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The American Transportation Systems

Nearly 18 per cent of US GNP is spent on transportation, with about one-half of that amount accounted for by cars and related equipment and infrastructure. This is down slightly from its 20 per cent GNP share held over most of the period following the Second World War, a reduction that has been attributed principally to recent economic deregulation of the for-hire industries. Transportation also constitutes a major part of business investments, representing about 13 per cent of total expenditure on new plant and equipment. In addition, transportation is a major consumer of other industries' products, accounting for some 70 per cent of the rubber, 64 per cent of the petroleum, and a quarter of the steel and cement produced (TPA, 1988; see also Deakin and Garrison, 1986).

Trends in mileage since 1982 have been mixed. Airways have grown to some 381,084 miles; highways have also increased, more slowly, to 714,255 miles in the federal-aid classifications. Intercity bus routes have been cut back sharply, while urban transit services have been trimmed in some areas but expanded elsewhere for little net change. Petroleum pipeline mileage decreased somewhat, and inland waterway mileages have grown only marginally. The rail system lost another 17,000 miles, bringing its mileage to less than two-thirds of that in 1945 (TPA).

Roadway vehicles and aircraft have been the fastest-growing portions of the transportation fleet. In 1980 there were over two roadway vehicles for every three US residents, up from less than one for every three in 1950. Qualitative changes in vehicles have also been notable over the past two decades. The widely recognized trend towards smaller, more fuel-efficient cars – actually a

trend only since the 1970s – has been accompanied by an increase in the size of the lorries and buses on US roadways. Railway freight cars have also increased in size. The urban transit vehicle fleet has become increasingly dominated by buses, which comprised just over two-thirds of the transit fleet in 1950 but over 80 per cent in 1980.

The performance of the US transportation sector is most easily considered by looking at transportation's primary functions: urban passenger transport, interregional passenger movement, and freight transportation (see also Deakin and Garrison, 1986).

Throughout the USA car use is increasing, reflecting the sub-urbanization of both population and employment, increased car ownership, and rising real incomes. In 1969, for example, on a nationwide basis, about 73 per cent of the trips to work were made by car, lorry or van, with about 7 per cent using public transit. By 1983, the private vehicle share had risen to 87 per cent; the transit share had fallen to under 4 per cent. Improved fuel efficiency in new cars kept the real cost of car use stable despite oil supply disruptions and fuel price increases in the 1970s. With the moderate fuel prices of the last few years, vehicle miles travelled have grown at rates exceeding 5 per cent a year in much of the country. Moderate fuel prices have also stimulated increasing consumer interest in somewhat larger cars.

Strategies to combat urban traffic problems often include improving transit, especially in the many urban areas where expansion of highway facilities is difficult. Transit plays critical roles in dense downtown areas and for those without other means of travel. Overall, however, most operators have not been able to attract a large ridership despite improvements in both capital equipment and services; in most metropolitan areas market share has declined. Problems include diminishing public subsidies and greater competition from both cars and paratransit, as well as a continued difficulty in serving low-density, dispersed settlement patterns and activities.

Travel demand management strategies are also being pressed into service. Most of these strategies have the advantage of being relatively low cost. However, they have produced limited payoffs; it appears that they match consumer needs for small segments of

the market. Indeed, several studies have estimated that the full range of low-cost, demand-modifying transportation measures are unlikely to produce more than 5 per cent improvements in operating conditions (Suhrbier *et al.*, 1979; Harvey, 1979).

As in the intraurban case, cars are the most important mode of transportation in interregional passenger travel in the USA. About 62 per cent of journeys over 100 miles in length are by car; air carriers serve another third of these interregional trips, with bus, general aviation and train together accounting for 3 per cent or less. Using a somewhat different definition – i.e. intercity or " long" journeys over 50 miles in length – the car carried about 80 per cent of the passenger miles in 1986.

Deregulation has also had notable effects on intercity rail and bus services. Railways were allowed to demonstrate unprofitability of a line; the result has been a dramatic reduction in services offered. Over 240 locations had their scheduled bus service reduced by more than 50 per cent within three months of the passage of the Bus Regulatory Reform Act in 1982. Increasingly, the bus services that remain are focusing on special market niches such as charter services or have gone to lower-cost franchising for ticket sales, terminal operations, and some routes.

About 40 per cent of total US transportation expenditures are for freight transportation. Changes in both the composition of economic output and the proximity of industry to markets have affected freight transportation significantly. Economic growth has been concentrated in industries with low freight densities, and the decline in freight transport's share of GNP reflects the relative decline of heavy industry. Shifts in industry location to the South and West have led to changes in shipping distances for many types of manufactured goods. These trends have tended to favour lorry over rail. So has suburbanization of wholesale, retail and industrial activities.

An important feature of American transportation policy is its lack of central organization. This does not mean that there is no US transportation policy; rather, transportation policy in the USA must be viewed as multidimensional, based on accommodation and built through accretion rather than designed to be consistent, or even coherent. The advantage of such a system is that it offers a relatively large number of entry points for new

ideas and technologies; the down side is that policies created by accretion can and do conflict, with no clear decision rule for their resolution.

A full description of the institutional arrangements and policy-making processes for all the US transportation systems could take book-length treatment. Since we are mainly concerned here with government policy and its environmental consequences, we shall concentrate most of our attention on the urban transportation modes and those features of government organization and policy which significantly affect environmental quality.

It has been said that the American public tradition is to follow the market (Altshuler, 1979). While this axiom surely holds for the transportation sector, government is also a major actor, strongly influencing virtually every aspect of transportation. Federal, state, local and special purpose governments all play major roles in the provision of transportation infrastructure. For these facilities, government is often responsible for planning, design, financing and construction, along with operations and maintenance. In some cases, interlocking sets of government agencies together provide facilities (the federal-aid highways are a good example). In other cases (e.g. many air and water port terminals), private-sector interests play partnership roles.

Federal, state and local governments are also involved in the provision of transportation services, both indirectly – as organizers, financiers and subsidizers – and directly, as operators. The federal government has been involved in such ventures as the St Lawrence Seaway Development Corporation, a government-owned corporation which administers operation and maintenance of the US portion of the seaway and, together with its Canadian counterpart, sets tolls to cover the operating budget; and Amtrak, a government-established rail passenger service corporation. States sometimes participate with Amtrak in the operation of intercity rail.

In addition to providing transport services and infrastructure, various levels of government also regulate the sector in a variety of ways. *Social and environmental regulation* focuses on equity aspects of costs and service and the management of adverse impacts of transportation systems in such areas as safety, pollu-

tion, energy consumption and noise. The trend since the Second World War, at all levels of government, has been towards an increase in both economic and social and environmental regulation of transportation, although economic regulation has been loosened quite recently.

Economic Regulation: Historically, economic regulation, especially federal regulation, has played a role in shaping the rail, pipeline, lorry, water, air, and intercity bus industries, and has strongly affected the taxi and transit industries locally. Both economic and political factors have motivated and shaped economic regulation.

In some industries, with rail the clearest example, large capital requirements and significant economies of scale, and consequent monopoly tendencies, were significant factors in economic regulation. In other industries, such as taxis, tendencies towards instability resulting from "excess competition" were reasons for economic intervention. In addition, industry desires for predictable operating environments and user desires for widespread service supported economic regulation.

Recently, however, concerns about inefficiencies and cross-subsidies resulting from economic regulatory practices have led to their drastic curtailment. Partial federal deregulation activities have occurred in the air, rail, lorry, and intercity bus industries. In several cases, federal deregulation was accompanied by restrictions on state regulation as well; also, some states reduced regulation on their own during the same period.

Social and Environmental Regulation: Regulation of transportation's social and environmental impacts at both federal and state levels grew rapidly in the 1960s and 1970s. This form of regulation has also been called into question in recent years, but few changes have actually been made.

Numerous federal (and state) laws now direct transportation agencies and industries to act in support of specified social and environmental objectives. The impacts of this regulation of transportation have been substantial. Federal car emissions controls, safety requirements and fuel efficiency standards have affected both vehicle manufacturers and users, and have spawned the development of new industries. Pollution standards, noise limits and equity provisions (such as those governing transit service for the elderly and disabled, and others calling for local

government involvement in state highway programme decisions) have steered the direction of planning efforts and have led to the establishment of new agencies and offices. State laws on these matters, which often parallel those at the federal level and sometimes surpass federal requirements, have had similar impact.

