or a reduction in km very well. Lacking direct tests, it is impossible to say how much pollution a CNG bus or a combination of filter and low sulphur diesel will emit relative to the present base line. Worse, one cannot take credit for "reductions from what would have been" since there is no real base line. In some cities, notably Mexico City, traffic and travel surveys have improved knowledge greatly, but dynamic monitoring efforts are only just getting started in the Ministry of Environment.[22] A similar effort has been underway in Sao Paulo (OD surveys) under the Secretariat dos Transportes Metropolitano.

There are, of course, established centres of expertise and sources of information within academia/public interest groups, government agencies and the private sector (consultants, companies, etc.) capable of providing the sort of information and expert input that will be needed by policymakers trying to design and implement cost-effective transport interventions[23] But a careful look at this institutional and information infrastructure reveals some serious shortcomings:

[22] Comision Ambental Metropolitana, 1996. *Inventario de Emisiones a la Atmospfere en la ZMVN*. Mexico City: CAM. And Secretaria de Medio Ambiente, Recursos Naturales y Pesa y Secretaria de Salud: *Programa para Mejorar la Calidad del Aire en el Valle de Mexico 1995-2000*. Mexico City: Departamento del Distrito Federal and Gobierno del Estado de Mexico.

[23] Norway's Institute for Transport Economics, Sweden's "SIKA", India's Transportation Research & Injury Prevention Programme, Indian Institute of Technology in Delhi, the Indonesian NGO Pelangi, the Federal University of Rio de Janeiro's COPPE all have important programmes in transport policy related to environment.

- In the depth and coverage of existing information and data bases relating to the key aspects of the problem, such as vehicles in use, vehicle usage, fuel economy, and emissions of most kinds.

- The actual components of "ASIF" belong to different authorities or constituencies. For example, estimates of vehicle km are done by road authorities, estimates of mobility are done by transport ministries, estimates of total emissions are made by the air quality authorities, and estimates of emissions/km usually made by the environmental testing authority or a local university. Fuel deliveries are usually recorded by energy or fiscal authorities. Getting all of these levels (and in many cases regions) of authority to sit down and work out numbers is difficult almost anywhere.

- In the explanatory power of "models" used by analysts, policy makers and investors to understand the situation and devise optimal strategies where little is really known about the present situation, e.g., data on vehicle use, fuel economy etc as key input data.

- In the issue coverage and expertise of existing institutions – particularly among those operating in the public interest and servicing developing countries where human and financial resources for developing baselines and monitoring the impacts of policies and technologies have been almost non-existent.

- In the fact that since multi-laterals and donors assess problems and design solutions via individual "projects", they are missing huge opportunities for significant synergies, as transport externalities must be addressed from a systemic perspective as they have national, regional and urban dimensions, are shaped by cross-cutting drivers and have impacts well beyond transport *per se*[24].

The net result is a very limited information pool, inadequate understanding and scattered institutional capacity to support the sort of significant multi-national interventions, aimed at both technology and in the policy sphere, that are now recognised as necessary to have a real impact on the transport challenge. This means authorities are poorly informed and unable to obtain relatively fresh information on what is going wrong…or what is going right!

Lack of Detailed Understanding of Local Policy Context Undermines Effective Intervention

The problems these "infrastructural" shortcomings pose for the transport policy-making process are compounded and greatly exacerbated by another feature of the current situation that is by far the most serious of all the weaknesses in current approaches to assessing the transport problem and devising solutions. Even when a solution appears to be solely technological, one size rarely fits all. For elementary improvements in vehicle technology, this is appropriate. But each region has its peculiarities that affect both technology and governance.

Basically, below the national level, - in virtually all developing countries and many OECD countries - very little timely, systematic analysis of transport trends is being carried out.[25] As a result, the information available is too aggregated or broad to generate the insights and understanding necessary to design optimal, second or even third-best policies.[26] Each of the

[24] To some extent the *Global Overlays* now being produced by the World Bank have begun to develop ways of recognizing environmental benefits beyond either those of any given project or beyond those accruing only to the local environment.

[25] Even in Curitiba, Brazil, the city with the most far reaching bus system in the world, it is virtually impossible to measure the overall balance of car use, fuel use, and emissions in the city, and thus impossible to give a bottom-line fuel and emissions balance for the city. (Source *MS Thesis,* R. Marston de Texiera, Univ of Sao Paulo, 1998).

