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THE PRINCIPLES OF INTEGRATION IN URBAN TRANSPORT STRATEGIES

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ABSTRACT

Integration as a principle in urban transport policy is frequently advocated but rarely defined. We suggest a range of types of integration, and highlight the problems in developing an effective integrated strategy, given the number of variables involved. We argue that integration should be designed to serve agreed objectives of transport policy, rather than being an objective in its own right.

We then consider the principles for designing an effective integrated strategy. We define the concept of synergy, which is often advocated as a benefit of integration, and discuss whether it, and other aggregation benefits short of true synergy, are achievable. We then consider the alternative approach of using integration to overcome barriers, an approach which is likely to be in conflict with pursuit of synergy, but more likely to lead to readily implemented strategies.

We then review a number of examples where these principles have been applied, and investigate them to assess whether synergy has been demonstrated. Generally we find little evidence of synergy in outcome indicators. We conclude with some more general guidance on approaches to integration.

1 INTRODUCTION

There has been growing interest in recent years in the development of Integrated Transport Strategies. Their origins can be traced to a growing realisation that a "predict and provide" approach was unlikely to provide a solution to growing transport problems (Goodwin et al, 1991), an acceptance that efforts to improve the supply of transport had to be matched by measures to control transport demand (IHT, 1996), and heightened interest in the role of land use planning as a complement to transport policy (Greiving and Wegener, 2003). While several government agencies have recently advocated the use of integrated approaches (e.g. DETR, 1998; ECMT, 1995; EC, 2001), the more visionary local authorities were appreciating the need for such approaches a decade earlier (May and Gardner, 1990; May, 1991; May and Roberts, 1995). However, there is still considerable confusion as to what is meant by integration, and how best it can be achieved.

This paper discusses the principles of integration. In it we offer a set of possible definitions, and then outline possible principles on the basis of which integration might be achieved. We then consider in greater detail two possible approaches: the pursuit of synergy and the removal of barriers. We illustrate these with a number of examples taken from predictive analyses. We then consider the role of sensitivity analysis as a means of identifying possible combinations of policy instruments. We conclude with broad guidance on the ways in which pairs of policy instruments might be combined to achieve integration. Techniques for developing optimal transport strategies offer an analytical approach to the design of integrated strategies (May et al 2005).

2 THE MEANING OF INTEGRATION

As noted above, several government publications have advocated an integrated approach, with the UK government going as far as to specify integration as an objective of its transport policy (DETR, 1998; DETR, 2000). However, few policy documents define what they mean by the term. At the operational level, integration of fares, services and information provision within public transport has always been an important concern. There is, in practice, a more strategic form of integration, which is directly relevant to strategy formulation: the integration of policy instruments to achieve greater performance from the overall strategy. Such integration can occur in four broad ways:

1) integration between policy instruments involving different modes;
2) integration between policy instruments involving infrastructure provision, management, information and pricing;
3) integration between transport measures and land use planning measures; and
4) integration with other policy areas such as health and education.

There is inevitably some overlap between these. Integration of types (1) to (3) draws on the increasingly wide range of types of transport and land use policy instrument available. One problem faced in developing such strategies is the lack of information on the performance of individual instruments. We return to this issue in the final section of this paper.

While a combination of policy instruments is likely to perform differently against a given objective from any one of the constituent instruments alone, the impact of the combination will depend on the types of instrument and the levels at which they are implemented. Much will depend on their ability to influence the underlying attributes of numbers of journeys, journey length, modal share and, to a lesser extent, time of day and route taken. Some instruments will also change the transport supply, and hence the costs to users. Costs of implementation and operation and revenues generated will also be relevant to the impact of the instruments, alone and in combination. All of these will be affected by the scale and intensity with which a policy instrument is used; fare changes, for example, can vary in magnitude, by time of day and potentially by route and area. The number of possible policy combinations is thus very extensive, and our parallel work on policy optimisation (May et al, 2005a) has been developed to assist in their analysis.

A carefully designed integrated strategy, particularly of types (1) to (3), should be better able to achieve the objectives set for it than any one or more policy instruments taken on their own. Some of the forms of integration outlined above may prompt a wider set of objectives; for example integration of transport and land use (type 3) may well raise a wider set of development objectives, while integration with other policy areas (type 4) will require an understanding of their objectives (Jones et al, 2003). As with any strategy, it is important to be clear as to those objectives before the strategy is developed, since the combination of policy instruments suitable for, say, the pursuit of economic development will differ from those which best meet environmental or health targets.