Probably the most controversial laws and regulations are those that include technology-forcing requirements. The Clean Air Act, energy efficiency standards for vehicles, and much safety legislation fall under this classification. The Clean Air Act, for example, created a regulatory approach involving both industrial and vehicle emissions controls, together with a complex State Implementation Plan for achieving ambient air quality standards; the Energy Policy and Conservation Act spelled out sales-weighted fuel efficiency standards to be met by all manufacturers. Similar laws have been adopted in many states.

Most observers agree that these laws and regulations have produced results – vehicle emissions have been reduced some 80–90 per cent from pre-control levels, and car fuel economy has more than doubled. The issues are whether the benefits are worth the costs, and whether a different style of control might be more efficient.

Government-required changes in the cars produced have particularly affected the industry. Safety, energy conservation and environmental regulations, for example, have added to the costs of producing a vehicle – costs that are reflected in retail prices. The Motor Vehicle Manufacturers Association reports that cumulative costs of safety and emissions requirements had reached some $1,700 per average new vehicle by 1983. The technologies needed to comply with these requirements have absorbed considerable resources, especially because of the short time frames in which compliance was due. At the same time, they have produced improvements in the product, at least some of which accrue to the manufacturers as well as the general public (e.g. safety requirements presumably have reduced certain liability risks).

As the preceding sketches illustrate, US transportation institutions are a complex set of loosely interrelated organizations and actors whose functions strongly reflect the histories, technologies

and markets of the modes. The institutions operate at federal, regional, state and local levels as well as in the private sector. They tend to be orientated towards a single mode, and for the most part have their own separate funding and regulatory styles. Decentralized and multiple assignments of responsibility are the norm.

Much of the policy direction from government comes in the form of investments, financial assistance, and direct subsidies in selected areas. Various forms of user charges (fuel tax, vehicle registration fees, etc.) are used to raise revenues to support these financing schemes. The major exception is transit, for which most money comes from general revenues.

The changes in intervention approaches in recent years have reflected both changing public attitudes about the appropriateness of intervention in the workings of the market, and changing opportunities and problems presented by broad social and economic trends. The movement away from economic regulation has removed barriers to innovation and allowed some improvements in efficiency. On the other hand, the evidence suggests that the vast growth in the number of lorries on the road has not been entirely efficient.

Social and environmental regulations have remained the basic approach used to direct transportation agency attention and control or moderate transportation systems' impacts. The wide range in subjects covered, and the vastly different level of control and direction implied, make it hard to generalize about effects, and especially so in the light of the lack of organizing policy direction or consistent programmatic thrust. Case examples, provided later on in this chapter, illustrate the issues and consequences for specific topics.

A final note on institutions and policy instruments is in order. The discussion here has focused on those institutions which are ordinarily considered to have major responsibilities for US transportation, and on the types of policy instruments they employ. In some ways, however, the organizations and practices that generate demand for travel are equally important in shaping transportation systems and their environmental consequences. Similarly, corporate and personal income tax policies covering such matters as the treatment of free parking, tax-deductible mortgage interest, and the like can have important transportation

implications. While a review of such broad-ranging issues is beyond the scope of this chapter, the reader would do well to bear them in mind.

Environmental Consequences of Transportation

Forms of environmental degradation

Transportation's effects on the natural, social and economic environment are both direct and indirect, positive and negative. Positive effects include the mobility and access provided by transportation systems – and the occasional inspiring design. More often, unfortunately, negative effects come to mind when transportation's environmental impacts are considered. Some argue that the harm associated with the US transportation systems, and especially highways, make it critical to reduce their use. On the other hand, an argument can be made that the best way to alleviate some of these problems is through spending on transportation capacity, technology, management and design. Such an argument could be based on an assessment that transportation's social benefits are often high enough to support fuller internalization of costs and provide for more facilities, newer and better vehicles, and more sophisticated operations.

Here we review the dimensions and costs of transportation's impact on the environment. Particular attention is given to three negative environmental impacts that have been of particular concern to US transportation policy:

- air pollution;
- noise;
- vehicular accidents.

A fourth critical impact, heavy energy use and petroleum dependence, is omitted from the discussion here but is widely recognized and closely related to the air-pollution issues.

While the three impacts addressed here are arguably the most important from the perspective of this study, many other impacts of transportation are of significant concern in the USA. These include aesthetics, community severance and disruption, vibration, visual intrusion, construction and manufacturing im-

pacts, waste-disposal problems, depletion of scarce resources, acceleration of urban sprawl, and loss of farmlands and other open space. Less work has been done to quantify these effects, and they also have been dealt with, for the most part, on an *ad hoc* basis rather than through central or widely adopted policy. They will not be considered further in this chapter, but this should not be taken as evidence that they are minor matters.

Air Pollution The United States regulates air pollution through the federal Clean Air Act, as well as through state and local laws and regulations. Under the Clean Air Act, the Environmental Protection Agency (EPA) is charged with setting national ambient air-quality standards for pollutants considered harmful to public health or welfare. The states are then responsible for meeting the standards with EPA assistance.

EPA has set standards for six major pollutants: ozone (O_3), carbon monoxide (CO), nitrogen dioxide (NO_2) lead (P_b), suspended particulates (TSP, now PM_{10}), and sulphur dioxide (SO_2). Of these six pollutants, transportation sources are responsible for much of the total emissions, except for SO_2. For example, EPA estimates that in 1986, on a nationwide average, highway vehicles produced some 58 per cent of the carbon monoxide, 34 per cent of the NO_X, and 30 per cent of the ozone precursor hydrocarbons (VOC) emitted (EPA, 1988.) Data from urban air basins suggest that transportation's role in their air-quality problems is even more severe. In Los Angeles, for example, mobile sources are responsible for 96 per cent of the CO, 72 per cent of the NO_X, and 52 per cent of the VOC emissions (SCAQMD, 1989.)

Significant progress has been made in reducing both emissions and ambient air-pollution concentrations. Between 1977 and 1987 EPA estimates that car emissions dropped some 90 per cent, while ozone levels dropped 21 per cent, CO dropped 32 per cent, NO_X declined 14 per cent, SO_2 37 per cent, and lead fully 87 per cent (due to the phase-out of leaded petrol). Nevertheless, about seventy-five metropolitan areas did not meet the air-quality standards by the latest deadline (December 1987, extended to mid-1988), and with projected growth in transportation, increases in the number of violations is anticipated starting in the late 1990s. The difficulties in attaining the standards

are complex. Uncertainties over the costs of pollution and the benefits of control, disagreements about air quality's importance in comparison to personal mobility and convenience, and conflict among agencies with different missions were all barriers to achievement, and were exacerbated by faster than anticipated growth and lower than expected fuel prices.

Estimates of the social costs of air pollution are problematic. Many of the estimates are based on enumeration of harm done and evaluation of the harm in monetary terms. Both steps must rely on heroic extrapolations of limited data. Horowitz (1982) points out that the health effects are not well understood, and even when they are, monetizing them can be difficult. For example, to assign a value to O_3-induced headaches it would be necessary first to know how much people would be willing to pay to avoid such symptoms and to what extent the symptoms cause productivity losses in affected workers. Lacking data on such matters, most studies assign them arbitrary values.

Kanafani (1983) reports air-pollution total social cost estimates ranging from $4 billion to $20 billion a year, with a "consensus" figure of $9.7 billion (1981 $), or around $14 billion in current dollars. In view of that figure, it is interesting to note recent EPA estimates that crop damage alone could be costing the USA $2.5–3 billion, and Los Angeles's estimate that damage to health and agriculture in that air basin alone sum to $3.65–7.3 billion – sharply higher costs than the "consensus" figure would tolerate.

One reason for the substantially higher estimates of pollution costs is the recent scientific evidence which suggests ozone may be more harmful than was earlier thought. EPA staff have suggested that the .12 parts per million standard be lowered to .08–.10 ppm, and others have suggested levels as low as .06 ppm. If social costs are even roughly proportional to the standards, earlier estimates could have been substantially too low. Moreover, none of the cost estimates account for the damages due to acid rain, in which transportation VOC and NO_x emissions are thought to play a contributing role, nor do the estimates consider possible global warming effects due to emissions of CO_2.