[26] Most analyses in fact hearken back to data provided by the IEA. That raises the spectre of circularities, since the IEA is stretched to the limit to analyze a limited set of internationally collected aggregate data on energy use and CO_2 emissions; the present "Energy Indicators" effort, is still in its infancy vis. a vis. collecting data from IEA Member countries and,

foregoing examples showed why what might seem like best practices can not be applied easily.

Some regional public authorities, donor agencies and well-meaning NGOs responded to the transport "crisis" with actual and proposed standards, taxes, regulations and an array of one-off, ad hoc interventions designed with little reference to reality of the local underlying cause-effect relationship of the transport externalities and system problems they are trying to address. The "forced" conversion of buses to CNG or ethanol under political pressures in many cities, and Mexico's "Hoy no Circulan" are two good examples. To be sure, these interventions may have some measure of success. But they may also prove to be an expensive waste of time and public money that allow the real problems to increase as they "creep" further and further into the warp and weave of the lives and livelihoods of everyone living in or close to urban areas. One important source of waste is not poor advice per se but the inability of authorities to follow the impacts of their interventions and discern success from failure in time to make corrective changes, in time to avoid great losses.

Even worse, the overall result of these interventions may be profound changes in the transportation system, generated via the wrong market signals being sent out, that are decidedly sub-optimal from a resource allocation, economic development and environmental protection perspective but whose efficacy cannot be assessed until its too late to take corrective action. Yet given the enormous lead times required to change transport trends and the enormous costs (environmental and economic) involved and at risk, authorities can ill afford long-term mistakes caused by inability to measure and see where the system is going. The good news is that Mexico City recovered from "Hoy no Circulan", Los Angeles and Mexico City concluded their ethanol bus programmes and moved on, and other cities learned lessons in designing their own behavioural strategies, or simply avoided the widest pitfalls and loopholes

Thus to a large degree, characteristics of technology performance, behaviour and lifestyles and in the impact of national or local policies and corporate or local, non-governmental initiatives to affect transportation are simply too poorly known to draw lessons, spot winning technologies, correct undesirable trends, or reinforce successful initiatives. For policymakers and donor agencies, this means it is almost impossible to design optimal interventions or to measure the added value of an intervention - while trends need to build up for a decade or longer before they emerge in a well-understood way, by which time it is often too late to change policies or change technologies except at very large cost.

Political Difficulties: Divided Markets and Divided Responsibilities:

One of the paramount problems of governance in transportation is that of divided responsibilities. Consider these examples of sensitive local situations where either markets (i.e., economic competition) or responsibilities (political competition) are divided:

- The role of "paratransit" is a sensitive issue in many large cities, because in the transport market, paratransit is both a competitor and a complement to organised public transit.

  In most third-world cities, informal transportation (or paratransit) co-exists with formally organised municipal buses, trams, and metros in a relationship that may not be totally sanctioned by the authorities. In Mexico City, around 30 000 "collectivos" (mini-buses

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equally important, getting member countries and major private and international interests as well to look closely at trends. And the IEA has only now begun to approach China, India, Russia, etc. to get their basic data in order.

and vans, akin to jitneys in the US and similarly around the world) have managed to garner about 30% of all trips in that region, mostly at the cost of regular bus and metro riders, but probably absorbing some car trips as well. Politically the collectivos are "tolerated", yet represent a chaotic, uninsured and sometimes unsafe mode of transport that nevertheless delivers a much desired service. Unquestionably the drivers are a strong political force. In Brazil, the equivalent modes have been brought into the system in some cities, tolerated in others yet officially hated in most. Given this tension, little effort has been made to clean up the vehicles or organise the routes to fit with bus and metro systems. Indeed, the appropriate vehicles are virtually unavailable as new vehicles in Mexico City today, making the existing aging fleet old and polluting. (the Collectivos consume more gasoline than the buses from the two public companies consume diesel!). Any transport solution must fit this kind of local circumstance squarely into the picture.

- Fierce competition between collective and individual modes has arisen in many cities, always as a function of peculiar local conditions.

In Delhi (and other Indian Cities) the most important mode of motorised transport is the two-wheeled scooter, most of which have dirty two-stroke engines. They compete directly with buses for much of the mobile middle-class. Because they are so numerous they are a significant source of air pollution and congestion, in fact they consume as much as 66% of all gasoline in metropolitan areas! Although most manufacturers are switching to clean, four-stroke engines (and even CNG for the three-wheeled taxis), these vehicles will remain a huge source of air pollution for many years. If bus fares are raised to permit acquisition of modern, comfortable vehicles with improved motors and clean fuel, one result could be further erosion of the bus market and a worsening of both air pollution and traffic. Yet if bus fares do not rise, bus operators (public, contract, and private) will stick with old, polluting vehicles based on ancient designs putting bus bodies on truck chassis.