A further type of integration is that between the agencies involved in the specification and implementation of this wide range of possible policy instruments. The European Commission's guidance on the preparation of Sustainable Urban Transport Plans (DGEnv, 2004) usefully distinguishes between:

- horizontal integration between agencies and departments within a city administration;
- spatial integration between adjacent local authorities; and
- vertical integration between local, regional, national and European administrations.

Such integration also requires a common understanding of these agencies' objectives, and of their relative importance. Defining integration as an objective in its own right, as was done in the UK's statements of transport policy (DETR, 1998; DETR, 2000) clouds rather than clarifies the issue. One needs to be clear what integration is designed to deliver, rather than seeing it as an end in itself.

3 POSSIBLE INTEGRATION PRINCIPLES

Most approaches to strategic integration focus on one of two types of principle: the pursuit of synergy (May and Roberts, 1995) and the removal of barriers (May et al, 2005b).

The pursuit of synergy involves finding pairs or groups of policy instruments which reinforce one another in achieving changes in the transport system, such as modal shares, or improvements against strategy objectives such as efficiency or environmental protection. Obvious examples are the provision of park and ride to reinforce a new rail or bus service; the use of traffic calming to reinforce the benefits of building a bypass; the provision of public transport, or a fares reduction, to intensify the impact of traffic restraint; and the encouragement of new developments in conjunction with rail investment. However, as will be shown later, true synergy is difficult to achieve through these means, and it will help to define the term and its associated concepts more precisely.

The removal of barriers implies identifying factors which hinder the implementation of an otherwise desirable policy instrument, and using a second instrument to overcome them. Key barriers to any strategy will often be finance, public acceptability, and concerns that some members of society will be adversely affected. Integration can contribute to the removal of barriers in three ways. Firstly it can involve measures which make other elements of the strategy financially feasible. Parking charges, a fares increase or road pricing revenue may all be seen as ways of providing finance for new infrastructure. Secondly, integration can package measures which are less palatable on their own with ones which demonstrate a clear benefit to those affected. Once again an example is to be found in road pricing, which attitudinal research demonstrates is likely to be much more acceptable if the revenue is used to invest in public transport (Jones, 1998). Thirdly, integration can involve measures which compensate losers. The selection of these depends on the side effects which arise from other elements in the package. For example, road pricing could lead to extra traffic outside the charged area, which could be controlled by traffic management, and could adversely affect poorer residents, who could be helped by exemptions or concessionary fares. We consider the issue of barriers more fully in Section 5 below.

4 THE CONCEPT OF SYNERGY

Policy instruments interact with each other in different ways. The term “synergy” is often used loosely to describe the effects of positive interactions between instruments. It is useful in practice to identify four terms that describe how the different instruments in policy packages combine with each other (Mayeres et al, 2003).

Complementarity
Complementarity exists when the use of two instruments gives greater total benefits than the use of either alone. This can be represented using the following notation:

Welfare gain (A+B) > Welfare gain A, and
Welfare gain (A+B) > Welfare gain B

Additivity
Additivity exists when the welfare gain from the use of two or more instruments in a policy package is equal to the sum of the welfare gains of using each in isolation. This can be represented as:

Welfare gain (A+B) = Welfare gain A + Welfare gain B

Synergy
Synergy occurs when the simultaneous use of two or more instruments gives a greater benefit than the sum of the benefits of using either one of them alone:

Welfare gain (A+B) > Welfare gain A + Welfare gain B

Additivity and synergy can therefore be considered as two special cases of complementarity.

Perfect Substitutability
Perfect substitutability exists when the use of one instrument eliminates entirely the welfare gain from using another instrument. This can be represented using the following notation:

Welfare gain (A +B) = Welfare gain A = Welfare gain B

The term welfare gain is used here generically to reflect the full range of net benefits relevant to a given set of objectives. It can be derived from a conventional cost benefit analysis, or from a more extensive multi-criteria analysis, but should relate to the underlying objectives of the authority concerned. It is perhaps worth asking why, in these terms, anything other than complementarity should be achievable. In a simple system, it seems unlikely that the application of two changes which are mutually reinforcing should achieve more than the sum of the parts. For example, an increase in frequency and a reduction in fare on a single bus route are both likely to increase patronage, but both will to some extent attract the same users, and the increase from the two combined is likely to be less than that from the sum of their individual impacts. However, the transport-land use system in a city is not simple; interactions between modes and routes, lags in response and feedback between transport and land use could all potentially result in discontinuities in the impact of policy instruments which could give rise to synergy.