The US motor vehicle fleet is cleaner now, on an emissions per mile basis, than it was when the studies cited by Kanafani

were done. However, if we accept that costs may be substantially higher than had been estimated, average cost may be in the range of $.005–.01 per mile (for cars), or roughly 6–12 per cent of current average operating costs. Of course, such a number should not be taken too seriously. It also should be noted that costs in heavily polluted air areas could be several times higher than the upper level of the range, perhaps as much as 10 cents per mile in pollution costs.

Noise pollution Transportation noise has been regulated and managed in a variety of ways in the USA. At the federal level, the Noise Control Act (1972) directed all federal agencies to carry out their programmes in a manner that promotes an environment free from unhealthy noise, and directed EPA to set certain noise standards. Six years later, the Quiet Communities Act directed the EPA to assist states and local governments in carrying out noise control programmes. (The EPA programme has since been disbanded.) Noise provisions are also found in laws directed towards the programmes of other federal agencies such as the Department of Housing and Urban Development (HUD) and the Federal Highway Administration (FHWA).

Noise standards for various classes of motor vehicles have been promulgated by the federal government as well as by several states. Federal standards pre-empt non-identical state standards, however, and are set at high levels by international standards.

Other federal initiatives to reduce transport noise operate through modal agency programmes. For example, the Federal Highway Administration's noise policy is actually a state-administered programme carried out with federal assistance, in keeping with the federal–state partnership in highway programmes. Analysis procedures to identify noise levels and design standards to reduce noise impacts have been promulgated. Noise barriers placed at critical locations are the most common mitigation measure; these barriers deflect noise rather than reduce it.

Estimates of the social cost of noise in the USA are hard to come by, partly because exposure and reception conditions are extremely site-specific, and partly because noise has never received much public policy attention. Motor vehicle noise standards apply technology to protect the public; impacts not sufficiently handled that way tend to be dealt with on a case-by-case basis. This should

not be interpreted as evidence that Americans are not bothered by noise. Resident surveys suggest that up to half the urban population is disturbed by noise of one sort or another (EPA, 1982).

Estimates of the number of people exposed to outdoor noise levels exceeding 55 dB(A) have been carried out; they suggest that perhaps 40 per cent of the US population is so affected. But data on indoor noise levels are available in only a few cases. Cost data for the US are also skimpy. Only a few studies have attempted to estimate health costs, and costs of outdoor noise seem to have been neglected entirely. The estimate presented by Kanafani is about $.001–.002 per vehicle mile.

Accidents Roadway accidents claimed an estimated 48,800 lives in the USA in 1987. This compares to about 3,000 deaths in all other modes of transport. Motor vehicle deaths have increased substantially since the early 1980s, probably because of higher speeds. On the other hand, the 1987 death rate per million vehicle miles was the lowest ever recorded (MVMA, 1988).

Cost studies of accidents are more detailed and more widely available than was the case for noise or air pollution. Kanafani reports that accident costs (including fatalities, injuries and property damage) are in the range of $.024–.027 per mile (1975). The range probably remains reasonable, because while VMT per accident has increased in the meantime, costs per accident have risen even faster. It should be noted that, to a far greater extent than for air pollution and noise, accident costs are internalized by road users. Insurance coverage and allocation of responsibility help to internalize some of these costs, while others not covered by insurance fall, at least in part, to the involved parties directly.

Overall impact

Social costs are not easily estimated, because many impacts of concern have not been – and cannot easily be – quantified. The dollar costs presented here are gross averages which fail to account for some costs altogether and ignore distributional differences; they should be used only with caution.

Comparisons of the cost estimates to motor vehicle operating costs borne by the user are revealing. Marginal costs of passenger

vehicle operation in the USA are currently some $.07–.09 per mile. Air-pollution costs of $.005–.01 per mile would add some 6–12 per cent to these average operating costs if a polluter-pays requirement were established. Noise costs would be quite a bit less, adding perhaps half a per cent to one per cent to operating costs. While accident costs are higher than either air-pollution or noise costs, unlike the others they are already (partially) internalized; if 50–60 per cent of accident costs were not, this would add roughly 12–19 per cent to vehicle operating costs. Together, an internalization of these costs would require an increase, on average, of 20–33 per cent in vehicle operating costs, or $.02–.03 per mile. A more targeted pricing strategy would produce higher charges in areas more prone to pollution or sensitive to its effects, and this could result in considerably higher charges. While a simple cost-per-mile charge would not necessarily be the most efficient way to assure that the polluter pays, it does indicate the magnitude of underpricing car use.

Urban Transportation and Land Use Planning

In fast-growth areas of the USA such as California, urban traffic congestion has become a problem with severe political as well as environmental consequences. Traffic congestion has toppled city councils and county boards of supervisors, and in some cases has led to initiatives to restrict, slow, or even halt growth. State and federal officials also feel the repercussions of mounting congestion, as constituents press them for assistance in finding relief from traffic woes. Since traffic congestion is widely perceived as the result of new development, much attention has been directed at restructuring the transportation and land use planning process.

Government interventions in this process are many. Land use planning itself is government intervention; and ttransportation involves a highly complex and varied set of actors and policy instruments. Here, we look at actions taken to reduce car use by encouraging the use of ride-sharing, transit and other commuter alternatives, as well as by encouraging growth-management-orientated land use strategies. The case illustrates how the accumulation of disparate policies can lead to public agencies working ineffectively and at cross-purposes.

In the USA land use planning and regulation has traditionally been an activity of local governments. In contrast, transportation planning has tended to be less visible at the local level. The reasons for local government's relative inattention, at least until recent years, are deeply rooted in government organization, staffing practices, and assignments of responsibility.

Governmental responsibilities for land use and transportation have traditionally been divided, with land use assigned to the planning department and transportation assigned to engineering. Many planners have had little training in transportation and have been satisfied to leave what they view as a technically based matter to another department. Many engineers are similarly unskilled in land use planning and lack interest in the policy issues it entails. Land use and transportation activities have thus tended to proceed along separate paths, reflecting differences in the training of the respective staffs as well as differences in scope of responsibility. This tendency not to co-ordinate transportation and land use is exacerbated by low levels of local government staffing for both transportation and land use planning. Small cities, for example, may call upon outside consultants for these skills on an as-needed basis instead of maintaining an in-house staff.

One result has been that the amount of development that would be permitted under adopted land use plans and zoning is frequently not consistent with available and planned transportation capacity, or has never been checked for consistency in any detail. Of course, whether permitted development levels would indeed materialize is often questionable. In most communities, land use plans and regulations set forth the community's aspirations for physical development and the housing opportunities, jobs and tax revenues that development would imply. But because land development is overwhelmingly a private-sector initiative, communities have relatively little ability to assure their plans will be realized.

Many local governments have plans and zoning that would permit development far in excess of what market forces are likely to generate, at least over a ten-to-twenty-year horizon. Co-ordinating transportation plans with such land use plans would lead to massive overestimation of transport needs. Other

communities, in contrast, operate with relatively conservative plans and zoning but repeatedly approve developers' requests for plan and zoning amendments, permitting larger projects than were anticipated in the planning and zoning documents. In such cases co-ordination of transportation capacity with planned land uses could lead to an underinvestment in transportation.

A related problem is the impermanence of land use plans and regulations. Indeed, much of the activity of the typical planning department involves dealing with plan amendments, and modifications of the community's plans and regulations. Because land use plans and regulations change so often, continual revisions to transportation plans would also be needed to maintain consistency. Major transportation facilities can take ten years or more to plan and implement, however, making such revisions impractical and difficult to accomplish.

Whereas land use planning is almost entirely a local responsibility, state and regional agencies are major actors in transportation planning and implementation. State agencies have long played dominant roles in the provision of inter-jurisdictional roads, while regional transit agencies have been the providers of transit services. There has been a strong tendency to rely on these other organizations for planning and implementation of all but relatively small-scale road facilities. Thus local engineers' transportation responsibilities have been focused on only a limited subset of transportation: the streets and parking under local control.

Sometimes local plans as approved would create the need for major investments in state highways, in transit, or both; without these improvements levels of service would deteriorate to "F". However, only a handful of states require local governments to avoid or mitigate succh impacts; in most states, local governments are free to proceed with the land developments even when the state and regional agencies have made it clear that there are no funds available for the needed transportation improvements.