- Fancy, new technology may be the least important component of the solution unless its acquisition and use is carefully adapted to local conditions.

In Brazil, the owners of buses are rarely the operators. :Whether owned by contractors to large cities (as in Sao Paulo), or by speculators, buses are resold after only a few years in service to the original purchaser. Most make their ways from larger to smaller cities. Hence few original purchasers are interested in expensive buses that they may not be able to resell. In El Salvador, virtually all buses were purchased used, primarily from the United States. And in both countries, small private operators dominate the bus business, few of whom can afford to buy more expensive, modern buses. While technologies to both improve fuel economy and drastically cut emissions in buses in both countries seem attractive, the present organization of the bus market presents a formidable barrier, even in the cities of Brazil with the most advanced systems, like Curitiba.

- Divided Political Responsibilities

In some important regions, political parties divided authorities. In both Sao Paulo and Mexico City, the Mayor is of a different party than the national or state government. This tends to impede progress. The most important issue diverting Federal and City authorities' time in Mexico in the spring of 2001, for example, was whether or not to move to Summer time!

- Divided Responsibilities arise where transport crosses geographical or administrative borders often undermines technological and behavioural solutions.

New York City Metropolitan Transit Authority operates one of the most important bus systems in the world. With long north-south streets on Manhattan and wide boulevards in

Brooklyn and Queens, it would seem a logical place for dedicated bus lanes. Yet MTA cannot easily develop bus paths, as it is technically a State entity, while the City of New York controls the streets. This kind of divided responsibility plagues other cities, too, such as Delhi, Sao Paulo, and Mexico, where two or more regional or even national authorities have to agree on a strategy because vehicles and people cross borders constantly. Experts in all three cities say authorities rarely do agree.

6. The Good News: Policies and Technologies are being developed

Lest this review appear unduly pessimistic, it is only aimed at being realistic. Recognising barriers and failures is as important as crowning successes, as lessons learned all around help guide future actions. Indeed, we noted that actions are being taking in key areas. Removing lead from gasoline, lowering the sulphur content of fuels, raising vehicle pollution controls, imposing some controls in traffic, and working through the governance process to bring transport operators as well as private citizens and NGOs, fuel companies and vehicle producers into a dialogue has been underway. In parallel is a larger array of smaller projects and collaborative initiatives among stakeholders emanating from multi-lateral agencies, private donors, NGOs and the private sector and all targeting transport's environmental and economic externalities[27]

Compared to the scale of the problem, these moves are very limited. Some even backfired! But they are at least indicative that the public, politicians, the policy-making system and even major private sector players are beginning at last to engage seriously with the transport dilemma and starting to look for answers. This upward trend in demand for action emanating from the public and the public sector can only accelerate in the future.

Mexico City's "hoy no circulan" was a policy that dictated that a car could not be driven one day per week, the day depending on the last number of the license plate. Newer cars with modern clean exhaust systems were exempt. The World Bank's study showed that the policy appeared to stimulate a significant uptake of used cars with license plates covering the "fifth day" in Mexico city, by those who could afford them. This led to more driving and fuel use, not less, since more cars were available.

Low Sulphur Diesel in Europe and the US. Pioneered in Sweden ("City diesel"), very low sulphur diesel has been appearing increasingly in bus fleets in Paris, London, and more recently in US Cities. The City of New York's Metropolitan Transit Authority soon will have switched all of its diesel fuel to very low sulphur diesel, and also embarked on an ambitious environmental program that has mean acquisition of several hundred compressed natural gas (CNG) buses, plans for an equal number of diesel hybrid electric buses (with significant savings of fuel and emissions) and addition of particulate filters to its diesel buses.

