Integrated Resource Planning for Transport: asking better questions.

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Abstract

Current transport planning methods do not deliver accessibility in a sustainable way—a phenomenon illustrated by the dominance of road construction as a means to provide access in cities. This research proposes a comprehensive evaluation methodology for investment decisions aimed at improving urban accessibility—Integrated Resource Planning (IRP) for transport. Using IRP in transport planning means agreeing on a metric for improved accessibility in a location and then developing a range of 'options' to meet this need. Each 'option' is evaluated in terms of cost per unit of improved accessibility. We propose that cost effective decisions will only arise from comparison of the full range of options using a consistent methodology.

Keywords: Cost and Investment Assessment, Transportation Demand Management, Transport Sustainability, Economic and Social Impact

1 Introduction

Historically transport planning has sought to address objectives of providing capacity for increased trips and reducing travel time. In the industrialised world post-WWII, increased suburban growth and motorisation led to an emphasis on road construction as the preferred strategy (Kitamura & Fuji [1]) and evaluation methods tended to reinforce this by focussing on travel time, trips, or even vehicle movements as the unit of service. Since the 1970s and the emergence of environmental and public health concerns about motor vehicle use, there have been attempts to incorporate environment and public health factors, and a multi-modal perspective into transport planning and evaluation tools.

Most of the emphasis in evaluating transport systems has focussed on project evaluation, typically using some form of cost benefit analysis and/or multi-criteria analysis as the main tool/s (Bristow & Nellthorp [2]). Some of these methods have been generalised to accommodate comparison between modes, such as comparing road and rail to deliver the same number of trips with comparable travel times. An example is the development in the UK of COBA (a standard cost-benefit analysis tool) and its evolution to NATA (a New Approach to Appraisal). NATA extends standard cost benefit analysis (focussed on financial parameters only) to include some qualitative and intangible parameters (Vickerman [3]).

All these methods rely principally on travel-time savings as a key benefit, but as Kitamura and Fujii [1] point out, travel is a derived demand. It is useful only by virtue of the desire or need for people to move between an origin and a destination using a mode or modes of travel. Attention therefore needs to be paid to the purpose, or objective of the travel, and to the suite of options that can be employed to meet that purpose or objective.

2 An Established IRP Methodology

Integrated Resource Planning (IRP) provides the foundation for a transport planning and evaluation approach focussed on the purpose of travel and incorporating a more comprehensive suite of options. Energy utilities first applied IRP in America's Pacific North West for investment decisions where they sought the lowest cost means of providing the same level of service to customers. The service to customers was conceptualised in terms of the disaggregated end-use of energy, for example heating, cooling and lighting rather than the amount of energy, which is a derived demand (Mieir *et al* [4]).

Since the initial application as 'least cost planning', this approach has become a powerful planning tool in both the energy and water sectors. For example, least cost planning is now used by water utilities throughout Australia and internationally (Howe & White [5], Skeel [6]).

2.1 IRP in Transport: DECIDE

Transport planners have also investigated using IRP. The IRP perspective means travel can be conceptualised as a derived demand required to access services. There is general agreement [7, 8, 9] with the following basic steps (e.g. as used by the Puget Sound Regional Council [10]), which we call the DECIDE approach to IRP in transport:

1. **D**efine the objective;
2. **E**stablish the system boundaries;
3. **C**onsider a broad range of options to address the objective;
4. **I**nvestigate the costs and benefits of the options;
5. **D**evelop a ranking of the options; and
6. **E**valuate and choose a package of options to implement and monitor.

The steps in the DECIDE framework for IRP in transport are as follows:

2.1.1 Define the objective

Step 1 is to define the objective of the proposed investment because the objective will vary depending on how and where IRP is applied. Examples might include: reducing travel in private cars; optimising travel through a constrained location at peak periods; reducing fatalities or reducing greenhouse gas emissions. Importantly, specifying one key objective does not exclude other impacts from the analysis. Instead, achievements relating to other objectives are counted as benefits (or 'disbenefits') and included in the 'net cost' per unit of improvement towards the key objective.

2.1.2 Establish the system boundaries for the analysis

Defining system boundaries is the second fundamental step in analysis of this kind and has three key components: geographic location, affected parties and analysis horizon. Firstly, the inherent place-based nature of transport means that geographic system boundaries will significantly influence evaluation outcomes, for example as pollution impacts vary with geography. Secondly, it is important to ensure inclusion of the full range of avoidable future costs (public, private and social) and this requires a system boundary including all affected people and groups (DeCorla-Souza *et al* [12]). Thirdly, changes over time (in travel patterns and costs and benefits) need to be included. For example, it is important to ensure that where a decrease in private vehicle traffic occurs (for example owing to a travel demand management initiative), any induced traffic growth is also measured. The time lag between increased capacity arising from infrastructure augmentation and induced traffic growth (the 'ramp up') is relatively short (Zeibots [13]). However, if original private motor vehicle trips gradually decrease, other travellers may switch modes or make additional trips, gradually resulting in another form of induced traffic growth. Including such travel changes and longer-term investment strategies requires extended analysis timeframes. Twenty or thirty year timeframes are typically used in IRP.