Traditional notions of public responsibilities for transportation have served to limit the scope of local transportation planning activities even further. Transportation has been viewed as a public utility to be provided on demand. While it has commonly

been agreed that local government has a legitimate role in guiding private development decisions, local government's role in transportation, in contrast, has been seen as providing the public facilities needed to assure safe, fast, efficient movement. Particularly within the engineering profession, there has been concern about the legitimacy of managing demand or denying requests for service. This concern has been shared by legislators and even the courts in some states.

Together, the separation of land use planning and transportation functions, the reliance on state and regional agencies for implementation of major highway and arterial facilities and transit services, and concerns about the legitimacy of managing transportation demand or limiting access have meant that many local governments have played partial and limited roles in guiding transportation development or co-ordinating it with land development.

The lack of co-ordination between transportation and land use plans was perhaps of less consequence in the 1950s and 1960s, when the funds were available to deliver transport facilities and services to meet demand. Then, land use plans and zoning might permit development at levels that would swamp available transportation facilities, but there was a reasonable expectation that capacity expansions would soon be forthcoming to correct the shortfalls. Today, however, traffic volumes are growing much faster than state and regional transportation agencies can deliver projects. Moreover, public concerns about the impacts of large-scale transportation projects on air pollution, energy dependence, urban quality of life, and transport finance have led many to question the advisability of continual transportation capacity expansion. Thus both the ability of state and regional agencies to "build their way out" of congestion, and the desirability of such solutions, have come into question.

One result is that local governments are finding it necessary to shoulder an increasing share of the responsibility for transportation. Because funding at the local level is limited and private funding is not always forthcoming, initiatives to increase the efficiency of the transportation system and encourage the use of alternative modes of travel or transportation systems management (TSM) options have been prominently considered. Developer exactions and impact fees have also become widespread, and

developers sometimes propose TSM as a way of reducing the need for costly infrastructure. Citizen pressures to minimize traffic impacts, coupled with resistance to new highway building, have also made TSM an attractive option to local governments. And in some areas, the co-ordination of transportation and land use has begun to receive attention.

Approaches receiving considerable attention at the present time include:

- Requirements that developers and/or employers help provide or pay for the transportation facilities and services they necessitate, via exactions and impact fees and, occasionally, benefit assessment districts. This approach puts emphasis on financing from non-traditional sources.
- Policies that call for the implementation of TSM measures, especially demand-modifying measures such as ride-sharing, flexitime and transit user subsidies, either through incorporation into the conditions of approval for new development projects or through special-purpose ordinances. This emphasizes reductions in car travel, especially peak-hour car travel, rather than its accommodation.
- Policies that co-ordinate development location, density, and/or site requirements with transportation capacity and mode choices, through general plan provisions, subdivision regulations, and zoning. This may emphasize reducing activity levels to those that can be accommodated by existing and planned transportation capacity; or may focus on site designs and development concentrations that would create environments conducive to travel by transit, bicycles and walking.

All these approaches have potential for affecting the environment. Private-sector provision of transportation infrastructure raises not only the questions about the impact of constructed facilities, but also about responsibility for environmental studies and mitigation. The TSM and transportation–land use approaches are intended to reduce rather than accommodate car use and often have an explicit environmental protection objective. Their success is not always apparent, however, for a variety of reasons which are examined below.

Transportation system management approaches

Over the past decade, a variety of TSM measures have been utilized to combat air pollution, energy consumption and congestion. Measures which increase capacity, such as improved traffic signal timing and supplementary transit services, have been pursued to the extent that budgets permit. Increasingly, however, emphasis has been given to demand-modifying measures such as ride-sharing promotion and transit user subsidies, parking price increases aimed at solo drivers, etc.

In most cases, TSM efforts have produced positive but modest results. Increases in vehicle throughput or reductions in peak-period car use in the order of 5 per cent are typical. For example, systematic retiming of traffic signals has improved average speeds and cut stops and delays by about 4–7 per cent in a number of cities (Deakin and Skabardonis, 1985); aggressive institution of car pool and van pool programmes has produced shifts from drive-alone to shared-ride commuting on the order of 2–8 per cent (with the higher percentage found principally when increases in parking fees have also been instituted: Harvey, 1979).

In part, TSM's modest performance reflects the difficulty in changing travel behaviour in a car-orientated society; given current land use patterns, activity systems, income levels and time constraints, the single-occupant car is frequently the most rational travel mode for the individual, though it may not be so for the community. But other factors are at least partially responsible for TSM's limited effectiveness (Deakin, 1989):

- First, the tendency has been to implement TSM as a series of separate projects, with different agencies and offices handling ride-share matching, transit promotion, high-occupancy-vehicle (HOV) lanes, and parking policy. This division of labour reflects the specialization of transportation professionals, but it also sharply increases the difficulty of co-ordination. As a result, the potential for cumulative and synergistic effects is often lost, and sometimes different projects even work at cross-purposes.
- Second, it has been difficult to obtain broad-based participation in TSM efforts, particularly among private-sector actors. Projects to encourage commuter alternatives do best when

implemented with employers' support; flexitime projects necessitate employer sponsorship; etc.

- Third, financing and staffing of TSM programmes have been problematic. Many ride-sharing programmes struggle for survival and staff spend a significant portion of their time securing next year's funding.

Recently, however, there has been growing recognition of the need to implement TSM measures more systematically. Multifaceted, integrated TSM programmes are being developed. Efforts to put TSM activities on stable financial footing and to broaden their client base are being made. In most cases, the objective is to increase the range of travel options available to the public and to provide incentives for using commuter alternatives; disincentives to car use are less frequently utilized. In addition, participation in many of these programmes is voluntary, or required only for those developers or employers who elect to take advantage of incentives or quid pro quos such as government-backed financing. Some jurisdictions, however, are beginning to develop TSM programmes with " sticks" as well as "carrots", particularly when TSM is tied to the approval of new development. In particular, increasing numbers of local governments are adopting policies that call for TSM measures to be incorporated into development conditions of approval, and are enacting ordinances requiring the ongoing implementation of demand management programmes such as ride-sharing, flexitime, etc.

TSM ordinances are being implemented because they offer a more uniform and certain approach to traffic management than the case-by-case approach commonly used for exactions, and because they can be used to establish procedures for ongoing programme implementation and monitoring. So far two different approaches are found in TSM ordinances. Some establish standard requirements or incentives for the support of transit use, ride-sharing, bicycling, walking, and flexible or staggered working hours, and/or mandate supportive site design and parking management practices and low-cost operations improvements such as traffic signal retiming. Other TSM ordinances call for developers and employers to establish a traffic management programme, leaving it up to the individual respondent to evaluate the options and put together a plan of action. In either case, it is

common for the ordinance to apply uniformly to broad groups (e.g. all employers of over a hundred employees), although increasingly stringent requirements may be imposed on larger developments and employers, and some exemptions by size or type of business may be available.

At present, most TSM ordinances are of limited scope and applicability. Most address only peak-period travel, or commuter trips; other trips, which constitute the greater part of the journeys made daily, are largely unaffected. Perhaps more importantly, many ordinances apply only to new development projects and employers, although application to existing developments and employers is becoming increasingly common.

The ordinances also tend to be quite weak on performance matters. Most mandate that certain TSM activities be carried out, but only a few set output objectives for these activities – the emphasis is on implementing programmes rather than on assuring specific results. For a number of programmes that do set performance standards, the technical basis for these standards is weak. In addition, estimates of mode shift potential are often "borrowed" from successful programmes elsewhere, without careful checking that the situations are analogous.

Finally, monitoring and enforcement are problem areas. Some of the ordinances are silent on these matters; others establish extensive monitoring and reporting requirements, but omit enforcement provisions. In a number of cases the public administrative costs of the monitoring and enforcement are substantial, but no additional funds have been provided to support these activities. And how to handle cases of non-compliance or sub-standard performance is an issue even when enforcement provisions are in the ordinance: there is doubt that enforcement actions will ever be taken against recalcitrant developers or employers.