5 THE TREATMENT OF BARRIERS

A barrier is an obstacle which prevents a given policy instrument being implemented, or limits the way in which it can be implemented. In the extreme, such barriers may lead to certain policy instruments being overlooked, and the resulting strategies being much less effective. Barriers can be grouped into four main categories (May et al, 2005b).

Legal and institutional barriers: These include lack of legal powers to implement a particular instrument, and legal responsibilities which are split between agencies, limiting the ability of the city authority to implement the affected instrument. A survey of 54 European cities (May et al, 2001) indicates that road building, pricing and land use are the policy areas most commonly subject to legal and institutional constraints. Information measures are substantially less constrained than other measures.

Financial barriers: These include budget restrictions limiting the overall expenditure on the strategy, financial restrictions on specific instruments, and limitations on the flexibility with which revenues can be used to finance the full range of instruments. Road building and public transport infrastructure are the two policy areas which are most commonly subject to financial constraints, with 80% of the 54 European cities surveyed stating that finance was a major barrier (May et al, 2001). Information provision is the least affected.

Political and cultural barriers: These involve lack of political or public acceptance of an instrument, restrictions imposed by pressure groups, and cultural attributes, such as attitudes to enforcement, which influence the effectiveness of instruments. The European survey of 54 cities showed that road building and pricing are the two policy areas which are most commonly subject to constraints on political acceptability. Public transport operations and information provision are generally the least affected by acceptability constraints (May et al, 2001).

Practical and technological barriers: While cities view legal, financial and political barriers as the most serious which they face in implementing land use and transport policy instruments, there may also be practical limitations. For land use and infrastructure measures these may well include land acquisition. For management and pricing, enforcement and administration are key issues. For infrastructure, management and information systems, engineering design and availability of technology may limit progress. Generally, lack of key skills and expertise can be a significant barrier to progress, and is aggravated by the rapid changes in the types of policy being considered.

Integrated strategies are particularly effective in overcoming the second and third of these types of barrier, and integration between authorities may help reduce institutional barriers as well. This apart, it is usually harder to overcome legal, institutional and technological barriers in the short term. It is often difficult to overcome a barrier without to some extent reducing the performance of the overall strategy. An approach which is feasible within a given financial constraint, or is modified to satisfy public opinion, is almost certainly less effective when measured against the underlying objectives than one which is unconstrained in these ways. The pursuit of synergy and the resolution of barriers are thus to some extent in conflict in the design of integrated strategies.

In the short term, a strategy designed to overcome barriers may ensure that something is implemented, rather than risking outright rejection of a better performing, but less acceptable, strategy. However, strategies should ideally be developed for implementation over a 15-20 year timescale. Many of these barriers will not still apply twenty years hence, and action can be taken to remove others. For example, if new legislation would enable more effective instruments such as road pricing to be implemented, it can be provided, as has happened to a limited extent in the UK. If split responsibilities make achieving consensus impossible, new structures can be put in place. If finance for investment in new infrastructure is justified, the financial rules can be adjusted. Barriers should thus be treated as challenges to be overcome, not simply impediments to progress.

6 SOME EXAMPLES

There is as yet little empirical evidence of the benefits of strategic integration, partly because the concept is sufficiently novel for there to be few implemented strategies, and partly because it would in any case be difficult to design a *post hoc* evaluation which successfully isolated the impacts of a combination of policy instruments. We therefore need to draw on analytical studies, most of which have focused on the pursuit of synergy. We review these first, and then look at an example of an attempt at the same time to overcome financial and acceptability barriers.