CNG Buses have become popular in many cities in Europe and the US. In the developing world, cities like Delhi and Jakarta have begun to convert to them, as have many cities in China. The conversion of all public buses to CNG before April 1, 2001 in New Delhi, India, has been ordered by the Indian Supreme Court, but as of May 2001, only a few hundred have been converted. When buses were ordered off the streets on April 2, some of the few that did appear were attacked and burnt by angry riders. But a useful side effect of this order is the wave of conversions of three and four-wheeled taxis, the former from gasoline, the latter from either gasoline or diesel, to natural gas. The Three-wheeled, two stroke taxis were a source of

[27] Including the World Business Council for Sustainable Development Industry Collaboration on Transportation, the World Bank's "Clean Air Initiative" with local governments in Latin America and Asia, the W. Alton Jones Foundation Clean Bus project involving the IEA and local and national governments in Asia and L. America, plans for dedicated bus-ways in El Salvador and Bangalore, India, etc).

horrendous pollution; the natural gas vehicles are no doubt burning more cleanly than those that were replaced. The real issue the Indian authorities have finally confronted is the difficulty of making choices and carrying them out in ways that meet all four tests of sustainability.

The City of Bogota, Columbia, which declared car-free Sundays, introduced its Millenia 2000 bus-way, reported to carry now several hundred thousand people per day.

A Voluntary Agreement on CO_2 Emissions from New Cars, in Europe was adopted by the manufacturers and EU, with Japanese and Korean importers agreeing to go along. The agreement targets a 25% reduction in sales-weighted new car emissions by 2008. A similar agreement was reached in Japan in late 1998. Data from the manufacturers and ECMT show that through 1999/2000, these test emissions are headed downward.

Honda Motor Co. pledged to phase out two stroke motors for its two-wheelers (scooters, mopeds), and the industry in India is slowly doing the same thing. A series of inspection and maintenance clinics is being developed in India to improve the running and reduce pollution from the millions of existing vehicles.

Thus there have been some important actions. Most of these actions are being watched closely, but not all produce cleaner air and other results that are unambiguous beyond the uncertainties of measurement. This creates problems for governance: how to take proper credit (or dole out blame) for results of initiatives?

Longer term efforts are being made. Sao Paulo is developing its long range plan, “PITU”, and Mexico City is commencing --- once again --- on a long-range vision. Bangalore India has laid out a long-term strategy for bus-ways currently awaiting international funding of the first stage, and Jakarta is developing a Master Plan of its own. Many other cities in Latin America besides Curitiba sport important new busways. Even Los Angeles, stung by the huge costs and low-ridership of its Metro and light rail lines, implemented a traffic signal synchronization scheme along two of its major bus corridors with measurable results – higher bus speeds, more passengers, and likely less fuel consumption and pollution as well. All of these achievements came about because authorities at different levels and in different regions – as well as in different parts of the same authority – began to work together to build sustainable governance for transportation.

At the same time, a number of very bold and important experiments are underway to test both technologies and behaviour, both individual and governance. RATP, the Paris transportation company, is running buses on low-sulphur diesel, natural gas, LPG, and even electric batteries, as are many other cities. The World Bank, the Global Environmental Facility, and UNDP are fostering experiments with advanced buses powered by fuel cells and diesel hybrid engines. Toyota and Honda are selling limited numbers of hybrid automobiles with very low emissions and low fuel consumption, and many companies have announced limited numbers of fuel-cell cars for sale by 2003. Cycle paths are being extended in Paris and other European cities, as well as in Shanghai and other cities in Asia and Latin America. Even Bangkok is trying, with its people mover. And the World Business Council for Sustainable Development has convened a large and far-reaching study of Sustainable Mobility, funded by fuel and transportation companies, that is engaging much of the Third World in local dialogues to diagnose the problems before imposing “solut9ions”. The first decade of the new millennium should be filled with experiments and signals about what works, and what does not, providing valuable insights into what might contribute in the longer term to the four pillars of sustainable transport.

7. The Way Forward A New Paradigm for Transport Planning and Implementation

Transportation is changing as each local system evolves and grows. These changes, and indeed the growth itself, is driven principally by changes in the choices made by individuals and transportation companies, guided or constrained by their own utility functions and by the infrastructure itself. Transportation is also changing because its technologies that provide transportation and reduce its negative impacts evolve. This evolution generally moves towards providing fewer choices, and often, lower costs as well. The kinds of vehicles, modes, fuels, and choice of speeds is far greater for many people today than ever before. Governance represents society's power to shape these forces and coax these changes in one direction or another. The goal of the Centre is to reinforce these efforts at understanding transport in the new century.