Evidence of the effectiveness of TSM ordinances is limited. The hope is that they will lead to attractive commuter alternatives being offered to most peak-period travellers, and will induce local governments to commit themselves to ongoing traffic management. Even if these ordinances succeed on both counts, however, questions about their effectiveness in congestion relief or environmental quality improvement remain. In many areas through traffic and spillover traffic from neighbouring communities is a problem, but this traffic is beyond the reach of a local

TSM ordinance. For some TSM measures cost-effectiveness has been questioned; for instance, showers and lockers for bike commuters, or shuttle services to remote transit stations may not be sufficiently effective to justify the investments. In addition, the sustainability of desired effects is at issue. For some TSM measures, continuing efforts are necessary to maintain the programmes' effects. In the case of signal retiming, for example, timing plans should be developed every three to five years in order to maintain benefits – a far cry from most local governments' usual practice, which tends to be to retime signals only when serious complaints develop.

Secondary impacts which could offset the benefits or cancel them out are another concern for certain TSM measures. For example, parking restrictions are often proposed as a way to reduce car use; in some cases, however, drivers simply shift to unregulated spaces in residential neighbourhoods.

Finally, TSM's sufficiency is sometimes in doubt. Shifts to alternate modes on the order of 5–10 per cent may be attainable through aggressive TSM programmes, but this may not be enough to produce acceptable levels of service on freeways and arterials. In Orange County, California, for example, the addition of an HOV lane to a congested freeway produced a substantial increase in average car occupancy – but did nothing to reduce congestion in the peak period, since additional travellers quickly took up any slack.

General plan, subdivision control, and zoning approaches

Another approach to congestion management is to revise general plans, subdivision regulations and zoning to provide for development patterns which will help reduce overall car use. Among the many strategies being used are:

- requirements for consistency between transportation capacity and land use plans and zoning;
- adequate public facilities provisions requiring compliance with minimum performance and level of service standards;
- conditional zoning setting a range of permitted uses and densities but allowing the more intense uses if impacts are fully mitigated and/or sufficient points are earned for additional publicly desired uses, services and amenities;

- growth management approaches, e.g. caps on the number of housing permits that can be issued per year and/or the number of square feet of commercial development that can be approved per year, etc.;
- downzoning to reduce permitted densities to levels that can be accommodated with existing and planned transportation capacity;
- restrictions on uses that generate large numbers of trips;
- jobs/housing balance requirements;
- density increases and/or bonuses in areas well served by transit, or as an incentive for developer provision of transit and ride-sharing;
- subdivision and site plan requirements for bike lanes, pedestrian pathways, transit turnouts and shelters, etc.;
- site design requirements for clustering of buildings to make walking, biking and other commuter alternatives more feasible and attractive;
- requirements for the provision of onsite services, e.g. convenience stores in housing developments, etc.

While each of these strategies has proponents, considerable disagreement remains about whether they are useful in managing congestion. First, most of the strategies are future-orientated; they arguably could shape land use and transportation patterns in the long run, but will not necessarily produce an immediate benefit. Moreover, there is no consensus on which of these strategies are effective.

Jobs–housing balance proposals illustrate the kinds of arguments that arise. The lack of affordable housing has been cited as a cause of lengthy car commuting; therefore the creation of communities where one could both work and reside has been proposed as a way to shorten trips. But others question its effectiveness, noting that many factors in addition to commuting distance influence housing location decisions. And still others point out that vehicle trips in the three-to-ten-mile category would probably increase under most jobs–housing balance schemes.

Political acceptability, however, is probably the most important issue concerning co-ordinated land use/transportation planning. Local officials resist proposals that would compel them to co-ordinate land use and transportation, despite concerns about

congestion; the steps such a requirement might necessitate are too controversial. Making land use and transportation plans consistent with each other would often mean either downzoning or developing considerably more transportation facilities and services. Downzoning could lead to conflicts with property owners over development rights, or be unattractive from an economic development/tax base perspective, while transportation expansions would raise financial and environmental issues – all problems of the sort local officials try to avoid.

Parking management: requirements in conflict

Parking management is a good example of a measure which analyses indicate to be highly effective at congestion relief, energy conservation and emissions reduction, but has been implemented in only a few areas. While parking management encompasses many strategies, here we shall consider the supply and price of parking provided for employee use and its impact on travel choices (see Deakin, 1989a).

Parking is provided by many US cities in municipal lots and garages. Because local governments do not pay taxes themselves and most have access to relatively inexpensive money, they can provide parking at less than it would ordinarily cost the private sector. When costs are low, cities often appear to make money on their parking supply activities while charging low rates. Even if municipal parking loses money, however, many localities justify it on the grounds that a convenient supply of parking supports economic development and business retention. Parking is also provided voluntarily by the private sector. Depending on land prices, demand patterns and parking rates, some companies apparently generate a profit by providing parking as a principal use. Often, parking serves as an important interim use during land assembly and building design and approval, bringing in enough revenue to cover holding costs.

Most US employment centres provide three to five parking spaces per thousand square feet of building floor area. There are several reasons for providing this parking:

- City zoning usually requires it. Concerned about the problems which might result from inadequate offsite parking, many cities have established requirements which would protect them from

maximum demand at an assumed zero price.
- Banks often require parking even if the zoning code does not. While not an iron-clad rule, developers report that proposals lacking plentiful parking are seen as riskier and may raise the cost of the loan.
- Plentiful parking is seen as an important competitive factor in the marketing of buildings and retention of tenants.
- Parking is seen as necessary from a public-relations perspective, to avoid problems from spillover into others' parking facilities or to the on-street spaces in residential neighbourhoods.
- Parking can occasionally be a good money-maker.

Another question is: why is parking provided free of charge? Here, too, there are several explanations, including most of those listed above. Some of the particulars reported by developers and employers are as follows:

- In some areas, parking can be provided at little cost in surface lots. Collection of fees and the responsibilities it entails can be not worth the effort.
- Local government restrictions such as setbacks, coverage requirements, etc., may mean that there is no alternative profitable use for the land. Providing surface parking may be cheaper than landscaping.
- For garage spaces within the building, separate cost accounting may not have been done. Allocation of costs of shared foundations, etc., may appear unduly complicated to the developer.

Perhaps more importantly, free parking is widely viewed as an important tenant amenity and employee benefit. Parking costs are thus embedded in lease terms and absorbed as a (tax-deductible) operating expense rather than charged to employees. It is estimated that nationwide, about 80 per cent of all employees receive free parking, and another 10 per cent pay only a portion of the cost (Shoup, 1982; UMTA, 1988).

Free parking is not, however, free in any real sense of the word. In most urban areas of the USA, a 320-square-foot space in a surface lot, financed over a thirty-year period at a 10 per cent interest rate, would cost at least $20–25 per month. A space in a garage would cost more: in most markets, construction costs

would run to $10,000–15,000 per space if the structure were above ground, and to $20,000 or more if below ground. Such spaces, considering amortization and operating expenses, would cost att least $120–250 per month.

Analyses indicate the size of the effect that charging for parking would have. Modelling results suggest that price cross-elasticities are low, in the .1–.3 range for most commuters, meaning that a doubling in drive-alone travel costs would reduce traffic by 10–30 per cent (Harvey, 1979; Suhrbier *et al.*, 1979). But even a moderate parking charge could double drive-alone commuter costs. Commuters behave as though their trips cost them 7–9 cents a mile excluding parking (fuel at 4–5 cents plus a little for oil, maintenance, etc.). At the median US commuter trip length of ten miles one way, operating costs are some $1.40–1.80 a day. Thus, parking at $30–35 per twenty-day working month would more than double the cost of the drive-alone journey – which should in turn cut drive-alone commuting by 10–30 per cent. Studies in Los Angeles have reported that a 30 per cent decline in drive-alone did, indeed, occur under fairly similar conditions to these (Shoup, 1982).

However, there are several barriers to change. First, the federal tax code is not supportive of a change in policy. Free parking is classified as a working-condition fringe benefit to employees. As such, parking is a tax-deductible expense for employers. Furthermore, the value of these tax benefits has no ceiling, and as indicated above can exceed $200 per month per employee in some areas. On the other hand, van pool and car pool subsidies are treated as taxable income, and transit pass subsidies are deductible only up to $15; any subsidy above that amount results in the *entire* subsidy being treated as taxable income. Thus the subsidized employee would pay the marginal tax rate for most of the market value of the subsidy, and the employer would have to undertake additional record-keeping and reporting.