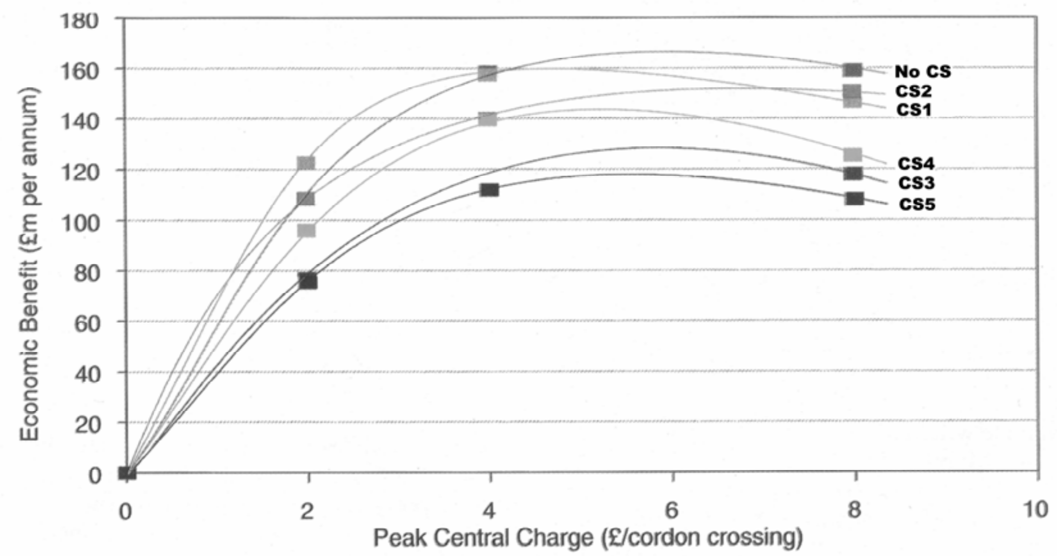
The London Congestion Charging Study

The investigation of beneficial interactions between instruments was only a side issue in the research into congestion charging in London (May et al. (1996)), as the emphasis was on the impacts of road user charging itself. Five additional complementary strategies (CS) were combined with alternative road user charging schemes to assess the potential combined impacts:

- CS 1) Bus priorities and traffic calming
- CS 2) Improved rail frequencies
- CS 3) Improved bus and rail frequencies together with bus priorities
- CS 4) New rail infrastructure
- CS 5) A combination of 3 and 4.

The study found that when adding congestion charges to each of the above strategies the highest additional economic benefit differed according to the congestion charge level. For example (Figure 1), at a congestion charge level of £2 for crossing the cordon the combination of congestion charging and bus priorities and traffic calming generated the most economic benefit. With the charge at £8 improved rail frequencies generated the largest economic benefit. Across all charges Strategy 5 generated the least extra economic benefit. The surprising result that congestion charging performs better alone than with complementary strategies throughout much of the range of charges tested arises because the resource costs of the complementary strategies have to be offset against their benefits, and some of those benefits, particularly through congestion relief, are already achieved by the congestion charging scheme.

Figure 1 Economic Benefit of Congestion Charging with Complementary Strategies (CS) in London



Source: May et al (1996)

<u>The PROPOLIS study of Dortmund</u>

The PROPOLIS study (Lautso et al, 2004) conducted a comparative study of the performance of a range of policy instruments, and selected combinations, in seven European cities, using three different land use transport interaction models. One of the case studies was Dortmund, for which the policy options were tested using the IRPUD model (Wegener, 1998). For this particular case study, a specific attempt was made to identify synergy (Wegener, 2004). PROPOLIS developed a comprehensive set of outcome indicators for the environmental, social and economic dimensions of sustainability, and a weighted aggregation of these for each of the three dimensions; it also used a conventional set of transport statistics to monitor performance (Lautso et al, 2004). The Dortmund analysis of synergy, however, was limited to a set of transport statistics and one outcome indicator: CO_2 emissions, as shown in Table 1.

Table 1: Evidence of synergy between increased car operating costs, faster public transport services and lower fares for Dortmund (Wegener, 2004)

Strategy tested	Difference from reference scenario in 2021 (%)						
	Trips	Mean trip length	Percent public transport trips	Percent car trips	Car-km per capita	Car owner-ship	CO_2 emission per capita
A Car operating costs +75%	–2.78	–14.77	+6.49	–3.61	–20.98	–6.24	–18.89
B Public transport times –5%	0.00	+0.02	+1.15	–0.06	–0.12	–0.05	–0.04
C Public transport fares –50%	+0.75	+2.49	+11.84	–0.42	–0.68	+1.95	+1.62
Total	–2.03	–12.26	+19.48	–4.09	–21.78	–4.34	–17.31
D Combined (A+B+C)	–2.00	–11.35	+26.68	–4.93	–23.03	–3.88	–17.43