The growth of the volume and importance of motorised transport since World War Two has surpassed most expectations in much of the world, contributing in important ways to economic growth. At the same time that growth has brought with it a host of externalities that become harder to face as the transport system becomes larger and more complex. We have suggested that in many ways the lack of governance, as well as resistance by most groups in society, has permitted these externalities to rise to the levels seen today in both developed and developing countries. We have also suggested that in spite of much bad news, that technological and behavioural solutions, wedded by better governance through regulations, economic instruments, and political compromise, could gain the upper hand, and is progressing in certain key regions against some of the most notorious problems. The goal of the new Centre is to aid that progress, report on where it has slowed, and find opportunities to speed it up.

In doing this, the Centre stands for a very simple kind of new model that emphasises good science before, during and after implementation of technological measures or new policies. Fortunately this paradigm has been adopted with increasing frequency in regions around the world. But a large number of the major cities of the developing world, and even some key cities in the developed world, are only now realising how little is really known about their predicaments. This new effort aims to improve knowledge and with it, improve transportation.

8. Strategic Questions and Issues to Consider

The Centre will approach a number of strategic questions that will be discussed at meetings and on line. We proposed to discuss these in a series of meetings and then on line:

- Do the four elements of sustainable transport (economy, environment, equity, and governance) fit together? How well a match must there be among efforts addressed at all these elements for real progress to occur?
- How well do the components of **ASIF** need to be known and monitored for success with technologies and policies?
- How do technologies, short-term behavioural change, economic forces, and urban planning fit together to affect the ASIF components?
- How can governance be harnessed to provide better solutions to tomorrow's problems? That is, how do public (i.e., local and national government, international organisations, lenders, and NGOs) and private-sector roles blend for sustainable transportation?
- What is the best mode for intervention: technological experiments or policy trials?
- Is the proposed Programme too ambitious, or too limited? Are there serious omissions?

Other Questions of Interest.

There are many questions related to these issues that this effort wishes to consider and discuss within the transportation and environmental communities. Many seem academic, yet they always arise in support of – or against --- consideration of both new technologies and new policy initiatives. These are listed here in the hopes of stimulating a productive discussion in the coming months.

What is Sustainable Transportation? Where is transportation unsustainable, and where are there other problems that may be intractable?

How much worse do things have to get before they get better? What are the limits of individual and social tolerance of poor air, bad congestion, etc.?

What is the role of very high tech solutions vs. simpler, low tech solutions, and what kinds of coalitions favour one or the other?

How flexible is transportation behaviour, and what kinds of stimuli will cause people and firms to change the way they move about?

Are there time paths that suggest how high and low-tech as well as behavioural solutions can be inserted firmly into transportation policy?

What are the real powers of economic instruments, both taxation of vehicles and of use of the infrastructure (e.g., road pricing), as well as taxation of fuels?

How can the impacts of changes in transportation costs arising from imposition of economic instruments be mitigated for economically disadvantaged groups?

What are the roles of the private sector actors (transportation companies, vehicle manufacturers, fuel suppliers) in supporting policy and technology experiments?

How can governance in transportation policy be improved? What stakeholders need to be brought into the process? What happens of particular problems or the lack of solutions are clearly traced to groups in – our out – of power?

Although the transport infrastructure is mostly public, almost all of the externalities are "caused" by private users, whether individuals or transport firms. How can public actions, in the form of imposition of economic instruments and regulations or changes in the infrastructure, influence the decisions of users, as well as the decisions of the manufacturers of equipment and fuels? How much can land use planning influence transportation activity?

How certain do authorities need to be to act, and how much more do they need to know to reverse their actions, or indeed strengthen them, when they see policies and technologies not working? In short, what is the required resolving power of the ASIF identity? And how much should public and private authorities spend on pre- and post-evaluation of their experiences?

Experiments with both policies and technologies are important to resolve both technical uncertainties and to validate or repudiate policies. How much should authorities risk on projects and how long should they have to wait to get results?

Competing modes all have their supporters and detractors. Are there ways of improving the integration of modes of transport?

Competing districts and agencies with THEIR supporters often rule differently on large-scale transport projects. Are there better models of geographical and administrative integration of transportation policies?