Attempts to redress this disparate treatment have so far failed. Given the federal budget deficit, any change would probably have to be tax-neutral. Thus, proposals simply to raise the permissible subsidy to commuter alternatives have so far failed. The Urban Mass Transportation Agency has suggested that an alternative approach would be to exempt all commuter subsidies up to $60 and to tax all over that amount; but they note that the taxes

would fall principally on core areas of major cities and hardly at all on suburbs (UMTA, 1988). Moreover, observers argue that the van pool/car pool taxable benefit is unenforceable in any practical sense because of the trail of audits that would be needed, as well as difficulties in determining "market value" of the van pool trips under many common circumstances. At the same time, market value of parking spaces could also be hard to establish given current cost accounting and leasing practices. Some conclude, then, that the only serious problem with the current situation might be that some employers are dissuaded from providing ride-share financial assistance because of the law.

Another reason for caution is that commuters may find ways to circumvent a parking surcharge. Many will make use of offsite free parking, especially if it is within walking distance. For example, in the central areas of Berkeley, California, where free employer-provided parking is rare and off-street spaces cost $35–65 per month, a severe problem with spillover into residential neighbourhoods has developed. In a number of other cities, commuters reportedly park in residential districts near transit stops and take the bus or train the last few blocks to avoid paying for parking.

Being among the first developers, employers or cities to forgo free parking could be uncomfortable. For developers or building owners/managers, competition from other buildings would be a concern, and banks might be reluctant to lend if the competition were to have better parking. For employers, taking away a benefit is usually nigh-on impossible; also, parking could become a labour negotiation issue. Not providing parking in the first place might be somewhat easier, but could be problematic in a tight labour market. For cities, the threat that a developer would merely "go next door", taking away desired tax base, is frightening.

Transportation and Air-Quality Planning

The Problem

In the USA, significant accomplishments in air-pollution emissions control have occurred over the past twenty years. Emissions have been substantially reduced by both industrial and transportation sources; over the ten-year period 1977–86, the EPA reports improvements in each of the six air pollutants for which health-

based ambient air-quality standards exist. Yet major problems remain:

- Some 100 million Americans live in the seventy-five or more urban areas that still violate the air-quality standards for ozone or carbon monoxide (CO). EPA reports that mobile sources make up one-half or more of the volatile organic compounds (VOC) and nitrogen oxide (NO_x) emissions in many cities, and that the CO non-attainment problem is almost entirely the result of mobile sources.
- Acid rain is increasingly recognized as a national and international problem, and while industrial emissions are the main culprit, transportation emissions of VOC and NO_x have also been implicated.
- While additional emissions reductions are technically feasible from industrial and vehicle emissions controls, regulation of fuel composition and handling, and more stringent vehicle inspection and maintenance, the costs of such reductions will probably be high and political opposition can be expected.
- Growth effects will begin to erode the transportation sector's air-quality gains of the last two decades unless additional control measures are implemented. In particular, increases in both the number of vehicles in use and the total vehicle miles of travel will more than offset the reductions expected from vehicle emissions controls if they remain at current levels. In especially fast-growing areas this may already be occurring; data released by EPA (1988) indicate that the number of metropolitan areas exceeding the allowable one-hour ozone level of 0.12 part per million increased from sixty-two to sixty-eight in a year. While the trend in CO levels is still downward, a reversal is projected to occur starting about the year 2000.

Given this situation, efforts to reduce emissions through transportation control measures are again being proposed, as they were under earlier air-quality planning efforts – see also Deakin (1989b), Deakin and Harvey (1982) and Suhrbier and Deakin (1988).

Economists have raised questions about the efficacy of additional emissions control, and they and policy analysts raise

questions about trade-offs with other valued goals. We shall not examine their arguments here except to note that the US Clean Air Act does not take into consideration the cost-effectiveness of various measures. As a result, overcontrol from a marginal costs and benefits perspective is a distinct possibility, as is undercontrol.

Clean Air Act renewal legislation, currently being developed, may assign an important role to transportation control measures. In one early proposal, eight categories of TCMs were set forth for use in offsetting the emissions associated with VMT growth. In another early proposal, the use of TCMs was to be encouraged in severe non-attainment areas through a fee on petrol and diesel fuel up to 5 cents per gallon in order to cover up to 50 per cent of the cost of TCM implementation. While Administration drafts have omitted explicit discussion of transportation controls, the drafts would require that non-attainment areas demonstrate a minimum average annual emissions reduction of 3 per cent from a baseline emissions inventory, after accounting for growth. Most non-attainment areas would have to utilize transportation control measures in order to achieve such an annual reduction target (EPA, 1987). Indeed, EPA is proceeding to develop guidance on transportation control planning in the expectation that additional actions will be needed one way or another.

Strategies which may be included under the TCM rubric include "technological fixes" such as additional on-vehicle controls, fuel substitution, and planning measures aimed at altering behaviour. The technological strategies have many proponents, but they raise concerns about declining benefits per dollar expended, and most entail substantial uncertainties. For example, substitution of methanol for diesel in heavy lorries and buses raises questions about whether adequate engines can be developed, as well as questions about methanol's toxicity and greenhouse gas contributions. The uncertainty concerning technological strategies is one of the reasons controls aimed at passenger travel behaviour are again being proposed. Transportation controls are also of interest, because of congestion problems. The same measures being proposed for TCMs are being tried out for congestion relief.

Past experiences with transportation control planning provide a clear example of the problems that can plague government

interventions. Conflicts among agencies, failure clearly to assign responsibility for action, uncertainties about effectiveness, and implementation finance difficulties all plagued the transportation–air-quality planning process.

The Legislation

Transportation controls were not initially a central feature of the Clean Air Act Amendments of 1970. That legislation mandated the establishment of health-based ambient air-quality standards, set nationwide deadlines for the standards' attainment, and required the implementation of new car emissions controls. Within that framework, states were required to prepare State Implementation Plans (SIPs) that would demonstrate attainment of the air-quality standards, but were given flexibility to devise such additional measures as they selected to meet the standards by the deadlines. The focus of the Act, and its legislative history, make it clear that technological changes were expected to reduce both industrial and vehicular emissions to levels necessary for attainment of the standards. "Transportation and land use" controls were mentioned as an option that could be included if necessary, but the Act did not discuss the nature of such controls.

By 1973 it had become clear that political, economic, and technological constraints would make achievement of stationary and mobile source emissions reductions a slow process, and that most metropolitan areas would be unable to meet the Act's 1975 attainment deadline. This gave the "transportation and land use controls" phrase in the 1970 Act new importance. At first, EPA took the position that transportation control measures were too new for them to be implemented feasibly within the deadlines; EPA consequently exercised its statutory authority to extend the attainment deadline by two years, to 1977, for all areas needing transportation controls. However, environmental groups successfully challenged in court the use of automatic, blanket extensions, and EPA was enjoined to mandate transportation control plan development aimed, at least initially, at the 1975 attainment date. Operating under a tight deadline and with limited input from transportation agencies, state air-quality agencies produced highly controversial plans that included a range of transit incentives and car disincentives. Petrol rationing was

mandated when that was the only way 1975 attainment could be demonstrated. Based on problems with implementing these plans, EPA then granted the extensions that it had initially proposed.

In most areas, the extensions provided the opportunity to modify the SIPs to remove the most controversial measures and refine other plan elements. Implementation of some measures proceeded, while others were submitted to further study. Progress was made as new emissions controls were introduced on cars and industrial sources. Despite these gains, it was soon apparent that the ambient standards could not be attained by 1977 even with transportation controls.

Congress addressed this problem in the 1977 Clean Air Act Amendments, modifying the deadlines for attainment and inserting much greater detail on transportation controls into the text of the law. In effect, urban transportation controls became another key element of the Clean Air Act strategy, providing the "safety valve" required to sustain rigorous performance criteria in the face of political and technical realities.

Diagnoses of the pre-1977 attempts at transportation control planning had revealed a number of problems. Reviews of early plans found that many transportation provisions were narrowly conceived, partially specified and poorly analysed. This appeared to be partly the result of tight deadlines and limited resources for producing the initial control plans, and partly due to the fact that there was little direct experience with many of the measures, nor was there data and know-how on which to base forecasts. Early plans had also been developed largely by agencies which lacked funding control or implementation authority for the transportation measures they suggested. In any event, many of the early plans included measures such as high-occupancy-vehicle lanes without stating exactly where such lanes might be located or how they would be financed; proposed major increases in transit service without consultation with the operating agencies; etc. The result was often a plan that was at once controversial, vague, of questionable effectiveness, and not demonstrably feasible.