The combination illustrated in Table 1 involves increases in car operating costs by 75%, potentially through fuel taxes or distance-based charges; reducing public transport journey times by 5% through bus priorities and similar measures; and halving public transport fares. It shows significant synergy in its ability to attract trips to public transport, with an increase 35% higher than that from the sum of the constituent elements. There is also clear evidence of synergy for car trips and car-km. As a result there is a modest indication of synergy for CO_2 emissions, with the combined reduction just under 1% greater than that for the sum of the constituent elements. The question arises as to why synergy should appear in elements of the overall travel pattern, but only to a very limited extent in performance against aggregate policy indicators such as CO_2. One possible answer is that these synergistic changes in, for example, public transport use are balanced by changes in other modes and elements of travel, within more stable aggregate values, such as travel time budgets. In turn, these aggregate constraints may limit the achievement of broader synergy.

The Edinburgh integrated strategy study

The Joint Authorities' Transport and Environment Study (JATES) was commissioned by the Scottish Office, Lothian Regional Council and Edinburgh District Council in 1990 (May et al., 1992). The clients sought a range of possible strategies to meet the identified broad objectives of efficiency in the use of resources; accessibility within the city; environmental enhancement; safety; economic development; equity; and financial feasibility.

Four possible land use and development scenarios were specified, and for each the future problems were identified, assuming a "do-minimum" strategy. These results were then used to identify a number of policy instruments which could be used to overcome these problems. These in turn were packaged into three hypothetical strategies, focusing on highway improvements; rail and public transport improvements; and better management of the existing infrastructure.

Extensive sensitivity testing of individual instruments was then conducted to sort the possible policy instruments into three categories:

a) those which were clearly beneficial;
b) those which were not and could be rejected; and
c) those whose range of impacts were both positive and negative, and merited further investigation.

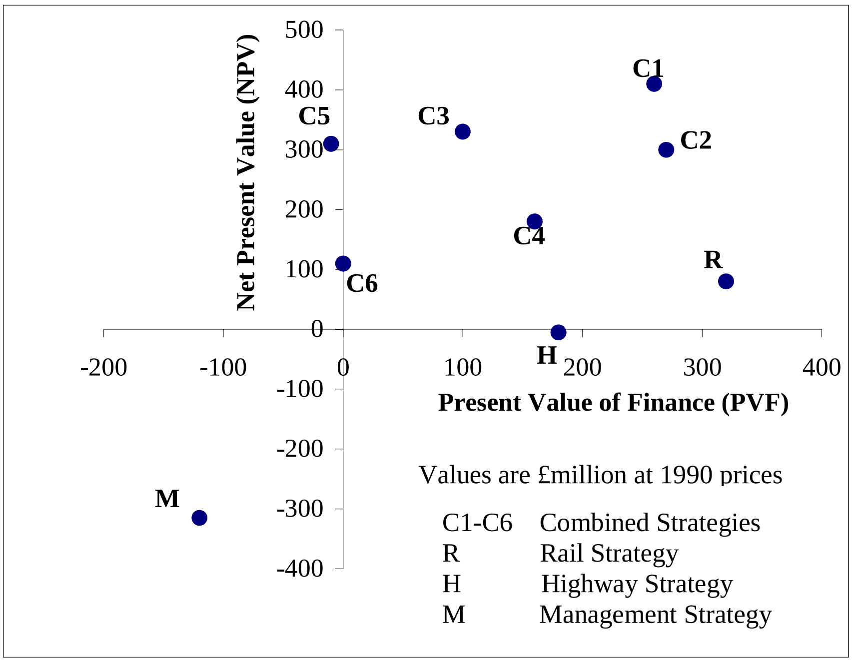
Those in category (a) were principally low cost means of managing the transport system more effectively; they included traffic management, signal coordination, bus priorities and traffic calming. Those in category (b) were primarily infrastructure projects, and the majority of inherited infrastructure proposals were rejected as having costs which far exceeded their benefits. Those in category (c) were in many ways the most interesting. They included the three most cost-effective infrastructure projects (two light rail lines and a relief road), fares reductions, a major pedestrianisation project and a proposal for road pricing in the city centre. Preferred strategies were then defined by combining the full set of instruments in category (a) with different combinations of those in category (c).