APPENDIX: THE ASIF IDENTITY[28]

The **ASIF** identity (see Figure 1 below) can be broken down further into the number of vehicles **N**, times the average distance each vehicle travels per year **K**, not shown in the figure). For any mode i, **A * S**, gives the number of vehicle-kilometers "produced" by that mode. **I** is the average energy intensity of each mode *i*. The precise definition of **F** (emissions ratio) depends on whether emissions are directly related to fuel use (such as for CO_2) or to vehicle travel (such as NOx or CO on vehicles with emissions control equipment). A CO_2 coefficient can be calculated using the carbon content of the fuel and standard IPCC coefficients to convert fuel (or electricity) used back to carbon emissions. For other pollutants, **F** typically can be measured in the laboratory, in a test station as occurs in many US states on a regular basis, on a test track, or (preferably) using on-board or remote sensing equipment to examine vehicles in service in real traffic.[29]

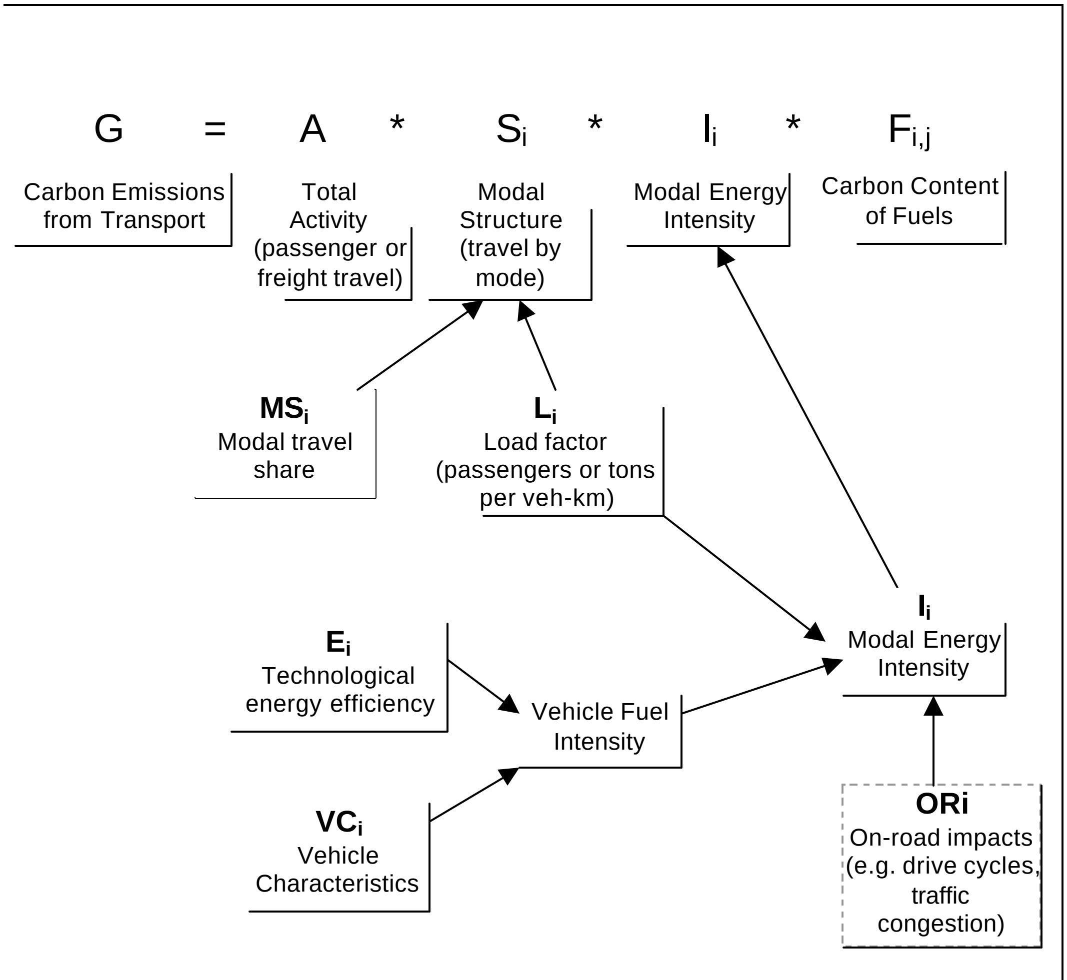
The modal energy intensity term itself is composed of several components:

$$\mathbf{I}_i = \mathbf{f}(\mathbf{E}_i \ \mathbf{VC}_i \ \mathbf{OR}_i) \qquad \textbf{(2)}$$

where **E** is technical efficiency, **VC** vehicle characteristics, and **OR** represents the difference between test efficiency and actual on-road fuel use for each mode *i*. Taking only **E** and **VC** yields what we call vehicle fuel intensity, typically fuel per kilometer of travel. While **I** is a straightforward function of the technical efficiency **E**, the impacts of other vehicle attributes **VC**, such as weight and aerodynamic shape, may be quite complex. However, this is not usually a problem since vehicle test fuel economy reflects most influences by **VC** (but perhaps not all – since some VC attributes, such as air-conditioning, influence on-road performance). However, the relationship between test efficiency and on-road efficiency is highly variable and often poorly understood and measured. This can be especially true in developing countries, where vehicle maintenance and on-road operating conditions are often quite poor. Obtaining realistic estimates of **OR** can be extremely important in developing countries as the on-road performance of vehicles is often well below their rated levels of performance under test conditions.