2.1.3 Consider a broad range of options to meet the objectives

One of the key challenges for transport evaluation according to EcoNorthwest [9] is to encompass multi-modal transport (walking, cycling, public transport and private motor vehicle travel) as well as the broad range of interventions now identified within the field of mobility management (EPOMM [14]). The range of options should be broad enough to include some options within each of the following categories: modifying existing transport facilities and services or adding capacity to existing systems (supply-side) and reducing demand for private motor vehicle travel (demand-side).

2.1.4 Investigate the costs and benefits of each option

Given a clear definition of the investment objective, an established system boundary and a broad range of options to contribute to the objective, the next step is to collate data to determine the likely costs and benefits of each intervention. It will not be possible to monetise all the costs and benefits of interventions fully, and often other methods will be required, including the use of deliberative assessment methods or some form of multi-criteria decision-making.

Of primary importance is the clear documentation of costs and benefits and the underlying assumptions.

The contribution of the intervention towards the key objective is the first aspect to quantify. A range of metrics could be used in an IRP framework, subject to the objective of the specific evaluation (see Section 3).

The second quantification task relates to the costs and benefits arising from the intervention, including the cost of the intervention itself, changes in the financial costs of operation and maintenance of the transport system, changes in environmental costs such as greenhouse gas emissions and changes in costs arising from accidents and injuries. To account for the timeframe within which benefits (and 'disbenefits') accrue, present value costs and benefits are used (Fane et al [15]).

2.1.5 Develop a ranking of the options using a common metric

The comparison of options is based on the estimated contribution each option makes toward achieving the key objective and the resulting costs and benefits to society of that change. The net cost per unit of service is typically used to compare options in a cost-effectiveness analysis. In the case of transport, option ranking could be based on the cost per unit of improved access.

2.1.6 Evaluate and choose a package of options to implement and monitor

A ranking of options (from lowest unit cost upward) is often used to communicate the results of analysis within an IRP framework. This is not to say that only the lowest cost option will be implemented, and in practice it is often useful to investigate the ranking of groups of options ('scenarios') and calculate the net present value of the total investment required.

2.2 IRP in Transport: applied

Most strategic planning processes, and transport planning specifically, are similar to the DECIDE approach outlined above. ECONorthwest [9] describe identify that key differences relate mainly to the relative importance and order of the steps, the planning horizon and the scope of the planning (e.g. incremental or comprehensive). Planning processes such as this rarely proceed in a purely linear manner—revisiting earlier steps is likely.

Important features distinguishing an IRP approach from cost benefit analysis include: a comprehensive view of the range of alternative options (specifically including supply and demand side measures); consistent evaluation from a number of perspectives; explicit sensitivity analysis; consideration of externalities; verification of outcomes and regular evaluation, and a formal and repeated public participation process (ECONorthwest [9]).

Furthermore, the flexibility of the IRP approach allows application across the full range of transport planning levels both retrospectively and prospectively, and for corridor or sub-regional analysis and system-wide strategic plans (ECONorthwest [11]).

3 Metrics: Limitations and Opportunities

DeCorla-Souza *et al* [12] identify the evaluation of alternative projects based on mode-specific effectiveness criteria as an inherent barrier to comprehensive evaluation using traditional methods. They suggest this can be overcome by IRP through use of a metric that is consistent across all types of alternative ways to achieve the key objective.

Transport evaluations and policies use a range of indicators of more sustainable transport, however, no consensus about an appropriate measure is evident. The OECD's Environmentally Sustainable Transport (EST) Project established quantitative criteria incorporating emissions of nitrogen oxides, volatile organic compounds, suspended particles and carbon dioxide combined with use of land and noise [16]. Australian policy examples include, at the state level, a target to stop the growth in total vehicle kilometres travelled (VKT) (established in the New South Wales Government's Air Quality Management Plan [17]) and the Victorian target of a modal split of 20% of motorised trips by public transport (established in Melbourne's Metropolitan Transport Plan (Victorian Government [18])). An appropriate IRP metric will be cost-effective to estimate and applicable to both supply and demand measures. Table 1 illustrates some examples.