Since the finance available was uncertain, and road pricing was seen to be a particularly sensitive issue, six combined strategies were devised. They were grouped into three pairs, one with road pricing (C1, C3, C5) and one without (C2, C4 and C6). Of the three pairs, C1 and C2 involved a high financial outlay; C3 and C4 a moderate financial outlay; while C5 and C6 were designed to pay for themselves. Other instruments included were those considered most likely to increase economic efficiency within the financial constraint. This approach offers an interesting application of both principles of integration: synergy between policy instruments is being sought, while at the same time an attempt is being made to overcome financial and acceptability barriers.

Figure 2 presents the results of an initial assessment of the six strategies in terms of the net present value of economic benefits (NPV) and the financial outlay (Present Value of Finance (PVF)) determined by discounting all cost and revenue streams to the present day). Higher values on the y-axis are preferable in having higher economic benefit, but higher values on the x-axis require greater financial outlay. The ideal position is thus towards the top left of the figure. The figure also shows the three initial hypothetical strategies: highway (H), rail (R) and management (M).

It can be seen that the strategies which included road pricing achieved higher levels of economic benefit at any level of finance than those which excluded it and that the benefits obtained were much less sensitive to the availability of finance with road pricing than without. Indeed, it appears possible to design a very effective strategy (C5) with no need for net financial support, provided that the revenues from road pricing can be hypothecated. It is clear that significant improvements in overall performance can be achieved by careful integration of policy instruments. Perhaps the most dramatic indication of this is the substantial improvement achieved in the recommended strategies (C1-C6) when compared with the initial hypothetical strategies (H,R,M). As with the other studies reported here, no attempt was made in this study to investigate the existence of synergy, but the results suggest that, while complementarity was found, true synergy was not present.

Figure 2 The economic and financial performance of the Combined Strategies for Edinburgh compared to Initial Strategies



Source: May et al (1992)

7 THE APPLICATION OF SENSITIVITY ANALYSIS

The approach adopted in the above examples of testing a range of combinations of policy instrument can be formalised through the application of sensitivity analysis. The strategic model MARS has been used to represent the Edinburgh region in the UK. The case study is described in more detail in May et al (2005a). The sensitivity approach adopted was as follows:-

- A number of policy instruments were run in turn, at different levels over a feasible range, and the results were recorded in terms of welfare gains based on a standard cost benefit analysis.
- The optimal level for each instrument was identified as that which maximised the objective function (termed OF) – this was either an internal optimum or a boundary value (the upper or lower limit of the practical range).
- Various combinations of policy instruments were then run with these optimal values to investigate the possible synergy effects.

The sensitivity tests were performed for each of the following instruments:

- Peak fares (-50% to +100%)
- Off-peak fares (-50% to +100%)
- Peak frequencies (-50% to +100%)
- Off-peak frequencies (-50% to +100%)
- Peak road pricing charge to enter the city centre (€2 to €6)
- Off-peak road pricing charge (€2 to €6)
- Parking charges in the city centre long stay (€2 to €6)

- Parking charges in the city centre short stay (€2 to €6)
- Road capacity changes peak (-10% to +5%)
- Road capacity changes off-peak (-10% to 5%)
- Fuel Tax increases (-50% to +300%)
- Fuel efficiency improvements (1% and 2% p.a.)

The optimal, or practical, level for each instrument is shown in the first row of Table 2. The fares are set at their lower bound of –50%. The frequencies and peak road pricing variables are set at optimal values. The off-peak road charges are set at €2, which is the lowest value tested; any increase gives a negative OF (the true optimum would be no off-peak charge). The parking charges are set to the same values as the road pricing variables to provide a better comparison even though these are not optimal for parking charges alone. The road capacity changes and fuel efficiency are limited to what is thought to be practical, while the fuel tax increase is limited to reflect political and public acceptability constraints. The other rows in Table 2 show the spatial coverage, objective function (OF) value or welfare gain and the present value of finance (PVF) for each instrument. All benefits and financial implications were assessed over a 30 year period.