[28] See Reference 20 (Schipper and Fulton) or Ref 10 (Schipper and Lilliu-Marie) for further discussion.
[29] We acknowledge there are many problems associated with each approach to measuring pollutants.

Figure 1: The ASIF equation in two dimensions (CO_2 case)



Potential feedback among the components of **ASIF** is important to consider. The level of travel (as well as driver behavior and traffic conditions) affects technical performance and fuel intensity. Lower fuel costs, which can result from lowered energy intensity, can stimulate increased levels of driving. (This may be especially important in developing countries because of stronger income effects.) Consumer shifts to larger, more powerful vehicles can also stimulate drivers to use these vehicles differently (e.g. go faster). Some terms in this decomposition that are nominally "technical", for example modal energy intensities, have important behavioral components as well. Total travel and modal choice are obviously "behavioral" factors too. The same is true for changes in vehicle power, changes in traffic and driver behavior, all of which affect how technology turns energy into mobility and pollution.[30]

An additional factor that is important to this analysis, but somewhat outside (perhaps parallel to) the **ASIF** framework, is the cost associated with each component, and with changing any of the components. For changes in the technical characteristics of new vehicles, engines, or fuels at roughly constant performance, many cost data exist. But to measure the "costs" of modal shifts, demand restraint, increasing load factors, or other large-scale changes in the transportation system (as opposed to individual technologies), costs are harder to measure

[30] A main case for using Laspeyres indices is their simplicity of calculations. However, note that Laspeyres indices often leave large residuals.

without more complex economic and econometric measurements of consumer and producer welfare.

For each externality in transportation (not simply emissions), typically it is a subset of the elements of **ASIF** that are under discussion. Congestion depends largely on the **AS** at certain places and times. Noise is mostly related to **A**, as it arises from all modes, but it is also a weak function of **S**: more from a single truck or bus than car, but then cars are far more numerous. The risks of accidents and their severity depend on vehicle type and mode (as well as in use conditions **OR**). Energy use depends on **A,S** and **I** and CO_2 emissions depend on all four terms. Other types of emissions may depend mainly on **A,S** and **F** and are only a weak function of **I**. Two- and three-wheelers use far less energy/km than other vehicles (low **I**), but tend to produce far more pollutants per kilometer than all but the dirtiest cars (high **F**). The intensity subfactors **E**, **VC**, and **F** are all functions of vehicle type (including make, model and configuration), fuel type, vintage, and a myriad of on-road factors.

Aaron Golub of the University of California, Berkeley, assembled the ASIF matrix in Table 3 for the State of Rio De Janeiro from data provided by the above named authorities. His estimates are not exact, yet are authoritative. But are they accurate enough to be used as indicators for score keeping on changes in any of the ASIF components? Probably not. But the table makes an important first start to quantifying the dynamic elements of Rio's transportation activity and emissions.

Table 2. Road transportation activity, passenger movements, fuel use and emissions in Rio de Janeiro State. Source. A Golub, Univ. of Calif. Berkeley

	Travel	Vehicles	Distance per vehicle	Total Distance	Fuel Economy	Fuel Use	Emission NOx	Total NOx	Emissions/ km
	Pass-km (bil)	(thou)	Km/veh/ year	Veh-km (bil)	Km/litre	Litres (mil)	Grams/km	Ktonne	CO_2
Car-petrol	21.01	1397	10,009	13.98	10.27	1,362	0.99	13.85	218
Car-alcohol	14.97	361	7,987	2.88	4.45	648	0.99	2.85	0
Diesel-All		94	19,782	1.87	2.00	934			1319
Rio Bus	66.00	14	96,333	1.34	1.98	340	22.09	14.89	
Non-bus Diesel		80.	6,451	0.52	2.04	255	19.43	10.08	1329