Table 1: Possible Metrics

Metric	Units	Comments	Evaluation Type
Travel in private motor vehicles	Total annual vehicle kilometres travelled	• Already measured • May not identify unmet access needs	Macro VKT targets
Mode share for private motor vehicles	% trips	• Does not measure growth in travel • Difficult to measure impact of small measures	Initiatives to reduce car use
Improved access	Number of people	• Requires robust, broadly applicable definition of 'improved access'	Addressing transport disadvantage A regional strategy
Meeting access needs	Number of people	• Requires robust, broadly applicable definition of 'access needs'	Corridor planning; capacity constraints
Reductions in total trips past a particular point	Number of trips	• Easy to measure • May not identify unmet access needs	Specific capacity constraints

Some of the metrics in Table 1 are readily used. For indicative purposes we have added less well developed measures relating to units of 'improved access'. This could mean 'the number of people with significantly improved access over the whole assessment period' involving a qualitative assessment of what 'significantly improved' access is (there may be more than one level of access improvement or it may be quantitative).

It has been suggested that the range of objectives met by transport and mobility interventions complicates the identification of a single investment objective (ECONorthwest [11]). On the other hand, defining the objective of the investment in a concise manner, whilst inherently difficult, is a key opportunity. The IRP framework has traditionally allowed a full suite of options to be compared consistently by using a 'unit cost', viz. 'costs per unit of service delivery' as the metric. The use of a unit cost means options with a smaller individual impact can be compared consistently with large-scale options. The result is that a package of small measures may be found to be cheaper and together to deliver comparable results to a more expensive, single, large-scale project. The alternative to a unit cost comparison—the use of total costs and benefits of several discrete projects—does not provide this advantage.

4 The Full Complement of Options: A Hypothetical Bridge

IRP, and the least cost planning analysis embedded within IRP, rests on a foundation of bringing forth all possible options for consistent evaluation. What follows is a hypothetical example of the kind of transport decision making aided by IRP.

The study area is an urban peninsula with limited access corridors leading from the mainly residential area to the central business district of the city. The key connection is via the Wave Bridge, a five lane bridge with two lanes in each direction and the additional middle lane operating in the direction of peak traffic flow. The bridge operates at capacity during the morning and evening peaks and lengthy delays and queuing occur. The queues extend intermittently beyond the bridge to the remainder of the route to the city, and delays and queuing also occur on weekends when the beaches along the peninsula are a recreational destination for residents of both the peninsula and other areas. An express bus service operates to the city along this route (without bus prioritisation) at 15-minute intervals during peak periods. There is a proposal to add additional lanes to the bridge using a form of 'clip-on' construction. This option is compared with other possible interventions in Table 2.

The first question is what the investment objective is and the second is what the supply augmentation will contribute to this aim. One possible objective is to improve accessibility for people who live or work in the peninsula. This helps narrow the focus to weekdays where the constraint is peak periods, thus guiding the development of options. Estimates in Tables 2 and 3 are informed through other published research and not through application of these measures to a particular location.

Table 3 demonstrates the comparative analysis of options with very different levels of impact. The ranking can form one input to decision making. In this case it may be appropriate to layer IRP analysis with other qualitative analysis. For example it may be appropriate to rule out a congestion charging approach, based on the regressive impacts this option may create for some people in the study area, if implemented without effective public transport. The important characteristic is the comparison of a *broad* range of options.

Table 2: Wave Bridge Options

Option	Impact on Access	Costs	Indicative Cost ($M)	Benefits
‘Clip-on’ Bridge Lanes	↑ bridge capacity by 2,000 vehicles/hour in each direction which induces traffic	Construction, maintenance Vehicle operation Pollution, accidents	300	↓ travel time ↓ pollution
Initiatives to encourage public transport usage (e.g. workplace travel program, individual marketing, parking policy)	↑ walking, cycling and trips by public transport	Workplace program development Communication strategy implementation Parking study	0.8	↑ physical activity ↓ pollution ↓ accidents
Bus Prioritisation	↑ trips by public transport	Cost of lane marking, signage and signals ↑ congestion and time costs for drivers	100	↓ pollution ↓ accidents
Congestion Charging on the Wave Bridge	↓ trips by private motor vehicle across the bridge in peak periods	May impact on job opportunities for people unable to pay the toll or use flexible working hours	0.3	↓ pollution ↓ travel time
Increase jobs/services north of the Wave Bridge	↓ trips for residents leaving the area	Jobs need to match local skills May induce trips from the south Long-term strategy needed	50	↓ pollution ↓ accidents

Table 3: IRP Assessment

Option	Relative Impact (People/day with improved accessibility during whole analysis)	Relative Cost ($M)	Unit cost ($’000/person with improved access)	Ranking
‘Clip-on’ Bridge Lanes	1,500	300	200	3
Initiatives to encourage public transport	50	0.8	16	2
Bus Prioritisation	200	100	500	4
Congestion Charging	100	0.3	3	1
Increase jobs and services	80	50	625	5

In addition to the broad range of options to improve transport services (on the supply side), diverse travel demand management options exist. We propose the following as a useful grouping of these instruments (whilst recognising that most initiatives incorporate elements of more than one instrument):

1. Regulatory approaches e.g. bus prioritisation (Tables 2 and 3), high occupancy vehicle lanes or planning controls on parking space provisions;
2. Economic instruments e.g. congestion charges (Tables 2 and 3) and distance-based insurance; and
3. Communicative strategies e.g. transport access guides and workplace travel plans (Tables 2 and 3).