Table 2 : OF and PVF for optimal or practical levels for individual instruments (€M)

	Peak fare	Off-peak Fare	Peak Frequency	Off-peak frequency	Peak road pricing	Off-peak road pricing	Parking Long stay	Parking Short stay	Road capacity Peak	Road capacity Off-Peak	Fuel Tax	Fuel efficiency per annum
Change in instrument level	-50%	-50%	50%	25%	5	2	5	2	5%	5%	200%	1%
Spatial coverage	Area	Area	Area	Area	Central	Central	Central	Central	Area	Area	Area	Area
OF (€M)	1162.4	406.8	155.8	50.8	373.7	-67.3	172.3	9.3	548.3	912.1	1177.5	238.6
PVF (€M)	-1217.1	-1484.9	-367.0	-177.1	1151.3	698.8	169.3	55.1	73.4	155.0	10105.1	-553.2

From these results we can note that in general fares and fuel tax are the most effective instruments in increasing the value of the objective function. Also peak instruments and area-wide applications are in general more effective than off-peak and spatially limited instruments. The table also indicates the implications for financial constraints; public transport improvements require additional finance, while demand management measures can provide finance.

Table 3 shows the results for various combinations of the previous instrument levels given in Table 2. The first three rows show the sum of the OF values over the relevant single instrument results, the OF value when run in combination and the implied synergy effect. Synergy is defined here as in Section 4, with a positive sign indicating synergy. The final row shows the PVF for the combined strategy.

Table 3: OF and PVF for combinations and possible synergy effects (€M)

Strategy	1	2	3	4	5	6	7
	All instruments	Fares, Frequencies, Road capacity, Fuel tax, fuel efficiency	Fares, Frequencies, Road capacity, Road Pricing peak, Long stay parking, fuel efficiency	Fares, Frequencies, Fuel tax, Road capacity.	Fares, Frequencies, Road capacity, Road Pricing peak	Frequencies, Road capacity, Road Pricing peak	Frequencies, Road capacity, Road Pricing peak, Long stay parking
Sum of individual OF	5140.3	4652.3	4020.8	4413.7	3609.9	2040.7	2213.0
OF of Combination	4487.1	4561.5	3797.0	4372.2	3580.6	2050.2	2033.8
Possible Synergy	-653.2	-90.8	-223.8	-41.5	-29.3	9.5	-179.2
PVF of Combination	6450.0	4910.9	-2704.2	6263.4	-2233.8	828.4	874.9

The first strategy combines all instruments at their given levels. It results in an OF value some €653M lower than the sum of the individual effects. It is not a good idea to implement all instruments at their own optimal levels simply because they give improvements when applied individually. The second strategy shows the effect of removing the parking charge and road pricing instruments. Again a negative synergy value is the result. However, the second strategy gives a better OF value than with the parking and road pricing charges included. This is because the charges overlap and are applied to the same element of generalised cost for some trips. Here we have identified that these instruments exhibit partial substitutability.

The third strategy removes fuel tax increases and looks at the effect of applying peak cordon and long stay parking charges with the other instruments. Once again the negative synergy effect implies that there is some obvious overlap between the cordon and parking charges and suggests that if these were to be applied together some other combination of charges would give better results. Here we can conclude that the cordon and parking charges also exhibit partial substitutability.

Strategies 4 and 5 show the effects for fares, frequencies and road capacity with fuel tax or peak road charging respectively; in each case there is only one charging instrument and no improvement in fuel efficiency. Again there exists a small negative synergy but as the overlap between instruments becomes less then the model exhibits additivity across instruments. Strategy 6 removes fare changes from the combination in strategy 5. Here for the first time there is limited evidence of synergy. Strategy 7 adds long stay parking to this. Once again there is negative synergy. It also confirms that combining the current road pricing cordon charges with the additional long stay parking charges results in partial substitutability.

The synergy effects for the given combinations appear to imply that the model is largely additive across instruments i.e. there is little interaction between them. Only when an instrument affects the same element of generalised cost, as is the case with the parking charges, cordon charges and fuel tax for some car trips is there any non-additive effect.

Regarding the PVF values, Table 3 shows that if fare reductions are to be implemented then these can only be afforded by including the complementary instrument of fuel tax increases. Increased frequencies and improved capacities can be afforded by including the cordon charges and, as noted above, this combination exhibits a small amount of true synergy. In general, it is possible to use the OF and PVF values together to identify combinations which maximise performance within a given financial constraint.

These model results have displayed the concepts of complementarity, additivity and substitutability for a selection of instruments. Pure synergy effects were only found to be present to a very limited extent with the given objective function and instruments tested, largely because many combinations of instruments appeared to be additive in their effects. It is of course possible that synergy could be identified in an extended set of such tests, but the evidence to date suggests that it may well prove to be of limited extent.