The 1977 Amendments and the guidelines that followed addressed these concerns in some detail. Deadlines for preparing transportation control strategies were extended. A list of measures presumed to be "reasonably available" was included in the

legislation. EPA was directed to produce information documents on the measures and on analysis and forecasting methods. Planning procedures that encouraged greater responsibility and action on the part of funding and implementing agencies were spelled out.

Key to the process was the requirement that a SIP revision be produced which demonstrated that the air standards would be attained, and that "reasonable progress" towards that objective would occur. Failure to produce an approvable plan could be dealt with by the withdrawal or restriction of federal transportation funds. Some $75 million in special funds were authorized to pay for transportation control planning and analysis.

The result was a highly structured process for transportation control plan development, with a dedicated funding source. The central activity in this process was the analysis and evaluation of the full range of reasonably available measures, with detailed development of those that appeared to be feasible in each area. Planning was to begin with a broad look both at the listed measures and at other components of ongoing planning activities; the preliminary evaluation was to consider a full range of impacts. Political, institutional and financial feasibility were also to be analysed. Measures which survived this initial screening were to undergo detailed design and further evaluation, then be integrated into an overall strategy for air standards attainment. Finally, the best options were to be moved forward to implementation through timely inclusion in work programmes and budgets.

Responsibility for carrying out this process was generally assigned to a lead agency, usually the metropolitan planning organization (MPO). Funds were allocated to the agency to pay for plan development. State, regional and local agencies with project approval and implementation authority were to participate throughout the effort, and were expected to assure consistency between air-quality planning and other planning activities. Part of the adopted plan was to be a clear statement of implementation responsibility, along with a demonstration of capability to fulfil implementation commitments.

Public involvement was to be a key component of the transportation–air-quality planning process. The role of the public was seen as twofold: first, citizen input and the response of elected officials were to provide an assessment of the acceptability of

various proposals; second, people concerned about the environment were to be given greater access to decision-making, so that programmes and projects beneficial to air quality would stand a better chance of being adopted.

The effectiveness

In short, the 1977 Amendments spelled out a rational-model planning process with strong pragmatic elements, but how well did this model work? A review of experience in a variety of urban areas indicates that results were mixed. Significant problems resulted from the legacy of previous transportation–air-quality planning efforts; difficulties in integrating air-quality planning and transportation planning; the relatively low priority given to air-quality attainment by most transportation agencies; and the lack of earmarked funds for the effort. On the positive side, Clean Air Act funds supported the first systematic analyses of transportation management and control strategies; and led to the implementation of certain beneficial transportation measures that might otherwise have been disregarded, while accelerating the implementation of others.

Legacy of earlier TCM planning effort In the early period of transportation control planning, air-quality agencies, working against tight deadlines and under court orders, often proposed measures which were widely seen as unrealistic and even punitive. While such proposals served primarily to justify the need for extensions of the attainment dates and were quickly withdrawn, they left many transportation planners, local officials and private-sector actors with the opinion that air-quality agency staff had an unrealistic view of the significance of air pollution as a public issue.

Problems also arose because clean air advocates were initially not knowledgeable about the planning or funding of transportation projects, and lacked experience with which to judge the feasibility or potential effectiveness of the proposals they were making. For example, air agency staff and environmental lobbyists advocated major expansions of bus services in suburban areas as a way of reducing car use, proposed that the MPO impose region-wide surcharges on commuter parking fees, recommended development bans in areas not served by transit, and proposed to

spend funds designated for a freeway expansion on ride-sharing programmes instead. These suggestions were often made in what was perceived as a confrontational way: i.e. in terms implying that transportation agencies had "caused" the air-quality problem.

It has been difficult for air agencies to overcome the doubts and antagonisms engendered by these early experiences. Indeed, transportation agency staff, business representatives and local officials continued to bring up these early experiences in discussing why they preferred not to be too closely identified with transportation–air-quality planning. Even though air agency staffers grew more sophisticated and no longer treated transportation agencies as "the enemy", bad feelings lingered as at least a partial barrier to increased co-operation.

Difficulties in integrating air-quality and transportation planning The fit between transportation–air-quality planning, as described in the 1977 Amendments and implementing regulations and the ongoing activities of the agencies responsible for the delivery of transportation facilities and services was far from perfect. Most of the lead transportation–air-quality planning agencies did carry out detailed studies of transportation control measures, and in so doing developed enhanced skills in air-quality analysis and a better understanding of what might be accomplished. However, translating these detailed studies into implemented programmes and projects proved to be another matter.

One factor was that most of the money provided for transportation–air-quality planning was retained by the lead agencies (usually the MPOs) to carry out the required analyses of the candidate measures and to put together the required planning documents. However, the MPOs themselves have few implementation responsibilities. The funds available for TCM planning were not adequate to allow for substantial pass-throughs to the implementing agencies. Most lead agencies spent the funds meeting the paperwork requirements, simply consulting with the other agencies.

Not surprisingly, TCM planning done by MPOs was orientated almost exclusively towards the projects and programmes included in their area-wide plans. Often, this meant conducting a detailed

air-quality analysis of the projects in the area's formal transportation planning documents, including (in the late 1970s and early 1980s), the transportation systems management element of the regional transportation plan; listing short-term operational strategies for improving the utilization of the existing capital stock; a transportation improvement programme (TIP); and an annual compilation of projects budgeted for implementation in the coming year or formally scheduled for implementation within five years.

Sometimes, different scenarios regarding funding levels and project priorities were tested; in other cases the adopted five-year and long-range plans were simply assumed to be given. Under either approach, the measures emphasized were – or could be – included in the regional plans and programmes: large or area-wide projects sponsored by state transportation agencies, transit operators and area-wide ride-sharing organizations, such as high-occupancy-vehicle lanes, new transit facilities and services, and regional car pool and van pool programmes. Most plans did include local projects funded with federal or state dollars, but locally financed TCMs received little attention.

But many TCMs, including parking management, most bike and pedestrian projects, and the majority of traffic engineering and traffic flow projects, rarely appear in regional plans and programs. These small-scale projects are for the most part developed and implemented by local agencies with little or no federal or state funding. For these TCMs, the regionally orientated planning approach was problematic. In some areas, the lead agency performed a general assessment of the feasibility and effectiveness of locally funded TCMs and stopped there; in other areas local projects were considered only if the local agencies themselves had developed and analysed them.

Secondary priority given to air quality Another problem with TCM planning stemmed from the relatively low priority accorded to air-quality issues by transportation professionals and local decision-makers. Transportation agencies clearly have had difficulties in reconciling air-quality goals with their own missions to improve mobility. In several areas, air agencies and transportation agencies disputed whether major highway projects were consistent with clean air goals.

Conformity requirements in the air-quality legislation illustrate the kinds of differences that often arose. The conformity provisions of the 1977 Amendments were intended to transmit a sense of urgency to urban transportation organizations. Under these provisions, various federal funds destined for a metropolitan area could be withheld if the planning organization did not demonstrate conformity between the transportation control plan and the transportation plans and programmes of the MPO.

EPA took the position that conformity meant no project should be approved unless it had been analysed and found not to create a violation or delay in attainment. DoT's position was that conformity merely meant that specific projects in the TIP were proceeding as scheduled. Eventually the two agencies reached an impasse, and gave different field instructions to their personnel.

There are other reasons for the low priority given to TCM planning and implementation. One is a widely held belief that until automotive technology changes substantially, little more can be done to relieve the car emissions burden, short of drastically restricting car use. Many transportation professionals believe that alternatives to the car are already in place and that those who conveniently could use them are for the most part doing so. They see gains from additional incentives and expenditures as potentially very costly, and not likely to make much difference. Furthermore, most professionals are decidedly reluctant to limit personal transportation choices through government policy, and many fear that car disincentives might hurt the local economy by reducing locational attractiveness.

In addition, many professionals report greater concern about industrial emissions and related problems such as acid rain than about car emissions. Even environmental groups suggest that control of the former air-pollution problems are of greater interest to them than transportation control. Thus there is little public pressure to "do something" about transportation-related emissions.