The diversity of possible interventions includes different kinds of street network (Henson & Essex [19]) and mixed use development (Katz [20]). Limited evaluation of some travel demand management interventions should not preclude their inclusion in analysis and implementation phases. In some cases, the costs to implement changes are relatively small compared with comprehensive evaluation costs and evaluation of a package of measures *post hoc* may prove more useful.

5 The Cost of Decision Making and the Cost of Decisions

The cost of data collection is pertinent in this, as with many analysis approaches. The unique dimension related to IRP is the explicit desire to consistently evaluate small, medium and large impact options. This requires data specifications that identify the costs and benefits to include in the analysis.

The cost perspective used in the analysis is fundamental. The perspective used in IRP is the ‘whole-of-society’. In practice, this means all costs are included regardless of who would normally pay the cost—individuals, government, transport providers or society generally (DeCorla-Souza *et al* [12]). However, only actual costs (and not transfer payments such as fares paid by passengers to operators) are included.

Changed travel time is a complex aspect of analysis within an IRP framework. As the backbone to most current transport planning analysis, it is difficult to argue that travel time benefits are not important. However, counting only significant travel time benefits should be ensured. In practice this may mean not including changes of seconds or even of a few minutes on usual trip durations (at least in part because such changes are not larger than the usual daily variation in trip time).

Given future uncertainty, costs and benefits are discounted to indicate the relative merit of interventions delivering benefits in the short term. Discounting benefits is a relatively new concept in IRP and has proved particularly valuable to level the analysis basis between large scale options which deliver benefits after some lead time and short term options delivering benefits more quickly. Given the significant potential for benefit erosion over time, discounting of both aspects is vital.

6 Analysis Impacting on People

The analytical approach described above has many advantages over traditional project evaluation approaches using cost benefit analysis. However, many of the underlying dimensions of the transport planning process lend themselves to the use of decision making approaches in which citizens are more involved, an element Szyliowicz [21] describes as inadequate in transport planning. For example, the objective-setting process is one in which values are as important as the scientific and technical aspects, and the valuation of many externalities defies a technocratic approach. To deal with this, requires the strategic use of emerging techniques for engaging citizens, other than stakeholders who are typically involved in decision making through 'submission and reply' methods. Instead, these processes need to be deliberative (allowing dialogue, information sharing and exploration of issues in facilitated small group processes), representative (using randomly selected, stratified samples of citizens) and empowered (a clear mandate in terms of influencing the decision) to allow for robust decision making (Carson & Hartz-Karp [22]).

7 Evaluating Implementation

In addition to the evaluation of options and scenarios as part of this IRP DECIDE framework the *post-hoc* assessment is an important component. Historically this has been poorly implemented. In practice, this is the monitoring and assessment of the impact of various interventions in the transport system, whether a road or rail construction project, congestion pricing or other forms of travel demand management. This assessment process is essential for good planning, as it allows feedback into the process and an improved understanding of the impact of options.

8 Conclusions

The total cost of transport to society continues to escalate, despite major technological advances, including at the individual vehicle level. Responses to this problem have been two-fold. Firstly, the emerging field of mobility management moves us toward multi-modal transport, recognising the important roles of active transport (walking and cycling), travel demand management, demand responsive public transport and a large field of management measures including regulatory, economic and communicative instruments. Secondly, there is a growing awareness that effective and meaningful involvement of citizens in the decision-making process is overdue. Despite these promising trends, the inevitable conclusion is our planning and evaluation tools do not yet successfully draw these approaches together. IRP in transport could begin to meet this need.

As we have shown, IRP could incorporate important improvements in transport planning. It can evaluate multi-modal analysis and demand management approaches, incorporate participation by citizens, compare interventions that differ greatly in size, measure changes over time and include externalities.

The DECIDE approach described here draws together a variety of research showing that the steps to apply IRP in transport are simple but the approach is sophisticated and robust. To date, despite some well-formulated documentation and tools, particularly by Puget Sound Regional Council, the application of IRP in transport has been limited. A decision to proceed with this approach could radically improve transport planning and, most importantly, help deliver more sustainable transport.

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