8 GENERAL DESIGN GUIDANCE

As noted earlier, one problem with the design of integrated strategies is the sheer number of different types of policy instrument which can be used. As a result, it is difficult to be certain how each combination of instruments will interact in general, let alone being able to predict their potential in any one context. In this paper we have introduced the concepts of different types of integration, and of the potential for integration to achieve complementarity, additivity and synergy, or to help overcome barriers of finance and acceptability. Some guidance is now available on ways of applying them to the development of effective integrated strategies.

The web-based knowledgebase, KonSULT (http://www.konsult.leeds.ac.uk), whose development is described in Jopson et al (2004), considers some 60 different types of policy instrument, grouped into six categories: land use; infrastructure provision; management and regulation; information provision; attitudinal change; and pricing. It assesses the potential contribution of each to a range of policy objectives, in different contexts, both from first principles and on the basis of well documented case studies. It also attempts, for each policy instrument, to identify those instruments which might complement it by reinforcing its benefits (the pursuit of synergy), by reducing financial barriers, by reducing political and acceptability barriers, and by compensating losers.

Figure 3, taken from the Decision-Makers' Guidebook (May et al, 2005b) produced as part of the European Commission's Land Use and Transport Research programme (http//www.lutr.net), provides a high level summary, suggesting ways in which the different types of policy instrument can complement those in other categories, through one or more of these approaches to integration. For example, reading the last row, pricing instruments can complement land use measures by reinforcing their benefits (e.g. by using higher distance-based charges to encourage short journeys in mixed development) and by compensating losers (e.g. through concessionary fares or lower parking charges for those living in particular types of development). Similarly, pricing can complement infrastructure and management instruments by reinforcing their benefits (e.g. through road pricing or parking charges to encourage use of light rail or bus services); by reducing their financial barriers (through the revenue generated from charges and fares); and by compensating losers (again through concessionary fares and exemptions). The matrix can clearly only serve as a broad design guide, but it may help to stimulate policy makers to consider a wider range of solutions to their transport problems. Current research is investigating the potential for incorporating this guidance into new tools for strategy option generation (Jones, 2005).

Figure 3 An Integration Matrix

These Instruments	contribute to these instruments in the ways shown					
	Land use	Infrastructure	Management	Information	Attitudes	Pricing
Land use		❋				❋
Infrastructure	❋✚		⦿			⦿
Management	❋✚	❋⦿✚			❋	❋⦿✚
Information	❋	❋⦿	❋⦿✚		❋	❋⦿✚
Attitudes	❋⦿	❋⦿	❋⦿			⦿
Pricing	❋✚	❋◈✚	❋◈✚	◈⦿	❋	

Key: ❋ benefits reinforced
◈ financial barriers reduced
⦿ political barriers reduced
✚ compensation for losers

Source: May et al (2005b)

9. CONCLUSIONS

Integration as a principle in urban transport policy is frequently advocated, but rarely defined. A distinction can be drawn between operational integration, usually of public transport, strategic integration between transport policy instruments with land use, with policy instruments in other sectors, and institutional integration within and between local, regional and national governments. All are important. Given the range of policy instruments and the scales at which they can be implemented, design of effective integration strategies is complex. Integration should be designed to serve agreed objectives rather than as an objective in its own right.

Most integrated strategies are developed either in pursuit of synergy, or as a means of overcoming barriers, or both. Synergy as defined is a special case of complementarity, in which the benefits from the sum of the elements is greater than the sum of their individual benefits.

The case studies investigated in this paper show little evidence of synergy in performance against objectives, though there is some evidence of synergy in responses within the transport system, such as trips by a given mode. It is not clear why this is. It may be that synergy is harder to achieve with a single objective, since the instruments which contribute to it will to some extent duplicate one another in their impacts. It may be that synergy becomes more apparent when objectives are in conflict, though much will then depend on the balance between these objectives.

It should be stressed that few of the studies reviewed were designed specifically to investigate synergy. More research is needed to investigate the concept, and more examples of the analysis of integrated strategies would be welcome. Further application of strategic transport and land use models will be needed to test whether the concept, as applied to transport strategy, is achievable or largely ephemeral. In the meantime it appears that complementarity is a more realistic goal than synergy.

Financial and acceptability barriers, in particular, can be overcome by careful integration of different policy instruments, thus increasing the chance of the strategy being implemented. However, the overall benefit is likely to be less; thus the use of integrates strategies to overcome barriers is likely to be in conflict with the pursuit of complementarity.

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