Reluctance to take stern action to control emissions also results from ambiguities in the scientific basis for air-pollution regulation. Among transportation professionals, a common view is that onerous steps should be taken only if there is a clear danger, and they see the case for air pollution as a clear danger as not yet established.

Effectiveness of transportation control measures Transportation control measures can be grouped into several categories, according to their primary objective or effect:

- **Improvements to alternative modes.** These increase the attractiveness of transit, car pools and van pools, bicycling and walking in comparison to the single-occupant car.
- **Disincentives to car use.** These are designed to discourage travel by single-occupant vehicle (SOV), usually by restricting their movements at certain times or in certain places, or by removing subsidies, increasing costs, or decreasing convenience.
- **Operational improvements for emissions reduction.** These are intended to reduce vehicular emissions directly without necessarily changing the amount of car use.
- **Technological changes to reduce emissions.** Fuel, engine, or other equipment changes reduce emissions per mile.
- **Reducing the need for travel.** These measures allow individuals to engage in desired activities with less travel – e.g. by substituting communications technologies.

TCM effectiveness depends on a number of factors, including the number and type of trips affected. For many of the measures included in transportation–air-quality plans, a major limitation is that they apply only to work travel. The journey to work is a natural target, both because it is the most susceptible to shift to alternative modes and because it is most likely to occur in congested conditions. But work accounts for only a third of the vehicle miles travelled and 20–25 per cent of the journeys in most US cities. Suppose that drive-alone accounts for 70 per cent of the travel to work in a specific area; shifting fully half of these commuters to alternative modes would affect only about 11 per cent of the VMT and less than 8 per cent of the trips. Since a more likely shift is less than 10–15 per cent of the drive-alone trips (Horowitz, 1982) net benefits per work-trip-orientated measure will probably not exceed a few percentage points in overall air-pollution reduction.

Another factor is the geographic scope of implementation of the TCM, and the percentage of trips affected. For example, car

restricted zones can reduce VMT, emissions and exposure levels. However, they are suited to central business districts and other concentrated areas of activity. Only trips that would otherwise have entered such areas would be affected. Similarly, freeway traffic flow improvements have an effect only on those trips using the freeway and, perhaps, parallel routes. As a third example, a city-wide tax on parking would affect the travel choices of only those commuters for whom the tax raised the cost. In many areas, only 10–20 per cent of all employees, and virtually no customers or clients, pay for parking.

Taking such factors into account, analyses indicated that TCMs would produce emissions reductions on the order of ½ to 1 per cent per measure, or 5 to 8 per cent for the total package (Suhrbier *et al.*, 1979). While this was not a minor amount, it was not large enough to persuade doubters that TCMs were worth the effort.

Funding problems A final problem was the lack of clear funding sources for TCM implementation. While Clean Air Act planning money made it possible to evaluate TCMs, funds were not provided to pay for their implementation. This restricted both what was considered and the priority given to the candidate programmes and projects.

The lack of clear funding for TCMs was exacerbated by the shortfalls in transportation funds which had begun to appear in the early 1970s. In many areas, lack of funds was making it difficult to implement even strongly supported projects: there was a great deal of competition for the available money. There was little interest in funding TCMs by cancelling or substantially postponing other projects. Operating under the politics of "fair-share", even the most desirable TCMs thus ended up far down on the funding list; the time frame for implementation was more likely to be six to fifteen years rather than the five years or less available before the Clean Air Act's deadlines of 1982/1987. This reinforced lead agencies' tendency to evaluate only projects that were already under consideration. Furthermore, a number of TCMs are not eligible for funding under most federal and state programmes; they have no established source of financing except for local general funds.

Consequences

The transportation–air-quality planning case shows how conflicts between agencies with different missions can develop and undermine implementation of environmental policy. The Clean Air Act's concept of transportation control assumed that clean air goals could be "piggybacked" on to existing transportation programmes, transforming the latter while assuring the availability of transport know-how and funding for implementation. But the legislation left the transportation agencies' missions, decision rules and formal and informal support networks intact; few changes in practice were explicitly required of the transportation agencies, and in the few cases where they were, first "paralysis by analysis" then open disputation were used to deflect pressures for change in transport policy direction.

If reductions in the federal role in transportation now being proposed come to pass, implementation of TCMs will become even more difficult, since the leverage provided by withholding federal funds due to " inconsistency" would no longer be available, or would be greatly restricted. Similarly, if private finance of transportation infrastructure becomes more common, broad questions about obligations to include TCMs, or in some states even to consider air-quality impacts, may arise. Significant rethinking of institutional approaches, incentives and penalties will be needed in either case.

Whether a more favorable institutional arrangement would make a difference in the overall performance of TCMs, and hence in the net social cost of transport, is a difficult question. If the estimate of 5–10 per cent combined reduction in emissions is approximately right, TCMs would not be sufficient to attain the air standards in the most seriously polluted areas; additional new car controls, alternative fuels, and industrial controls would still need to be considered again. Nevertheless, a 5–10 per cent reduction is appreciably greater than what was actually achieved, except in specific market niches. Moreover, if TCMs are valued for other purposes, such as congestion relief, a new round of TCM efforts armed with hindsight and public concern might be cost-effective, and could reduce controls needed in other sectors so they, too, might perform better.

Assessment and Prospects

It is difficult to estimate the magnitude of effects of current US policies on the efficiency, size and composition of the transportation sector, or on larger but clearly related issues such as economic development, patterns of trade, land use and development patterns. Road users are often not covering the average costs, let alone marginal costs, of the services they consume, and this leads to overconsumption, with attendant air pollutant emissions, noise, and other harm to the environment. In turn, underpriced road transportation supports higher vehicle ownership, longer trips, and perhaps more urban and suburban sprawl than would otherwise occur.

It must be recognized, however, that numerous government interventions distort land markets, development patterns and transportation costs. For example, for the individual or household important interventions include housing subsidies, as well as zoning, urban limit lines, and other growth restrictions. Depending on the nature of the market and level of demand, the benefits and costs of such interventions may or may not be capitalized, making it hard to draw general conclusions about effects on prices and consumer behaviour, and hence on what would happen " but for" the interventions.

Government attempts to reduce emissions and energy consumption through direct regulation have been successful, although car manufacturers and fuel producers argue that technology-forcing imposes wider costs in forgone research and development. Additional benefits through more stringent controls are technologically feasible but will surely meet stiff resistance from manufacturers.

Reluctance to use road pricing constrains the policy options. Road pricing is resisted because of the US tradition of "free" ways, because direct taxation of any form is unpopular, and because of concerns about exacerbating differences between rich and poor. Uncertainty about how to set the price, recognition that prices should vary in complex ways by location and time of day, and the lack of a clearly efficient way to collect the charges are also barriers to action. In the case of air pollution, appropriate fees would vary by pollutant as well as location and time of day, probable fee levels would be insufficient to deter much traffic, amounts

collected would be insufficient to fund corrective actions, and no clear mechanism for compensating those harmed has been proposed. In the case of congestion pricing, probable fee levels would be so high as to be political dynamite. All these matters lead policy-makers to be sceptical about road pricing's utility, at least under current conditions.

Intervention failures thus range from failure to co-ordinate actions to failure to act altogether.

Recently, concerns about the state of the US transportation systems have led to renewed consideration of transport policy at both federal and state levels. Efforts are proceeding in several directions, including development of new road and vehicle technologies, alternative fuels, and different legal, institutional and financial frameworks.

Some of these initiatives appear to be opening up opportunities for the more effective use of economic instruments in transportation management. For example, new toll roads are being built and many more have been proposed. While the planned tolls neither approximate congestion pricing nor incorporate social costs, they may serve to increase the public's awareness of transport costs and their acceptance of road pricing. Meanwhile technological developments in automatic vehicle detection may make pricing strategies easier and cheaper to implement.

At the same time, if toll roads are privately built and the less stringent environmental review standards applied to private development in some states are maintained, major questions about environmental effects could be raised. These questions could also be raised if, as has been proposed in some states, environmental reviews are curtailed or eliminated due to desires for faster delivery of congestion-relieving projects. It remains to be seen whether transportation will follow this path, or opt for a more environmentally responsive direction.

While direct regulation will probably remain the major means of regulating transportation's environmental impacts, then, recent developments may open the way for greater use of pricing as a complementary tool, and in some cases as a preferable means of intervention.

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